

Natural History of Hawaii.

SECTION FOUR

THE INTRODUCED PLANTS AND ANIMALS OF FOREST, FIELD AND GARDEN.

CHAPTER XVII.

A RAMBLE IN A HONOLULU GARDEN: PART ONE.

To anyone coming to the islands from the more rigorous climate of the mainland, the verdure to be seen in Honolulu is little short of a dream of paradise come true. In many ways the city of Honolulu appears as a great tropical botanical park, conducted on a coöperative plan, the advantage being that the residents, as shareholders in the enterprise, have their homes dotted about here and there over the spacious well-kept lawns. The houses, covered as they are with vines and surrounded with luxuriant foliage, add to the picturesque beauty of it all, so that more than one person has been heard to exclaim, "This Pacific Paradise is indeed the land of heart's desire."

FIRST IMPRESSIONS OF HONOLULU.

It is not too much to say that from the morning of the day of one's landing after a weary sea journey to the very hour of their departure, be it in a day, a year, or a life time, the rare tropical trees and plants to be seen on every hand, but especially in Honolulu, furnish a source of never-ending pleasure and delight.

If one has an interest in plant life, it is a rare treat to be brought face to face for the first time with living examples of such symbols of the tropics as the breadfruit, the cocoanut palm, or the banana. One is made to feel that no picture has ever done justice to such visions of beauty as they often present in their natural setting, and the observant person is at once alive with interest, anxious to know something of the multitude of interesting and curious trees and plants with which these conspicuously tropical species are often grouped. The visitor is always keen for a ramble through any of the attractive gardens that abound on every hand and anxious to know more of the wonderful exotic flora that embowers the thrifty island capital.

Perhaps the first general observation in this connection is one made from the deck of the steamer as it rounds Diamond Head and reveals Honolulu as a city, not built on a hill, but hidden beneath a canopy of waving green trees that are so large and dense that only the tallest buildings and spires can be seen

above the tree tops to serve as a guarantee that beneath the wealth of green lies one of the most cosmopolitan and beautiful cities in the world.

As one walks or rides about the streets he observes that so far as the flora is concerned Honolulu may be said to be simply a very good reproduction of the Kew gardens of London, the difference being that in tropical Honolulu the gardens are done on a very large and elaborate scale. In most instances, in both places the plants that one sees are not native to the country but are those that have been brought hither from the very ends of the earth and set growing for the interest, the benefit or the pleasure of those who know how to enjoy them.

The streets of Honolulu are often narrow and winding, but most of them, even the very broadest, are shaded by various species of trees that reach out from the yards on either hand. Often great trees will be left in the center of the sidewalk and occasionally the street itself is divided by some fine specimen that has been allowed to stand, by an appreciative and public-spirited road overseer.

PALMS.

Palms are to be seen in great variety and abundance. Of the more than seventy species occurring everywhere about the city all but two or three are foreign to the islands. The most conspicuous and stately among the introduced species is the royal palm.¹ It was brought to the islands long ago from its home in the West Indies. Planted singly, in straight avenues or in irregular groves, it is an attractive tree that cannot fail to arrest the eye, since it everywhere gladdens and enriches the landscape. Their lofty, clean, grey trunks are absolutely vertical and as symmetrical as though turned in a lathe. No scar of growth or blight of disease mars their marvelous straight Ionic shafts up to the crowning tuft of long, beautiful balanced, pinnate leaves of deep shining green that form fitting capitals for such splendid stately pillars. The slightest stir of breeze sets every leaf waving and singing, and night and day one knows "when the wind is in the palm trees" by the gentle rustle that they make.

The blossoms are small, sweet-scented, cream-colored flowers that hang in a great pendant cluster from the base of the lowest leaves. Their faint odor is a pleasant one in the soft balmy evening, and by day a source of great concern to swarms of busy bees that reap a rich harvest of honey during the few days that the blossoms last. At length the blossoms are followed by the fleshy fruits that are eaten by the mynah birds, and by them the seeds are carried from place to place.

A FALLING LEAF.

I well remember with what surprise and alarm I first heard a palm leaf fall. It was in the still of the night soon after my arrival in the islands. Scarcely a breath of air was stirring when suddenly I was aroused with a start at hearing, somewhere in the garden, a mighty ripping noise that ended abruptly

¹ *Oreodoxa regia*.

in a loud cracking sound as though a whirlwind had broken loose among the tree tops. Then followed a swirl and a swish, a rustle, and a rush that seemed to leave no doubt but that all the trees in the garden had been suddenly set whirling through the air. But after a moment of breathless suspense the whole affair ended in a terrific clatter and thump, after which all was again as silent as before. In the morning when the leaf was shown to me there remained no doubt but that it was the cause of the "eyelone" of the night before. The leaf was a trifle over eighteen feet in length and weighed several pounds! Though accustomed to regard a falling leaf as an exceedingly melancholy thing, I had never before thought of the harm that might be received in the tropics at least, from so simple and ordinary a thing as having a withered leaf strike one unawares as it circled gracefully to the ground.

THE COCOANUT PALM.

The cocoanut palm² is perhaps native, or at least of very early introduction by the natives, and is among the most showy of the palms. It is the cocoanut palm by the sea that first greets the stranger on his arrival in Hawaii. Basking in the languid warm sunshine it has stood for generations at the post of honor by the broad portal of this earthly paradise. Breathing the very spirit of the tropics it has come to be the symbol of true hospitality and stands ever ready to cast that magical spell that none can resist. At the parting it is this stately sentinel by the water's edge that is always the last living thing to reluctantly wave a fond good-bye to those who must depart, knowing in their heart of hearts they are to return again.

Its feathery plumes tower out above everything else, as they are often sixty feet or more in height. All things considered there are indeed few trees among the wild, semi-cultivated or exotic flora in Hawaii that equals in picturesque beauty this "the prince of palms."

Few trees so frequently and effectively figure in the domestic setting for the Honolulu home. They are of fairly rapid growth and come into bearing, in favorable soil, in ten or fifteen years. The tree continues to grow in height until thirty or forty years of age, when they seem to have attained their limit of growth, but they continue to live on indefinitely without gaining materially in size or height. On the beach at Waikiki are trees that are known to be several hundred years old, while a splendid grove near by has very nearly caught up with them in height in a single life time. This palm will never branch and never sends up shoots from the ground, and like many other trees in the tropics that belong to a great group known as Endogenous plants, they are easily killed by destroying the plume-like top.

The cocoanut trees thrive best at or near the sea-shore. However, they do reasonably well in some localities two or three miles inland. Elevation apparently has more influence in retarding growth than the absence of the effect of the sea. Where water is to be had in abundance any soil seems to do so long as it is

² *Cocos nucifera*.



PLATE 64. VIEWS IN TROPICAL GARDENS IN HONOLULU.

1. A by-path in the tropical gardens at Anahau showing Crotonea (*Cordia alliodora*) in the foreground; to the left further on the Umbrella plant (*Cyperus alternifolius*). 2. Date Palm drive in Kapiolani Park. 3. Coconut trees are several species of *Philodendron*.

easily penetrated by the roots of the palm. For this reason the sandy soil near the sea-shore furnishes its best environment. The structure of the tree fits it to withstand wind of almost any force and they seem to prefer plenty of rain, wind and sun.

The yield of nuts fluctuates greatly from year to year and from tree to tree. There are reports of as many as 400 nuts having been gathered in one season from a single tree in some of the more favored islands of the south Pacific. In Hawaii as many as 200 nuts, besides innumerable blossoms, have been counted on a tree at one time, but it is doubtful if an average of eighty mature nuts could be gathered during a year. It is a curious thing that nuts perfectly green in appearance will be as ripe as those having yellow husks. For this reason, it is desirable to pick the oldest nuts on the tree without waiting for them to ripen and fall to the earth. While no one in Honolulu, to my knowledge, has ever been injured by a falling cocoanut, the constant danger from that source is apparent since a good-sized nut in the husk weighs several pounds. Those who are familiar with the delicate flavor of the young nut prefer to gather them when half mature and spoon the soft meat out of the shell before it has had time to solidify and become oily.

Of late years the tree rat has become a great pest in the cocoanut trees and does great damage to the young nuts by gnawing holes in them. They readily pass from one tree to another along the leaves, and when a colony of rats becomes established in a grove the tin sheaths so commonly placed about the trunk of the tree does but little good, unless the tops of the trees are kept clear of the neighboring foliage.

While it is considered a difficult thing to tell how the milk gets into a cocoanut, the rate of growth and the remarkable changes that take place during the period of germination and early growth when the milk is getting out of the nut can be easily studied and well repays the trouble of making the observation. The time occupied in germination varies greatly, owing to a number of conditions, especially the amount of moisture and sunshine, but in general many weeks must pass before the first leaf opens.

Just how the cocoanut came to Hawaii in the first place will never be known. Its legendary history dates far back, and doubtless the tree has accompanied the Polynesians on all of their wanderings about the Pacific. To this day the native country of the cocoanut is not definitely known. DeCandolle finds twelve reasons for thinking it of Asiatic origin, but singularly enough there is one reason—an almost unsurmountable one, for believing it to be an American plant. Botanists have proven that none of the other nineteen species of the genus exist anywhere in a wild state except on the American continent, and therefore conclude that the familiar species must have had the same origin. Some say that the Philippine Islands is its ancestral home, and that it was from thence carried in all directions by ocean currents or by artificial means. At any rate it ranges over the whole of the tropics, and within that range there are many varieties based mainly on the size and shape of the fruit. However, these variations are

strongly marked and retain their characteristics when grown from seed. For the reason just stated we may regard those grown in Hawaii—at the northern limit of the range—where the climate is scarcely warm enough for their best development, as forming a fairly distinct variety, namely the Hawaiian cocoanut.

The cocoanut, or niu, had many uses in Hawaii a century ago. The trunk of the tree furnished fairly heavy timber, while the long pinnate leaves were used in former days as thatch, and laced together they formed the walls of the native lanai. From the husk of the nut a durable rope was made, and various household utensils were manufactured from the shells. The natives drank the juice and ate the meat of the nuts. They also healed their wounds with a balm made from the juice, and with the oil extracted from the meat of the nut they anointed their limbs and embalmed the bodies of their dead.

THE DATE PALM.

Less striking, perhaps, but even more beautiful in certain ways than the foregoing, are the date palms³ with their splendid fronds that are often larger and always more numerous than are those of the cocoanut palm. To many these sturdy, thrifty trees are the symbol of strength, beauty and repose.

The date palm was long ago introduced into Hawaii and it has been a conspicuous tree in the islands ever since. Though it bears large bunches of orange-colored dates, the fruit is seldom eaten, as the pits are usually so large that the little flesh that surrounds them is not worth the effort required to secure it. Without doubt, however, a good quality of dates can be produced here, when suckers are secured from selected parent plants.

The leaves of this and other species of palms are often used for decorations, especially on Palm Sunday. It is thought that for this reason the parent plants were of very early introduction into the new world by the Spanish missionaries.

ORNAMENTAL PALMS.

The betel nut,⁴ though with a very slender stem, is in superficial appearance not unlike the royal palm. It bears a yellow fruit, the size of a hen's egg which has one seed surrounded by a fibrous husk. The seeds are chewed by the natives of certain south Pacific and East Indian islands to blacken the teeth. The word betel is erroneously applied to this fruit, as it is the name of the leaf of a totally different plant.

Of the native palms a few specimens of the loulu palm are to be seen here and there about the city. They are a fan palm with smooth trunks and in their wild state grow in secluded places in the forests often to an elevation of three thousand feet above the sea. One species, the loulu lelo,⁵ has small ovoid fruit, while the loulu hiwa⁶ has large globular fruits. Of the innumerable varieties of fan palms to be seen only a word can be said, since their number and variety defy a brief characterization. However, the class can be easily recognized by

³ *Phoenix dactylifera*.

⁴ *Areca cathecu*.

⁵ *Pritchardia Gaudichaudii*.

⁶ *Pritchardia Martii*.

their fan-shaped leaves. The more common, though less attractive wine palm,⁷ can at once be recognized owing to its large coarse bipinnate leaves and wedge-shaped leaflets that are strongly toothed at the extremities. The wine made from this palm in India is drawn off by cutting the ends of the flowering stems from which exudes the sweetish sap. This is then boiled down into a syrup or by fermentation made into a toddy. The splendid examples of the Washington palm,⁸ with their tall robust trunks clothed with the pendant remains of dead leaves, are sure to attract attention from travelers, especially those from California, where this "weeping palm" is a native.

Two or three species of the beautiful *Rhapis* palms occur in the islands, where they are usually planted in pots and tubs. They are one of the few palms that produce suckers at their base, thereby forming thick clumps. The large species⁹ often grows eight or ten feet in height and has the stems armed with prickles. The smaller species¹⁰ most commonly have the stems unarmed and the leaves with about ten segments. It can easily be identified as a different species from the plants having leaves with from five to seven segments.¹¹ All of the species are native to Japan and China and are occasionally called Japanese or Chinese palms.

Other plants of interest are the sugar palm,¹² a spineless species growing forty feet high; and the oil palm,¹³ with a stout coarsely and deeply-ringed stem twenty or thirty feet high. It has red fruits which yield the palm oil of commerce. The bottle palm,¹⁴ with a curious bottle-shaped stem or caudex, and the blue palm,¹⁵ with splendid bluish fan-shaped leaves, are easily recognized.

Only two or three species of the tropical palm-like eyecads are found here, and these are the common kinds to be seen growing under glass in more rigorous climates. The plants are propagated from seeds. They are very curious in their method of flowering since the flowers appear in a mass in the heart of the great crown of leaves. In time the flowers are followed by the fertile seed from which they readily grow. The sago palm¹⁶ is the commonest species in cultivation, though the much larger species¹⁷ is not uncommon.

ARAUCARIA.

Passing to the evergreen-like trees, the giant *Araucaria* of Australia and elsewhere grows to an enormous size and is frequently seen in gardens. Some splendid species of the Norfolk Island pine¹⁸ are to be seen in the older gardens in Honolulu. The monkey-puzzle or Chili pine¹⁹ is also common about the city. The Monterey cypress²⁰ seems to thrive in the islands and is much esteemed as an ornamental tree.

A tree which is more common than any of the foregoing, and one which might be easily mistaken for a pine, is the Australian ironwood,²¹ beefwood or she-oak. The fruit is cone-like in appearance and together with the needle-

⁷ *Caryota urens*. ⁸ *Washingtonia filifera*. ⁹ *Rhapis Cochinchinensis*. ¹⁰ *Rhapis humilis*.
¹¹ *Rhapis flabelliformis*. ¹² *Acrota saccharifera*. ¹³ *Elais guineensis*. ¹⁴ *Hyophorbe amaricaulis*.
¹⁵ *Lantania glaucocephala*. ¹⁶ *Cycas revoluta*. ¹⁷ *Cycas circinalis*. ¹⁸ *Araucaria excelsa*.
¹⁹ *Araucaria imbricata*. ²⁰ *Cupressus macrocarpa*. ²¹ *Casuarina equisetifolia*.



PLATE 65. VIEW IN THE OLD GOVERNMENT NURSERY SHOWING A NUMBER OF RARE EXOTIC PLANTS.

In the foreground a bunch of Pampas grass (*Quercium argenteum*); to the left a young date palm; in the background a fine Traveler's palm (*Ravennata Madagascariensis*).

like branchlets would seem to entitle it to claim relationship with the cedar, cypress or pine. Though the tree is widely distributed it was not known to the native Hawaiians before its introduction by the whites. The tree has its greatest use as wind-breaks. However, it has been extensively planted about the city and reminds the visitors from northern climes of the winter season as the wind whistles and sighs through its branches.

THE KUKUI.

Look where one will in the city he will find but little that really belongs to the native flora. The few species to be seen that pass as native trees are for the most part those brought here from Polynesia by the natives themselves. However, there are a few of these that are of common occurrence and especially striking in appearance. The kukui or candle-nut tree²² is always identified by its conspicuous pale yellow-green, almost silvery foliage. It is one of the most beautiful and abundant trees of the group from sea level up to two thousand feet. In sheltered nooks and shady ravines the silvery-green foliage can be made out from far out at sea, and is usually proudly pointed out to the stranger from the deck of the steamer as one of the most beautiful and picturesque trees of Hawaii-*nei*. It is a luxuriant shade tree and is well worthy of a larger place in the parks, private grounds and streets of the city than it now occupies.

The wood is soft and white and is useless for building purposes; but the nuts, which are similar in shape and size to a black walnut, were made by the natives to serve in many useful ways. The shell of the nut is hard and black and capable of taking a very high polish. They were strung into leis and fashioned into other ornaments. The oily kernels were strung on splinters of bamboo to form *tohehes*, whence the name candle-nut. The acrid juice contained in the covering of the nut was the base for a black dye for *tapa* and also served as an ink in tattooing the skin. The nuts, roasted and mixed with salt, form a very pleasant side dish at native feasts. The oil was pressed from the kernels and burned in stone lamps of native manufacture. It also made a waterproof coating for *tapa*, and was occasionally used among the old-time Hawaiians to oil the body for various purposes, especially to render it slippery in evading their opponents in physical encounters. The gum which exudes from the bark also had several uses.

It is of interest in this place to note that all branches of the Polynesian race know the kukui by the same name. Though the kukui is generally dispersed over the islands, and forms a large part of the forest up to the upper edge of its range, it has but few enemies among the Hawaiian insects. This fact is taken to indicate its being of comparatively recent Hawaiian introduction, and suggests that there has not been sufficient time for it to attract serious insect pests.

THE BREADFRUIT.

Another native importation of much value is the breadfruit,²³ or *ulu*, of the

²² *Aleurites Molluccana*.

²³ *Artocarpus incisa*.



PLATE 66. MISCELLANEOUS GROUP OF CULTIVATED PLANTS.
(FOR DESCRIPTION OF PLANT SEE OPPOSITE PAGE.)

natives. It is planted singly about the gardens in the city and is quite commonly met with in groves of some size in the various valleys of the group. Wherever grown it adds materially to the beauty of landscape and in addition it has a great utility value. The young tree usually grows in the form of a perfect cone. The leaves are often two feet or more in length, dark, vigorous green in color and deeply lobed. The tree always has a thrifty look which it retains long after it has lost the charm of perfect form. The large green globular fruits are three to five inches in diameter and are especially esteemed by natives and Europeans as food. When very ripe the baked fruit has a flavor suggesting sweet potato. When cooked green the flavor is less pronounced and less pleasing. The tree attains a height of forty to sixty feet. The wood is a saffron color, very durable and not liable to split. Elsewhere it has been used to some extent in the manufacture of wheel hubs, but in Hawaii it is not used commercially. The Hawaiians used the leaves for polishing, the bark as a medicine, and the gum for capturing birds. Like the kukui, the breadfruit has accompanied the Polynesians on all their wanderings wherever the climate would allow it to live.

The tree is exceedingly difficult to propagate. As the Hawaiian variety rarely, if ever, produces fertile seed the plant has been distributed by root sprouts and by layerings. It is not as important here, however, as in Tahiti, where the fruit is made into a breadfruit poi.

MANGO.

The mango ²⁴ is a strikingly beautiful tree and is as much prized for its shade as for its delicious fruit. It forms one of the most stately trees to be seen in the city or about the islands. Its compact growth and its dense foliage of large, dark-green leaves serve to identify the tree, but the rich purple-red or red-brown young leaves, usually grouped on opposite sides of the tree at different seasons, make it especially conspicuous and worthy of remark.

Most of the trees bloom in January and the fruit ripens along in July and August. However, these dates vary greatly and are frequently reversed, so that there is hardly a day in the year when ripe, fresh fruits may not be found in the city. The bearing trees make but little growth owing to the heavy fruitage which bends low the sturdy branches. Often only one side of a tree will be in fruit at a time.

The fruit of the mango is of the most exquisite shape and color. It is about the size of a pear, ovoid, slightly flattened with the two sides developed unequally.

²⁴ *Mangifera Indica*.

DESCRIPTION OF PLATE.

1. A fine Algaroba tree [Kiawe] (*Prosopis juliflora*). 2. Leaves of the Sacred Banian (*Ficus religiosa*). 3. A Bougainvillea in full bloom. 4. A Rhaps Palm (*Rhapis Cochinchinensis*). 5. Bird's Nest Fern [Ekaha] (*Asplenium nidus*) from the native forest. 6. Flowers of *Clerodendron Thomsonia*. 7. Fruit, flowers and leaves of the California Pepper (*Schinus Molle*). 8. Air-plant (*Bryophyllum calycinum*). 9. A Cycas (*Cycas* sp.). 10. *Phylodendron* in an Algaroba tree; a Bottle Palm to the left, a Fan Palm to the right.

giving it a thick comma shape. When ripe the fruit is a rich yellow with apple-red cheek on the side turned toward the sun. But they vary in size, shape and color as much as apples do, for, like the apple, they seldom come true from the seed.

The tree is supposed to have originally come from India. It is the only one of thirty or more species belonging to the genus *Mangifera* that has any value. As many as five hundred varieties have been reported from India, and perhaps forty or fifty of the best sorts to be found are established in Honolulu. While usually grown from seed they may also be propagated by budding. This, unfortunately, is a somewhat difficult process involving much care and skill. Within the last few years the trees here have been affected with a blight not common elsewhere. It is due to a fungus disease that is thought to be aided in spreading by the blue-bottle flies and other insects carrying the spores from flower to flower. It will be noticed that the sooty mould, when severe, often gives the whole tree a blackened appearance.

MONKEY-POD.

In almost every yard and square about the city, and indeed over the whole group, will be found one or more monkey-pod trees.²⁵ The better name for the tree is samang; although it is sometimes called the rain-tree, since it blossoms at the beginning of the rainy season in its native home in tropical America. It is an exotic, having long been introduced. It belongs to the great group of acacia-like plants, and has compound or multi-compound leaves. Like most of its relatives it has the habit of closing its leaves in sleep at night. After sundown it presents a wilted appearance and does much toward changing the aspect of the whole city after nightfall. Trees of this species that are several feet in diameter at the girth and spreading shade over a space 150 feet across, are to be commonly seen about the islands. It is a permanent shade tree, and aside from the litter of the discarded leaves and pods and a slightly ragged appearance during the winter season it is highly desirable as an ornamental tree. As a tree to be planted along the sidewalks it is hardly to be recommended, as it grows at such a furious rate that it is liable to lift the walk and injure the curbing. It is therefore a tree better suited to ample lawns, open spaces and parks.

THE ALGAROA.

Of all the introduced trees the algaroba²⁶ is the favorite. It is a mesquite, perhaps of the southwestern United States and Mexico, and has been greatly improved and modified by the change of environment. The original tree in Hawaii grew from a seed planted in 1837 on Fort street, near Beretania, by Father Bachelot, founder of the Roman Catholic mission. It is thought that the seed was brought from Mexico, though this point is far from being settled by the historians of the islands. The tree is still in a thrifty condition and is the pro-

²⁵ *Pithecolobium Samang*.

²⁶ *Prosopis juliflora*.

genitor of more than 60,000 acres of forest distributed over the entire group. At first it grew only at the lower levels, but, little by little, succeeding generations have crept higher and higher until now they thrive from the sandy sea beach to 1,500 feet elevation. The lee coasts of Oahu, Molokai, and parts of Hawaii have been changed from deserts to forests by the algaroba alone. Curiously enough, the land which it has taken possession of is usually arid or stony, or so steep that it was considered generally worthless. If left alone they shade the ground with a dense growth and attain a height of fifty to sixty feet. When trimmed and thinned, as they are in the city, their delightful shade moderates the heat of the tropic sun, allowing the growth of the lawn grass beneath, and in dry seasons protecting it from the direct rays of the sun. Their slender, brittle branches are often too much in evidence to be asthetic in themselves, but nevertheless they have a weird picturesqueness of their own. The trunk at first seems uncouth, but there is a grace and poise to the slender vine-like branches and feathery leaflets as they toss to and fro in the trade wind, that over-balances the ruggedness of the gnarled and twisted trunk.

In addition to its asthetic qualities the algaroba is one of the most useful of trees. Besides yielding an enormous amount of wood of splendid quality, they are valuable for the pods that are produced with great regularity after the tree is three years old. The pods ripen gradually during the summer months, and, next to the grasses, form the most important stock food. They are eaten by horses, cattle and hogs with great relish. The hard, horny seeds which are embedded in a sweet pulp are not digested by the stock, and hence are in prime condition for growing and are scattered broadcast in this way.

The algaroba is also our most important honey-producing plant. Bees are exceedingly fond of the nectar of the flowers and the sugar of the beans. Many apiaries in algaroba groves produce honey of attractive appearance and superior flavor.

The tree exudes two different kinds of gum. The most valuable collects in clear, amber-colored, tear-like masses on the bark. It resembles the gum arabic of commerce. As it contains no tannin and desolves readily in water the gum has elsewhere been used in laundries and to some extent in the manufacture of gum-drops. In Mexico it is also valued for certain medical properties. In Hawaii it has never been collected or used, though large quantities of the gum could be secured.

CHAPTER XVIII.

A RAMBLE IN A HONOLULU GARDEN: PART TWO.

THE POINCIANA.

Turning to the purely ornamental trees, first place is usually given to the scarlet-flowered royal Poinciana,¹ or to one of the closely allied species or varie-

¹ *Poinciana regia*.

ties. The common species grown here, known as the "flame tree" or "flamboyant tree," has been so well named as to scarcely require further description. Though it is a fairly rapid grower it is not a large tree as a rule. The smooth trunk is expanded at the base in a curious way, forming buttresses that correspond with the principal roots. This peculiarity in connection with its rich-green foliage arranged in horizontal spreading layers of fine pinnate leaves, makes it a tree so dainty as to attract attention at all seasons. But when it bursts into full flower it is one solid mass of crimson, the admiration of all, and without doubt it is one of the most striking of tropical trees. Although it sheds its leaves at certain seasons it is at such times almost as remarkable for its large pods as for the blossoms which preceded them. The generic term, which is the one commonly used as the name of this species, was given in honor of Governor-General Poinci, who wrote on the natural history of the West Indies during the middle of the seventeenth century. The species and varieties common in warm countries are found here.

PRIDE OF THE BARBADOES AND THE GOLDEN SHOWER.

The pride of the Barbadoes,² with orange-colored blossoms and a second variety with yellow flowers, are quite common, the latter being known as the yellow poinciana. But more conspicuous through the summer months is the golden shower,³ or after the pods have set on it, the "pudding-stick" tree. The foliage is quite scant, consisting of large pinnate leaves. The flowers appear in pendant panicles and for several months there is a succession of pure primrose-yellow, fragrant blossoms that justify the popular common name of the tree. Another species is the purging Cassia⁴ or horse Cassia, with pink and white flowers and leaves that somewhat resemble the locust. It is most conspicuous when bearing the large club-like pods eighteen to twenty inches long and an inch or more in diameter. Another species known locally as the "pink shower" resembles the latter in many ways, but has the pods divided off with transverse diaphragms separating the seeds which are embedded in pulp. In this species⁵ each seed is enclosed in a tiny pillbox-shaped case, the seeds lying collectively in the pod like so many coins rolled together in a case. The flowers grow in clusters closely resembling those of large, rich-colored crabapple blossoms and surround the bough of the previous year's growth. The tree remains in full blossom ten or twelve weeks and is a delight to all beholders. But of this large genus there are numerous species represented in the introduced flora of the islands, many of them producing handsome trees and shrubs.

PRIDE OF INDIA.

The pride of India,⁶ also a second and smaller species from Jamaica,⁷ both with delicate lilac-colored flowers, are often called the "umbrella tree." The flowers are followed by a crop of yellowish berries which are eaten and dis-

² *Cassipouira pulcherrima*, ³ *Cassia fistula*,
⁶ *Melia Azedarach*, ⁷ *Melia semperirens*.

⁴ *Cassia nodosa*.

⁵ *Cassia grandis*.

tributed by the mynah birds. The larger species without doubt came originally from India, but has been extensively planted in warm climates everywhere.

The tamarind,⁸ a name which, by the way, is derived from the Arabic meaning "Indian date," is an exceptionally beautiful and useful tropical tree. It attains a great height and its delicate acacia-like foliage crowded together so as to produce a dense head makes it a shade tree that is considered by all travelers to be one of the noblest in the tropics. It is probably a native of India or Africa, but has been generally introduced in tropical countries. The pods, numerous and from three to six inches long, contain an acid pulp that in the islands is made the base of a cooling drink of much the same character as that made from lemons or limes. Occasionally the pulp is also used in making a delicious tamarind butter, but as a general rule they are allowed to fall to the ground or to be carried off by roving children. The wood is greatly esteemed in the manufacture of furniture. It is yellowish-white, sometimes with varicolored sap streaks, and is very hard and close-grained.

THE BANIAN.

The Banian (or Banyan) tree, a name derived from the fact that it furnished shelter for the open markets of the banians, or Hindu merchants, and therefore literally a "market place," is a common tree in Honolulu. The family to which it belongs is well represented in the gardens and parks of the city, there being at least a dozen or more of the large arboreal species that can be easily recognized, usually, though not always, by the pendant aerial roots. The Banians all belong to the great order⁹ to which the common fig¹⁰; the Indian rubber plant,¹¹ the Bengal banian tree,¹² and the creeping fig¹³ on our garden walls, as well as some six hundred other similar species scattered throughout the tropics, are referred. The most ornamental plant, perhaps, is the India rubber plant. But the great spread of the typical banian tree, which sends down some of its branches or aerial roots that in time take root in the soil, is one of the largest and most thrifty-looking trees growing in Hawaii. Many of the related species have the same or similar methods of reproduction.

PEPPER TREE.

Among other important shade trees in the islands must be mentioned the pepper tree¹⁴ that grows so extensively throughout California. It is easily recognized by its graceful, swaying branches and red berry-like clusters of fruits about the size of peppercorns, from which resemblance it derives its popular though misleading California name.

The kamani,¹⁵ or tropical almond, often planted for the shade afforded by its broad, horizontal branches and large, broad leaves, is an introduced species coming originally from Asia. Before the leaves fall they take on the brilliant autumn colors common in cold climates, and thus add much to their picturesque beauty. The tree is also known as the Demerara almond, on account of the

⁸ *Tamarindus Indica*.

⁹ *Urticaceae*.

¹⁰ *Ficus Carica*.

¹¹ *Ficus elastica*.

¹² *Ficus Benghalensis*.

¹³ *Ficus pumila*.

¹⁴ *Schinus Molle*.

¹⁵ *Terminalia catappa*.



PLATE 67. VARIOUS VIEWS IN HONOLULU GARDENS.
(FOR DESCRIPTION OF PLATE SEE OPPOSITE PAGE.)

edible almond-like, filbert-flavored nut they produce. The nuts may be eaten either raw or roasted.

This tree should not be confused with the native kamani¹⁶ which has beautiful glossy, oblong or ovate leaves and globe-shaped nuts an inch or more in diameter. This species is a splendid ornamental tree that is believed to be an ancient Hawaiian introduction, as it occurs throughout Polynesia and southern Asia.

THE WATTLE.

The black wattle¹⁷ and the silver wattle¹⁸ have been cultivated in Hawaii for nearly half a century, and these or their numerous relatives are common in the city and constitute the chief trees planted in the Tantalus forest. Likewise the Australian oak or silk-oak,¹⁹ is common in parks and gardens and is easily recognized by its fern-like leaves and sweet-scented golden-yellow trusses of flowers.

Of the bananas and citrus fruits, and fruiting vines, that have some commercial value and are grown both for their fruit and foliage, we will say nothing here, deferring so engaging a subject for another chapter. Next to the trees in their striking ornamental effect, however, are the numerous species of vines and vine-like plants everywhere about the city. The property holder in Honolulu feels that his fence, his house, and his out-buildings are doing full duty only when loaded with a profusion of luxuriantly flowering vines, and there are perfect tangles of vines and blossoms about many homes.

BOUGAINVILLEAS.

The most conspicuous of all in this class are the Bougainvilleas. Magenta, scarlet-red and brick-red are among the common forms, and as to abundance they occur in the order mentioned. Of the magenta colored species²⁰ there are two common varieties, one of which is an ever-bloomer. Throughout the year this species is one continuous mass of purple, and is one of the most striking of the introduced plants. The salmon, brick-red, orange and scarlet varieties are to most people more pleasing than the brilliant magenta species; but when a blaze of color is required, the Bougainvillea of any shade will never be a disappointment. The curious thing about them is that it is not the blossoms after all that are so remarkable. An examination shows that it is only the bracts that enclose the inconspicuous flowers that are so highly colored. All told there are

¹⁶ *Calophyllum Inophyllum*.

¹⁷ *Acacia decurrens*.

¹⁸ *Acacia dealbata*.

¹⁹ *Grevillea robusta*.

²⁰ *Bougainvillea spectabilis*.

DESCRIPTION OF PLATE.

1. Japanese flower peddler. 2. Night-blooming *Cereus* (*Cercus triangularis*) on Oahu College wall. 3. Washington Palm (*Washingtonia filifera*); to the left a Royal Palm (*Orce-dora regia*); to the right, a Date Palm (*Phoenix dactylifera*). 4. *Zamia* sp. 5. A Banian tree (*Ficus Indica*), showing the curious aerial roots. 6. Wine Palm in fruit and flower. 7. The Monstera (*Monstera deliciosa*). 8. A Mangosteen (*Garcinia Morella*) or Gamboge tree.

perhaps a half-dozen or more of these South American shrubs from which several varieties have been propagated. The name was given in honor of Bougainville, an early French navigator.

ALLAMANDA.

The Allamanda, with two or three species, one of which ²¹ is a conspicuous vine especially common about verandas, is easily recognized by its thick, green leaves and large, fragrant yellow flowers that are always blooming. Another favorite is the trumpet-creeper or fire-cracker vine.²² Its orange-red flowers are the color of living flame of varying shades and tints. When in blossom (and it blossoms for weeks at a time), the green of its foliage is often completely hidden from view, and the porch, barn or out-building over which it runs is a magnificent show of flowers.

OTHER VINES AND SHRUBS.

A favorite especially suited to stone walls and to some extent as a climber in trees, is the Bignonia or bird-claw vine.²³ The Bishop Museum is literally overrun with this rich, glossy-green climber, and at certain seasons the beautiful yellow blossoms transform its otherwise uninteresting exterior into a palace of gold. The masses of this flowering vine as they hang pendant from the tallest trees about the city produce a vision of airy, golden loveliness that lingers long in the mind's eye. More prized perhaps than any of the foregoing, but unfortunately less common, is the Stephanotis,²⁴ known as "Kaulani's flower." Its fragrant white blossoms at certain seasons transform the trellises of the city into veritable banks of snow. With the Stephanotis will often be seen a fragrant climber, known as the wax-plant,²⁵ so named on account of the thick, waxy leaves and wax-like star-shaped flowers.

Here and there in old gardens one sees various species of *Convolvulus*, giving a touch of the familiar morning-glory blue to the scene, or, with as much ease a dash of yellow ²⁶ from India and the Orient. The pretty climbing Mexican creeper or mountain rose,²⁷ "Rosa de la Montana de Mexico," with its delicate sprays of pink blossoms, and the more obscure though wonderfully fragrant Chinese violet ²⁸ with greenish yellow blossoms, are both always in evidence.

Several species of jasmine are common. The beautiful climbing snow-white ²⁹ is a favorite, as is the perpetually blooming Arabian jasmine,³⁰ with handsome white flowers that turn purple as they die. The beautiful purple wreath ³¹ is one of the most striking of the rarer climbers; the five-pointed deep-lilac flowers hang in graceful racemes and come into full bloom in April and May, lasting several weeks.

More conspicuous and tropical than any of the foregoing are the several species of arboreal plants with large foliage leaves, the number of which growing in Honolulu is too great to receive more than passing notice here. The

²¹ *Allamanda cathartica*, ²² *Bignonia venusta*, ²³ *Bignonia unguis-cati*, ²⁴ *Stephanotis floribunda*,
²⁵ *Hoya carnosae*, ²⁶ *Ipomoea chrysoides*, ²⁷ *Antigonon leptopus*, ²⁸ Native name 'Pakalani.'

²⁹ *Jasminum grandiflorum*, ³⁰ *Jasminum Sambac*, ³¹ *Petrea volubilis*.

South American group of tree-loving *Philodendrons* is represented by perhaps a dozen species that are among the more common climbing plants. They are usually characterized by broad coriaceous, though often with divided, leaves and are to be seen hugging palms, climbing trees and running over stone walls everywhere about the city. The *Monstera deliciosa*, like the foregoing, is a tree-loving plant and is easily recognized by the enormous dark-green leaves that are occasionally two feet in length and pierced by curious, large elliptical holes. The flowers are small and betray the plant's relationship to the order *Aracea*, to which great group the taro and the calla lily belong, by having the boat-shaped, creamy-colored spathe. The succulent fruit of coherent berries requires many months to ripen. But it eventually becomes a fruit a foot long by two inches in diameter, resembling an ear of corn in shape and having a very delicate tang suggesting both the pineapple and banana in flavor.

The city abounds in ornamental shrubs. What it lacks in annual and perennial flowering plants is compensated for by the gorgeous, highly-colored and varied leaves of this class of ornamental plants.

The Christmas flower, or poinsettia,³² is recognized by the stranger in the islands from temperate climates as a familiar hot-house friend. But instead of being a scraggy plant growing in a tub, it grows in Hawaii in the open and attains a height of fifteen to twenty feet. At Christmas time it is most conspicuous, lighting up the city with the splendid scarlet-red of the flowers, though the so-called flowers are in reality a cluster of large leaf-like bracts that surround the small insignificant blossoms. A white variety is also occasionally seen about the city.

The poinsettia belongs to the great tribe of euphorbias and has a white milk-like juice. The genus was named as long ago as 1828 for the Hon. J. R. Poinsett, an American minister to Mexico, who discovered the common species now in cultivation, growing wild in that country.

Of recent years the beautiful *Ixora* has found much favor as a Christmas flower owing to its large, showy clusters of bright-red blossoms and large glossy-green leaves. The plants, however, do not confine their flowers to the holiday season but generally extend their Christmas cheer throughout the year. The species most common in Honolulu is a member of the typical genus in the tribe *Ixorea* which belongs to the larger order *Rubiaceae*, to which the coffee plant belongs. The generic name *Ixora* is given as the name of a Malabar deity to whom the flowers are offered in their native country. A number of the hundred or more species belonging to the typical genus are occasionally met with in hot-house collections in Europe and America, but in the congenial climate of Hawaii they thrive with but little care, forming one of our most attractive and conspicuous garden shrubs.

The crotons of the floriculturist, so extensively grown as foliage plants in Hawaii, are not crotons at all but *Codiaeums*, and like the foregoing, belong to the great order *Euphorbiaceae*. The word *Codiaeum* is of Malayan origin, and it is

³² *Euphorbia pulcherrima*.



PLATE 68. BLOSSOMS FROM A HONOLULU GARDEN.

1. Purple wreath (*Petrea volubilis*), 2. Madagascan Periwinkle (*Vinca rosea*), 3. Fire-cracker vine (*Bignonia venusta*), 4. Spanish Jasmine (*Glossinum grandiflorum*), 5. Bird-claw vine (*Bignonia unguis-cati*), 6. Senna (*Cassia* sp.), 7. Thumbergia (*Thumbergia laurifolia*), 8. Beaumontia (*Beaumontia grandiflora*), 9. Mexican Creeper or Mountain Rose (*Antigonon*).

from there the single species with three well-marked varieties have been distributed all over the world to be developed into more than a hundred cultivated forms and sub-varieties. While most of the forms have been given names, the practice among botanists is to regard them all as belonging to one species.³³ A majority of the best known forms may be found growing in Honolulu gardens.

These beautiful plants, with their many forms of odd and handsome foliage of the most brilliant coloring, are to be seen in profusion everywhere. The colors range from almost pure white to light and deep yellow, orange-pink, red-crimson, and all these joined in the most remarkable combinations. In some cases one color predominates, in others every possible combination is represented. But a close study of the form of the leaves will demonstrate that three principal types exist, namely, those with ovate, short-stalked leaves, those with narrow and spatulate leaves, and those with narrow and often cork-screw twisted leaves. Planted in clumps and masses the effect produced by the combination of their rich colors is charming. They are often used to advantage as hedges and are made in one way or another to give color to almost every lawn.

The garden varieties of Colens are also a legion, and many of them or their near generic relatives thrive in the city and occasionally escape, as on Hawaii, into the wooded stretches along the roads and lanes. A very deep-red, large-leaved foliage plant of this family is in general favor. It is planted in rows to form hedges about gardens and is wonderfully variegated in foliage.

HEDGE PLANTS.

The hedge plant that is most conspicuous and, happily, the most common in Hawaii is the Hibiscus. Of this splendid shrub about six forms and innumerable varieties are in general cultivation. Of the common varieties, miles and miles of hedges have been made. These are among the first objects to attract the attention of tourists and visitors, and one never tires of the display of blossoms of all sizes and colors that line the street. There are at least four native species, two or more of which have been cultivated to some extent by Hibiscus enthusiasts. Much has been done here and elsewhere along the line of producing new varieties by cross-breeding, so that every color from white, yellow, salmon to deep red, in double and single blossoms, are abundant. It is to be hoped that this splendid shrub may become so popular as to be regularly adopted as the "City Flower" of Honolulu. As the hedges of scarlet and pink Hibiscus are ever a delight to the eye a keen rivalry may well develop among householders in the production of rare forms, since new varieties are easily produced by cross pollenization.

Ki.

A plant that is common in the mountains and is often planted in hedges is the ki ³⁴ plant, the *Dracena*, or more properly the *Cordyline* of botanists. There are several cultivated varieties, especially one with wine-red leaves that are cou-

³³ *Codiaeum variegatum*.

³⁴ *Cordyline terminalis*.

mon in Honolulu gardens. The natives find many uses for it that must be mentioned elsewhere. Its leaves are articles of daily use, however, especially as a wrapping for fresh fish in the markets.

Still another shrub that is a favorite for hedges in the city is the beautifully variegated *Phyllanthus rosco-pictus*. The leaves are small, alternate, and entire in two rows on small branchlets, so that they appear like pinnate leaves. They vary in color, being variously mottled with pink and red as well as with white and green.

Most of Hawaii's visitors who come from northern climes for their first visit to the tropics are greatly surprised to find the Oleander,³⁵ variously called rose-bay, rose-laurel or South Sea rose, growing in beautiful ever-blooming hedges ten to twenty feet in height. This old-fashioned evergreen shrub, so common as a hot-house pant, flourishes here with but little care and blossoms in various shades of pink, white and cream color. It is not generally known that all parts of the Oleander are poisonous, and that there are authentic records of people who have died from eating the flowers; death has also occurred from using its wood as skewers in cooking meat.

A beautiful tree frequently seen in gardens about the islands is locally known as the "bestill-tree," owing to the fact that its large, slender, daintily poised, shining green leaves are set in motion by the slightest breeze. It is also called the yellow Oleander, on account of its golden, funnel-shaped flowers that are further characterized by having the edge of the corolla made up of a series of over-lapping lobes. The flowers and the foliage suggest the typical Oleander—to which it is distantly related—and makes the name not inappropriate even though it is not a true *Nerium*. This common species (*Theceta nerifolia*) is elsewhere known as the quashy-quasher, and is widely distributed in the tropics, particularly in the West Indies and tropical America. The wood is hard and even-grained, and its seeds yield the fixed oil called exile-oil. The genus belongs to the great order *Apocynacea*, which includes in its numerous tribes such well-known and widely-differing ornamental plants as the Vinca, Oleander, Allamanda, and the Plumieria.

PANDANUS.

Several species of Pandanus or screw-pine are found growing, in old gardens, some forms attaining great size. They are remarkable for their stilt-like aerial roots, and the perfect spiral arrangement of their long sword-like leaves, which are held aloft on a few scarred, naked branches. The aerial roots gradually lift the trunk out of the ground, but at the same time anchor it firmly in all directions. Two species are common, one of which is a variegated form. There is not space here to go deeply into the question of varieties, for there are as many as fifty species known and many of them are in cultivation in Honolulu gardens.

The splendid specimens of Hereules' club, or angelica tree,³⁶ commonly

³⁵ *Nerium Oleander*. ³⁶ *Aralia spinosa*.

called *Aralia*, are often among the more showy plants about houses and on lawns. Another species³⁷ has white margins to all the leaves and is much esteemed and used as a quick-growing hedge. The candied leaf-stalks of angelica are not an uncommon confection.

The *Plumeria*³⁸ is a favorite, especially with the natives, and few of their gardens are without one or more of these curious plants. From the white-and-yellow flowers they are accustomed to make leis (wreaths) that rival in sweetness the jasmine or the tuberose. Though they may be unsightly in appearance for a month or two, when the leaves drop from their thick, club-like stems, they make ample atonement for this defect during the rest of the year when they are bedecked with a profusion of rich-colored, star-shaped, sweet-scented blossoms. The genus was named for a celebrated French botanist, Charles Plumier, and includes about forty species, three or four of which are grown in Hawaii.

FERNS.

Although ferns abound in every garden, there are but few that belong to the native flora. Perhaps the curious bird's-nest fern³⁹ or *ekaha*, is the most conspicuous of this class. It stands out boldly against the background, formed by the trunk of the tree in the fork of which it is established and is often five or six feet in diameter across the curious whirl of paddle-shaped leaves. It grows naturally in the mountains, but stands transplanting in tubs and rockeries in the city. The tree ferns which abound in the native forests are seldom seen in the city. They do not thrive in the drier climate of the lower zone. This is unfortunate as nothing in the native flora could be more ornamental. Owing to the difficulties encountered in growing native mountain ferns the town gardener has come to depend to a large extent on the hardy fish-tail or Boston fern⁴⁰ and everywhere, in the ground, in pots and hanging baskets this species thrives. The beautiful, graceful, dark-green, always fresh looking, maile-scented Staghorn fern (*Gleichenia longissima*), a favorite for hanging baskets or rockeries, is a vigorous grower in the low altitudes, and prevents the fishtail from having an apparent monopoly of this style of ornamentation. But in hot-houses, where the amount of moisture and sunlight are more easily regulated, a profusion of rare and beautifully delicate ferns are grown that are the source of just pride among growers and furnish the basis for much rivalry among the inhabitants of Honolulu. Some of the larger collections have scores of species represented, among them some of the most delicate, as well as the largest and most showy forms known.

Coming to the garden flowers, the visitor is usually doomed to disappointment. Although almost any of the flowers in general cultivation elsewhere will grow with little care and many of them thrive here, it is the exception to find a yard in which any attempt is made to have a flower-bed of annuals, much less an old-fashioned flower garden. In place of flowering plants bordering the driveways, foliage plants and ferns are quite commonly substituted. Occasionally,

³⁷ *Aralia Guifoylei*.

³⁸ *Plumeria acutifolia*.

³⁹ *Asplenium nidus*.

⁴⁰ *Nephrolepis exaltata*.

however, flowers are planted, but usually such hardy bloomers as white and pink Vinea⁴¹ will have their place about the base of a palm tree or by the garden wall, and likewise the beautiful blue phlox-like leadwort⁴² will be seen, but as a rule the flowers that one sees are such as require little care and are perennials. As there is abundant color in the flowering trees and shrubs one does not miss the old-fashioned flowers as much as otherwise would be the case.

The old-fashioned four o'clock⁴³ is a familiar flower so long established in Hawaii, that, in favorable situations, it has escaped and grows by the roadside. They are handsome, branching herbs with opposite leaves, the lower petiolate, the upper sessile, and with quite large, often fragrant, flowers which are white, scarlet, or variegated. There are perhaps a dozen other species that are native to the warmer parts of America, a few of which are occasionally cultivated, but the common four-o'clock, or marvel of Peru, is the one usually seen. It derives its name from the fact that the flowers open daily in the late afternoon.

Occasionally the curious sprouting-leaf plant, or "air" plant,⁴⁴ will be seen in some neglected corner, and will be identified as a begonia-like plant that may be propagated by leaf cuttings. In fact, if one of the thick, fleshy leaves is pinned to the wall, little plants will spring up from the notches on the edge of the leaf.

NIGHT-BLOOMING CEREUS.

It would not do to draw this long chapter to a close without mention of the wonderful blooms of the night-blooming Cereus.⁴⁵ Likely as not fragments have been carelessly piled on the stone fence at the bottom of the garden where they have grown unnoticed until they have transformed an unsightly fence into the semblance of a sprawling evergreen hedge. At intervals of not more than a few weeks, especially during the summer, it clothes its ungainly, fleshy, triangular stems with giant creamy-white, lily-like blossoms a foot or more in diameter. Few there are who have visited Honolulu and not been delighted by the famous cactus hedge at Punahou Academy. On the wall about the campus is a continuous stretch of Cereus, five or six hundred yards in length, on which thousands of these great flowers may be seen in blossom each year. They open soon after the sun goes down and remain in full bloom during the night. But by nine o'clock of the following day the glory of the night before will have departed, although the following night belated blossoms will somewhat restore it. Fortunate, indeed, is the visitor whose 'ramble in a Honolulu garden' has been so timed that he may be present at the "Cereus season," since the occasion is without doubt one of the most remarkable and wonderful of the city's many floral exhibitions. The night-blooming Cereus is a wonderful climber; it has clambered high into many large algaroba trees in Honolulu, its magnificent blossoms tantalizing beholders by being out of reach.

⁴¹ *Vinea rosea*.

⁴² *Plumbago Capensis*.

⁴³ *Mirabilis Jalapa*.

⁴⁴ *Bryophyllum calycinum*.

⁴⁵ *Cereus triangularis*.

CHAPTER XIX.

TROPICAL FRUITS IN HAWAII.

Until recently the brains and energy of the people in Hawaii have been so centered on developing the more profitable field crops, that but little systematic effort has been put forth towards the introduction and cultivation of edible fruits. Nevertheless many delicious fruits are found growing in the islands in both a wild and cultivated state. In much the same way that we compare Honolulu to a botanical garden, by reason of the number and variety of its ornamental plants, we may compare Hawaii to a great unkempt experimental orchard.

NATIVE AND INTRODUCED FRUITS.

Many rare, curious and toothsome fruits have been brought to Hawaii from the ends of the earth in times past by fruit lovers. But, unfortunately, they have too often been planted out among ornamental plants, in out-of-the-way places or left in neglected corners to shift for themselves. With few exceptions such plantings have not materially advanced the cause of fruit-growing more than to help demonstrate that a long list of worthy fruits will grow in Hawaii almost without attention.

Many native-grown species of our most common fruits are seldom, if ever, seen in the markets of Honolulu, while the great majority of the list of island species are to be seen only in the private grounds of the older residents. Although it is true that most of the varieties as yet have a greater ornamental than commercial value, a few, as the pineapple and the banana, are extensively cultivated. Their production has come to be important industries. It is to a brief review of some of the more interesting and important of the island fruits, both native and introduced, that this chapter is devoted.

Botanists tell us that the islands at the time of their settlement by the aborigines had few native indigenous fruits. The Chilean strawberry¹ has long flourished on the high mountains of Hawaii and East Maui at an elevation of from four to six thousand feet. The natives have always held this small though delicious berry in high esteem under the name ohelo papa. It seldom reaches the market, but from May to September it is abundant; on Hawaii it is one of the principal articles of food for the Hawaiian goose. There are several cultivated species of better quality that find their way to market. Strawberries do not thrive well at sea-level, but prefer the higher and cooler regions. As a result they are grown in beds in Nuuanu Valley, at Wahiawa and elsewhere, where conditions are favorable. By changing the elevation, moisture and soil conditions, an extended period of bearing is secured. As a matter of fact, if they were more skilfully handled, fresh strawberries could be grown for the market every day in the year. As it is there is not more than a month or so when fresh fruit cannot be secured.

¹ *Fragaria Chilensis*.

NATIVE RASPBERRIES.

There are at least three, and probably more species of the native raspberry, or akala. They prefer the high altitudes and have been found growing on all of the high islands with the exception of Oahu. In the deep woods on Molokai, at the head of Pelekunu Valley, I have found the spineless Hawaiian raspberry² growing under ideal wild conditions, as a perennial, attaining a height of twelve to fifteen feet, with stems three or more inches in diameter at the ground. While the fruit is neither abundant nor of especially good quality, the few berries that it produces are of large size and attractive appearance. The species is worthy of propagation by horticulturists, on account of the important characteristics possessed by it that might be developed through cross-fertilization.

In the mountains of Hawaii and Maui is found a low-spreading, prostrate shrub with long, stiff, trailing branches that bear round, black fruit about a half inch in diameter known to the natives as kukui neenee.³ The fruit is not pleasant to the taste, but the wild Hawaiian goose feeds voraciously upon it. They are common in the open country about the Volcano House.

THE OHELO.

Of more importance and general interest than the foregoing are the beautiful and delicious ohelo berries⁴ found especially abundant about Kilauea. They belong in the same genus with the familiar bog-cranberry of commerce. The berry is like the cranberry in size, shape and color. It is slightly astringent, but not enough to render it unpleasant to the taste, when eaten out of the hand. It also makes excellent pies and preserves, and being a very prolific bearer is worthy of attention by those interested in the production of new fruits. The berries vary greatly in color from almost white, through various shades of yellow and red to almost purple, and are covered with a waxy bloom. They grow crowded together along the branching stems of the low erect shrub, which attains a height of from one to two feet. The bush grows more or less in patches, often covering considerable areas. In former times it was used as a propitiatory offering to the goddess Pele, and a century ago no Hawaiian would approach her abode without first making a suitable offering of these berries to the far-famed goddess of the volcano. The Hawaiian islands have two distinct species and several recognized varieties, though the berries of the taller species, fairly common in the highest mountains of the different islands of the group, are seldom eaten.

MOUNTAIN APPLES.

An important native fruit tree, or at least one that must be considered as of early native introduction, is the mountain apple, or ohia ai.⁵ The tree attains a height of from twenty-five to fifty feet, and usually forms a clump or grove

² *Rubus Macraei*.

³ *Coprosoma ernodeoides*.

⁴ *Vaccinium reticulatum*.

⁵ *Jambosa* = (*Eugenia*) *Malaccensis*.

along the streams. In the forest they are easily recognized by their dark-green leaves and waxy-red or deep-crimson fruits, which are as large as apples and are borne twice a year in great profusion. In the market the fruit is of such attractive appearance that the watery, insipid flavor comes at first as a disappointment; however, the curious cooling property of the fruit compensates for what it lacks in flavor. It bruises easily in handling and is but little used, except occasionally in making sweet pickles. The tree occurs on all the larger islands of the Pacific and is highly esteemed by the natives for its fruit. The fragrant flowers were formally the favorite haunts of several of the native birds, which were caught in the branches by the use of bird lime. While the tree grows here and there in the city of Honolulu, it is by no means common, and must be seen in its native habitat to be appreciated at its full worth as a forest tree.

POHA.

The poha, cape gooseberry, or ground cherry,⁶ is a spreading shrub belonging to the great tomato family. It bears yellow berries in a bladder-like calyx, and grows quite common on mountain slopes throughout the group, especially on Hawaii and Maui. The fruit is edible, has a pleasant flavor and when cooked makes an excellent jam. In this form it has established a place for itself in Hawaii at the head of the list of preserves. It is only occasionally seen in the market in the raw state, and as it is mostly gathered from the wild plants, it is usually high in price. The plant is said to be a native of Brazil, but has long been naturalized in Hawaii. As it is only one of some thirty or more known species, it is quite possible that it would be worth while to introduce other species for cultivation.

BANANAS.

The banana is a conspicuous and valuable plant everywhere in the tropics. The striking bunches of fruit, and its broad, bright-green leaves occupy a prominent place in the ornamental foliage about almost every home in Hawaii. The banana is important among the commercial fruit-bearing plants of the islands. If we accept the broadest use of the term, the word banana includes all of the species and innumerable varieties of the genus *Musa*. This genus, which is supposed to have been named for Antonius Musa, a physician to Augustus the Great, belongs to the order *Scitamineae*, to which also belong several genera, including many well-known plants found growing in Honolulu gardens—such conspicuous ornamental plants as the traveler's palm or traveler's tree,⁷ the Canna and ginger⁸ being among them. The original home of the banana is thought to have been southern Asia. Doubtless it has been long ages under cultivation, and in very early times found its way into Polynesia. For this reason it is thought that the wild, or native banana, or maia, found growing everywhere in the mountain valleys, even in the most remote districts of the

⁶ *Physalis Peruviana*.

⁷ *Ravenala Madagascariensis*.

⁸ *Zingiber*.



PLATE 69. WILD AND CULTIVATED FRUITS.

1. Breadfruit [Ulu] (*Artocarpus incisa*). 2. Chinese Banana [Maia] (*Musa Caradishii*). 3. Avocado or Alligator Pear (*Persa gratissima*). 4. Pineapple (*Ananas sativus*). 5. Thimble Berry (*Rubus Jamaracensis*). 6. Mango (*Mangifera Indica*). 7. Ohelo Berry (*Faccium reticulatum*). 8. Purple Water-lemon [Lilikoï] (*Passiflora edulis*).

group, are all of very early Hawaiian introduction from the islands to the south of the Equator. The natives know as many as twenty-five and perhaps fifty varieties of so-called wild bananas, having a name for each, but as the same fruit is known by different names on different islands, many names disappear as synonyms. It has been found that three main groups or types can be recognized. But the native nomenclature will doubtless withstand the attacks that may be made upon it by the systematic botanist and horticulturist, and as a consequence, the more important and striking forms will long continue to be recognized, in the markets at least, by their native names.

While the original plants were doubtless set out well up in the mountain valleys, in sheltered, moist, well-drained places, by the native planters, they are now distributed along the streams. In certain sections peculiar forms are common, and it is not improbable that new varieties have been originated in the islands by the natives through intelligent selection, or by isolation, or from other causes. The koae, for example, is a striped variety, having the fruit and leaves variegated with pale and dark green, that is said by some to have originated in Kona, Hawaii, and to have been brought from there to Honolulu for ornamental purposes. The oa is striped, reddish and green, and like the variety just mentioned is also said to have originated in Kona. Other interesting varieties of possible local origin are the poni, or black-trunked banana, the rose, and the sweet-scented varieties.

Among Europeans the nomenclature of the banana is in an uncertain state. The same varieties have different names in each country where grown; even the class terms, plantain and banana, are used with varying meanings. In some localities the plantain is understood to mean almost all the edible species, while in other localities banana has an equally wide and uncertain application. It is urged that the better usage is to reserve the term plantain for the varieties that can only be eaten after they have been cooked. Since it is the custom to recognize two kinds of bananas, namely, cooking and eating, the two terms, used so far as possible as above, would be generally useful.

In addition to the many excellent native varieties that are to be had in the local market, there are a number of introduced species and varieties which, though they stand high, are of but little commercial importance, as they will not stand packing and shipping. This class includes some of our best table bananas; the Brazilian, the apple, the largo, the kusaie, and a long list of other less common ones should be mentioned as among the more important. Of the native varieties the iholena and lele are considered as the choicest varieties for both cooking and eating.

The most important commercial varieties are the Chinese or Cavendish,⁹ the Jamaica, Martinique or Bluefield, and the red Spanish or Jamaica red. The latter is sold in the fruit stalls as a fancy variety. The Bluefield, which takes its name from the principal port from which the variety is shipped into the United States, was introduced into Hawaii in 1903 and has been fast winning

⁹ *Musa Cavendishii*.

favor among the more intelligent growers, as it sells in the market at about one-third more per bunch than does the common Chinese variety. Its fruit has a tough, slow-ripening, golden-yellow skin, and the hands, or clusters, grow in large, very compactly-arranged bunches.

The Chinese variety was introduced into the islands from Tabiti about 1855, and has long been the leading commercial banana. It is characterized by its low growth and large bunches of yellow fruit of fine flavor and good keeping qualities. Only a single bunch is produced by a plant. The fruit ripens at all seasons, requiring, in low levels, ten to twelve months for the bunch to mature; in higher elevations, twelve to eighteen months.

It has been found that an acre of good ground under favorable conditions, well watered and tilled, will produce in a year 1,200 bunches of bananas weighing sixty pounds each. While dried banana and "banana flour" is prepared from the fruit elsewhere, the common varieties in Hawaii have never been extensively used in this way.

Of the various cooking plantains very little is known outside of the tropics. It is quite possible that when the value of the plantain becomes more generally known as a winter substitute for vegetables, its export from Hawaii will materially increase.

As is generally known, the varieties of bananas most useful to man seldom if ever reproduce from seed. They increase from suckers that spring up about the base of the plant. If allowed to grow undisturbed a single plant will soon develop a considerable clump, which may be divided and transplanted as desired.

The leaves are interesting, as the parallel veins stand at right angles to the mid-rib and are joined together to form the broad leaf. Heavy winds in many places tear the large leaves into shreds, hence a sheltered location is usually selected for the cultivation of the fruit.

The flower of the banana is somewhat unusual in appearance. Each plant bears but a single bunch of flowers which grows out of the center of the top of the stock on the end of the elongated spike. It appears first as a purple-red spike that curves downward as it grows. This spike-like head is made up of a large number of flowers grouped in clusters, each cluster later developing into a "hand" of bananas. As the clusters emerge they are covered by the thick, reddish bracts which curl up and expose the flowers. In time the tubular, cream-colored blossoms fall off, leaving the long ovaries. These in turn develop into fruits. Each bunch of bananas contains from one to a dozen or more of these clusters and each cluster from twelve to twenty-four bananas.

So far, the banana in Hawaii is fairly free from disease and pests. Three forms of fungus diseases are known to prey on the plant, but as yet they are nowhere serious. Two species of nematode worms are somewhat troublesome, and the cane borer, common throughout the group, has been occasionally found boring in the stem. The red spider, which is well known to most gardeners, has been instrumental in causing a brown smut to gain a foothold on the fruit.

Though this fungus has long been found on the fruit grown here, its effects are never serious.

The history of the development of the banana business is an interesting one, but it must suffice here to note that the first exportation of the fruit was made in 1864, when 121 bunches were shipped to the mainland.

PINEAPPLES.

The pineapple¹⁰ is a native of America, and is the most important member of the family¹¹ in which it is placed. This family has nothing whatever to do with either the pine or the apple families. The pineapple is a sorosis, or collection of fruits formed by the cohesion into a mass of the ovaries and perianths of the compact fruit. The flowers themselves are abortive. In the cultivated pineapple, seeds are rarely found, but the wild variety, from which it originated, has many seeds.

In Hawaii it is extensively cultivated, and was of early introduction. It seems well adapted to the islands and several varieties are grown, which produce fruit of the most excellent flavor. There are instances where the fruit has escaped or has been abandoned, where it is to be found growing in a wild state.

As is well known, the plant usually produces but a single fruit crowded in a rosette of stiff serrated leaves, on the top of the stem of the plant, which matures in from twelve to twenty months. The fruit is itself crowned with a cluster of stiff leaves. The plant is propagated by means of slips, suckers, crowns and rattoons. Over fifty well-defined varieties are recognized, some of them quite distinct forms, which vary widely in color, size and flavor. The most important species grown locally are limited to a few carefully selected types that are especially suited to the requirements of the canneries.

Fruits of the largest species not infrequently attain a weight of twelve or more pounds. The crop is harvested at certain seasons, but fresh fruit reach the market the year around. The plants are not entirely free from pests and diseases. The most serious disease, perhaps, is known as the "pineapple disease" of sugar-cane. This disease, which attacks the fruit causing it to prematurely decay and ferment, was first discovered on cane and received its name from the fact that it produced an odor in the decaying cane similar to that of the pineapple.

THE AVOCADO OR ALLIGATOR PEAR.

The avocado, or alligator pear,¹² though technically a fruit, is from the culinary standpoint a salad vegetable, in that it is used much the same as the cucumber, since it is usually eaten with salt, pepper and vinegar. It is almost the only fruit which is eaten only as a salad. Persons who are served with this curious pear-shaped fruit for the first time are usually disappointed. But a just valuation of the rich nutty or butter-like flavor of the fruit is soon acquired, and once it is fully appreciated the taste becomes little short of a craving.

¹⁰ *Ananas sativa*.

¹¹ *Bromeliaceae*.

¹² *Persea gratissima*.

The tree, which is a native of the American tropics, was of early introduction into Hawaii and is rapidly gaining in favor as an island fruit with a possible commercial future, which, however, has been somewhat interfered with through fruit quarantine measures that prevent its shipment to California for fear it may carry with it the much-dreaded fruit-fly that has already established itself in Hawaii.

The earliest known account of the avocado is found in Oriedo's report to Charles V. of Spain in 1526. At that time it was found growing wild in the West Indies, doubtless having been introduced there from the continent of America. In various places and in diverse ways the fruit has come to be known under no fewer than fifty names, no one of which is less suitable than the common English designation, since it is neither an alligator nor a pear, and moreover the combination of names is in no way pleasing, appetizing or appropriate. The fruit is justly entitled to a characteristic name, and avocado seems suited to the requirements.

In 1860 it reached Tahiti, and must have been planted in Hawaii very soon after that date. Trees about the city grow rapidly to a height of from twenty to sixty feet, and are at once identified by their large dark-green leaves and large pear-shaped, green and purple fruits, which contain a single large seed. The avocado belongs to the *Lauracea* and has such distinguishing relatives as the cinnamon,¹³ camphor,¹⁴ and sassafras,¹⁵ all of which were introduced into Hawaii many years ago, but the avocado is the only member of the family that has been cultivated to any extent. As the fruit is usually grown from the seed, the quality varies with the different trees. Now the ripe fruits have been successfully shipped from Hawaii to New York and Washington, and as recent experiments have proved that choice trees can be propagated by budding, there is every reason to think that the avocado has a future before it, as it seems to be reasonably free from the attacks of the fruit-fly. Selected trees, sheltered from the wind and with other conditions favorable, have yielded as many as 250 fruits to a tree, while the yield from exceptional trees has been more than a thousand pears.

PAPAYA.

Like the foregoing, the papaya¹⁶ is a native of tropical America, probably Brazil, and is a fruit much esteemed in the islands. It is one of the commonest fruits in many private yards, and considered as a fruit, vegetable, salad or simply as an ornamental plant, it is a general favorite. Its large, golden, melon-shaped fruits and handsome, thrifty, green, palmate leaves render it a species that attracts attention at once from strangers.

By some the fruit is called papaw, a name which should perhaps be reserved for the tree and fruit of *Asimina triloba*, which is a tree common throughout the southern United States. It bears smooth, oblong fruits that in no way resemble the papaya of the tropics. They are three or four inches long, banana-

¹³ *Cinnamomum Zeylanicum*. ¹⁴ *Cinnamomum camphora*. ¹⁵ *Sassafras officinale*.

¹⁶ *Papaya vulgaris* = *Carica* Papaya.

shaped, and are filled with sweet pulp in which are embedded the bean-like seeds.

The papaya is an interesting example of a dioecious plant, as it has the male and the female flowers on separate plants. The edible fruit is produced by the female tree, as a rule. It is therefore desirable, in order to insure the best crop of fruit, to plant a number of trees of both sexes in close proximity.

There are a number of varieties under cultivation, all of which are known locally as papaya. While it is usually a small, short-lived tree with a single, stout, unbranched trunk, crowned with a cluster of leaves, there are many old specimens thirty feet or more in height that so differ in appearance that only the characteristic leaves prevent them from being mistaken for some rare species of curious tropical plant.

It is extensively grown in the tropics, and may now be found wherever climate and conditions are favorable. The milky juice of the plant has a property similar to, though different from that of pepsin. If tough meat is wrapped in the fresh leaves for a short time it will become tender. The seeds also possess valuable properties as a vermifuge.

GUAVA.

Several species of guava thrive here. They grow from seed so readily and spread so rapidly that the lemon-guava,¹⁷ at least, is no longer cultivated. In many sections this species forms dense thickets. As it fruits abundantly at nearly all seasons at different elevations it furnishes a refreshing fruit that may be enjoyed on mountain rambles.

Of the 130 species known several are well established in Hawaii, but aside from the common lemon-guava and the smaller red strawberry-guava,¹⁸ the other species are rarely met with. The fruit is supposed to be more agreeably acid and hence more palatable if gathered in the early morning. The lemon-guava, besides being a rich, aromatic fruit, makes fine jam, guava whip, and jelly, the latter being one of the finest-flavored jellies known. In spite of this fact comparatively little of it is manufactured, and thousands of tons of the fruit waste every year. This acid vegetable material, however, when added to the lava soils of Hawaii is a decided benefit to the land. Since the bushes grow on all kinds of soil under widely varying conditions the wedge-work done by their roots has proven a decided help in opening up the more resistant soils.

LEMONS, ORANGES AND LIMES.

The orange¹⁹ is one of the oldest of cultivated fruits; although its nativity is not known, it probably originated in the Indo-Chinese region. It is now widely distributed and just whether it was introduced into these islands by the natives themselves or by the earliest explorers will probably not be definitely known. Vancouver is generally accredited with its introduction, as in 1792 he came from Tahiti, where it had long grown, having received a large store of supplies from the natives there. Arriving on Hawaii he left with the native

¹⁷ *Psidium Guayana*. ¹⁸ *Psidium Cattleianum*. ¹⁹ *Citrus Aurantium*.



PLATE 70. HAWAIIAN FRUITS.

1. Dates (*Phoenix dactylifera*). 2. Wi (*Spondias dulcis*). 3. Grenadilla (*Passiflora quadrangularis*). 4. Papaya (*Carica Papaya*). 5. Breadfruit tree [*Ulu*] (*Artocarpus incisa*). 6. Lemon-Guava (*Psidium Guajava*).

chiefs of Kona a number of valuable seeds and "some vine and orange plants." A few days later he left some "orange and lemon plants" on the island of Niihau. It is supposed that these plants were the parents of the famous russet Kona oranges that are such general favorites among islanders. On Molokai, far back in the mountains, a few years ago I found an old orange grove in a fairly thrifty state, in which some of the trees were two feet in diameter at the height of my shoulder. Everything about them indicated their great age, and it is highly probable that this grove antedates the introduction of the plants by Vancouver.

Oranges, lemons,²⁰ limes²¹ and the grape fruit, pomelo or shaddock,²² have all found an equally congenial home here, and there are many Hawaiian varieties, and seedlings that lack names but that, nevertheless, are excellent and point to the fact that our soil is well adapted to their growth and culture. As is to be expected, the citrus fruits are here, as elsewhere, subject to a number of pests. Many of them are in an unchecked state and can do much damage. Among them are root-rot or gum disease affecting the trunk; ripe rot, due to a fungus attacking the fruit, and sooty mould, causing the blackened or mouldy appearance of the leaves, fruit and twigs. It is interesting to know that this last disease does not feed on the tissues of the plant, but thrives on the sweet dew-like substances deposited by aphids and scale insects. Lichens in moist localities; 'die back,'²³ and lemon scab²⁴ are among the more common diseases.

Among the insect enemies, the purple scale is quite prevalent. It may be readily identified, when adult, as a purplish object shaped somewhat like a miniature oyster shell. A species of mealy bug, appearing as a cottony mass, occurs in the terminal twigs causing them to grow twisted. The orange aphid or black fly is a minute insect living in the fine twigs. And lastly, the orange rust mite, which, though very tiny indeed, is the cause of the russet oranges. It pierces the surface of the fruit and feeds on the oils therein. The same species affecting lemons causes them to turn silvery. It is a curious fact that fruits affected by this mite are usually better flavored than those that are not troubled by it, though they are less attractive in appearance. The most serious pest of all, however, is the recently-introduced Mediterranean fruit-fly, elsewhere described at length.

The lime is extensively grown, there being several local varieties. The supply at present is almost sufficient for the local demand. The citron²⁵ is generally grown in yards and gardens. Both the oblong and round lemon-like kumquat²⁶ thrive, as does the shaddock, which is recognized by its size (six or seven inches in diameter) and coarse texture. All of the foregoing have long been cultivated and are found in deep valleys in such a wild state that they might almost be considered as part of the native flora. The pomelo deserves more care than has so far been bestowed upon its culture. Several of the Japanese

²⁰ *Citrus Limon*. ²¹ *Citrus acida*. ²² *Citrus Decumana*.

²³ A disease traceable to unfavorable condition in the soil.

²⁴ Cone-like elevation on leaves, fruit and twigs.

²⁵ *Citrus Medica*. ²⁶ *Citrus Japonica*.

and Chinese types of oranges bear astonishingly well, and should the trees be more intelligently and extensively cultivated they would yield even more abundantly.

The wi or Tahiti apple²⁷ has a golden fruit that grows in clusters, on a tree resembling the walnut in appearance. The fruit, which is the size of a peach, and has a curious seed, somewhat suggests the pineapple in flavor. It is a native of the South Pacific islands and is now widely distributed in the tropics.

THE CUSTARD APPLE AND ITS ALLIES.

The custard apple genus,²⁸ of which more than fifty species are known, is represented in the islands by at least three common species that occur here and there, usually as ornamental trees or curiosities in door-yards about the islands. Included in this genus is the sour sop.²⁹ It comes from the West Indies, where it is a favorite fruit. This thrifty green tree bearing a large conical heart-shaped, green, spiny fruit, six to eight inches long and weighing as much as five pounds, will be recognized at once by the novice. The white, soft, juicy, sub-acid pulp of the fruit is used to some extent as a flavoring for sherbet and fruit punch.

The sweet sop³⁰ bears a fruit resembling a short pine cone in shape that is three or four inches in diameter, yellowish-green and tuberculate. The pulp is creamy-yellow, custard-like and very sweet.

The custard apple,³¹ a smooth fruit, is also a favorite in the West Indies, which is probably its home. Both the custard apple and the sweet sop are worthy of more attention in Hawaiian gardens.

Cherimoya³² is a thrifty tree coming originally from Peru, but now widely naturalized. It is of comparatively recent introduction into Hawaii, the fruit coming mostly from Kona. The fruits are slightly flattened spheres, two or more inches in diameter, brownish yellow in color with the flesh soft, sweet and rich in flavor. It is a well known fruit in the tropics. All three of the *Anonas* just mentioned are easily propagated from seed and thrive in ordinary heavy soils.

The sapodilla,³³ a tree of Central America, is much esteemed under the more common name of Sapota pear. The fruit is the size and color of a small russet apple. It is a firm fruit with ten or twelve compartments and as many large black seeds. The flesh is sweet and pear-like in flavor. From the sap of the tree chewing-gum is made.

The loquat³⁴ or Japanese plum, a native of China and Japan, is a small tree with thick, evergreen, oval-oblong leaves that are covered with rusty hair beneath. It bears well in Hawaii, usually producing two crops each year, and is an excellent decorative fruit. The pear-shaped fruit is yellow with large seeds and has a pleasant flavor. It is extensively planted in southern California and elsewhere in the southern states.

FIGS, GRAPES AND MULBERRIES.

Several varieties of figs³⁵ are grown here, and but for the attacks of birds

²⁷ *Spondias dulcis*. ²⁸ *Anona*. ²⁹ *Anona muricata*. ³⁰ *Anona squamosa*. ³¹ *Anona reticulata*.
³² *Anona cherimolia*. ³³ *Achras sapota*. ³⁴ *Eriobotrya japonica*. ³⁵ *Ficus carica*.

and insects would flourish. The fig, as is well-known, is a native of Asia. It is a true *Ficus*, belonging to the same genus of plants with the ordinary rubber tree or banian common in the islands. Several varieties of the choice Smyrna fig have been introduced recently, together with the interesting wasp which is necessary to fertilize the flowers. The story of the development of the Smyrna fig industry in the United States is one dealing with a remarkable triumph of economic entomology and is a tale of absorbing interest.

Grape culture is carried on to some extent in a commercial way, especially by the Portuguese. Although the grape³⁶ has been cultivated by man since the beginning of history, it was unknown in Hawaii before its introduction by the whites, which took place at an early date. The Isabella is the type of blue grape most cultivated and is to be had in the markets throughout the year. All species grown are subject to the attacks of insects, the most important pest being the Japanese beetle. This insect is especially troublesome, often completely defoliating the vines.

Certain varieties of apples³⁷ have been grown in the islands at high altitudes, though they seem to require a different climate. Peaches³⁸ thrive fairly well in the islands. While not producing fruit of marketable appearance or flavor, it seems to be bound to no set season, blossoms and fruit being found at different elevations, and under varying circumstances, the year around.

The black mulberry³⁹ was early introduced into the islands for the purpose of supplying food for silk worms. It was hoped by the missionaries that the silk industry might be established among the natives. Interest was allowed to lapse, however, though the mulberry does well here, having escaped into a wild state in many sections. The white mulberry⁴⁰ has also been introduced. Should fruit-eating birds be extensively introduced it would doubtless be spread by them into the mountains generally.

EUGENIA.

Of the large genus of *Eugenia*⁴¹ many species have been introduced into the Hawaiian islands. Of the fruiting shrub-like bushes seen in yards, the Cayenne or Surinam Cherry⁴² is most common. It is a native of Brazil, is bush-like in growth, seldom if ever growing more than twenty feet high. It is easily identified by its dark red edible cherry-like fruits which are an inch in diameter and ribbed from the stem to blossom end. The delightful, spicy, acid flavor of the fruit is characteristic. Elsewhere it is much used for jellies and jams, and is sometimes improperly called the French cherry.

The rose apple,⁴³ another *Eugenia*, is also frequently seen in gardens in the group. It is a tree usually attaining the height of twenty or thirty feet with long, thick, shiny green leaves much resembling the oleander. The fruit, which has little to recommend it as a fruit, is white or yellowish in color, tinged with a

³⁶ *Vitis* spp. ³⁷ *Pyrus Malus*. ³⁸ *Prunus Persica*. ³⁹ *Morus nigra*. ⁴⁰ *Morus alba*.

⁴¹ Named in honor of Prince Eugene of Savoy. ⁴² *Eugenia Michellii* = *E. uniflora*.

⁴³ *Eugenia Jambos*.

bluish blush and is an inch and a half or more in diameter. It is peculiar in being rose-scented and apricot flavored. Another species of *Eugenia* that is an especially prolific bearer is known locally as Java plum.⁴⁴ The tree grows thirty or more feet in height and bears a wealth of black fruit the size of a small plum; they are quite common in gardens in the islands. The mynah birds are fond of the fruit and may be seen carrying it about when it is in season. Flying to the nearest house-top or fence post, they eat the flesh off allowing the hard seed to fall and take root as it will.

THE PASSION FLOWERS.

Of the great order *Passifloracea* or passion flowers, a number of species are in cultivation, some of them producing fruit of a remarkable quality. The passion flower⁴⁵ proper, is a slender vine coming originally from Brazil. It is perhaps the most common garden species. The leaves are deeply divided into five segments, the lower two being sometimes again divided. The flowers are three to four inches across and slightly fragrant. It is interesting to know that the Spanish, when they found this flower growing in the South American forests, took it as a token that the Indians should be converted to Christianity. They saw in its several parts the emblems of the passion of our Lord, hence the *flos passionis* was described as early as 1610 as a marvel of prophetic beauty, and properly enough the description then made has been the foundation for the name of the whole group of plants.

The devout, or those gifted with a fertile imagination, find in the various parts of the blossom, the crown of thorns; a blood colored fringe suggesting the scourge with which the Master was tormented; the nails; five blood stains, standing for the wounds received on the cross; the fine filaments, seventy-two in number, agreeing with the traditional number of thorns with which the crown was set, and lastly the lance-like leaves of the plant referring to the instrument which pierced the Saviour's side. The leaves are also marked beneath with certain spots suggesting the thirty pieces of silver.

But to return to the fruits belonging to this order, the species most commonly seen in the market is the egg-shaped water-lemon.⁴⁶ This is an edible fruit yellow in color, spotted with white, the seeds having a sweetish, cool pulp about them with a delicate and, to many, pleasant flavor. The flowers are about two or three inches in diameter; the leaves entire with a short, sharp point.

The purple-fruited water-lemon or lili koi,⁴⁷ is also common, having escaped to many places about the islands. The ganadilla,⁴⁸ the largest of the passion fruits, is a most remarkably strong-growing climber introduced from tropical America. The large leaves three to five inches across, and the long yellow-green melon-shaped fruit, often nine or ten inches in length, make it a striking plant. The fruit is edible, being used to advantage as a flavoring for sherbets.

⁴⁴ *Eugenia Jambolana* = *Syzygium Jambolana*.

⁴⁷ *Passiflora edulis*.

⁴⁵ *Passiflora cœrulea*.

⁴⁶ *Passiflora laurifolia*.

⁴⁸ *Passiflora quadrangularis*.

POMEGRANATES.

Pomegranates ⁴⁹ are grown throughout the islands in gardens, more as ornaments than for the fruit. Their bushy growth and awl-like spines and narrow, glossy-green leaves, with red petioles, make it conspicuous. The fruit is globular with a bright, smooth, yellow, red-blushed rind and a prominent crown-like calyx. The interior consists of a number of seeds enveloped in a bright crimson-colored pulp, the seeds being crowded into several segments. The cooling, astringent juice of the pulp is enjoyed by many. The pomegranate, a native of Asia, is supposed to have been introduced into southern Europe by the Carthagenians at a very early date, and has from there been widely distributed. There are several varieties grown in Hawaii, among them a double flowering variety that is quite popular as an ornamental plant.

We could extend the list of fruits and fruit-like products indefinitely. The liehi ⁵⁰ of China; the mangosteens ⁵¹ of China; the water-melon ⁵² of Africa; the musk-melon ⁵³ of southern Asia; the fruit of the prickly-pear ⁵⁴ from Mexico, are all to be seen among the fruits in the Honolulu markets. In fact, a list enumerating considerably over one hundred well-defined species of fruits occurring in Hawaii has been prepared, and it is safe to assume it could easily be extended; a number of the rarer fruits receive brief notice in the index.

CHAPTER XX.

AGRICULTURE IN HAWAII: ITS EFFECT ON PLANT AND ANIMAL LIFE.

The remarkable agricultural transformation of the Hawaiian Islands, from the time when taro-growing was the chief occupation of the primitive inhabitants, to the present, when the growing of sugar-cane is the dominant industry of the land, furnishes a story filled with facts of the greatest interest. The account of this transition, however, would come more properly within the scope of a political and industrial history of Hawaii. Nevertheless, agriculture, in the broad sense, is a natural employment, having to do with plants and animals. It has been, and doubtless will always continue to be, the chief vocation of the people of the islands, and as agriculture and the occupations growing out of its practice will long continue to be the main source of prosperity and wealth, a brief account of the natural, as distinguished from the commercial history of some of the industries, at least will not be out of place here.

AGRICULTURE IN RECENT TIMES.

Our present interest in the subject, however, comes mainly from the fact that the phenomenal development of agriculture in Hawaii in recent times has

⁴⁹ *Punica Granatum*, ⁵⁰ *Xophetium Litchi*.

⁵¹ *Garcinia mangostana* from Sumatra; also the more common *Garcinia xanthochymus* from India.

⁵² *Citrullus vulgaris*, ⁵³ *Cucumis Melo*, ⁵⁴ *Opuntia Tuna*.



PLATE 71. MINOR AGRICULTURAL INDUSTRIES.

1. Taro ponds at the head of Manoa Valley. 2. Coffee berries; one-half natural size. 3. View on a sisal plantation; gathering the leaves, the first step in securing the fiber. 4. General view over recently planted rice plantation; beyond the first headland the smoke from a plantation trash fire may be seen. The walled enclosure in the first bay is a mullet pond. 5. Picking coffee.

not only brought in a host of both beneficial and injurious plants and animals from abroad, but through tillage, has brought about changed conditions in the natural environment. These sweeping changes have affected the primitive natural history of the Hawaiian Islands more than all other agencies put together.

Enormous areas of land have been cleared of the natural growth of forest and field and usually put under artificial irrigation, with the result that more radical changes have been made in the character and use of the land of the islands, in one generation, than was brought about by the operations of the primitive inhabitants during the whole period of their occupation of the group. Such wide-spread changes in the character of the country have been reflected in numerous remarkable changes in the native fauna and flora. In numerous instances, the extension of agriculture must be credited with the extermination of many forms of life formerly common in such sections as are adapted to the purposes of the planter and the ranchman.

THE SUGAR INDUSTRY.

Foremost among the industries of this class is the production of sugar. All other field crops dwindle to insignificance in comparison with it. Few places in the islands where cane can be grown at all, will yield less than thirty or forty tons, and from that up to sixty and seventy tons to the acre. Such a yield of green stuff can hardly be obtained from any other farm crop, and the development of the industry has been as remarkable as the yield.

Cane is now cultivated extensively on the four main islands, being planted from near the sea-shore up to elevations of about two thousand feet. As a rule, however, it is the rich lands skirting the islands up to 500 feet that constitute the chief sugar-growing sections. The maximum area that can be put under cultivation for this crop has been about reached, there being approximately 80,000 acres now planted to cane which yield on the average about 500,000 tons of raw sugar annually. The yield per acre varies greatly according to the character of the soil, and the position of the plantations, whether in rainy or rainless regions, the amount of fertilizer employed, and so on.

Under favorable conditions ten and a quarter tons of sugar have been the average yield for an entire plantation; while single acres have given much higher yields. Some lands less favorably located fall far below this yield. Next to soil and climate, one of the most important factors in the production of a good crop is the amount and character of the water used. Salt in the water, if in any considerable amount is detrimental, and often conditions are such that one hundred grams to the gallon would absolutely prevent the plant's growth.

As to the original introduction of sugar-cane into Hawaii, little is known. There are writers who think the islands in the south Pacific were the original home of the sugar-cane, since there are peculiar species there that are found nowhere else. It is argued that the plants were introduced from there into Hawaii by the natives. But the cultivation of cane has been carried on so long in widely distributed regions that the real home of the plant is lost in antiquity.

The probabilities are that it was used by man ages before there was any record of the fact, and that its culture and use as food in a raw state were among the first agricultural efforts of any tropical people.

The invention of the processes for extracting the juice and converting it into sugar or molasses has long been practiced, but only during the last century has it been brought to a high state of scientific perfection. The plant is now grown under such exacting conditions and handled by such a great variety of special mechanical devices, and the sugar extracted by such intricate methods, that it is doubtful if there is another plant grown that has been more exhaustively studied and exploited.

The plant,¹ as is well known, is a gigantic perennial grass with heavy maize-like stalks that grow from eight to twenty feet tall. Unlike most members of the grass family the stems are solid and contain an abundance of sweet juice.

The many varieties of cane have different sugar-producing qualities that cause one kind to be substituted for another owing to their adaptability to peculiar soils. The varieties vary usually in the color of the stem; being yellow, purple, green and variously striped. Five well recognized types of cane are extensively grown in Hawaii, though there are numerous varieties of doubtful scientific value. The chief types are the Yellow Otaheite; the Cheribon or Wray's Batavian; the Tanna, the Salangore and Cavengerie canes.

The cane leaves are about two inches in width by three to five feet in length. The flower stem is pampas-like, silvery-gray, or mauve, in color, and when in blossom the field is strikingly beautiful.

While cane had long been used in the islands, it was not until about 1828 that it was first made into sugar. Its culture was not really begun, however, until about 1850, when with crude wooden and stone mills and inferior boiling kettles a yield of one ton of low-grade sugar per acre was secured.

Since then all of the resources of science have been brought to bear on the production of sugar, with the result that today Hawaii leads the world in the scientific production of this valuable commodity. By experimentation, many kinds of soil have proved suitable to the growth of cane. Those preferred are the deep sedimentary deposits common in the lower zone or cane-belt of the islands. These deposits, varying in thickness from one to fifty feet, have been derived from the normal lavas that have undergone decomposition and disintegration in the warm and often dry climate of the lower coastal zone. The process of erosion has been actively at work on them for ages. Such soils are mainly red in color, owing to the great amount of iron they contain. The most fertile of these soils are usually those that have been darkened as the result of the decay of vegetable matter.

The first step in preparing the land for cane, or, indeed, almost any crop, is to clear it of all trees, shrubs and stone, and render the surface as level as possible. Plowing is then undertaken. This may be done by mules or oxen.

¹ *Saccharum officinarum*.

or by huge steam plows. Where the character of the country will admit, the latter method is the one generally preferred.

The machinery consists of large, double gang-plows that are drawn back and forth across the fields by wire cables that wind and unwind from large drums operated by traction engines located at opposite ends of the field. In this way five or more furrows sixteen inches wide by twelve inches deep are turned over at once. The field is then plowed crosswise of the furrows. Occasionally a giant plow that opens a furrow thirty inches deep is employed to reach the subsoil. The plowing done, the ground is allowed to fallow for several weeks. After it has thoroughly weathered, it is harrowed to break up the clods and level the surface; a heavy drag is sometimes used for the purpose.

If the crop is to be grown by irrigation, the main ditch lines are next laid out by the plantation engineers. The trunk ditches or main flumes usually remain in the same place from year to year, and are frequently walled with stone or wood, and often are cut through the solid rock. Where they cross gulches or are raised above the ground for any purpose, the flumes are made of wood or metal, and much skill and money has been expended in these preliminary operations in many sections. Water, which is the life of the land, is transported in large quantities for long distances in this way.

The secondary ditches are next laid out in such a way that water may be made to flow along every row of cane on the plantation. The furrows in which the cane is planted are made by a curious double plow which is so constructed that it will throw the earth both ways, forming ridges between the furrows. These furrows are made from eight to twelve inches in depth, and from four to five feet apart.

Sugar-cane is propagated by cuttings called seed-cane. Each seed joint must have one or more living buds. To insure sufficient buds they are usually cut in sections having two joints to the piece. These pieces are dropped into the furrows, a few inches apart, by the planter from a bag carried on the shoulder. The seed cane is then covered an inch or two deep with soil and water turned on. In about a week the cane sprouts. From that time on the growing crop is hoed and watered as required. Often loose soil is drawn over the moist earth from the ridges between the rows to prevent the rapid evaporation of the water; but the processes of cultivation vary widely on different plantations.

Several times during the growth of the crop the cane is stripped of the dead leaves to prevent the water from being held along the stalks and souring the juice. The bundles of leaves are piled on the ground under the tangle of growing cane to support the stalks.

The age at which the cane matures varies greatly, but ranges from one to two years. The tassel is the index that tells when it is ripe. The crop should be cut as soon as possible after it is through blooming, as the juice is at its best at that time.

In harvesting the crop the stalks are cut and trimmed in the field, the

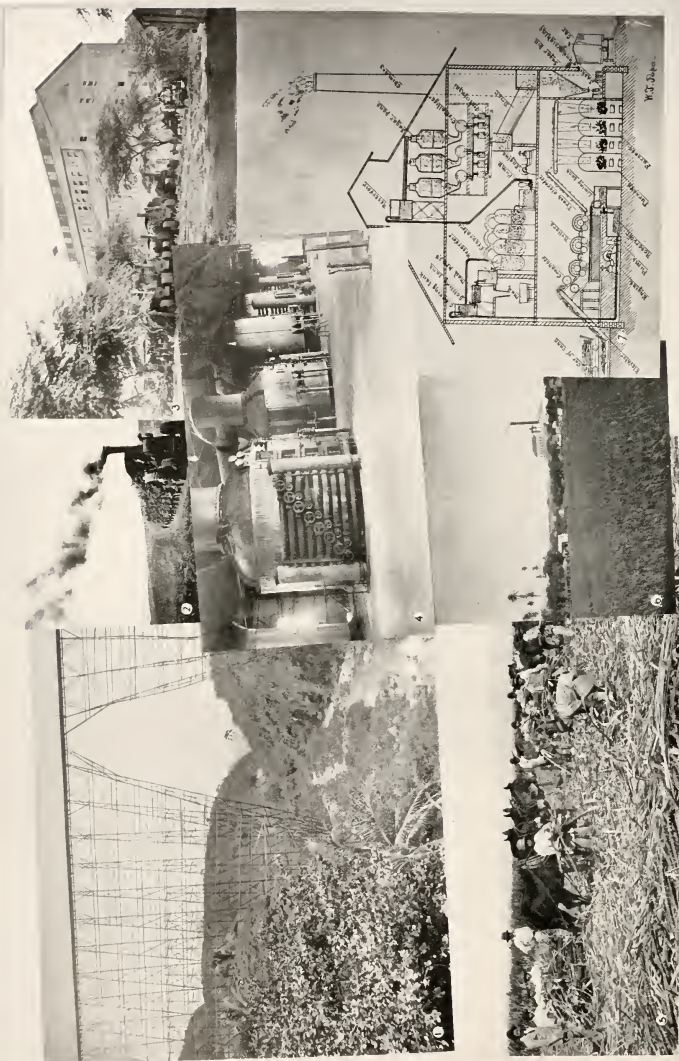


PLATE 72. THE MILLING OF SUGAR CANE.

1. High flume across a gulch on Hawaii. 2. Hauling cane to the mill with a traction engine. 3. Plantation machinery and a sugar mill. 4. Type of evaporating pans in general use. 5. One method of gathering sugar cane. 6. Plantation scene. The mill at Aiea. 7. Diagram of the process of milling sugar cane.

refuse and trash being left on the ground to be burned later on. The trimmed stalks, which average eight or ten feet in length and more than an inch and a half in diameter, are loaded upon carts or cars drawn over portable tracks by horses or by small locomotives. Where there is a surplus of water the cane is often floated to the mill in the flumes. In this way the water flumes are utilized in the production and harvesting of the crop in both wet and dry districts.

The loaded car on arriving at the unloading shed is brought alongside a moving floor that, in reality, is a wide endless chain-belt that carries the cane to the elevator. The cane in most cases is unloaded by machinery that pulls the load from the car to the moving floor. From the floor the cane is elevated on a conveyor which delivers it to a pair of large corrugated rollers that crush the stalks, extracting much of the juice. The crushed mass is then passed through several sets of rollers, each set made up of three close-fitting cylinders. In the final crushing process, hot water is added to aid in extracting the last particle of juice that may remain. The dry mass, now called "bagasse," is carried on elevators to the furnace room, where it is used at once for fuel.

The juice from the rollers is collected and conducted to the liming tank, where a chemical change is effected by adding slaked lime. From a receiver near the liming tank the juice is passed to the settling tanks.

After it has stood a few hours, the juice of the top portion is drawn off and the muddy lower portion agitated by steam. This hot mixture is then passed to the mud presses, where the clean juice is separated from the mud. The liquid mixed with the clear juice from the settling tank is next conveyed to the evaporating pans, where it is changed by heat from juice into syrup.

The evaporators are a series of four or more large iron boilers connected one with the other. The air is removed from them in order to create a partial vacuum. The juice will then boil with less heat and the syrup is prevented from scorching. The syrup, when sufficiently reduced, is conveyed to the vacuum pans, where the grain in the thick molasses is produced by another boiling.

At this stage inventors have made many improvements in the process by which the thick mass is passed into the crystallizers, where the syrup or sucrose is made into firm, dry grains. Small amounts of syrup are transferred to the tub-like machines called centrifugals. These tub-shaped cylinders have central cavities made of wire netting. This wire cage revolves rapidly and by centrifugal force throws the molasses out, retaining the crystals of sugar within the cage. The uncrystallized liquid is carried to the boilers again and is made into second-grade sugar. The higher grade sugar drops from the centrifugals into a large retort known as the drying machine. Through this the sugar works its way among hot coils that dry the crystals before they are carried to the sugar bin. From this bin the raw sugar is drawn out, sacked and weighed. Each burlap sack contains about 125 pounds of light-brown sugar.

Most of the sugar is sent as light brown, or raw, sugar to the mainland of

the United States to be refined or purified. One mill on Oahu, however, produces refined white sugar. In the refining process it is melted and boiled again, and at the same time is chemically treated, the crystals becoming pure white and transparent. It is in this condition that it is sold everywhere as granulated sugar.

RICE.

Next to sugar and pineapples, rice² is the most important field crop in Hawaii. Although the most primitive methods are practiced in its cultivation and milling, the annual product, from the ten thousand or more acres under cultivation, reaches as high as ten million pounds a year. Five crops can be grown on the same land in three years, the annual yield per acre being about eight thousand pounds. The crop is grown almost exclusively by the Chinese on leased lands, for the use of which they pay an annual rental ranging from ten to fifty dollars per acre. Their methods of propagation, culture, harvesting and milling are extremely crude; they are, nevertheless, interesting and picturesque.

The rice plant is the only important economic species belonging to the genus of grasses *Oryza*. It is said to furnish food for one-half of the human race. The plant seems to have been originally a native of the East Indies, probably being first cultivated in India. From that region it has spread to all quarters of the globe where conditions are favorable. Our Hawaiian rice, so called, is thought to have been originally derived from a South Carolina stock, as the first rice cultivated here was obtained from that state. It has since been mixed with a number of other varieties, however. Somewhat extensive experiments under the direction of Professor Krauss have been made in recent years with a view to introducing improved varieties. It is said that there are more varieties of rice known than of any other crop, there being more than a thousand varieties in India alone.

The plant is an annual, growing from three to five feet high in Hawaii, according to variety and conditions. The seeds or grains grow on little stalks springing from the main stalk, and when ripe, the appearance of the plant is between that of barley and oats. Rice in India is known as paddy. The term is also used to designate the rice in the husk, and in Hawaii the small shallow ponds in which it grows are called paddies.

Rice is grown in Hawaii by what is known as the Oriental method of culture. The seeds are planted in carefully prepared seed-beds that are kept moist but not flooded. After the seed has germinated and is three inches tall, the ground is kept flooded until the plants have reached a height of six to ten inches. They are then pulled from the muck and water and the roots soundly beaten on a board; the object being to prune back the root sprouts. The seed plants are topped and tied in convenient size bundles and taken in large baskets on shoulder poles to the field to be planted. The advantage of this

² *Oryza sativa*.

method of planting is that a more uniform stand may be secured, resulting in a larger yield in a shorter time.

The small fields, which are arranged so they can be flooded with water, have been previously prepared by plowing six or seven inches deep. The water cow,³ known also as water buffalo or carabou, is used in the plowing operations as a general rule, but occasionally horses are employed. After plowing, the earth is covered with water and a curious harrow used until the soil is reduced to a fine, thick mud. It is next covered with water to the depth of an inch or two, when it is ready for planting.

The planting is done by hand. The bunches of seed rice are distributed over the paddies at convenient intervals along straight guide-lines set out across the patch. The entire force of field hands rapidly plants out the shoots by sticking the sprouts in a straight row ten or twelve inches apart, with six or eight inches between the plants in the rows. The plants tiller or spread from the roots, so that each root planted sends up many stalks.

After the plants are set, the field is kept flooded with water, the depth of the water being increased somewhat as the plants grow. When the crop is about fifteen inches high the field is gone over to weed, thin and transplant where necessary. At this stage the wild rice,⁴ which is found wherever rice is cultivated, is pulled up and destroyed. It differs from the cultivated rice in being a coarser type with deeper green leaves and in having fruit which has large awns. The wild species falls to the ground as soon as it is ripe, thus seeding itself before the regular crop is harvested. As it thrives on the same treatment as the commercial species and spreads its seed broadcast, it is by far the worst weed in the rice fields. When compared with other crops, however, rice is singularly free from pests and diseases, and produces a remarkably full and uniform yield, year after year.

The water is allowed to remain on the ground until about ten days before the grain is fully ripe. The ripening period is generally indicated by the heads bending over from the weight of the heavy grain. From the time the head begins to form, a period marked by the peculiar odor given off by the opening glumes, to the final gathering of the grain, the fields are guarded from dawn until dark, by the planters, to prevent the three introduced pests—the linnets or rice birds; the weaver birds, and, to some extent, the English sparrows—from destroying the crops. In spite of their vigilance, considerable quantities of the maturing grain are consumed or spoiled by the birds, especially when the rice grains are in the milk stage.

The harvesting of the golden-yellow crop is indeed picturesque. There are usually a dozen or more Chinese engaged in the operation. The grain is cut once near the ground, with reaping hooks, then mid-way of the straw. The grain portion is laid in neat straight piles on the coarse straw or bound into good-sized bundles and left to cure. When sufficiently cured the bundles

³ *Bos bufalus*.

⁴ *Zizania aquatica*.



PLATE 73. PLANTING AND HARVESTING SUGAR CANE.

1. Plowing with a double gang plow and two engines. 2. General view of a plantation; cane cars on the siding in the foreground. 3. Planting seed cane. 4. A patent cane loader in operation. 5. Unloading device at the mill. 6. Loading cane onto flat cars. 7. Field of cane in blossom ready for harvest. 8. Cutting and stripping cane.

are carried, a few at a time, on each end of a carrying stick over the shoulder, and stacked near the thrashing floor and mill.

The grain are tramped out in the most primitive fashion by horses on a smooth, hard floor. It is further dried on the floor and is then stored in sacks.

The removing of the hull or husk is a laborious task, occupying hours of time and all the machinery that the ingenuity of the Chinese race has been able to bring to bear on the problem. The process, to be appreciated, is one that must be seen in its primitive crudeness at the mills themselves, where the Chinese miller, cheerfully explaining the operation in answer to every question, blandly replies, "Oh, Chinaman, him long time do alle same, me no sabbie." However, it should be remarked that a few of the more progressive rice growers are making use of some of the modern American machinery, and it is quite probable that before many years the change in methods of growing and milling will be complete.

COFFEE.

Coffee growing is essentially a tropical industry, and the coffee⁵ plant has found a favorable home in the higher districts in the Hawaiian Islands. The industry, for various industrial reasons, has not prospered of late as it should. The plants were first introduced into the islands in 1823 by Mr. Matain, who established a small plantation near Honolulu. Coffee was again introduced from Rio de Janeiro, in 1825, by Mr. John Wilkinson, a practical gardener, who came to the islands from England in the ship *Blonde* at the request of Governor Boki. He settled in Manoa Valley, where he made a beginning in both the sugar and coffee industries. Plants from there were set out in Kalihi, Panoa and Niu valleys. A year or two after (1827-28) plants were introduced from Manila and were also set out in Manoa Valley. From this start coffee plants soon spread to other localities throughout the group, and there are trees in existence over sixty years old that are still in a thrifty condition.

The plant without question is a horticultural success in the islands, attaining an early maturity and bearing heavy crops. The berries are frequently so crowded on the stem that there is scarcely room for one more. The coffee of the islands has a marked flavor, and pure "Kona" is said to be superior in every way to the best Mocha or Old Government Java.

The coffee plant was first cultivated by the Arabs, who transferred it from its native soil in eastern Africa to Arabia, about the 16th century. From Arabia it was carried to Batavia, the capital of the Dutch East Indies, a hundred years later. From this beginning many cultural varieties have been developed that are now grown in the coffee zone throughout the world.

In a wild state coffee is a slender tree and grows fifteen to twenty feet in height, but in cultivation, for convenience in picking the fruit, it is not allowed to grow over ten or twelve feet tall, and the tree is made to assume a pyramidal

⁵ *Coffea Arabica* and *C. Liberica*.

form. The leaves are evergreen and leathery; the flowers are small, snow white and fragrant, and the whole appearance of the tree is so very pleasing that they are frequently grown in gardens and elsewhere as ornamental shrubs. The fruit when ripe is of a dark scarlet color, and the seeds are horn-like and hard. The seeds are usually called coffee-beans. Not that they are beans at all, but because of the Arabic word "bunn," which means coffee.

The berries are very unequal in ripening. In Hawaii three or more pickings are made annually. There are different methods of curing the berries. By the old method the fruit is placed on floors especially adapted to the purpose and allowed to dry in the sun. It is then passed between rollers to remove the dried pulp of the bean, and the membrane which encloses the seeds themselves. The coffee is afterwards freed from impurities by winnowing machinery. By a new method the berries are freed from the pulp and their coverings by maceration in water, with the aid of a pulping machine. The beans are sometimes subjected to polishing.

Three types of coffee are in cultivation in Hawaii, namely, the Hawaiian, of the original introduction—a very hardy type; the Java, brought directly from Java; and Horner's Guatemala, a variety supposed to have been introduced from a Javan source, but nevertheless of uncertain origin. However, the latter variety is the most extensively cultivated, being a hardy, heavy bearer and not subject to disease. It bears a large, flat berry resembling the best types of imported Java coffee.

SISAL.

The growing of sisal⁶ has attracted considerable attention on the island of Oahu, where several hundred acres are now planted to this crop. The plant not only grows luxuriantly on the better lands, but does well on land not suited to other field crops. Sisal was first introduced and widely distributed for trial in 1892. It has been found to thrive from sea level to three thousand feet elevation, and to be especially suited to the lee or dry side of the islands. The species is a native of Central America and closely related to the century plant.⁷ As a source of cordage it yields a fiber second only to Manila hemp in strength. Its smooth, straight strands of fiber are obtained by decortivating the leaf. The life of a shoot, if undisturbed, is six or seven years, after which period it sends up a blossom stalk as high as twenty-five feet, and then dies. Cutting the leaves for fiber, however, extends the life of the plant several years.

OTHER FIBER PLANTS.

Manila hemp, secured from a species of banana,⁸ has been grown experimentally in the islands for a number of years, and is reported from various localities. It was introduced from Manila many years ago, and was well

⁶ *Agave Mexicana* var. *sisalana*.

⁷ *Agave Americana*.

⁸ *Musa textilis*.

known to the older Hawaiians, being used by them in making rope. Also New Zealand hemp⁹ has been grown in a limited way.

As a fiber plant Upland cotton,¹⁰ or Sea Island cotton¹¹ now bids fair to outstrip any of those mentioned. Unfortunately, it has been held in check owing to attacks of the boll worm. Cotton of cultivated varieties was introduced into the islands long ago. A sample of the fiber grown here was sent to China by Kamehameha the Great. The plant in this latitude is a perennial. Several varieties have been experimentally grown from time to time, among them being Sea Island, Georgia, Peruvia and Caravonica, and a number of other strains that have received experimental attention at the hands of Professor F. G. Krauss and his associates. Although the revived industry is hardly beyond the experimental stage, it is reassuring to know that the fiber was an article of export from Hawaii during the Civil War.

The cotton fiber is distinguished from all others by the peculiar twist that it possesses. This twist makes it very valuable in spinning, and it has long been employed in the manufacture of cloth. Its use is spoken of by the earliest writers, and the plant was long described as a natural wonder under the name of the "lamb tree." The cotton of commerce is the product of several species of the genus *Gossypium*, belonging to the order *Malvacea*, to which also belong the hollyhock and Hibiscus, the flowers being very much alike. There are fifty or more species of cotton. In fact, one,¹² a shrub with sulphur-colored flowers and having very short, brown fibers about the seed, is found growing in a wild state in the Hawaiian group in dry situations near the seashore. It is known to the natives as mao, and can be separated easily from the small tree-like species called kokio,¹³ which has brick-red flowers. The cotton plant produces varieties that readily and rapidly adapt themselves to new conditions. Single trees are common in Hawaii that are twenty feet or more in height.

RUBBER.

The cultivation of rubber is among the newer industries that promise well in the islands. Several species of rubber-producing plants are well established in various places on the principal islands, and other species are in process of introduction.

One of the oldest, if not the oldest grove of rubber trees, is a small planting of the Ceara species,¹⁴ located at Koloa, on Kauai. It was planted in 1893, and from it a grove was planted at Lihue in 1899. Experimental tapping, under the direction of the Federal Experiment Station, has given a yield of fifteen pounds of rubber per annum from the thirteen-year-old trees, and it is expected that this can be materially increased by proper care, cultivation and improved methods of tapping. The seeds are curious in that they have a thick, hard coating and often require some months for them to germi-

⁹ *Phormium tenax*. ¹⁰ *Gossypium* sp. ¹¹ *Gossypium Barbadosense*. ¹² *Gossypium tomentosum*.
¹³ *Gossypium drynarioides*. ¹⁴ *Manihot Glaziovii*.



PLATE 74. CATTLE RAISING IN HAWAII.

1. Cowboys ready for a round-up on an upland ranch. 2. Herd of white-faced cattle. 3. Rounding out stock for market. 4. Chinese rice-farmer with curious harrow and Water Buffalo. 5. Two Water Buffalo. 6. Loading cattle; the start. 7. Animals being towed out to the steamer. 8. Loading an animal onto the steamer in port where wharfing facilities are not provided.

nate. To hasten germination the seeds are sometimes carefully rasped on either side with a file. The tree is of rapid growth, thriving best in a moist climate. The natural home of the species however, is in the drier regions of Brazil. It is closely related to the Cassava, mentioned elsewhere, and belongs to the spurge family, which also includes the Para¹⁵ and many other rubber-producing plants. The latex or milky sap occurs in the leaves, stems and trunk. There is a continuous network of milk-tubes all through the living green portion of the bark of the tree. The latex is collected by various methods of tapping, and from this gum-like mass the rubber of commerce is refined.

While the earlier plantings were largely of the foregoing species, there is considerable area being planted to Hevea. Both species belong to the *Euphorbiacea*. They and their near relatives may be distinguished from other rubber-producing plants by the hard, flinty seeds and the palmate leaves, resembling those of the horse-chestnut. Such latex-producing trees, belonging to the banian family, as the Assam rubber,¹⁶ the pipul tree, or banian fig,¹⁷ are well established.

To the list of introduced species must now be added the Hawaiian rubber tree¹⁸ brought to the attention of the Hawaiian Experiment Station in 1912 for investigation. Its latex-producing characteristics were noted by a chance discovery in the Kona district on Hawaii, where there are several thousand acres of this promising tree. The natives were long familiar with its gum-like latex and gave to the tree the name koko or akoko, in allusion to the milk-sap which exudes freely from the injured bark. The fact that it is a conspicuous tree, often twenty-five feet high, with a trunk ten inches in diameter, and that it occurs in more or less extensive areas on several islands of the group; and, furthermore, that it has long been known to botanists, having been described as a sub-species by Dr. Gray many years ago, indicates how little attention has been given as yet to the investigation of the native flora from the economic standpoint. The tree belongs to the typical tribe¹⁹ of euphorbias in which the flowerhead resembles a single flower. The species has the flowerhead almost sessile and is marked by having small linear leaves with the veins oblique to the rib. So far as its latex-producing qualities have been investigated, the koko seem to give much promise as a rubber-yielding plant. Its discovery points to the wisdom of extensive investigation of this and other economic plants native to the islands, as well as those of promise from other lands that may be suited to Hawaii's soil and climate, with a view to the establishment of economic species in much of the island Territory now given over to cattle ranges, or classed as waste land.

TOBACCO.

Climate and soil are thought to have a marked influence on the quality of tobacco,²⁰ and experiments that have been conducted in the islands in recent

¹⁵ *Hevea Braziliensis*.

¹⁶ *Ficus elastica*.

¹⁷ *Ficus religiosa*.

¹⁸ *Euphorbia torifolia*.

¹⁹ *Euphorbiaceæ*.

²⁰ *Nicotiana Tabacum*.

years, under the direction of Mr. Jared G. Smith, demonstrate that there are extensive areas about the group especially suited to the production of high-grade tobacco. The growing of tobacco, however, is by no means a new thing in the islands: it was early introduced by the whites and grown by the Hawaiians. It received only haphazard cultivation, was improperly cured, and was invariably too strong for commercial use. It was, however, smoked by old Hawaiians to some extent; it being a custom among the natives to take a whiff or two and pass the pipe (made of a root, or a stem or branch) about from one to the other.

The tobacco plant is of American origin, belonging botanically to the tomato and egg-plant family. The earliest voyagers to America found the Indians using the leaves for smoking, chewing, and as snuff; pipes and other means for smoking tobacco have been found buried in prehistoric mounds in the United States, Mexico, and Peru.

SWEET AND IRISH POTATOES.

Formerly potato²¹ growing was an important island industry. In 1849 potatoes stood at the head of the list of exports. The lands best adapted to their growth are in the Kula district of Maui, where they were introduced and planted as early as 1820. Of late years the industry has diminished, owing to unskilled methods of culture and the appearance of various enemies. There are several species and almost innumerable cultural varieties adapted to various soils and conditions that, if introduced, would doubtless extend and revive the industry.

Sweet potatoes²² were at one time an important field crop. Like the "Irish" potatoes, they were extensively exported during the period of the gold-rush to California. The natives recognized as many as twenty varieties of uala (sweet potato), and several important varieties have been introduced from time to time by Europeans and others. It belongs to the morning-glory family and is easily grown, thriving in loose soils where the rainfall is not too abundant. The sweet potato is usually propagated by cutting off the tops and planting them in a hill of dirt which often is only a pile of loose ash-like soil scraped together.

CASSAVA AND THE CASTOR BEAN PLANT.

Cassava,²³ though not extensively cultivated, is grown with success in Hawaii. It is an introduced European plant that thrives on all the islands, is free from pests and requires but little cultivation. Its roots produce a useful starch; they are used both as food for man and domestic animals, and in the manufacture of laundry starch. There is a native plant well known to the older Hawaiians as pia, or arrow-root, and in Hawaii, Cassava seems to have fallen heir to this name. Hawaiian arrow-root²⁴ formerly grew wild,

²¹ *Solanum tuberosum*.

²² *Ipomoea Batatas*.

²³ *Manihot utilissima*.

²⁴ *Tecoa pinnatifida*.

being most abundant on Kauai. It is quite common throughout Polynesia, growing without care in the native gardens.

The castor bean plant,²⁵ cultivated in several places, has escaped and grows everywhere as a roadside shrub, often fifteen to thirty feet in height, with a trunk twenty or more inches in diameter. It is a native of western Asia and eastern Africa. The large palmately-lobed, reddish-green leaves and large terminal flower clusters followed by the prickly three-parted burrs, which bear the vari-colored seeds, mark this familiar plant, grown in many gardens on account of its distinct ornamental value. Attempts to grow the castor bean as a field crop have failed only for want of the right kind of labor to gather the crop.

LOTUS.

Another plant of considerable importance, both ornamentally and as a crop, is the Chinese lotus.²⁶ It is a native of China and the East generally, and is grown in Hawaii by the Chinese farmers in taro and rice ponds; often several acres will be seen in a patch. The root tubers, for which it is grown, creep in the mud at the bottom. They are dug at irregular intervals and suggest strings of white sausage, as they are seen in the vegetable stalls. While the tuber is a favorite food of the Orientals, especially the Chinese, Europeans and others seldom taste them, preferring to admire the ornamental effect of the large orbicular leaves and splendid cream-colored, showy flowers that stand high above the water. The seeds are found in an odd-shaped, flat-topped receptacle, and are also esteemed as food by the Orientals.

NUTS.

The curious Chinese horned-nut²⁷ is also cultivated in shallow ponds by the Chinese, who boil the nuts, much as chestnuts are prepared by the Japanese.

Peanuts,²⁸ ground-nuts or goober-nuts, as they are variously called, were once grown to some extent, principally for the oil. The crop is well adapted to conditions in Hawaii, as has been proved by recent experiments, and it is to be regretted that they are only grown for the local demand, since, being a member of the great bean family, they store much valuable nitrogen and are therefore beneficial to the soil, besides producing a valuable forage for animals. In competition with the large California nuts, the island-grown product is much finer flavored and are generally preferred in the local market.

The peanut is really not a nut, however. It is a ripened pod with edible seeds, produced by a plant resembling a pea or bean. When the flower falls, the flower stem grows rapidly, curving down into the ground. The peanut is a native of Brazil, where several closely-allied species are found. In cultivation a number of important varieties have been produced, several of which have been experimentally grown in Hawaii.

Among the plants grown especially as green food for animals is sorghum.²⁹

²⁵ *Ricinus communis*. ²⁶ *Nelumbium speciosum*. ²⁷ *Trapa natans*. ²⁸ *Arachis hypogaea*.

²⁹ *Andropogon Sorghum*.

It is a grass-like plant, very well suited to the soil, and is regarded as the most profitable crop for forage in the islands. It is grown usually by irrigation and has its greatest use as feed for milch cows.

FORAGE GRASS.

Of the grasses, Bermuda grass, known locally as manienie³⁰ or creeping grass, has found a permanent place in the islands. The lawns are sodded with it, and it spreads over waste places and affords valuable pasture for stock below the elevation of 800 feet. It was introduced in 1835 by Dr. A. F. Judd. Alfalfa or lucerne³¹ is also cultivated to some extent under irrigation, especially by dairymen. It is a native of southwestern Asia, but has long been extensively cultivated in Europe and America. Its purplish-white clover-like flowers and hairy, coiled seed pods will separate it from the true clovers,³² which are seldom seen in Hawaii. Guinea grass³³ is also cultivated by many dairymen, yielding a number of crops from one seeding, if grown under irrigation, but Para grass³⁴ is gaining favor more rapidly than any of the strictly forage grasses.

All of the foregoing grasses and a long list of other species were, of course, introduced, coming with commerce or being purposely planted. They supplement a number of native grasses, some of which are of value as food for stock. Among the more important indigenous grasses should be mentioned the native manienie,³⁵ the kukaepuaa³⁶ and the pili,³⁷ which grow generally over the group to 4500 feet elevation. The latter, while very good pasturage for horses and cattle, is not as good for sheep, for, like the piipii,³⁸ a common grass on open dry plains and slopes, it bears sharp, stiff awns about the seeds that get entangled in the animals' wool.

Most of the foregoing grazing grasses are being rapidly crowded out by the rank-growing, worthless Iilo grass,³⁹ which is not eaten by animals. It appeared about 1840 in the district of Iilo, having been brought to the islands in some unknown way, presumably from tropical America. The edges of its coarse leaves are rough to the touch, and the stem ends in two slender spikes, three to five inches in length. A closely related species⁴⁰ has from three to six alternate spikes and is common in swampy ground in heavy soil. It was used by the Hawaiians to some extent as a thatch. The mischief done by Iilo grass is an example of the damage that may be brought about through the introduction, purposely or otherwise, of undesirable plants or animals.

WEEDS.

Space is too limited for an extended list of imported plant pests affecting the farmer and ranchman, but a number of undesirable species have been introduced and have prospered in Hawaii. Among them are the common pur-

³⁰ *Cynodon dactylon*. ³¹ *Medicago sativa*. ³² *Trifolium*. ³³ *Panicum maxima*.

³⁴ *Panicum Molle*. ³⁵ *Stenodaphnum*. ³⁶ *Panicum pruriens*.

³⁷ *Setropogon* = (*Andropogon*) *contortus*.

³⁸ *Chrysopogon aciculatus*.

³⁹ *Paspalum conjugatum*.

⁴⁰ *Paspalum orbiculare*.

slane or pussly⁴¹ of our gardens; two species of pepper grass;⁴² a sensitive plant⁴³ with fine leaves and small, round, pinkish flower heads; the flea-bane,⁴⁴ the iliohe of the natives; the cocklebur,⁴⁵ growing almost perennially and occasionally attaining a diameter of three inches at the ground; the sand burr;⁴⁶ the Jamestown weed;⁴⁷ the plantain;⁴⁸ the wild geranium;⁴⁹ and, lastly, and perhaps worst of all from an agricultural point of view, the nut grass, coco grass or Japanese grass—a pest reproducing by nut-like bulbs and by seed, and necessitating the utmost care to eradicate from cultivated fields, lawns and gardens. Among the more common of the related species,⁵¹ often called nut grass, is one that first appeared in Hawaii about the year 1850 and has since spread to all cultivated lands. In this species the tubers of the root-stock have a curious pungent taste.

LIVESTOCK.

This account of agriculture would be incomplete without at least a passing reference to the live stock of the islands. All of the domestic animals have been introduced since the first visit of Captain Cook. In many instances live stock has had more to do with bringing about the altered conditions with which the native fauna and flora have had to contend than all the other agricultural pursuits put together, epoch-making as they have been.

The first cattle and sheep were introduced in 1794 by Vancouver and landed at Kealakekua Bay, and in time became wild in the mountains on all the islands. A large proportion of all the meat consumed in the islands is home-grown. Formerly cattle were so abundant that they were slaughtered for their hides and tallow, but that time has long since passed. Horses were first brought to Hawaii in 1803. They were landed at Kawaihae and Lahaina and were the progenitors of the island strain of horses. Pigs and goats of English breeds were first introduced in 1778 by Captain Cook. Turkeys were introduced as early as 1815.

Wild cattle, sheep, hogs and goats were allowed to run at will in the forests, with the result that the animals trampled down the undergrowth and destroyed the bushes, even digging up the roots of many of the more nutritious of the forest growths. Owing to the exposure of their roots and stems, many of the larger trees died and soon after became infested with insects, which in turn multiplied in proportion to the increased supply of their favorite food.

⁴¹ *Portulaca oleracea*. ⁴² *Lepidium Virginicum* and *Senebiera didyma*. ⁴³ *Mimosa pudica*.

⁴⁴ *Erigeron Canadensis*. ⁴⁵ *Xanthium strumarium*. ⁴⁶ *Cenchrus echinatus*. ⁴⁷ *Datura Stramonium*.

⁴⁸ *Plantago major*. ⁴⁹ *Geranium Carolinianum*.

⁵⁰ *Kyllinga monocephala*, a species often confused with several species of the related genera of *Cyperaceae*.

⁵¹ *Cyperus rotundus*.

END OF BOOK ONE

BOOK TWO
THE ANIMAL LIFE OF THE GROUP

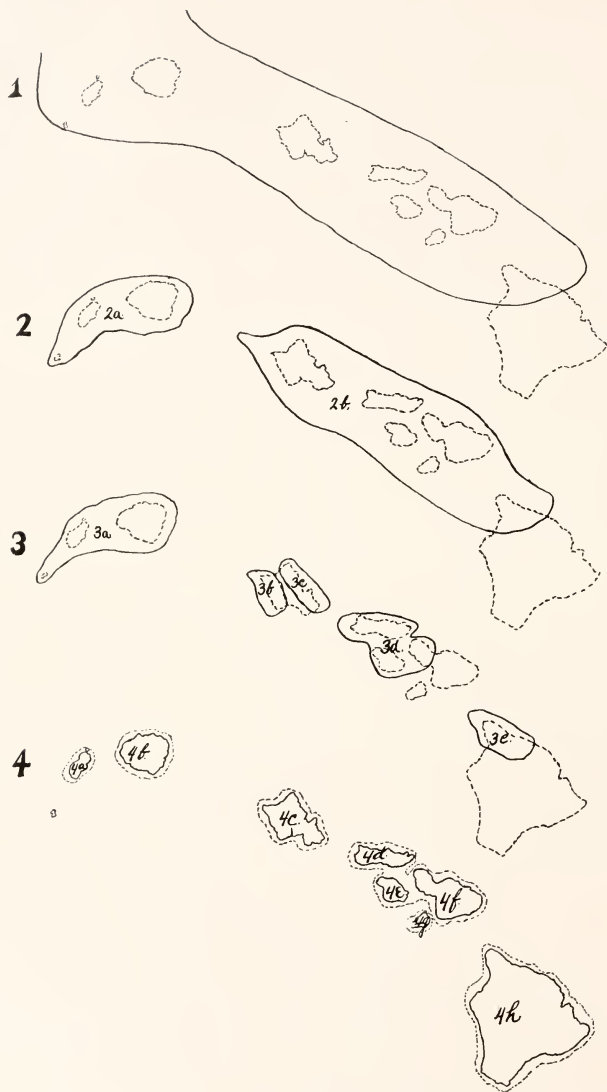


PLATE 75. FOUR STAGES IN THE DEVELOPMENT OF THE HAWAIIAN ARCHIPELAGO (After Pilsbry).

1. Showing the outline of the pan-Hawaiian island. During this stage the group from beyond Kauai to and including the Kohala mountains were united by land. 2. The first
(Description of Plate Continued on the Opposite Page.)

Natural History of Hawaii.

SECTION FIVE

THE ANIMAL LIFE OF THE GROUP.

CHAPTER XXI.

VARIOUS ANIMALS FROM LAND AND SEA.

HAWAIIAN RATS.

The Hawaiian rat¹ was the largest land animal inhabiting the islands at the time of their discovery by Captain Cook. Unfortunately, the species appears not only to have completely disappeared, but so far as is known not a single specimen has been preserved in any natural history collection or museum.² This seems most singular, as we know from Hawaiian tradition that at one time they were very abundant, and for many years were troublesome in cane fields.

From all accounts, they were small in size, and for that reason it is suggested that their place was taken shortly after the discovery of the islands by the common, wide-ranging grey and black rats, as these two species have traveled all over the world in ships and were no doubt passengers on the first ships to touch at the group. It is thought that the early and complete disappearance of the native species may have been due to the aggressive disposition of the new comers, particularly of the brown or Norway species, as wherever this rat has gone—and it is a great traveler—it has gained a footing and, in many places, completely replaced the less pugnacious native forms.

The brown rat³ is the larger of the two common species in Hawaii at the present time. It is generally believed that this species is a native of Western China, but it was known in England as early as 1730, where it came to be generally, though erroneously, called the Norway rat. It can be at once recognized by its heavy build, massive blunt muzzle, comparatively small ears and

¹ Iole.

² Mr. J. F. G. Stokes, of the Bishop Museum, secured bones of what is supposed to have been the Hawaiian rat on Kahoolawe, April, 1913.

³ *Mus demmanus*—*Mus norvegicus*.

(Description of Plate Continued from Opposite Page.)

period of subsidence formed the channel between Kauai (2a) and the Oahu, Molokai, Maui, Lanai, Kohala land (2b). 3. The second marked period of subsidence separated Waianae (3b) and probably Koolau (3c) as islands at one end and Kohala (3e) at the other end of the Molokai, Lanai, Maui area (3d). 4. Shows the last stage of subsidence; the island of Niihau (4a) separated from Kauai (4b); the two islands (3b and 3c) united to form Oahu (4c) and the islands of Molokai (4d), Lanai (4e), Maui (4f) and Kahoolawe (4g) separated by channels less than 100 fathoms deep.

relatively short tail, the tail always being less than that of the head and body and usually not longer than the body alone. The color of the upper part is usually a grayish brown.

The black rat,⁴ or one of its numerous varieties, is our common tree rat. It is smaller and more elegantly built than the brown rat, and has a longer and thinner tail. The body of a full-grown specimen is about seven inches in length, while the tail may be eight or nine inches long. Its long, slender snout, large ears and bluish color are characteristics that serve to make it easy of identification. Like the brown rats, they were introduced into Europe from the East, but at a much earlier date, reaching the continent early in the thirteenth century. In Hawaii they live both on the ground and in trees, but owing to the presence of their pugnacious cousins, they prefer the treetops. There they make their nests, usually in the crowns of cocoanut palms, and feed upon the fruit of these useful trees, often doing much damage by gnawing the young fruits. They also gnaw through the roofs of houses. They are seldom seen during the day, but at night they become very active, and in the twilight may be seen leaping from branch to branch and from tree to tree. On several occasions the writer has seen them travel along the electric light wires from one pole to another. It is in this manner that they often make their way into houses and outbuildings that are thought to be rat-proof.

Four species of rats⁵ have been taken in Hawaii by the official rat-catchers for the city, and are recognized as residents of Honolulu.

RATS AS PLAGUE CARRIERS.

Since it has been definitely determined that the fleas so common on rats are the carriers of the germ which cause the bubonic plague, every precaution has been taken to prevent rats landing in the various ports of Hawaii from vessels coming from seaports where plague is known to exist. Moreover, a sustained effort has also been made to reduce the number of rats in the islands.

It has been proved beyond question that the plague germ may be carried from the infected rat by the fleas that feed on the blood of the living animal. If the rat dies, the fleas leave their host and seek some other rat, or, failing that, will take up a temporary residence on a cat or a dog. This minute but troublesome insect may then be transferred directly or indirectly to a human host. Its bite too often results in transferring to the blood of the individual the germ which it drew into its system from the infected rat. In many cases the person so bitten contracts the dreaded disease, which often has proved fatal.

ROYAL SPORT.

A species of mouse was also common in ancient Hawaii. They furnished the upper class of natives with a form of royal sport out of the usual style

⁴ *Mus rattus*.

⁵ *Mus rattus*, *M. alexandrinus*, *M. norvegicus* and *M. musculus*.

of amusement resorted to by kings and princes; it consisted in shooting mice as a pastime. This royal sport did not partake of the nature of a cross-country hunt. The tiny animals were confined in a cockpit-like enclosure and were shot at with small bows and arrows. Singularly enough, the bow and arrow in the hands of the Hawaiians was only a toy, being used solely for killing mice and the flightless Hawaiian rail in the manner suggested in an early chapter.

MICE.

The house mouse ⁶ is the same species that is common all over the world. They doubtless originated in Asia, but their partiality for human habitations, and their omnivorous food habits, has resulted in their being carried far and wide by man as an unwelcome passenger in his goods wherever cargo has gone by sea or land. In domestication, white and spotted varieties of both the house mouse and the black rat are common and have long been kept as children's pets.

There is a species of long-tailed field-mouse that is quite common in the fields about Honolulu. It is probably of more recent introduction, doubtless reaching the islands from California in bailed hay or in grain.

RABBITS AND GUINEA PIGS.

Rabbits ⁷ have been introduced and liberated on two or three small islands in the group. Rabbit Island, a tuff-cone on the windward side of Oahu, near Makapuu Point, is thickly populated with a mongrel breed, the original stock of which was introduced a number of years ago.

In 1903 and 1904 rabbits of several varieties, including the Belgian hare and large white rabbits, were liberated on Laysan Island. They increased at such an astonishingly rapid rate that within six years the island was overrun with them. A special expedition was sent out by the Government for the purpose of exterminating them, as they threatened to wipe out the scanty native plant life found there.

The familiar variegated European guinea-pig, although a common pet in captivity in Honolulu for many years, was liberated on Laysan Island at the same time as the rabbits, and has found a congenial habitat, though its rate of increase has by no means been so rapid as that of the rabbits. As to the origin of the domestic guinea-pig, zoölogists are somewhat in doubt. It is thought, however, that Cutler's cavy ⁸ was kept in a state of domestication by the Incas of Peru, and that the guinea-pig was introduced into Europe by the Dutch in the sixteenth century, shortly after the discovery of America. Various breeds have been developed under domestication as pets for children, but in more recent times they have been much used in laboratories for experimental purposes.

Cats ⁹ were early brought to the islands, probably coming on the first ships. They were called popoki ¹⁰ by the natives. In course of time they

⁶ *Mus musculus*.

⁷ *Lepus* sp.

⁸ *Cavia cutleri*.

⁹ *Felis domestica*.

¹⁰ Poor pussy.



PLATE 76. HAWAIIAN AQUATIC ANIMALS.

Hawaiian Seal (*Monachus schauinslandi*) and Green Turtles [Honu] (*Chelone mydas*) on shore at Laysan Island. Laysan Albatross in the background. Sea Turtles [Honu] thrown on their backs on the sand.

began to escape to a wild life, living on birds and mice in the mountains. Wild cats are particularly troublesome in Hawaii. They are occasionally hunted, especially by sportsmen in pursuit of wild cattle, goats, pigs, chickens and turkeys, all of which, like the cats, have lived many generations in a perfectly wild state in the mountain forests on different islands of the group.

NATIVE BATS.

There seems to have been at least one and perhaps two species of native bats in the islands. They have always been rare, but apparently are still to be seen in the uplands of Hawaii; Dr. R. C. L. Perkins reports having seen the small Hawaiian bat,¹¹ or opeapea, on both Oahu and Kauai. This bat appears to be the only undisputed natural mammalian immigrant to the group, as the so-called native rat and mouse could have been easily carried to Hawaii in the wreckage of foreign¹² vessels that may have reached the islands by chance long before their discovery by Cook.

HOGS AND DOGS.

While it is perfectly proper to say that the rat, bat, and mouse were the only native species of mammalia found by Captain Cook, we can well afford to consider in this connection mammals that were of native introduction—namely, the hog¹³ and the dog.¹⁴ Just as the Polynesian people carried useful plants with them on their wanderings, they also brought with them in their canoes these two highly-prized and useful domestic animals known to them in their more ancient home. The hogs¹⁵ varied greatly in color, as they were black, white,¹⁶ brindle, striped, reddish and spotted, indicating that the species had long been in domestication. The Hawaiian dog was fed largely on poi, and was much relished as food in old-time Hawaii. Like the hogs, they were classed according to their color, there being several well-recognized color-types. The Hawaiians also introduced a fowl,¹⁷ which was everywhere a common article of food at the time of Captain Cook's visit.

INTRODUCED ANIMALS.

Since the discovery of the islands a number of mammals and birds have been introduced by accident or design which have been permitted to return to a wild state and in many instances are quite common. The first introduction of this class was that of goats and English pigs, and was made by Captain Cook himself. One ram and two ewes and a pair of pigs were left by him on Niuhau in 1788. Cattle and sheep were introduced by Vancouver from California in 1794. They were landed on Hawaii and rapidly increased in number. The first horses in Hawaii arrived in 1803 and were presented to Kamehameha I.

¹¹ *Lasiurus scroto*. ¹² Spanish. ¹³ Puua. ¹⁴ Ilio. ¹⁵ *Sus* sp.

¹⁶ The white hogs were often used in making offerings and sacrifices to the gods of ancient Hawaii.

¹⁷ Moa=chicken; moa kane, rooster; moa wahine, hen.

The first deer were brought to Hawaii from Okhotsk, Siberia, in 1856, but the Molokai herd of spotted deer¹⁸ originated from a small flock of eight that were sent to Kamehameha V., from Japan in 1867. They increased in numbers at a remarkable rate; so rapidly, indeed, that they were thought to threaten the destruction of the forests. Some years later the government found it necessary to employ professional hunters to reduce their number; but deer are still plentiful on Molokai, and they furnish the sportsmen of the islands with big game shooting each season.

The ground color of the fur of the spotted deer is rufous-fawn; the whole of the body being marked by a number of spots which are present at all ages of the animals and throughout the year. These spots tend to arrange themselves in longitudinal lines. There is a blackish line running down the back from the nape of the neck to the base of the tail. White prevails on the inside of the ears, the chin, the upper part of the throat, the inside of the legs, as well as the under surface of the tail. A few very large bucks have been shot on Molokai, but the average of the largest would seem to be about 150 pounds, while the does seldom weigh more than half as much.

The spotted or axis deer is a native of India and Ceylon. It is a common species in deer parks everywhere, and has been liberated in several countries in the Orient. They prefer to live in the forests at from three to four thousand feet elevation, where they frequently congregate in small droves, usually in the neighborhood of their drinking places. During the middle of the day they manage to keep out of sight, but as darkness comes on they become active and continue to feed during the night and for some time after sun-up. If disturbed during the day they try to steal quietly away by creeping stealthily off though the undergrowth.

THE MONGOOSE.

The mongoose was first brought from Jamaica, West Indies, in 1883. Thirty-six pairs were imported and liberated on Hawaii in the hope that they would be of value in freeing the cane fields of rats. Unfortunately, they were carried from one island to another before their habits were fully understood, with the result that all of the islands, with the exception of Kauai, are now infested with this animal that has proved to be a pest, about which but little can be said in its favor. The mongoose¹⁹ is a native of India, where the common species is easily tamed. It is yellowish-gray in color, flecked with black, and is mink-like in size and general appearance. Its fondness for poultry and eggs renders it a serious menace to the ranchman. In the back country and the wild mountains it does much damage to ground-nesting birds, and is listed as one among the many causes of the rapid decrease in the number of several of the Hawaiian species.

SKINKS AND GECKOS.

Of the land reptiles only seven species of small geckos and skinks have

¹⁸ *Cervus axis*.

¹⁹ *Herpestes griseus*.

so far been described from the islands. They are commonly called lizards by Europeans, but were all known by the name *moo* by the native inhabitants, and were worshipped as gods by the female chiefs. All of the species are quite generally distributed over the group, and, according to my friend Dr. L. Stejneger, who has given the subject much study, the species found in the islands have a wide distribution throughout Polynesia.

They are interesting, harmless little creatures that do much towards keeping mites, ants and mosquitoes in check. For the most part they are nocturnal in habit and are very often seen about houses, on lanais and window screens. During the daytime the common species find shelter in the dark, under boards, in crevices in the bark of trees or any place where they can secrete themselves. Their white eggs are about the size of a small bean, and are usually attached to some object near the place where the mother hides during the day. In due course of time the young animal hatches from the egg and is a miniature of the adult. It is about an inch and a half in length, and at once takes up the task of supplying itself with its natural food. They become quite tame and in many homes are protected and live a sheltered life in a state of semi-domestication.

Of the seven species, four belong to the gecko family.²⁰ The peculiarities which separate them at once from the skink family are the presence of a large symmetrical shield on the top of the head and the absence of minute scales over the body. All four species of gecko have been taken in the same house, and the characteristics which separate them from one another are somewhat obscure, to the ordinary observer. Those interested in identifying the species should consult Dr. Stejneger's account of the land reptiles of the Hawaiian Islands.

The three species of skinks²¹ are small, smooth and shiny, and all have more or less conspicuous longitudinal stripes. They have much the same habits as have already been described for the geckos and, like them, are very liable to lose a portion of their tails at the slightest provocation. The missing portion may be replaced in due time with a new tail which is usually smaller than the portion lost. On rare occasions two or three tails will grow out of the injured stump, giving the animal an odd appearance. The ability of the gecko to change color in order to resemble the object upon which it is resting furnishes an example of voluntary color protection that is most interesting.

FROGS AND TOADS.

The first frogs were brought to the islands by the Royal Agricultural Society at a date prior to 1867. The earliest definitely recorded shipment, however, was made in the year just mentioned, when "frogs were liberated at Pawaa," in Honolulu. Several species of frogs and toads have been introduced into the group in more recent years, from Japan and America, with the result that they are now common in all the fresh water streams and ponds

²⁰ *Geckonidae*. ²¹ *Scincidae*.



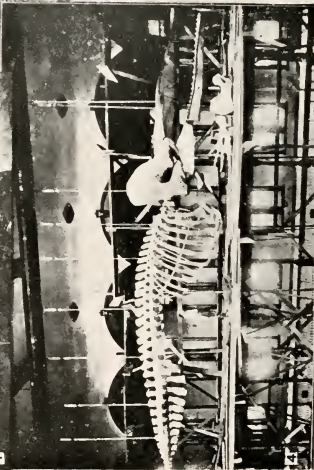
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PLATE 77. WHALES AND WHALING SCENES.

- 1, Sperm Whale stranded on Kauai, October, 1910. 2, Whaleship stripping off "blubber." 3, Whaleboat, fast to a whale. 4, Skeleton of a Sperm Whale in the Bishop Museum (assembled by the author). 5, A race for a whale.

in the Territory. They are of much importance in the ever-present fight against mosquitoes, since they are known to feed on their larvæ. They are also supposed to feed on the liver-fluke which is quite common in certain localities. Bullfrogs²² of very large size and with very deep bull-like voices are well established, and frogs' legs are often seen in the markets.

Tadpoles of the various species of frogs and toads are plentiful in the pools along the streams far up into the mountains and are sure to attract the attention of the student of nature. A few captured and placed in a jar at home or at school will prove of great interest, as the transformation proceeds from an aquatic fish-like animal with gills, to an air-breathing quadruped with lungs.

NO SNAKES IN HAWAII.

Fortunately, there are no land snakes in Hawaii. On several occasions, however, snakes from California have reached the islands in bailed hay, but as yet they have never made their escape so as to become established here. The same is true of certain California lizards. A specimen fifteen inches in length was killed on the wharf in Honolulu harbor a few years²³ ago. But as commerce from outside ports is safeguarded at present, there is little danger of the larger reptiles gaining a foothold here.

Turning from the land and fresh-water vertebrates to those inhabiting the sea, three specimens of sea-snakes are reported to have been collected in Hawaiian waters. Two specimens, secured on opposite sides of Oahu, are preserved in the Bishop Museum. The first specimen reported, however, was identified by Prof. H. W. Henshaw. It was taken alive at Lanipahoehoe, on Hawaii, in 1902, by Mr. E. W. Barnard. When found, the creature was sunning itself on shore and had evidently come from the water to shed its outer skin, which was still attached to the body. The family of sea-snakes²⁴ to which this species belongs is characterized by having the tail flattened to serve as a fin. The specimen,²⁵ being the first sea-snake to be taken in Hawaii, made quite a stir at the time, but as it was but two feet in length, and as only three specimens have been reported in the history of the islands, their occurrence here may be considered purely accidental.

SEA-TURTLES.

Among the more important animals inhabiting the sea, mention should be made of the two species of sea-turtles that occur in the waters about the islands. They are known as the honu and the e-a by the natives, who are very fond of the honu as a food. In former times the Hawaiians made use of the shell plates in the manufacture of fish hooks, scrapers for removing the trash from olona fiber, and, to some extent, in more recent times, in the manufacture of ornaments. Turtles two feet or more across the shell are not rare, though the specimens which reach the market are usually much smaller. In both species the limbs have become completely modified into flippers or paddles which

²² *Rana catesbiana*.

²³ 1911.

²⁴ *Hydrophidæ*.

²⁵ *Hydus platurus*.

enable them to swim swiftly in the sea, but render them almost helpless on the land, where if turned on their back, they cannot regain their normal position. They deposit their eggs in the sand in nests which they scoop out to a depth of two feet or more. The most abundant species about Hawaii is the green turtle.²⁶ It has a strong bill and the center of the back is made up of thirteen plates arranged in three rows, which lie perfectly smooth and never overlap, as they do on the rarer hawksbill turtle²⁷ or e-a, which furnishes the tortoise-shell of commerce. As its name suggests, this latter species always has a hooked bill. It also has thirteen plates over the back which overlap like shingles on a roof, until it is nearly grown, when they assume the arrangement occurring on the related species.

GALAPAGOS LAND-TORTOISE.

A specimen of one of the many species of Galapagos land-tortoise²⁸ is also to be seen in Hawaii. It belongs to the former Queen Liliuokalani, and was brought to the islands by Capt. John Meek between 1812 and 1825. It is reported that at his place on King street he kept "many land-turtles" which were brought home by him on numerous trips to Mexico. When they were finally disposed of the specimen now in possession of her Majesty was given to King Kamehameha III. It eventually passed into the hands of Kapiolani, and after her death was still held in the royal family. It was a large animal when brought to these islands almost one hundred years ago, and without doubt was very old at that time.

A second specimen²⁹ was kept for a number of years on Nuuanu street in Mrs. Mary E. Foster's wonderful garden of tropical plants. In their native home in the Galapagos Islands, the tortoise feed on cacti and coarse grass, but in captivity they feed on kitchen refuse. While they are dull creatures they are nevertheless objects of great interest and curiosity.

PORPOISE AND DOLPHIN.

At least two and probably more species of porpoise³⁰ occur in the waters about Hawaii. The commoner species³¹ is dark gray in color over the back, and is white beneath, varied with small gray spots, and is about six feet in length. The teeth on both jaws are numerous, being about forty in number. The porpoises belong to the great order of aquatic mammals with fish-like bodies³², which include the true whales and the dolphins, and are known as naia by the Hawaiians. In this order there are no posterior appendages. The anterior appendages act as paddles and are without joints. The tail is horizontally expanded to form a powerful propeller.

The porpoises associate in herds or schools, and their sportive gambols are familiar to almost everyone who has made a sea voyage in the Pacific. As they dive and sport under the bow of a slow-moving vessel they present a sight long to be remembered. At one moment will be seen the roll of the

²⁶ *Chelone mydas*.

²⁷ *Chelone imbricata*.

²⁸ *Testudo* sp.

²⁹ Died 1908.

³⁰ *Prodelphinus*.

³¹ *Prodelphinus attenuatus*.

³² *Cetacea*.

arched back surmounted by the curved fin; at another the white belly will flash in the sunlight as the creature swims along in a series of graceful curves in the surface water. Not infrequently scores of them will be seen swimming and leaping about a vessel for hours together. It is then that the voyager is often given his first opportunity to see a harpoon thrown from the bow of the vessel. Perhaps if a successful thrust is made, one of these odd mammals will be brought on deck, where it can be examined at close range.

The term dolphin is rather loosely used and is sometimes applied to a fish, sometimes to a narwhale, but more often to the grampus or killer. The name properly belongs to a genus of animals world-wide in their distribution, of which the common dolphin,³³ a species that abounds in all temperate and tropical seas, may be considered as typical. But as there are several closely-related species, it is difficult to identify them in the water or to separate them from the porpoises without specimens and recourse to extended technical descriptions.

WHALES.

It should be stated in this connection that the waters of the Pacific are inhabited by several species of whales, of which the right whale or whalebone whales,³⁴ with three or more wide-ranging species, are the most important. However, the sperm-whale or cachlot³⁵ and the humpback³⁶ are perhaps the most common. In times past the pursuit of whales and the whaling industry was a matter of great commercial importance to the Hawaiian Islands.

Although by their mode of life they are far removed from observation, whales are in many respects the most interesting of all creatures, and there is much in their habits worthy of study. The whalebone, or Arctic right whale³⁷, attains, when full grown, a length of from forty-five to fifty feet. The head is enormous in size, exceeding one-third the length of the creature. The upper jaw resembles nothing so much as a large spoon. The whalebone blades acquire a length of ten or twelve feet; there being about 380 on each side of the upper jaw. These blades are black in color, fine and elastic in texture, and fray out on their inner edges and ends into soft, delicate hairs. The remarkable development of the mouth and of the various structures connected with it bear a close relation to the food habits of this whale. By means of the seine or seive-like apparatus just described, it is possible for these animals to capture the minute forms of life which swarm in immense numbers in the seas it frequents. The elastic whalebone of commerce has long been a valuable commodity, and many a fortune has been made from the whaling business. In recent years, owing to the decrease in the number of whales, the price of whalebone has been as high as twelve thousand dollars per ton.

The sperm-whale, or palaoa of the natives, is the largest representative of the toothed whales, and in length and bulk it somewhat exceeds that of the

³³ *Delphinus delphis*.
³⁷ *Balaena mysticetus*.

³⁴ *Balaena* spp.

³⁵ *Physeter macrocephalus*.

³⁶ *Megaptera* sp.

right whale just mentioned. The head differs from that of the right whale in being over one-third the length of the body, very massive and high, and is abruptly truncated in front. This curious development of the head is mainly caused by the bulk of fatty tissue massed in the large hollow on the upper surface of the skull. The weight of the skull is very great. The skeleton of the specimen assembled by the writer, now on exhibition in the Bishop Museum, weighs almost three thousand pounds.

The blow-hole is placed on the anterior extremity of the head a little to one side of the center. Owing to the curious shape of the head in the sperm-whale, the "hump," when the animal comes to the surface to blow, is in front of the spray; in the right whale and the humpback, the hump is behind the spray. Owing to this difference the experienced whaler is able to identify the species miles away from his ship.

The lower jaw of the sperm-whale differs from that of the right whale in being narrow and in having from twenty to twenty-five stout conical teeth six or eight inches in length, that are composed of ivory of good quality. Whale ivory was much prized by the native Hawaiians, and used by them in the manufacture of the jewelry and ornaments of which mention has already been made.

The sperm-whale is doubtless one of the most widely distributed of living animals, being met with usually in herds or schools in almost all tropical and sub-tropical seas. Its food consists mainly of squid and cuttlefish, but the larger fish are also devoured, though how they are captured yet remains a mystery. The substance known as "ambergris," formerly used in cookery and medicine and now in the manufacture of perfumery, is a concretion formed in the intestines of this and perhaps in other species of whales, and is occasionally found floating on the surface of the sea or cast up on the open beach.

The right whale is pursued primarily for its whalebone, though its blubber is a valuable by-product. The sperm-whale is sought for chiefly for the large quantity of whale oil which it yields. This oil varies in color from a bright honey-yellow to a dark brown, according to the part of the animal from which it is taken. The best oil is that taken from the head, where it occurs as pure oil and may be dipped out with a bucket. Sixty to eighty barrels of oil from the head alone were not uncommon records when whaling was at its height.

The humpback whale,³⁸ or kohola of the Hawaiian seamen, is a large species and belongs to the group characterized by the presence of a number of longitudinal flutings or folds in the skin of the throat, and by the fin on the back. They were formerly quite common off the Island of Maui during the winter season, and were occasionally captured and brought to land. In more recent times, while both humpback and sperm-whales are seen quite frequently each year about the islands, but little attention is paid to them unless they chance to become stranded, as occasionally happens. In ancient times all whales and porpoises³⁹ east ashore were the property of the alii, or chiefs, and the wearing of whale-ivory ornaments was limited to that class.

³⁸ *Megaptera boops*. ³⁹ *Naia*.

THE WHALING INDUSTRY.

In the old whaling days vessels engaged in the trade ranged up to four hundred tons burden, and were often outfitted for a two or three years' voyage. Their usual destination being the "south seas," they frequently utilized Hawaii as a depot station. A whaling vessel usually carried six whaleboats. These were about twenty-seven feet in length, with four-foot beam, and were pointed at both ends.

When a whale was sighted, four boats put off at once, each being provided with a pair of two-hundred-fathom harpoon lines and carrying a crew of six men. "It was the business of the boat-steerer to harpoon the whale when it came to the surface to spout. When this was done he changed places with a member of the crew, whose duty was to kill the animal with a lance. When a whale was harpooned, immediately after the first struggle and when it was lying exhausted from its endeavors to escape, the boat was pulled close alongside, and the headsman began the work of destruction by thrusting his lance into the vital parts behind the flipper. As soon as the whale was lanced the boats were backed with all possible speed. When first struck the whale frequently 'sounded' or descended to immense depths, sometimes taking out nearly all of the eight hundred fathoms of line carried by the four boats. Subsequently, however, when weakened by the loss of blood, it kept on or near the surface, towing after it one or more of the boats. By hauling in the line the boat or boats were pulled up alongside and the monster finally destroyed, either by darting or thrusting with the lance."

Whaling as thus carried on was full of dangers, and an occupation calculated to be followed only by the most hardy and venturesome; hundreds of accounts of hairbreadth escapes from death have been chronicled in the pursuit of this business in which, at its height in 1852, no fewer than two hundred and seventy-five American vessel were engaged, in the north Pacific alone. The amount of oil taken that year by the fleet exceeded 337,000 barrels, and more than 5,000,000 pounds of whalebone was secured.

The Hawaiian Islands were in the center of this trade, and thousands of the native Hawaiians were employed as whalers. The business developed in the ports of the islands furnished the impetus and the foundation for more substantial and diversified trade that has rapidly increased in volume to the present, though whaling, on anything like an extensive scale, was practically at an end by 1875.

As long ago as 1824 the brig *Ainoa* set out from the islands for a sealing voyage. At different times, but particularly in 1859, sealing expeditions have been made among the islands to the west of Kauai. In that year the *Gambia* returned to Honolulu with fifteen hundred skins and two hundred and forty barrels of seal oil. This furnishes us with a record of the former abundance of the seal ⁴⁰ in the Hawaiian group. Of recent years they have been far from

⁴⁰ *Monachus schauinslandi*.

abundant, though seals are regularly reported from Laysan, Lisiansky, Pearl and Hermes Reef, and are occasionally seen at Midway. In January, 1912, the U. S. Revenue cutter Thetis returned from a cruise to Midway and Laysan and brought a seal-skin back which was presented to the Bishop Museum. Baby seals were seen at that time, and it is quite probable that, if not interfered with, the herd will increase in numbers.

CHAPTER XXII.

INTRODUCED BIRDS.

The nature-lover visiting Hawaii for the first time is sure to be disappointed by the limited number of species of birds to be seen in Honolulu and along the main traveled roads about the islands. Were it not for the presence of the dozen or more species of birds that have been introduced into Hawaii by accident or design, it is doubtful if the average tourist would see or hear a single bird during his stay in the group. It is unfortunate that of the one hundred and twenty-five or more species enumerated in the list of birds in the islands, not more than half a dozen will be seen within the city of Honolulu, and all of these are introduced from other lands.

THE ENGLISH SPARROW.

The English sparrow¹ is perhaps the most abundant bird about the city. This pert, saucy and industrious Britisher is six inches or so in length, and has a brownish back, streaked with black. In the adult male the conspicuous black throat patch makes it a species easily recognized as an old acquaintance of a distant land, and serves to distinguish it from the house finch or the "rice bird,"² the only other species with which it can be confused. The latter species is about the size of its English cousin, but is light ashy-brown, streaked with dark brown above. During the mating season the male has the throat and breast a crimson color. The English sparrow's eggs are always spotted, while the house finch's eggs are smaller and are a very pale bluish tint.

RICE BIRDS.

There is also another rice bird, much smaller than the California house finch. It is usually seen flying in small, compact flocks. In reality it is a weaver bird and belongs to a different family from that of the two species just described. Doubtless it arrived in Hawaii many years ago as a cage bird that came originally from the Malay Peninsula. As so often happens with pets, it probably escaped from captivity and has since become common throughout the group. While it is called a rice bird, it is better known locally as the Chinese sparrow.³ It is about two-thirds the size of the larger rice bird, and

¹ *Passer domesticus*.

² *Carpodacus mexicanus obscurus*.

³ *Munia nitoria*.

in general color is a warm chocolate brown. When a specimen is in hand it will be found that each feather over the back is marked by a narrow white shaft line. All three of these sparrow-like birds feed at certain seasons on the cultivated rice—a fact that has produced much confusion in the popular mind as to just which species is in reality entitled to be called the rice bird.

The combined damage that these birds do to the growing grain from the time the kernels of rice begin to form in the heads until the crop is finally harvested, amounts to many thousands of dollars annually. The rice farmers patrol their fields during this season, from early morning until sundown, discharging "rice guns," shouting and conducting a general crusade against the birds. Many Chinese farmers set up scarecrows, to which windmills and noise-making devices are attached, to guard the ripening crop. Others will ingeniously run stout wire supported above the grain on bamboo poles, over an entire field of grain. From these dangle a motley array of old tin cans, clappers and other noise-producing junk. The free ends of all of the main wires center at a conveniently-placed elevated platform from which the farmer keeps a sharp lookout for the feathered despoilers of his harvest. Just as the flock alights on the drooping heads of grain, the farmer pulls the main wire that runs to the place under attack. The neighborhood resounds with the din, with the result that the intruders fly to some other spot, where the same form of repulse is resorted to. In a short time the birds find that they are more scared than hurt by the noise, and become more and more bold, often standing their ground without wavering through the veritable pandemonium. The writer has watched with much interest the development of courage among these uninvited and unwelcome bird guests, and doubts whether much is gained in the long run by this form of warfare, save the satisfaction to the farmer of doing something to protect his crop.

CHINESE TURTLE-DOVE. -

The Chinese turtle-dove,⁴ as its name suggests, came originally from China. It is another introduced bird that is abundant in the rice fields, more especially after the crop has been gathered. They then visit the fields in pairs or in small flocks to glean the scattered grain that may be left after the frugal Chinese farmers' wives have gathered in the last straws left lying on the ground by the harvest-men.

Dove shooting is said to be real sport in Hawaii, and those who indulge in it as such are always anxious for the open season to begin. An expert marksman, in the height of the season, will secure a bag of fifty or sixty birds in a single day. Though the dove is modest and retiring, its mournful call is not an uncommon sound in the city; the flat, loosely-constructed nest in which two white eggs are laid, is occasionally found in the trees and shrubs forming the tropical tangle that often surrounds the Hawaiian home.

⁴ *Turtur (Spilopelia) chinensis*.

THE MYNAH BIRD.

No bird in Hawaii is more conspicuous or more thoroughly at home in his adopted land than is the false mynah⁵ or mina. The mynah was brought to Hawaii by Dr. Wm. Hillebrand years ago to feed on the cutworm of a certain moth.⁶ The birds flourished and multiplied and have had an important part in the reduction of the pest. Although not without bad habits, they must be regarded as generally beneficial in their food habits.

Had they not become fond of the seeds of the introduced lantana—and thus become directly responsible for its being spread broadcast over the islands—there is little doubt but that the mynah would have been generally held in higher esteem than it is today. Their size, industry and sociability make them interesting objects wherever they are, and the study of their nests, food, and life habits will well repay the observing bird-lover.

The false mynah is so called to distinguish it from the true mynah of India, a bird which they resemble in size, habit and general characteristics. It is an exceedingly sagacious bird, and readily learns new tricks that enable it to adapt itself to peculiar and unusual conditions of life. There are cases on record where the young have been taught to say single words; but in linguistic attainments they are not the equal of their Indian cousins.

Their nests, which are built in odd places about buildings, under rafters, in eaves-troughs, or occasionally saddled into forks of trees, are invariably bulky affairs. Their eggs are of fair size and blue in color, resembling those of the American robin. All day long they scold, call or try to sing as fancy strikes them, but at night, as they congregate in certain large banian trees about the city in flocks of hundreds, the noise they make in taking leave of each other and of the day, before going to roost, is little short of deafening. The first faint glow in the east is the signal for them to take up the argument and the work where they left off the day before. So day after day the unmusical voice of the mynah, as it dins its call into the ears of the traveler, morning, noon and night, comes to be the sound from Hawaii that lives longest in the memory. Likely as not, years afterward, when the sight of old Diamond Head and her waving cocoanut palms and the languid caress of the soft air of the tropics are but shadowy memories, it will be some harsh bird-note, caught by the listless senses in an idle moment, that will again vividly bring to the mind of the traveler the mynah, and its noisy evening song, and the twilight scene it revives in fancy.

There is a popular though erroneous belief in Hawaii that the mynah is responsible for the disappearance of the native birds. The fact that this noisy stranger is frequently found in the forests at an elevation of five or six thousand feet, is offered as an explanation for the singular passing from the forest regions of many species of native birds. There is little reason,

⁵ *Acridotheres tristis*.

⁶ *Spodoptera mauritia*.

however, for supposing this to be the true cause. There may be cases, about settlements especially, where the mynah has been known to interfere with the nests and eggs of certain birds, particularly those of the English sparrow, a species with which its habits bring it in sharp and direct contact; but so far as the opinions of the best observers and my own experience go, the mynah, when he finds himself in the forest, lives at peace with the native birds. The general habits of the forest birds differ widely from those of the mynah, and their nesting and food habits are so different that the two seldom come into conflict.

THE SKYLARKS.

The English skylark ⁷ was introduced into Hawaii purely for sentimental reasons, because of its beautiful song. Many persons who have settled in Hawaii came directly from England, and were familiar with the profuse strains of this songster in their native land; naturally, the lark is a favorite with them. These birds, now fairly common in the pastures and on the open fore-hills of the principal islands of the group, are descended from birds brought by the Hon. A. S. Cleghorn from New Zealand, where the bird had been successfully introduced from England by early colonists.

The lark is a dull-brownish bird, well known to every one who strolls along the paths that lead into the mountains. Often they will be startled into song from the roadside by the rumble of a carriage or the tread of a pedestrian, and, singing, they will mount higher and higher into the sky, carrying their song with them, up, up, until both singer and song are lost to sight and ear. They are not content with merely lifting their song to the heavens, but will sweetly and skilfully coax it back with them to earth again. It often happens that a half dozen of these blithe singers will mount skyward at the same time, dropping after them a veritable shower of song that could but delight the most careless cross-country rambler, and bring him home again glad that there is in Hawaii such a bird as the skylark.

PHEASANTS.

The several species of game-birds that have been introduced into Hawaii are of special interest to the sportsman. To the credit of many of our foremost citizens of a generation or more ago, pheasants and quails were brought to Hawaii at private expense and liberated. New breeding stock has been brought in, from time to time, and the welfare of the game-birds so guarded by law that they have increased, particularly on the islands of Kanai and Molokai, until they are sufficiently abundant to make game shooting an enjoyable sport.

Two species of pheasant are now well naturalized in Hawaii. The ring-neck or Chinese pheasant ⁸ came originally from China, but as it has been extensively reared in England and America, usually as a cage-bird, it is dif-

⁷ *Alauda arvensis*.

⁸ *Phasianus torquatus*.

fiend to tell from whence the Hawaiian stock was derived. The back of the male is a fine coppery-chestnut color, the neck a beautiful metallic-green, with a narrow white collar about the middle, and the breast a gorgeous metallic-copper color with purple reflections.

The Japanese pheasant⁹ is about the same size as the Chinese species. The pure-blooded male can be easily identified, as its underparts are dark green and there is no white ring about the neck. The females of the two species are more difficult to identify, especially in Hawaii, where hybrids between the two species frequently occur that rival the pure stock in size and beauty of plumage.

THE CALIFORNIA PARTRIDGE.

The California partridge¹⁰ is well established in the islands, especially on Hawaii, Maui and Molokai. The pretty black crest and throat and black scale-like markings on the belly, with a central patch of chestnut on the breast of the males, and the prevailing smoky or brownish color of the females, taken together with the habit, size and rapid flight of the partridge, makes it an easy bird to recognize, as they scurry across the road or take flight from under foot and whirl through the air like so many winged bullets.

The pheasants and partridges prefer the open country, the forehills, and straggling scrub about the lower edges of the mountain forests, and in spite of the damage to them and their nests that is directly traceable to the mongoose, they are generally believed to be increasing in numbers.

The wild fowl, or moa, was introduced by the natives long before the coming of the white man, but since his coming other breeds have escaped into the mountains and a mongrel Hawaiian wild chicken has resulted. The introduction and liberation of certain domestic birds, as turkeys, pea-fowls, guinea-fowls and the like, have been made from time to time until they are quite common in a wild state on the different islands.

Other birds have escaped and become established, among them a parrot on Maui and a Chinese thrush¹¹ on Oahu: though the latter is not a thrush, but a reed-warbler. It is to be hoped that ere long the scientific introduction of desirable economic species will be undertaken, since there are many species of birds in America and elsewhere that, if brought to Hawaii, would fill a useful place in the economy of nature, and at the same time add by their presence to the pleasure of life in both city and country.

CHAPTER XXIII.

BIRDS OF THE SEA AND OCEANIC ISLANDS.

REGULAR VISITORS AND OCEAN WAIFS.

Of the little list of less than thirty species of sea-birds of which Hawaii can boast, almost half the number are very rare winter visitors. As a rule

⁹ *Phasianus versicolor*.

¹⁰ *Lophortyx californica*.

¹¹ *Trochalopteron canorum*.

these are ocean waifs—young and unexperienced birds—that have lost their way in an attempt to migrate for the first time along the American coast on their way to their winter homes in the South. Such birds are rare in the islands and are seldom seen outside of museums. They are usually, though not always, common west coast species of gulls and terns¹ and ducks.² Birds of these families are well adapted by nature to enjoy life on the island shores and reefs, and one is led to wonder why some of them, in times past, have not taken up a residence and settled down to a fishing life, and become abundant along Hawaii's coasts, now sadly destitute of sea-bird inhabitants.

Unfortunately for the bird student, only a few of the species that regularly frequent the waters about the islands ever come close enough to the shore to be identified more exactly than to say that they are large or small sea birds. Of the limited list that may be said to be common about the group, there are as many as four species that nest in holes which they find or make in the faces of the high cliffs in the mountains in the large inhabited islands. They may be seen occasionally in the daytime flying over the land, but generally only their curious calls can be heard, as they are nocturnal in habit and are seldom abroad during the day.

TROPIC BIRDS.

The white-tailed tropic bird³ is the species most commonly seen during the daytime. It is a beautiful white bird, and in fine weather, in favored localities, as many as half a dozen may be seen at once, gracefully floating about the cliffs at the head of the principal valleys of the islands. They lay but a single large, cream-colored egg—thickly blotted, splotted and mottled with rich brown—which they deposit in a nest of loose straws, tucked in a crevice in the face of the cliff. The young nestling differs from the adult in that the body and head are mottled black and white. In this stage they resemble the young of the red-tailed species⁴ which occurs on the low sand islands of the northwest chain. The adults differ from the red-tailed species, as their name suggests, in having their long tail white, or salmon color, instead of deep red. The plumage of both species was much used in Hawaii in times past in the manufacture of the native kahilis that are elsewhere described. The birds were also used as food by the natives.

PETRELS AND SHEARWATERS.

The Hawaiian petrel,⁵ Newell's shearwater,⁶ and the Hawaiian stormy petrel⁷ are all small or medium-sized, dark-colored sea-birds with hooked bills; they nest in holes in the mountains. Although they and their habits were well known to the Hawaiians, who were expert naturalists, they have continued to be very rare specimens in collections, owing to their night-flying habits and the almost inaccessible places in which they nest. They were a

¹ *Laridae*.

² *Anatidae*.

³ *Phaethon lepturus*.

⁴ *Phaethon rubricauda*.

⁵ *Estrelata sandwichensis*.

⁶ *Puffinus newelli*.

⁷ *Oceanodroma cryptoleucura*.



PLATE 78. GROUPS OF HAWAIIAN BIRDS IN THE BISHOP MUSEUM.

(Collected and mounted by the Author.)

(FOR DESCRIPTION OF PLATE SEE OPPOSITE PAGE.)

favorite food in the old days, much resembling squab in flavor, and were preferred on the Hawaiian table over the tropic bird, whose flesh had a strong fishy flavor. These species all lay but a single dull-white egg. Without doubt all four of the cliff-nesting species mentioned above are doomed to extinction in the islands, owing to the inroads made upon them by the mongoose, which is a serious menace to all ground-nesting birds.

Perhaps the average person sees more birds from the deck of an island steamer than in any other way. In fact, most of the more common day-flying, sea-going species may be identified by a practised observer while crossing the channels between the islands.

TERNS.

The small, graceful black bird with a silvery-gray crown, flying usually in small flocks, is almost sure to be the Hawaiian tern,⁸ although it is easily confused with its cousin, the noddy tern,⁹ from which it differs chiefly in being a trifle smaller and of a more slender build.

Both species are active fishers, capturing their prey by flying close to the surface of the ocean and swooping down upon any of the small, unwary species of fish that abound in the surface water five or ten miles off the coast. Both of these graceful birds have much the same habits and disposition. The writer has taken the nests and eggs of both species from crevices in steep sea-cliffs as well as from the tops of low bushes growing on the flat sand islands of the group. Both birds were formerly used to some extent as food. They were usually captured by the natives at night by the aid of torches. The light served to bewilder the birds, causing them to fly, aimlessly about, when it was an easy matter to knock them down with sticks and poles.

Like many sea-birds, both species lay but a single egg, which they place on a small heap of sticks and seaweed that serves as a nest. The eggs are

⁸ *Micranous hawaiiensis*.

⁹ *Anous stolidus*.

DESCRIPTION OF PLATE.

1. View of birdlife on Laysan (opposite side of the group shown in fig. 7). In the burrow, Bonin Petrel (*Estrelata hypoleuca*); under the bushes a Red-tailed Tropic Bird (*Phaethon rubricauda*); on the bushes two Noddy Terns (*Anous stolidus*) and an old and young Hawaiian Tern [Noio] (*Micranous hawaiiensis*); on the rock and bushes a Red-footed Booby (*Sula piscator*); on the rocks two old and young White Terns (*Gygis alba kittitzi*); on the sand one Christmas Island Shearwater (*Puffinus nativitatis*). 2. Pair of Man-o'-war Birds [Iwa] (*Fregata aquila*) on the nest showing the large red gular pouch on the male. 3. Group showing old, young, immature and egg of the Black-crowned Night Heron [Ankuu kohili] (*Nycticorax nycticorax nauius*). 4. Black-footed Albatross (*Diomedea nigripes*). 5. Group of Hawaiian shore-birds; five Turnstones [Akekeke] (*Arenaria interpres*) are shown in the act of lighting; on the rock a Bristle-thighed Curlew [Kioea] (*Numenius tahitiensis*); to the left Hawaiian Stilt [Kukuluao] (*Himantopus knudseni*); by the water's edge Pacific Golden Plover [Kolea] (*Charadrius dominicus fulvus*); one just rising and one preening Wandering Tattler [Uli] (*Heteractitis incanous*). 6. The Hawaiian Goose [Nene] (*Neoschen sandvicensis*). 7. Opposite side of fig. 1. Birds in flight Sooty Tern (*Sterna fuliginosa*); on the bushes Red-footed Booby (*Sula piscator*); on the ground left Blue-faced Booby (*Sula cyanops*); on the ground in center Grey-backed Tern (*Sterna lunata*); in the deeper hole Bulwers Petrel (*Bulweria bulweria bulweri*); in the shallow burrow Wedge-tailed Shearwater (*Puffinus cuneatus*) old and young.

even more alike if possible than the birds, and a description of one will suffice for both. They are usually a little smaller than a bantam chicken egg, and clear grayish-white, variously splotted and mottled with clove-brown, varied often with lilac markings.

The sooty tern¹⁰ is a beautiful, graceful species common in the waters about the islands. It may be identified by its typical tern-like flight and the fact that the upper parts are sooty-black while the under parts, forehead and a narrow stripe over the eye, are white.

Two or three species of small, tube-nosed swimmers that skim singly, or in pairs, over the water, that all pass in the distance as "mutton birds," are as liable to be one as the other of the wedge-tailed shearwater,¹¹ the Christmas Island shearwater,¹² the Bonin petrel,¹³ or the Hawaiian petrel.¹⁴

Where careful identification is possible they may prove to be something very different, however, and it is unsafe to hazard more than a guess as to the name of a species seen on the wing at sea. Fortunately, there is no ground for uncertainty in the identification of the large, tube-nose swimmers.

ALBATROSS.

The black-footed albatross¹⁵ is sooty-brown all over, while the Laysan Island albatross¹⁶ has the abdomen white. Both species are about the size of a large goose and are called gooneys by the sailors. They both follow vessels crossing the Pacific, for hundreds of miles on their journeys to and from the islands. Not infrequently a flock of three or four birds will follow a steamer for days, eagerly seizing the bits of waste that may be thrown overboard from the cooks' galley.

MAN-O'-WAR BIRD.

The majestic black man-o'-war¹⁷ bird, often little more than a mere speck in the clear blue sky, is easily recognized as it sails high overhead, circling round and round for hours at a time without the slightest apparent effort; they are objects of never-failing interest, serving often as a welcome diversion to relieve the monotonous round of daily life on board an ocean liner in the tropics.

Interesting as the Hawaiian species of sea-birds may be when on the wing, their home life is a great deal more so, and fortunate indeed is the person who is able to spend a few days in one of the large colonies to be found on all of the smaller uninhabited islands that lie to the northwest of Kauai.

BIRDS OF LAYSAN ISLAND.

Laysan is perhaps the largest sea-bird colony in the tropics, and its teeming hordes of bird inhabitants may justly claim for it a place as one of the great natural wonders of the world. The island itself is scarcely two and a

¹⁰ *Sterna fuliginosa*.

¹¹ *Prionus cuculatus*.

¹² *Puffinus nativitatis*.

¹³ *Estrelata hypoleuca*.

¹⁴ *Estrelata sandwichensis*.

¹⁵ *Diomedea nigripes*.

¹⁶ *Diomedea immutabilis*.

¹⁷ *Fregata aquila*.

half miles long by one and a half broad, and is about forty feet above the sea at the highest point. In form, it resembles a great oval platter, and dish-like, it holds a shallow salt-water lake that varies in size to correspond with the amount of rain that falls on the island. There seems to be abundant geologic evidence to prove that the island was at one time a closed coral reef or an atoll that in the remote past was elevated above the surface of the sea. Thus, the coral stone foundation was formed around the salt lake that the sea and the wind have since made over into a sand island.

The low sand rim that surrounds the lake and forms the island proper, slopes gently toward the sea without, and the lake within. On this double beach that is half or three-quarters of a mile in width, a few varieties of hardy beach plants have established themselves. Besides helping to hold the sand in place with their roots, these plants have added the last touch necessary to form an ideal home for this monster bird colony.

This sand ring in the midst of the ocean is the regular home of more than twenty species of birds, five of which are found nowhere else in the world. I have estimated from personal observation and data gathered for the purpose that more than ten million birds formerly visited Laysan Island each year. In addition to the rather large list of regular residents that form the bulk of the inhabitants, the island has a goodly number of species that visit it each winter, including such birds as tattler, plover, curlew, turnstone, canvas-back, shoveler, and a dozen or more occasional or accidental wanderers, making a total of at least three dozen species of birds that are known to visit this mere speck of dry sand.

Naturally, the struggle for existence, often for mere nest-room, is intense. The air, the vegetation, the earth—all literally swarm with bird life. Almost every inch of land down to the water's edge is occupied. In their home life this concourse may be likened to the inhabitants of a great city. Not finding room enough for all to live on the ground, they have turned the island into a great apartment house, several flats in height. Nor are all the flats above ground. Some of the petrels, for example, dig holes five or six feet deep and in them live thousands and thousands of night-flying birds that rear their young, as it were, in the deeper sub-basement of the colony. Another species digs but two or three feet deep in the sand, and in this way occupies the entire sub-basement flat, without fear of molestation by the neighbors, above or below.

The basement is inhabited by the wedge-tailed shearwater. It has chosen this part of the island as a home, and the burrows that they make are in countless thousands and of such size that a person walking across the island must be careful where he steps, lest in an unguarded moment he caves in the roof of a burrow and drops hip-deep into it.

The surface of the ground, to continue our comparison, is the most valuable and hence the most densely-populated part of this wonderful bird city. Under the bushes, in the roots of the grass, in the open spaces about the bunch-grass, along the shore of the lake, or on the sea slope, a dozen species find the

conditions, conveniences and location that appeal most to their fancy, and they occupy the site selected by the colony to its fullest capacity. In the bunch-grass the little flightless rail¹⁸ is found, nesting among the thick stems close down to the ground. The miller bird¹⁹ and the Laysan canary²⁰ nest in the main stems of the bushes, and next above them the tastefully arranged nests of the Laysan honey-eater²¹ is placed. On the tops of the bushes, occupying the choice top-flats, terns, boobies and man-o'-war birds contend among themselves and with their neighbors for the desirable locations; while overhead the air is literally filled with swarms of birds.

Laysan is a veritable bird-lovers' paradise, for, having no knowledge of man, most of the species are without fear and may be lifted from the nest with the hands like a setting barnyard fowl.

THE ALBATROSS DANCE.

By reason of their number, size and unusual personalities, there are no more interesting birds in the colony than the two species of albatross to which allusion has already been made. The Laysan or white-breasted species are most abundant and are widely distributed over the island. From the middle of October, when they begin to reach the colony—returning from, nobody knows where—all through the winter months and until the young are ready to leave with their parents the following July, the island is covered with albatross. Looking in any direction, one can see the old birds standing stolidly about, sitting on their nests, or engaged in their curious dance—a singular performance for which the albatross is justly famed.

This game, or dance, or eake-walk, or whatever one may care to call it, is more than a form of courtship, since it is indulged in at all times, day or night, during the entire period of the birds' long stay on the island. It is without exception the most amusing performance I have ever seen birds indulge in. The dance is so aptly described by Dr. W. K. Fisher, that I quote from his account:

“Two albatrosses approach each other, bowing profoundly and stepping rather heavily. They circle around each other, nodding solemnly all the time. Next they fence a little, crossing bills and whetting them together, pecking meanwhile and dropping stiff little bows. Suddenly one lifts its closed wings and nibbles the feathers underneath or, rarely, if in a hurry merely turns its head, and tucks its bill under its wing. The other bird during this performance assumes a statuesque pose and either looks mechanically from side to side or snaps its bill loudly a few times. Then the first bird bows once again, pointing its head and beak straight up, and utters a prolonged nasal groan, the other bird snapping its bill loudly and rapidly at the same time. Sometimes both birds raise their heads in the air and either one or both utters the indescribable and ridiculous bovine groan. When they have finished they begin bowing to each other, almost always rapidly and alternately,

¹⁸ *Prozanula palmeri*.

¹⁹ *Acrocephalus familiaris*.

²⁰ *Telespiza cantans*.

²¹ *Himatione freethi*.

and presently repeat the performance, the birds reversing the role in the game or not."

Many variations occur in the order of the dance. Sometimes three or more birds will become involved, which adds to the ludicrous nature of the performance, as it becomes at once evident that the birds are unable to dance the more complicated round dances and attempts to do so almost invariably result in a breakdown before the dance is carried to the squawking stage. By way of variety, one of the birds will sometimes pick up a feather or stick and tender it to its partner, who promptly returns the compliment, when they pass to the next form, and so on. Through varying figures and manœuvres these birds will continue their play, often for ten or fifteen minutes without cessation. When the end comes, however, it usually follows the uttering of a prodigious groan, after which the birds retire to a respectful distance from each other and resume their ordinary vocation of preening, sunning themselves or merely looking on while their neighbors amuse themselves in the same form of play. So common is the "dance" among them that dozens of couples may be seen engaged in it at any hour of the day or night.

While the albatross rears a family of but one, they devote much time to the feeding and care of their offspring. The downy nestling issues from a large, dirty white egg (as large as that of a goose) that may be heavily blotched with brownish-maroon, which encircles the egg in a band; or from a brownish-buff egg, without any markings whatsoever. However varied the color of the egg may be, the young birds look so much alike that it is impossible to tell how they are recognized by their parents. Fortunately, there seems to be little difficulty, and the old birds seldom molest one another or their neighbors' children.

The old birds seem to be very active at night and apparently do a great part, though not all, of their fishing at that time. Returning to the island from a fishing expedition, they proceed at once to feed their young. The parent bird settles down beside the nestling, which without delay begins to pick her beak gently. Presently the parent bird stands up and, lowering its head, opens the beak and disgorges a mass of partially-digested squid and oil; but before it is too late the young bird inserts its bill crosswise into that of its parents, and receives the offering with apparent relish. The young bird is in no way modest in its demands, and continues to beg for more until the supply is entirely exhausted, when the old bird pecks back savagely, or walks off to a safe distance and settles down to rest and sleep.

The black-footed albatross does not visit Laysan in such large numbers as do the foregoing species, and as a consequence they live in more restricted colonies. In their habits they closely resemble their white-breasted cousins.

In the guano beds for which Laysan Island is famous commercially, the workmen often find the eggs of the albatross and the shearwaters bedded in the rock-like guano deposits in a semi-fossil condition.



PLATE 79. BIRD LIFE ON LAYSAN.
(FOR DESCRIPTION OF PLATE SEE OPPOSITE PAGE.)

NESTING HABITS OF THE MAN-O'-WAR BIRDS.

Of the large sea-birds on Laysan, the nesting habits of the great man-o'-war birds are second in interest only to those of the albatross. Though its habits have gained for it the most undesirable of reputations among its fellows, the species is worthy of more than passing notice. Their nests are rude structures of sticks and vines, in bulk the size of a bushel basket, that are placed on top of the low bushes. On a desert sand island it is not an easy task to secure the necessary material for the hundreds of nests required by the birds in a colony of the size of that on Laysan. As a result the birds have become notorious thieves, stealing from each other without the slightest regard for the ordinary rules governing the possession of house-building materials among birds. When both the owners of a nest chance to leave it at the same time, if only for a few minutes, their neighbors will greedily carry it away, often not leaving a single vestige of the nest to mark the former home of the absent owners.

Both sexes sit on the single large white egg, turn about, seldom leaving it for an instant day or night for fear it will be broken and the nest stolen by their neighbors. They are forced to keep even a closer watch over the naked young than over the egg in the nest, to prevent their defenseless chicks from being carried off and devoured.

In securing their daily rations they have acquired a skill that makes the acts of an ordinary highwayman seem commonplace. Their habit is to establish their colony in the neighborhood of a booby colony. Here they patrol the island up and down, out over the open sea, a few hundred yards from shore, lying in wait for the return of the industrious boobies and tropic birds that have been out sea-fishing. As the birds near the shore heavily laden with fish, the man-o'-war bird gives chase, often a flock of these winged pirates focusing their attack on a single booby. They fly over it, in front of it, and pick it and otherwise buffet and molest it, until, in self-defense, the confused bird lets go its catch of fish one by one. The fish are eagerly caught up in mid-air by the assailants and the attack renewed, until, more times than not, the booby, after a hard day's work securing food for her family, arrives

DESCRIPTION OF PLATE.

1. Albatross eggs. The manager of the guano company at one time packed down a few barrels of eggs for use by the laborers, but eggs were never exported from the island. The picture here shown and often published was especially arranged for spectacular photographic effect. 2. Black-footed Albatross in the wake of a steamer. Both the black and the white species follow ships at sea and are called gooneys by the sailors. 3, 4. Two views of an enraged Red-footed Booby. 5. Bristle-thighed Curlews roosting on a pile of guano rock. 6. Colony of Hawaiian Terns—all facing to windward, a habit of sea-birds. 7. Red-tailed Tropic Bird on the nest. 8. Family group of Blue-faced Boobies. 9. Sooty Tern with egg. 10. Laysan Albatross—the end of the dance. 11. Wedge-tailed Shearwaters at home. 12. Young Laysan Albatross; partly fledged. 13. Miller Bird and nest. 14. Hawaiian Tern on a bush of *Chenopodium Sandwichicum*. 15. Laysan canary nest and eggs. 16. Group of Man-o'-war Birds on the nest. 17. General view on Laysan looking to the east across the salt water lagoon.

at her nest in an exhausted condition, without a morsel of food left for the expectant young at home.

During the calm warm days of summer the sea is frequently so smooth that the booby is unable to bring home its usual catch of flying-fish. At such times the man-o'-war birds not only resort to cannibalism, but infanticide as well, in order to satisfy their demand for food. If by chance the parent bird of a nearby nest should happen to leave its young unguarded, the ever-watchful pirate-bird, with a swoop of wings and a vicious snap of beak, will seize the almost naked, helpless nestling and mount high in the air, dangling the young bird from its beak. When in the bird's judgment the fall will be sufficient to crush the life out of its prey, the man-o'-war bird, with murderous intent, will drop its neighbors' offspring to the ground. The falling nestling is closely followed in its descent by the bird, that it may be first in at its death. If the fall was sufficient to kill the young bird, it is snatched from the ground and gobbled down by the greedy pirate-murderer. If the young bird struggles, it is again carried into the air, this time to a greater height than before, and again allowed to fall to the ground. This performance is often repeated several times before the helpless young bird is pronounced dead, when its body is swallowed by its assassin in a single gulp.

WHITE TERNS.

There is not space in one brief chapter to describe the interesting nesting habits of the beautiful white terns or love birds,²² the colonies of thousands upon thousands of gray-backed,²³ noddy and Hawaiian terns; the shearwaters, petrels and boobies, all of which occur on other islands of the group, but it seems unfair to nature, to Laysan, and to the reader, to fail to mention, even though it must be in the briefest manner, the species that are found nowhere else in the world.

THE LAYSAN DUCK.

The sportsman finds it almost impossible to believe that a distinct species of duck, the Laysan teal,²⁴ could make so small an island its only home, but such is the case. On a recent visit, however, I found this little colony so reduced in numbers that the species could easily be exterminated in a single day with dog and gun. This little teal, a close relative of the Hawaiian duck, is perfectly fearless. On one occasion a pair, out of curiosity, swam up to the bank of the little lagoon where I was partially concealed, and, coming out on the bank, walked up so close to the camera that it was necessary to draw back to bring them into focus on the plate.

THE FLIGHTLESS RAIL.

The great natural curiosity of the island is the little flightless rail.²⁵ The common belief that they are wingless is an error—growing out of the fact that

²² *Gygis alba kittlitzii*.

²³ *Sterna lunata*.

²⁴ *Anas laysanensis*.

²⁵ *Prozanula palmeri*.

the wings have become so reduced in size as to be almost hidden in the body-feathers, and so weak as to be useless in flight. Almost every square rod of the grassy portion of the island has its pair of rails, and they are, without doubt, the most interesting, industrious and inquisitive creatures in the world. At the slightest alarm they slink into cover under the grass tussocks, only to peer out cautiously in their endeavor to get first-hand knowledge of the cause of their alarm. Of their many interesting habits none is more entertaining than the way in which they secure a portion of their food from the Laysan canary.

LAYSAN CANARY.

The Laysan canary is a sturdy little finch-like bird that nature has endowed with a strong bill. One of its habits is to break open the thin-shelled eggs of the terns and other ground-nesting species during the nesting season. However, the canary is seldom allowed to enjoy the fruits of its labor undisturbed. The little rails are always on the lookout, and at the proper moment will rush out at the canary and, with a great show of fuss and feathers, drive it away from the broken egg. The rail will then calmly spoon up the contents of the egg with its weak, slender bill, leaving the canary to open another egg if it really cares for fresh eggs to eat. As to how this active little rail came to be on the island we can only conjecture. As the species has no near relative that can fly over a wide range, it is probable that the ancestors of the Laysan rail came to the islands very long ago by accident, possibly being lost at sea during the season of migration, or may have been stranded there by the submergence of lands connecting Laysan with other islands of the group. Finding the island small, but well stocked with food and without serious natural enemies, the species doubtless settled down to live the island life. Having but little use for their wings, they gradually lost the power of flight.

The Laysan canary is the best songster on the island, and as a result many of them have been captured by occasional visitors and carried to Honolulu to be kept in cages as pets. On Laysan they are very numerous. Being of good size and absolutely fearless, they are most interesting, often coming into the rough houses built by the guano company, to look for seed or to secure a drink of fresh water. Fresh water is a real luxury to them, though they never care to bathe in it as ordinary canaries do.

THE MILLER BIRD.

The miller bird, as it has been called on account of its unusual fondness for a certain species of miller that is very abundant on Laysan, is a small reed-warbler. This small brown bird is the only representative of this extensive family of insect-eating birds to be found in the native fauna of the group. Ornithologists have been much interested in the discovery of this well-marked species occurring only on this isolated spot of land, since all of its relatives are capable of making extended flights by sea and occur widely distributed in

Australia and China and on various Pacific islands. Like its neighbors, it is quite fearless and is always busy. They often break into a sweet, strong, melodious warble, that seems quite out of place on a low, hot sand island; the song being entirely out of proportion to the size of the bird.

The remaining species peculiar to the island is the Laysan honey-eater. It is an island form of the apapani, a related species that is common in the forests of the higher islands of the group. It is a small bird, red in color, that so clearly resembles its better known relative as not to require description here. While not so abundant as the other species just mentioned, their bright scarlet plumage renders them more conspicuous. Like their cousins, they are especially fond of the nectar of flowers, and their long, slender, curved bills and tube-like tongues make it an easy matter for them to drink the sweet fluid from the blossoms of the *Portulaca* that grows abundantly about the edge of the lagoon. They are also fond of insects and make many a meal from the large grey millers on the island. They are most regular in their habits, returning hour after hour and day after day to the same bush or flower to search for food.

A number of years ago the Laysan rail was liberated on Midway Island, where it has established itself in a thriving colony. The Laysan canary has also been introduced on Midway and has found conditions there entirely suitable to its habits. In 1909 Mr. D. Morrison purchased a pair of the common yellow canaries²⁶ in Honolulu and soon after liberated their young on Midway. They have increased in numbers until it was estimated that there were more than a thousand birds on the island by the end of the nesting season of 1914. They are sweet songsters, and although not quite so friendly as the Laysan finch, they will feed with a person standing within a yard of them. The future of this colony will be followed with much interest by those who are interested in the introduction and naturalization of song and game birds, since it furnishes an excellent example of a species returning to its natural wild habits after centuries of confinement and artificial breeding and feeding.

CHAPTER XXIV.

BIRDS OF THE MARSH, STREAM AND SHORE.

More than half of the complete list of birds recorded as occurring in the Hawaiian group are shore and water birds. This part of the fauna includes resident species, regular winter migrants, and a considerable list of occasional or accidental visitors. As those species that are met with in Hawaii only at irregular intervals are seldom seen and cannot be expected to contribute much to the numerical strength of the meager bird population, the present chapter deals only with the more common forms.

We have observed in an earlier chapter that the city as well as the

²⁶ *Fringilla canaria*.

farming lands on the lower levels about all the islands are without native birds of any kind. Fortunately, this is not true of the ponds, marshes, streams and the sea-shore, as the waters of Hawaii are still inhabited by several characteristic forms. Unfortunately, some of the species of the region are now very rare, while others that are more common are of more than usual interest, since they are not met with elsewhere in the world. The majority of the birds belonging to this low-land section, however, are representatives of wide-ranging species that visit Hawaii as a winter resort to escape the rigors of the climate in the far north where most of the shore and water birds repair every summer to nest and rear their young.

THE GOLDEN PLOVER.

Conspicuous among the migrants visiting Hawaii each year are the golden plover, the wandering tattler, the turnstone and the sanderling. A stroll along the sea-shore, especially in the country districts during the winter season, will be rewarded by a sight of one or more flocks of at least some of these species as they follow up the receding waves in search of the dainties that are left strewn on the sand by the sea. Often the plover¹ will be seen in large numbers, feeding on the upland, where, in the freshly-plowed fields or in the newly-planted cane or on the open grass lands, they find an abundant supply of worms and insects. They doubtless render a great service to the planter and farmer during this season, and are entitled to all the protection they receive in return.

When the plover arrive at the islands in the autumn, from the summer spent in the far north, they are usually in poor flesh. But when we think of the long journey they must make over the three thousand miles of ocean without a rest, the wonder is that they do not perish on the way. Just why the plover and all the other migratory birds undertake these wearisome flights across the wild open ocean, it seems must ever remain a mystery. Without doubt, when storms are encountered many must lose their way and go down to watery graves or, thrown from their course, must fly for days over the great dull expanse in search of land. Perhaps it was in some such accidental way that the first plover happened to visit Hawaii in the long ago. Since it doubtless found the islands a pleasant land, it seems almost incredible that a helpless wanderer should ever put to sea again in search of the distant land from whence it came. But the instinct to migrate to the far-away north and rear a brood and return again to these little islands over the sea must have been very strong—strong enough to carry it and its descendants back and forth year after year. Doubtless such is the story of the beginning of the colonies of most, if not all, of the different species of migratory shore and water birds that visit Hawaii each year.

¹*Charadrius dominicus fulvus*.

OLD 'STUMP LEG.'

It is interesting to know that once the journey is successfully made, barring accident the voyager is able ever afterwards to make the passage with unerring accuracy. An interesting case in point is the record I secured from Mr. Max Schlemmer, who for several years was the manager of the colony of laborers formerly stationed on the little sand island of Laysan. This island is but a mile and a half across by two miles in length. Nevertheless, plover occur there in large flocks each winter season.

On one occasion a fine male bird that was in the habit of roosting every night on a little mound of sand a few rods from the door of the manager's house, attracted his attention as it fluttered about on the sand apparently unable to fly. Picking it up it was found that a bunch of hair and refuse was wound about the bird's foot and leg, and that this had been added to with dirt and sand until a bunch large enough to weight the bird down had formed. In its efforts to fly it had broken its leg and was in a pitiable condition. The manager amputated the leg at the fracture and set the bird at liberty. To the surprise of all, it healed perfectly. The stump-leg furnished a mark for identification that served to distinguish the bird from its fellows, and it naturally became an object of interest in the colony. It remained about the island all winter, returning each night to its favorite roosting-place on the sand mound. It became unusually tame and fearless. When spring came, however, it responded to the most powerful call that stirs the avian brain, the homing instinct, and with its fellows left the wave-washed shores of Laysan to make the long flight back from whence they came, seemingly for no more intelligible reason than that they had made the journey before.

Naturally, the manager bade good-bye forever, as he thought, to his bird neighbor the first night it failed to return to its roost. But being a seafaring man, and accustomed to the excellent discipline of keeping a ship's log-book, whether on land or sea, he accordingly made a note of the fact with day and date and dismissed the incident from his mind. The summer passed, and one early autumn day the whole colony was thrown into a state of excitement by the announcement that the stump-leg plover had returned the night before and had been found that morning occupying his sand-pile roost. The bird was apparently as much at home as though a summer cruise to some distant land was a regular occurrence and a matter of little consequence. Naturally, so important an event as the return of the stump-leg plover to its winter home was made a matter of record in the log for the day. The bird more than ever became the object of interest and concern on the part of all hands, for had he not accomplished a feat entitling him to the highest respect among seafaring

(Description of Plate Continued from Opposite Page.)

Petrel [Ooec] (*Oceanodroma cryptoleucura*). 5. Hawaiian Tern [Noio] (*Micranous hawaiiensis*). 6. Bonin Petrel (*Estrelata hypoleuca*). 7. Hawaiian Coot [Alae keokeo] (*Fulica alai*). 8. Hawaiian Hawk [Io] (*Buteo solitarius*); light plumage. 9. Hawaiian Gallinule [Alae] (*Gallinula sandvicensis*).



PLATE 80. HAWAIIAN BIRDS OF VARIOUS ORDERS.

[From plates in Aves Hawaiiensis.]

1. Wandering Tattler [Ulili] (*Heteractitis incanans*). 2. Hawaiian Duck [Koloa maoli] (*Anas wyvilliana*). 3. Hawaiian Goose [Nene] (*Nesochen sandviensis*). 4. Hawaiian Stormy

(Description of Plate Continued on the Opposite Page.)

men? Had not this bird, without a chart or compass, started from a given point in the very middle of the Pacific Ocean, and made a cruise extending over several months, and at least 6000 miles of trackless water, returned again, arriving by night at the very point of starting? Certainly old "Stump-leg" was an able seaman and a master navigator.

But this remarkable record does not stop with the report of the single trip. The log-book records that, for five years, each fall this bird returned to Laysan, arriving each year at almost the same date and departing in the spring with equal punctuality for parts unknown. But, at last, "Stump-leg" failed to return. Whether he was killed by hunters in Alaska or gave out on the weary and dangerous journey, or lost his bearing and went down struggling against fate, or died a natural death, will never be known; but certain it is that his voyage to and from Laysan Island and the records made of them constitute a most interesting and valuable incident, throwing much light on the unerring accuracy of the mysterious instinct which, doubtless through hundreds and perhaps thousands of generations has served to guide our feathered friends in their migrations to and from Hawaii.

It requires but a few weeks in the islands before the plover are all in good condition, and long before they leave for the north the following spring they are plump and heavy with fat. When in that condition everyone knows that the plover is a toothsome morsel. In the old days it was much prized as food by the natives of Hawaii, who exhibited great skill in the capture of the wild birds. So skillful were they in imitating the plover's peculiar whistle that they were often able to lure the birds close enough to the hunter to enable him to pelt them with stones. Another less sportsmanlike method was to bait a fish line with a tempting worm. The bait was placed along the beach at a promising spot and the birds called to partake of it.

It was customary to cook the kolea (plover) and, indeed, any of the game birds, by filling the body cavity with a smooth hot stone, that was especially suited to the purpose. The bird, stone and all, was then wrapped up in a neat package of ti leaves and sufficient time allowed for the heat from the stone to accomplish the desired result.

THE TURNSTONE, SANDERLING, TATTLER AND CURLEW.

Like the foregoing species, the turnstone,² the sanderling³ and the tattler⁴ arrive in Hawaii late in August or September and leave the following April by thousands. However, there are usually a few individuals of each species that fail to leave for the north. An examination of the summer birds proves them to be birds that are young and barren or too weak to undertake the long flight.

Of the remainder of Hawaii's migratory wading birds it is only necessary here to mention the bristle-thighed curlew,⁵ as such other species as occasionally occur are rarely if ever seen by the ordinary observer.

² *Arenaria interpres*.

³ *Calidris arenaria*.

⁴ *Heteractitis incanous*.

⁵ *Numenius tahitiensis*.

The curlew is by no means abundant on the large islands, but on the low-lying islands to the northwest they are fairly common. The curlew are much larger birds than the plover, and are such conspicuous objects when they do visit the inhabited islands that the securing of a specimen is always a real event. This fine game bird is easily recognized, as it is the only shore bird that has a bill about three inches in length that is slightly curved downward. It derives its common name from the peculiar feathers of the thighs, which terminate in long bristle-like points. It is of interest to know that this species visits the sea-coast of almost all of the hundreds of islands in the Pacific ocean at all seasons, but curiously enough no one has ever found its nest and eggs on any of them.

THE HAWAIIAN STILT.

A bird that is occasionally seen along the sea-coast or about the salt-water marshes is the peculiar Hawaiian stilt.⁶ Its long neck, black back, white breast and unusually long pink legs make it a conspicuous and interesting object. Unlike any of the foregoing, it is a resident of the islands throughout the year. Its ancestors, doubtless, long ago gave up the habit of making the useless journey away over the ocean every summer to rear their young. The Hawaiian stilt, therefore, is found nowhere else in the world. As it is rare even in Hawaii it is an interesting bird, since it has doubtless come to differ from its near relatives by reason of the fact that it has long been isolated from others of its kind.

BLACK-CROWNED NIGHT HERON.

No one who visits the sea-shore at sundown or is abroad at sunrise will fail to see the long-legged, black-crowned night heron,⁷ as it flies from its home in the valleys to its fishing grounds on the tide-flats or along the mullet-pond walls. While this heron lives throughout the year in the islands, it has not been long enough cut off from the rest of its relatives to become a distinct species, as it is still impossible to distinguish it from specimens of the same heron collected in America.

They feed almost entirely on fish, the mullet being a favorite with them. In certain localities they levy a considerable toll on the mullet ponds in the vicinity of their rookeries. They secure their food along the sea-shore, mostly at night, and retire during the daytime to the thick woods in the mountain valleys, where they nest in colonies. Their nests are bulky affairs made of sticks, and often are two feet in diameter. Sometimes a dozen nests will be found in a single tree. The eggs, which are pale blue in color, are as large as small hen eggs.

The old birds, with their long necks and legs, are very picturesque as they crouch in the treetops or wing their heavy flight about the valleys. The black back and black crown are in contrast with the fine bluish-gray color of the body

⁶ *Himantopus knudseni*.

⁷ *Nycticorax nycticorax naevius*.

and wings, all of which are marks of maturity. The male during the mating season is designated from the female by a pair of long white streamers that curve gracefully down from the back of the head. The young birds are always spotted and mottled in various shades of brown, buff and white, and are so different in appearance in this immature plumage that the Hawaiians, even though they were very close observers, gave to the old and young aukuu different names.

THE COOT AND GALLINULE.

The Hawaiian coot⁸ is almost as large as a small fowl. It is seldom seen except in the fresh-water ponds, and brackish and fresh-water marshes. This curious bird and its cousin the Hawaiian gallinule,⁹ a bird that in size and general habits it resembles very much, are Hawaiian species that have near relatives on the mainland from which they differ but slightly. The coot is a dark slaty-gray color, and is peculiar in that its toes, instead of being webbed as they are on a duck's foot, are provided with conspicuous lateral lobes or flaps which enable it to swim with great speed and to dive almost at the flash of a gun. The upper bill has a curious large white shield over its base. This white shield and the lobed feet help the beginner to identify the bird and prevent it being mistaken for the gallinule. The latter has the frontal shield, a vermilion red, and the toes are without the curious lobes. Both species build their nest of dead rushes and grasses, placing them in the swamp near their favorite haunts.

THE LEGEND OF MAUI AND THE ALAE.

The Hawaiians have a very interesting story that seeks to explain how the alae or gallinule acquired the red spot on its forehead. According to the legend, the great Maui, who dwelt in the islands before the process of making fire was invented, had four sons, who were fishermen. Each morning at sunrise they would take their canoes and go offshore to a favorite fishing ground. One morning they espied a fire on shore and, being desirous of having their food cooked, rowed to the spot where the fire had been seen, but lo! no fire could they find. The next day they repeated the experience and were again disappointed. After repeated failures they resorted to strategy. Dressing up a huge gourd to resemble a man, they placed the dummy in the boat as a substitute for one of the four fishermen, and sent the canoe out to fish as usual.

The man on shore crept close to where the fire had been located and waited patiently. To his surprise he found it was the alae that had guarded the secret of the fire so well.

Knowing Maui had but four sons, this cautious bird had waited each time until they were all away fishing before it dared to light the fire, and keeping a sharp watch it scratched it out again when they started home with their boat. This time the dummy in the boat had fooled the bird. At the proper moment

⁸ *Fulica alai*.

⁹ *Gallinula sandvicensis*.



PLATE SL. SIX INTERESTING HAWAIIAN BIRDS.

[From plates in *Aves Hawaiiensis*.]

1. Hawaiian Crow [Alala] (*Corvus hawaiiensis*). 2. Hawaiian Hawk [Io] (*Buteo solitarius*) dark plumage. 3. Hawaiian Stilt [Kukuluao] (*Himantopus knudseni*). 4. Wedge-tailed Shearwater [Unukane] (*Puffinus cuneatus*). 5. Hawaiian Rail [Moho] (*Pennula caudata*). 6. The same showing the expanded wings.

the oft-defeated fisherman leaped from his hiding place and, seizing one of the birds, threatened to kill it for hiding the secret of the fire from them. The bird very ably argued that if it should be killed the secret of the art of making fire would die with it. At last, just in time to save his neck and after considerable parley and repeated attempts at evasion, the bird finally divulged the ancient art of making fire by rubbing one dry stick on another. So exasperated had the son of Maui become before he succeeded in producing fire, for he was told to rub together first one thing and then another, that at last he rubbed the top of the bird's head until it was red with blood, and the red spot has remained thereon to this day.

THE HAWAIIAN DUCK.

Although both the gallinule and the coot were eaten by the Hawaiians, they were not so highly esteemed as was the Hawaiian duck,¹⁰ a small species that formerly was plentiful in the streams and marshes on all the large islands. Of recent years they have become very rare except on the Island of Kauai. It is thought that the mongoose, together with the sportsman, have brought about this unfortunate state of affairs, since this species is peculiar to these islands. As a matter of fact, such foreign ducks as the shoveler,¹¹ with its spade-like bill, and the pintail,¹² with its sharp-pointed tail, and other less common species that visit the islands each winter, coming down from the northwest coast, are now much more liable to be shot in the group, during the open season, than is the native Hawaiian species. As with the shore birds, there are other species of ducks, and occasionally even geese, that from time to time wander from Alaska on their migrations; but their occurrence is scarcely ever observed by other than the professional sportsman.

CHAPTER XXV.

BIRDS OF THE MOUNTAIN FORESTS.

With the shore, the marsh and the ocean birds considered in other chapters, we come now to the peculiar and therefore more interesting part of the Hawaiian bird fauna, namely, that which is at home in the mountain forests. The exploration of these almost impenetrable, dense, moist, often cloud-swept jungle-like forests is by no means an easy task; but in order to see the Hawaiian birds outside of a museum collection, it is necessary to explore them, since it is there alone that the curious forms of bird life for which Hawaii is noted are found.

Unfortunately, many of the more interesting forms are either extinct or so rare that they are no longer to be seen alive. Of the forms that still exist, a few species are sufficiently abundant and conspicuous in song and color to give an interesting touch of life to the forest that adds not a little to the pleasure of a holiday spent in the mountains.

¹⁰ *Anas wyvilliana*.

¹¹ *Spatula clypeata*.

¹² *Dafida acuta*.

THE ELEPAIO.

A list of fifty-six species of living and extinct passerine birds are all that has been known to exist in the forests of the inhabited islands of the group. This small list must be further reduced by sixteen species which are now regarded by ornithologist as extinct. Of the remaining forty species, which are about equally distributed among the six islands, there are none better known or more commonly met with than the Hawaiian flycatcher, or elepaio of the natives.

Kauai, Oahu and Hawaii still have living species of this fearless little brown bird that on each island can be recognized at once by its pert air and the saucy cock of its fan-shaped tail. They are common on the mountainside all the way from the sea to well up into the higher levels. When hidden in the forests they are easily identified by their curious, loud, clear, insistent call—"elepaio," which is varied by a kissing noise as well as by a number of other whistled notes and calls.

The elepaio¹ is one of the best known of any of the Hawaiian birds. Its nest is a beautiful little structure about two and a half inches in diameter, that in appearance is not unlike that of the humming-bird. It is composed of very fine grass, mosses and lichens, and is placed in the fork of a tree, usually but a few feet from the ground. While the elepaio is a bird famous in song and story on all of the islands, and according to David Malo was formerly used for food, it seems not to have been seriously reduced in numbers and still remains the most abundant Hawaiian species.

THE APAPANE AND IIVI.

The species most commonly noted by strangers, however, is the beautiful dark blood-red bird, the apapane² of the natives. It is about five and a quarter inches in length and can readily be distinguished from the beautiful scarlet iivi,³ which is a slightly larger and more brilliant bird, with the bill and feet vermilion or at least not black, as is the case with the apapane.

Both these species of red birds occur in the forest on all the larger inhabited islands in favorable localities from near the sea-shore to the upper limit of the large forest trees, but they are most abundant at from two to four thousand feet elevation. Both are equally fond of nectar, and both frequent the flowering ohia trees. The two species are perhaps the most easily observed by visitors in the vicinity of the Volcano House on Hawaii, where the pleasant though somewhat monotonous song of the apapane can be heard from early until late.

AMAKIHI

All the larger islands are inhabited by a small green-and-yellow or olive-green bird⁴ with a curved beak, known as the amakihi. While they differ

¹ *Chasiempis gayi* = Oahu, *C. sclateri* = Kauai, *C. sandriensis* = Hawaii.

² *Himatione sanguinea*.

³ *Vestiaria coccinea*.

⁴ *Chlorodrepanis* spp.



PLATE 82. SOME SONG BIRDS OF THE HAWAIIAN ISLANDS.

[From plates in Aves Hawaiianis.]

1. Yellow-tufted Honey-eater (*Moho apicalis*): Oahu—extinct. 2. Kauai Akiakoa (*Hemignathus procerus*): Kauai. 3. Puaiohi (*Phaethornis palmeri*): Kauai. 4. Ulaehawane
(Description of Plate Continued on the Opposite Page.)

slightly in size and color from island to island, they all belong to one genus and are easily recognized as one of the most common and widely distributed species. They are nectar-feeding species and are frequently seen in company with the red species just mentioned. They are also fond of insects and spend much of their time searching through the foliage. The call note of the amakihi is a sweetly-whistled "tsweet," which is easily imitated. Their song is a short trill, and when it is at its fullest is loud and penetrating but not very musical.

All of these birds (as, indeed, are all of the birds belonging to the family *Drepanididae*) are characterized by a very strongly-marked and peculiar odor. This goat-like scent is so peculiar and persistent in this family of birds that often after they have left the spot the air retains a musk-like smell. The nest of the amakihi is a simple structure of twigs, leaves and roots and is usually, though not always, near the ground.

THE GENUS *OREOMYSTIS*.

There is a small olive-green bird occurring on Hawaii, belonging to an entirely different genus⁵ that is so similar in appearance to the species of amakihi found in the group that the Hawaiians themselves did not give it a separate name. Several species on the other islands, however, are easily recognized, the adult males especially differing greatly in color, voice, habits and general appearance from the species of amakihi to be found on the respective islands.

The difference between the two genera which would serve to most readily distinguish them in the field, is that instead of feeding almost entirely on insects and nectar from the flowers and leaves, as is the habit of the amakihi, all of the species of *Oreomystis* feed in a large part on insects secured from the trunks and limbs of the forest trees and bushes. They are all expert climbers, working either upward or downward and along the upper and under side of the horizontal branches. The difference in color of the species on the different islands is a most remarkable feature, since gray-green, olive-green, yellow-olive, yellow and bright red species occur.

THRUSH AND FINCH-LIKE BIRDS.

The five genera mentioned above are represented on all of the large islands by one species or another. A large brown thrush-like bird⁶ that is a remarkable songster, and the stocky, olive-green yellow-headed one⁷ are the two species that are next in abundance. Their representatives on Oahu have been extinct for many years, but on one or the other of the islands one or both are occasionally seen by the casual observer about camps and mountain houses.

⁵ *Oreomystis*.

⁶ *Phoronis* spp.

⁷ *Psittacirostra psittacea*.

(Description of Plate Continued from Opposite Page.)

(*Ciridops anna*): Hawaii. 5. Kona Thick-bill (*Chloridops kona*): Hawaii. 6. Nukupuu (*Heterorhynchus hawaiiensis*): Kauai. 7. O-o (*Moho nobilis*): Hawaii. 8. Maui Parrot-bill (*Pseudonestor xanthophrys*): Maui. 9. *Heterorhynchus lucidus*: Oahu—extinct. 10. Akialoa (*Hemignathus obscurus*): Hawaii. 11. *Palmeria dolei*: Maui, Molokai, a very rare species. 12. Molokai o-o (*Moho bishopi*): Molokai, very rare.



PLATE 83. SOME RARE AND EXTINCT BIRDS OF THE MOUNTAIN FORESTS.

[From plates in *Aves Hawaiianensis*.]

1. *Viridonia* (*Viridonia sagittirostris*): Hawaii. 2. Black Mamo [Hoi] (*Drepanorhamphus funereus*): Molokai, very rare. 3. Kipi (*Hemignathus lichtensteini*): Oahu, extinct.
 (Description of Plate Continued on the Opposite Page.)

Still rarer are the various species of the genus *Lorops* or the akepa, which are foxy-red or orange color, according to the age and the species of the bird. As they feed chiefly upon the insects secured from the foliage of the trees, they are very active little creatures; they resemble the olive-green amakihi in habits, and although possessed of a short finch-like bill, they may readily be mistaken in the treetops for their cousins with the slender curved beaks. The striking peculiarity of all the species, however, is that the beak is not symmetrical. The tips of the mandibles cross each other in much the same fashion as that of the common "crossbill" finches elsewhere.

The remaining species are too rare to be met with, except by the merest chance, by any one save a professional ornithologist, and even then the enthusiast is often forced to remain for weeks in the wildest mountain forests before even hearing the voice of the species sought, and more times than not the whole effort to see or secure a specimen results in the most depressing disappointment.

RARE AND EXTINCT BIRDS.

Of the species that have been known to inhabit the islands in times past, no fewer than twenty are now so rare in collections, and for years have been so scarce in the mountains, as to entitle them to have their names entered on the list of species no longer in existence, or at least bordering on extinction. The Island of Oahu can make the melancholy boast that it has a greater list of extinct birds, in proportion to the total number of species known from the island, than any other like area in the world. On Hawaii the moho⁸ has been extinct for years, having been exterminated, it is thought, by the domestic cats that long ago ran wild. As it was a small flightless rail resembling its cousin on Laysan, it is doubtful if it would have been able to survive the inroad of the more recently introduced mongoose, which has been everywhere merciless in its attack on ground-nesting birds.

The fine black mamoo⁹ was brought to the verge of extinction by the Hawaiians years ago. From its rump the natives secured the rich golden-yellow feathers used in the making of their feather cloaks, helmets and leis.

The o-o¹⁰ likewise was driven to the verge of extinction for similar reasons. When the mamoo became rare the natives began to substitute the yellow feathers growing under the wings of the o-o for the rump feathers of the former. Though they were not so rich in color, they made acceptable substitutes, and as a result these beautiful birds are now practically all gone on Hawaii, while on Molokai and Kauai the two species belonging to the same

⁸ *Pennisca caudata*. ⁹ *Drepanis pacifica*. ¹⁰ *Moho nobilis*.

(Description of Plate Continued from Opposite Page.)

4. Mani Amakihi (*Chlorodrepanis wilsoni*): Mani. 5. Hawaii Half-bill (*Heterorhynchus wilsoni*): Hawaii. 6. Mamoo (*Drepanis pacifica*): Hawaii, extinct. 7. Mauiiio (*Oreomystis montana*): Lanai. 8. *Chatoptila angustipluma*: Hawaii, extinct. 9. *Lorops rufa*: Oahu, extinct. 10. *Lorops ochracea*: Mani, becoming quite rare. 11. *Oreomystis maculata*: Oahu. 12. *Rhodacanthis palmeri*: Hawaii, very rare.



PLATE 84. SIX FAMILIAR MOUNTAIN BIRDS.

[From plates in *Aves Hawaiianensis*.]

1. Iiwi (*Vestiaria coccinea*): found on all the islands. 2. Kauai Elepaio [*Apekepeke*] (*Chasmeipis sclateri*): Kauai. 3. Kauai Amakihi (*Chlorodrepanis stejnegeri*): Kauai. 4. Apapane (*Himatione sanguinea*): all islands. 5. Maui Half-bill (*Heterorhynchus affinis*): Maui. 6. Hawaiian Thrush [*Omau*] (*Phainopepla nitens*): Hawaii.

genus are rapidly dying out, apparently of their own accord, or at least from other unassignable causes. The Oahu species¹¹ has long been extinct.

HAWAIIAN DUCK AND GOOSE.

The Hawaiian duck,¹² the gallinule and the coot are diminishing in numbers on all the islands where the mongoose is found; while the puffin, the petrel and the native goose¹³ are all subject to its toll.

All of these birds are becoming extinct from known causes, but there are species which have died out for no assignable reason. The splendid *Chatophila angustipluma* of Hawaii is a case in point. Though it was rare when first discovered by naturalists, it has not been seen in the forests from that day to the present.

Likewise, there seems to be no adequate explanation for the extinction of at least five of the six species that are now known from only a few museum specimens collected by early naturalists, as only one of the extinct species, namely, the Oahu mambo, was ever killed by the natives for their feathers. Although numerous theories have been advanced, the cause of their extermination will doubtless ever remain one of nature's own secrets.

In considering the future of the Hawaiian birds, especially those that have been rare or very limited in their distribution, we must remember that the forest areas are diminishing owing to the devastation of animals, the ax and the settler, and that in consequence the birds are constantly being brought into sharper competition among themselves and into a struggle with a different if not a new environment.

Already several species that a decade ago were regarded as fairly common in certain localities have disappeared from them entirely, while others are only found after long and diligent search.

HAWAIIAN CROW.

An interesting phase of Hawaiian bird life is shown by the native Hawaiian crow.¹⁴ It occurs on a certain portion of one island only, and there over an area from which it never seems to attempt to pass. Having originally gained a foothold in the Kona and Kau districts of Hawaii, the bird seems to be unwilling to extend its range to the windward forests that adjoin its habitat, even though they are known to abound in suitable food.

The *Viridonia*¹⁵ is a handsome olive-green bird which furnishes a still more remarkable instance of a restricted habitat. This, one of the rarest of Hawaiian birds, is only found on Hawaii, and there it is confined to an area of a few square miles and is absolutely unknown outside this little valley region, where it was so rare as to be unknown to the native inhabitants.

THE BLACK MAMO.

The hoi or black mambo¹⁶ is confined to the Island of Molokai. There it

¹¹ *Moho apicalis*. ¹² *Anas wyvilliana*. ¹³ *Nesochen sandricensis*. ¹⁴ *Corvus hawaiiensis*.
¹⁵ *V. sagittirostris*. ¹⁶ *Drepanorhynchus funerea*.

finds forest conditions that are suitable to its habits over only a very limited portion of the mountain area of the island. While it is an active, energetic bird, it has apparently never attempted to cross the channels to the nearby island of Maui. For a hundred years at least it has been a rare bird on Molo-kai, so rare, indeed, that in 1907 the writer secured but three specimens as a reward for seven weeks spent in the mountains in a search devoted to locating this interesting and curious species.

Still another interesting example of limited distribution among Hawaiian birds is that of the nene or Hawaiian goose, which is confined to the Island of Hawaii, where it leads a life of seclusion, high up on the mountainside, seldom if ever descending to the sea level. The Hawaiian duck is more widely distributed, having occurred in considerable numbers on all islands of the group. Unfortunately, since the introduction of the mongoose it has been quite rare except on Kauai, where the mongoose has never been liberated.

A NATIVE HAWK AND OWL.

The Hawaiian hawk or io¹⁷ occurs only on Hawaii, where it is still fairly common. The Hawaiian owl¹⁸ occurs on all the large islands. It is quite closely related to the short-eared owl, common on the American continent. Since it differs from the American species only in minor details, it is regarded as an island form of that species which has been reduced in size through isolation. Like the coot and mud-hen, it is one of the more recent arrivals that have made the islands their home long enough to allow the principles of evolution, especially those involved in isolation, to produce slight, though easily recognizable, changes in the appearance of the species. Though the natural history of the Hawaiian birds is of much general interest, it will be seen that the subject of the evolution of the various species presents material for consideration that is of deep and absorbing interest to all.

THE FAMILY DREPANIDIDÆ.

The family *Drepanididæ*, which includes the majority of the song birds of Hawaii, is perhaps the most remarkable example of the evolution of a group of birds to be found anywhere. The family which is peculiar to the islands, includes about forty species that are found nowhere else in the world. While they are all much alike in their general structure, they differ amazingly in the form of bill and also exhibit striking differences in the color of the plumage. In almost all other families the form of the bill is quite uniform among the species that belong to it. That organ usually bears a close connection with the feeding habits of the group, and these are usually very nearly the same for all the species in the family. But among the *Drepanididæ* of Hawaii we find them fitted by their structure to almost every kind of life for which a song bird in the tropics can become adapted. This adaptation of the bill has

¹⁷ *Buteo solitarius*. ¹⁸ *Asio accipitrinus sandvicensis*.



PLATE 85. COMMON HAWAIIAN BIRDS.

[From plates in *Aves Hawaiianensis*.]

1. Hawaii Elepaio (*Chasiempis sandvicensis*): Hawaii. 2. Kamau (*Phlorornis myadestina*): Kauai. 3. Ou holowai (*Loxops caeruleirostris*): Kauai. 4. Akikihi (*Orcomystis bairdi*): Kauai. 5. Oahu Elepaio (*Chasiempis gayi*): Oahu. 6. Apapane (*Himatione sanguinea*): all islands. 7. O-n (*Psittacirostra psittacca*): formerly on all islands. 8. O-o a-a (*Moho braccatus*): Kauai. 9. *Loxops ochracea*: Maui.

led to some most remarkable changes. From the firm, straight bill of the genus *Orcomystis*—the genus supposed to most closely conform with the ancestral form which may have come from America in very remote time, and the form from which all other genera of the family are supposed to have evolved—we have widely different types of bills developed.

In one branch of the family the bill passes through several genera, each slightly modified, until the normal straight bill becomes an unusual one, very long and slender and singularly curved, with a tubular tongue, especially adapted to securing the nectar from long tubular flowers. The opposite branch leads off by gradual degrees to where a short thick bill of astonishing strength terminates the line of evolution in *Chloridops kona*—a grossbeak-like bird that confines its food habits to cracking the flint-like seeds of the bastard sandalwood. Between the long, slender, curved honey-eater beak and the heavy finch-like beak are all manner of special forms. In one the bill is parrot-like; in another it is suited to a fruit diet, so that many forms of bill occur.

HAWAIIAN BIRDS BECOMING EXTINCT.

With the high specialization of the bill these birds have lost their power of adaptation. As most species are confined to but a single island, and in some cases to a single district, and there to a single species of tree, we can see how difficult it would be for them to adjust themselves to any sudden change in their environment after they had gradually become fitted through countless centuries for the conditions that existed in any particular locality. Developed under conditions most unusual and peculiar—each within its own chosen and restricted sphere—change of any sort, and competition however slight, is likely to find them unprepared to compete, though some species are better endowed to take part in the struggle than are the majority. In the light of their own past history, they seem strangely susceptible to any change that may occur. When the few remaining species are gone there will be left behind them, as tokens of their existence, only a few dried skins in the museums of the world and a few meager pages in such books as this, telling too little of their life history and habits.

CHAPTER XXVI.

HAWAIIAN FISHES: PART ONE.

The waters of Hawaii have long been celebrated for their fishes of many peculiar habits and characteristics, odd shapes, and remarkable size and color. As a result, so much has been written in a popular and scientific way concerning them that they are perhaps better known than any other form of life about the islands.

FISHING IN FORMER TIMES.

Doubtless fish have always been one of the chief articles of animal food for the natives, and a visit to the busy markets will not only repay one for the trouble, but convince him that the business of fishing still constitutes one of Hawaii's important industries. The name *i'a* was given by the Hawaiians to all food products secured from the sea, "whether they moved or not." But for our purpose we will speak only of the fishes, reserving the many other interesting forms for discussion in other chapters.

As has been said in the account of the people, fishing in former times was associated with much religious ceremony and idol worship. Altars and heiaus, especially devoted to the needs of the fishing class, were very common. The fish gods, more numerous than the heiaus, were faithfully worshipped by the fishing class and their every tabu and requirement most studiously observed. Before the fishermen would go out on their expeditions, everything that could be done to placate the gods would be carried out by the devout.

However, we are told that in those days, as in these, there was a certain class, more skeptical than the rest, who went fishing whenever they chose to do so, without observing any religious ceremonies whatever.

FISHING EQUIPMENT OF THE ANCIENT HAWAIIANS.

There was a great variety of implements and apparatus employed by the fishermen, and their description and enumeration seems hardly necessary here; but it is of interest to know that they had devices for capturing every kind of creature inhabiting the waters about the islands, with the single exception of the whale.

The canoe was, of course, the most important part of the equipment of a fisherman. These were almost invariably made of koa. Many of the older ones were fashioned from huge trees, so large, indeed, that the finished canoes were often from thirty to sixty feet in length. A canoe to seat three fishermen would be about thirty-three feet long, while a single-seated one was usually eighteen feet long by seventeen inches wide. Some of the canoes used sails, but as a general rule the paddle was the only motive power.

The seines were the most important part of the fisherman's outfit. These were frequently two or three hundred feet in length, and in certain cases they occasionally joined the long ones together. Their seines for catching bait were much smaller, usually only a few yards in length, with mesh as fine as quarter inch. Gill nets of different sizes and designs were also much used. They were used mostly at night and were commonly set across openings in the reef. Frequently these nets were laid out so as to enclose a large coral rock. The native fisherman would then dive down and drive the fish from the rock.

Another method sometimes used by the natives was to join several seines together and then paddle out to sea in a semicircle, paying out the seine as they went. The net would then be hauled in to shore and the last few yards



PLATE 86. THE SHARKS AND RAYS.

[Assembled from U. S. Fish Comm. Bulletin No. 23.]

1. Hawaiian Cub-shark [Mano] (*Carcharias melanopterus*). 2. Thrasher Shark (*Alopias vulpes*). 3. Mackerel-shark (*Isuropsis glauca*). 4. Dog-shark (*Squalus mitsukurii*). 5. Hammer-headed Shark [Mano kihikihi] (*Sphyrna zyggana*). 6. Blue Shark (*Prionace glauca*). 7. Sting Ray (*Dasyatis hawaiiensis*). 8. Spotted Sting Ray [Hihimann] (*Stoasodon narinari*).

of fine net brought together in a circular form. When advisable the fish thus caught might be left in the seine trap in the water for several days. Certain species of fish that run in school, as the akule, can be seen a considerable distance at sea. It is the practice among native fishermen to post one of their number on the land at an elevation from which their practiced eyes can locate the school of fish as it approaches the shore. In directing the operations of the fishermen from the shore, the lookout uses a white flag and observes considerable superstitious ceremony in his work.

Several forms of bag nets have been employed by the Hawaiians, some of them more than two hundred fathoms in length. The usually have detachable bags in the middle often thirty feet long by half as many feet in width. These were used in water twenty feet or more in depth. The opelu or bag nets are commonly about a dozen feet across by three times as deep, and have a hoop fastened in the mouth to keep the net open. In use they are baited and lowered, and then at the proper moment rapidly hauled in. Several ingenious nets are used in capturing various species of fish—the upena hehu, upena pua, kapuni nehu, upena uhu and the upena poo being important among them.

Several forms of dip nets were also devised by the Hawaiians. One was formed by tying two slender parallel sticks to a fine net about five feet apart. By running a string through the lower end and shirring it through the net, a rude bag was formed that was used in shallow water and for fishing in rough, stony places.

The Hawaiians seem to have used but few fish baskets, the two kinds used in catching the shrimp¹ being the most important forms.

Several species of fish were taken in fish-traps or pens. The group of shark pens removed from Pearl Harbor when the channel was dredged were among the best examples in the islands. They were so arranged that the fish, which enter them freely at high water, are caught as the water recedes, by means of a small seine.

Fish spearing was an art with the old Hawaiians, and they were very adept in the use of the weapon, which consisted usually of a long hardwood pole six or eight feet in length, ending in ancient times with one or two sharp wooden prongs, but in modern times, with a thin rod of iron, a foot or so in length, that is slightly barbed at the tip. This implement was only used in shallow water about the reef, where it might be employed in spearing squid, turtles, and other slow-moving surface-swimming forms. In the hands of an expert diver, however, it might be carried down into the water several feet and used with effect in caves and holes about the reef.

FISH POISON.

The natives were expert in making and using a certain fish poison known as holahola. A poisonous weed² which grows on the mountainside was col-

¹ Opae. ² Ahuhu.

lected and pounded together with sand. The sand was used to make the mixture sink more readily to the bottom. With a quantity of this poison in the canoe the fisherman would search out a tide pool, cove, or hole in the reef inhabited by a number of species of fish. A long seine was first put out in a circle about the spot to prevent the fish from escaping. The poison mixture was then rolled in small packages or placed in a bag and carried down to the bottom by the fisherman in order to distribute it about to advantage in the holes in the rock. In ten or fifteen minutes the fish would come to the top in a stupefied condition, when they were easily gathered from the surface of the water. If allowed to remain too long in the water they would recover from the effects of the drug. When used as food they seem to be in no way injured by the poison used in their capture.

FISHING AT NIGHT.

A very picturesque method of fishing, much employed in former times by the natives, was by the light of the torch. At favorable seasons dozens of fishermen could be seen, each with a lighted fagot in one hand made of a bundle of ti leaves or a string of kukui nuts wrapped around with ti leaves to make a handle, and in the other a small net or spear. As the men and women waded about over the reef, the reflection in the shallow water from the flickering lights, together with the shadowy outline of the natives, their excited voices and weird, fantastic movements produced an impression on the mind of the spectator that time could not readily efface.

A method of fishing with a snare was perhaps peculiar to the Hawaiian Islands. This method was much employed in fishing for eel. It consisted in throwing the bait near a hole. In this way these greedy and unsuspecting animals were enticed through a wide noose which, attached through a loop, dangled from the end of a heavy pole. When the critical moment arrived the noose was hauled taut about the eel, and up snug against the end of the pole, by drawing in on the end of the line which passed along the pole to the hand.

Fishing with the hands was a common practice among the natives, but line fishing was more extensively followed and in general yielded better returns. Ingenious fishhooks made of mother-of-pearl shells were much used, though bone, ivory and tortoise-shell found an important place in the manufacture of these useful implements.

FISH BAIT.

The selection of a suitable bait was by no means a simple task. While the live shrimp or opae was very frequently used, Mr. Joseph S. Emerson collected a list of no fewer than twenty-two compounded baits that were built up on a single base material. It is estimated that there were probably more than a hundred kinds of bait known to the skilled fisherman in ancient times in Hawaii. For line fishing, however, the live bait was preferred, and they had a method for catching the daily supply that will bear repeating among Hawaiian

fishermen of today. One man with a small calabash of dried shrimp was left on shore while the rest of the party took a seine with very fine mesh and paddled their canoes out a few yards from the shore. The man with the bait then walked along the beach a short distance, and after chewing up a few shrimp, would select a promising place and throw the morsal as far out to sea as possible. If small fish come up immediately the net was cast about the spot and a draw made in which all hands participated. If the bait was unmolested new bait was prepared and thrown out as before at what appeared to be a more favorable place. By this little trick, the fisherman was saved not only the time employed in making unprofitable hauls, but the chagrin of finding nothing, not even bait in his net, when it was landed.

SHARK FISHING IN ANCIENT TIMES.

In the capture of shark the ancient Hawaiians, especially the chiefs and ali'i, found much sport—and since the use of human flesh as bait was in great vogue among them, the method then employed is of more than ordinary interest to us; of course, the flesh of other animals has been substituted in these latter days.

The human body used was usually that of a slave, or at least some one out of standing with the royal fishermen. The person to serve as bait was killed two or three days in advance of the anticipated fishing expedition. The flesh of the victim was then cut up, placed in a container and left exposed to the air to decompose.

With the bait loaded on the outrigger of the canoe in such a manner as to admit of its leaving a dripping trail of blood and oil on the surface of the water, the fishing party would row their canoes out to where sharks were plentiful. Large bone or wooden hooks, some of them a foot long, were baited with the tempting morsels and lowered to the eager prey. Great skill and courage was shown by the members of the royal party on such occasions in roping and landing the captured shark.

Every part of the bone and skin of one of these savage animals was supposed to confer unflinching bravery on its possessor. For this reason Kamehameha I. was especially proud and jealous of his title as the great shark-fisher. He kept his victims penned up near the great heiau³ of Mookini, near Kawaihae, Hawaii, so there was always a supply of bait on hand.

In the olden times the capture of a shark was really a great event, but it has been more than one hundred years since the last human being was made to figure in the preliminary plans of a day's aquatic sport. However, shark fishing is indulged in as a sport today, but the motor boat, the flesh of a horse for bait, and the use of rifles has done much to dull the heroic setting shark fishing must have had in days that are gone.

While the Hawaiians recognized but five species of sharks and gave to

³ Temple.



PLATE 87. FISHING SCENES IN HAWAII.
(FOR DESCRIPTION OF PLATE SEE OPPOSITE PAGE.)

each a characteristic name, there are as many as sixteen species belonging to a dozen genera that have been taken by scientific fishermen from the waters about the islands.

MAN-EATER SHARKS.

Of this number the larger species are usually spoken of as man-eater sharks, or tiger sharks. The real man-eater is a great white shark sometimes thirty feet in length. It is by all odds the most ferocious of all fish-like animals. Specimens have been taken in Europe, Japan, California, Hawaii and the Carolinas indicating that they encircle the globe. While but one species of this genus,⁴ known as *nuihi* by the natives, is alive today, the teeth and certain other bones of extinct species that lived in former times, have been dredged from the sea bottom in the Mid-Pacific. Some of the other living species are really quite voracious, but that they are really man-eaters in the sense of pursuing, capturing and devouring the living body of a man is doubted by those who have given time and attention to the verification of the various shark stories that are current in Hawaii, as well as in all seaport towns.

Sharks with mouths twenty inches across, that are crammed with triangular teeth an inch or more in length, are not uncommonly captured about the islands. Since the number and size of the teeth is said to be directly in proportion to the ferocity of the shark, the larger species are to be studiously avoided, be they living or dead, even though we are continually reassured that they are not dangerous—as an incident taken from my note-book will demonstrate.

Several years ago I was on board a four-masted sailing vessel bound for Laysan Island, when our good ship became hopelessly becalmed. We had on board a party of Japanese laborers to be employed in the guano business on the island. To pass the time, and in response to an ancient and honorable superstition of the sea, all hands fell to fishing for sharks—since, as everyone who has sailed with canvas knows, the catching of a shark by a becalmed mariner has never failed to bring a fair wind. As all winds that blow for becalmed seamen are classed as fair, we were not surprised, within an hour after our crew had succeeded in hooking and loading an eight-foot shark, to find our vessel under headway again. As the Japanese are fond of shark stew, they were granted permission to make an open fire on deck and dress and cook the slimy savage token of our good luck.

An hour later one of the laborers commenced to clean the deck of the blood

⁴ *Carcharodon carcharias*.

DESCRIPTION OF PLATE.

1. Shark fishing as practiced for the sport of the chase. 2. Catching skip-jacks [Aku] or Ocean Boneto from the jib-boom of a sailing vessel. 3. Five minutes' catch from the jib-boom. 4. Hawaiian spearing fish with a double pronged spear [kao]. 5. Fisherman with a throw net. 6. Man-eater Shark [Niuhu] (*Carcharodon carcharias*) captured off Pearl Harbor. This shark is the most voracious of all the fishes. 7. Natives fishing at Kahana Bay with long sea net [upena kuu]. 8. Large dip-net for reef fishing.

and offal left by the butchers. The ghastly head with its gaping mouth was first to be dropped overboard. Thrusting one hand for want of a better hold into the open mouth of the dead animal, the laborer slipped his other hand under the head as it had been cut free from the body, when, without warning, the yawning mouth clapped shut in a death grip on the hand and wrist of the Japanese. The suffering man was only extricated from the vice-like jaws by main strength. One of his comrades seizing him, another the shark's head, his hand was literally pulled, in a frightfully lacerated condition, from the dead animal's mouth. In spite of the fact that the animal's flesh had been boiling an hour, and was ready to be served to the waiting company of Japanese, the muscles of the jaws had responded to some stimulus that caused them to clamp the man's hand.

Sometimes the natives hunt for sharks in pools and caves in the reef, where they are occasionally found fast asleep. When a "shark hole" is located a diver will go down and deftly slip a noose about the tail of a shark, which is then hauled up and dispatched. Experts have captured six or eight fair-sized sharks in a day in this manner.

The skin of sharks in the hands of the natives found its principal use in the manufacture of heads for their hula drums, while the teeth and bones were used as ornaments and implements. The flesh was generally eaten, but out of respect to the great shark god it was tabu to women, who were forbidden to partake of it under pain of death.

THE HAMMER-HEAD SHARK.

Among the various species of sharks the hammer-head,⁵ or *mano kihikihi*, is perhaps most curious in its characteristics. It is a wide-ranging form found from the Mediterranean to Cape Cod in the Atlantic, as well as at widely-scattered localities in the Pacific, including Hawaii. The singular form of the head is one of the most unusual modifications among fishes. Instead of retaining the usual form, the front part of the head of these sharks is broad, flattened and extended on each side into a process, on the flat terminal surfaces of which are situated the eyes.

THE DOGFISH.

The Hawaiian dogfish,⁶ which is also found in Japan, is an active species of the smaller sharks that may be identified by the stout spine in the dorsal fins and by their sharp, squarish cutting teeth. In the Atlantic, dogfish are sometimes captured in large numbers, their livers being used for the production of shark-oil. In Hawaii shark-oil fishing has never been carried on to any extent, though sharks are abundant in certain localities, and once or twice vessels have been fitted out to engage in the trade.

THE MACKEREL SHARK AND 'KILLER' WHALE.

Mackerel-sharks seven to nine feet in length, which furnish the large

⁵ *Sphyrna zygora*.

⁶ *Squalus mitsukurii*.

jaws commonly seen preserved as curiosities in Hawaii, and the thrasher-sharks, are found about the group. The latter, sometimes attaining a length of twenty feet, may be identified at once by the great length of its cycle-shaped tail-fin. They are not especially ferocious, and the current stories of their attacking whales doubtless arise from mistaking the Orca for this shark. The Orca, or killer, is not a shark at all, but is a mammal belonging to the order of whales and is allied to the porpoise. As a passenger between Honolulu and San Francisco I once saw a number of them attack a school of whales. From the deck of the steamer we could see them clinging with their strong teeth about the heads and mouths of the great animals. The whales, panic-stricken, would leap clear out of the water, producing a terrific splash in their efforts to free themselves from their pursuers. Often they would roll over and over in their frantic endeavors to escape. Occasionally they would dislodge one of their tormentors, and it would be sent whirling through the air, apparently enjoying the novel experience. As the battle was at close range and lasted for a quarter of an hour or more, I was able to satisfy myself as to the identity of the combatants.

RAYS AND SKATES.

Three families of rays or skates are represented in Hawaii by five well-defined species. Though differing widely from the sharks in form, they are related to them, and belong to the same sub-class of the great group of fish-like vertebrates. Three species of sting-rays have so far been taken from Hawaiian waters. These flat, disk-like animals have very long, slender, whip-like tails that are without typical fins, but in lieu of fins the tail is provided with a strong, jagged spine covered with slime. The mouth is armed with broad saw-like teeth. The spine inflicts a dangerous wound, not through the presence of any specific venom, but from the danger of blood poison arising from the slime and the ragged and uneven cut. Specimens six to eight feet in length are not uncommon in Hawaii. They may be distinguished from the eagle-rays or spotted sting-ray⁷ by the fact that with the former the fin on the side of the disk extends forward on both sides to form the tips of the snout, while with the eagle-ray the muzzle is entire and free from the fin.

THE SEA DEVIL.

The sea devil,⁸ or hihimannu of the natives, is even more terrible in appearance than the sharks and rays, and is characterized by resembling the latter, but the anterior lobes of the pectoral fins are developed so as to stand up like horns or ears on the head. They are by no means common about Hawaii, and as all the members of the three families belonging to this order are of little value as food, they are seldom seen at the markets in the islands. They differ from the sharks in that they frequent the sea bottom, where they feed principally on shell-fish, which they crush with their flat teeth.

⁷ *Stoasodon narinari*.

⁸ *Mobula japonica*.

CHAPTER XXVII.

HAWAIIAN FISHES: PART TWO.

The scope of this brief account of the fishes of Hawaii will not permit of more than passing notice of some of the more interesting, curious, valuable or common species. It is left for those who are especially interested in the subject to either fish for themselves or to visit the Honolulu Aquarium, the market, or the Bishop Museum, where extensive collections offer opportunity for an exhaustive study.

FOOD FISH IN THE MARKETS.

Some idea of the fish resources of Hawaii can be gained from the fact that of the six hundred or more species that scientists have found in the island waters, more than three hundred and fifty are sold in the markets of Honolulu for food, each species having a Hawaiian name by which it is usually designated. Often several dozen species may be seen in the market in a single day—a fact which adds not a little to the confusion and difficulty of the inexperienced person when attempting to select a choice specimen for table use from the many fish of various sizes, shapes and colors.

Unfortunately, though the number of species to select from is very large, (as is usual with animals in warm countries) the number of individuals of any one species is not liable to be so plentiful in the tropics as in the colder climates. As a result fish are not as abundant nor as cheap in the markets as one could wish, where sea food should form the basis of a wholesome and cheap diet.

As many species run in schools and are liable at times to be very abundant and cheap at certain seasons and entirely wanting at others, it behooves the prudent housewife to be able to take advantage of bargains at the market as well as in the shops and stores.

For the benefit of those who may care to vary their fish order for one reason or another, the writer has secured, through the coöperation of a number of friends interested in the culinary side of the problem, the accompanying list¹ of especially useful food fishes, all of which are worthy of trial in any home. All of the long list of fish offered for sale are wholesome; the brief list appended serves simply as a suggestion and is offered with the view of encouraging readers to explore further on their own account. It will be noted that twenty species are enumerated which are used by all nationalities, which are regarded as the favorite fish of Europeans in the islands. Other columns show the various fishes used by the several principal nationalities visiting the Honolulu market. As an aid in identifying the choicest food fish, fourteen species are figured together on a single plate.

IMPORTANT HAWAIIAN FOOD FISH.

¹ A list of sixty-five of the more important food fish found in the Honolulu market, showing the species preferred by the various nationalities in the city is shown in the following table. The culinary uses made of twenty of the species most frequently purchased by Europeans is also shown, by the following designation marks placed after the native name, i. e., * = baking; † = boiling; ‡ = pan fish.

(Continued on opposite page.)

IMPORTANT HAWAIIAN FOOD FISH (See note on opposite page).

Native Name.	Scientific Name.	All races, espe- cially Europeans	Hawaiians	Portuguese	Chinese	Japanese
Ahaaha.....	<i>Tylosurus giganteus</i>				X	
Ahi.....	<i>Germo germo</i>					X
Aholehole.....	<i>Kuhlia malo</i>		X		X	X
Aku.....	<i>Gymnosarda pelamis</i>		X			X
Akule * † ‡.....	<i>Trachurops crumenophthelma</i>	X	X	X	X	X
Aleihi lakea.....	<i>Pseudocheilinus octotania</i>		X			
Ama-ama * † ‡.....	<i>Mugil cephalus</i>	X	X	X	X	X
A'a.....	<i>Xiphias gladius</i>		X			
Awa.....	<i>Chanos chanos</i>		X			X
Aweoweo.....	<i>Præacanthus cruentatus</i>		X			
Hapu'u pu'u * † ‡.....	<i>Epinephelus quernus</i>	X	X	X	X	X
Hihimau.....	<i>Mobula japonica</i>				X	X
Hihu.....	<i>Anampses curier</i>			X		X
Hinglea lauwihi.....	<i>Thalassoma duperrey</i>		X			
Humuhumu nukunuku apua'a.....	<i>Balistapus aculeatus</i>		X			X
Iheihe.....	<i>Hemiramphus depauperatus</i>		X			
Kahala * † ‡.....	<i>Seriola purpurascens</i>	X	X	X	X	X
Kaku.....	<i>Sphyrna nodigrassi</i>				X	
Kala.....	<i>Acanthurus unicornis</i>		X			
Kawakawa.....	<i>Gymnosarda alletterata</i>		X			
Kaweale.....	<i>Trachinocephalus myops</i>		X			X
Kikakapu.....	<i>Chaetodon lunula</i>		X			X
Kumu * † ‡.....	<i>Pseudupeneus porphyreus</i>	X	X	X	X	X
Kupipi.....	<i>Abudefduf sordidus</i>		X			
Kupoupou.....	<i>Chelto thermis</i>		X			
Lae †.....	<i>Scomberoides tolloparah</i>	X	X	X	X	X
Lauia †.....	<i>Callyodon lauia</i>	X	X	X	X	X
Mahihi * † ‡.....	<i>Coryphæna hippurus</i>	X	X	X	X	X
Mai'i.....	<i>Hepatus elongatus</i>		X			
Makiawa.....	<i>Etrumeus micropus</i>			X		
	(<i>Paræxocoetus brachypterus</i>)					
Malolo.....	<i>Exocoetus volitans</i>		X			
	(<i>Cypsilurus sinus</i>)					
Mamamo.....	<i>Monotaxis grandoculis</i>		X		X	
Manini †.....	<i>Hepatus sandwicensis</i>	X	X	X	X	X
Mano.....	<i>Squalus mitsukurii</i>		X			
Moi * † ‡.....	<i>Polydactylus scyllis</i>	X	X	X	X	X
Mu.....	<i>Monotaxis grandoculis</i>		X		X	
Nehu.....	<i>Anchovia purpurea</i>		X		X	X
Ohua.....	<i>Cantherines sandwichiensis</i>		X			
Oio.....	<i>Albula vulpes</i>		X			
Omaka.....	<i>Stethojulis axillaris</i>		X			X
Omilu * † ‡.....	<i>Carangus melampygus</i>	X	X	X	X	X
Ono.....	<i>Acanthocybium solandri</i>		X			X
Oopu †.....	<i>Eleotris sandwicensis</i>		X		X	
Oopuhue.....	<i>Chilomycterus affinis</i>		X			
Oopukai.....	<i>Cirrhitus marmoratus</i>		X			
Opakapaka * † ‡.....	(<i>Apilus microdon</i>)	X	X	X	X	X
	(<i>Bomopsis violaceus</i>)	X	X	X	X	X
Opelu palahu †.....	<i>Scomber japonicus</i>	X	X	X	X	X
Opelu.....	<i>Scomber</i>		X			X
Opule.....	<i>Anampses curier</i>		X			
Pakii †.....	<i>Platophrys pantherinus</i>	X	X	X	X	X
Pakuikui.....	<i>Hepatus achilles</i>		X			
Palawi.....	<i>Hepatus dussumieri</i>		X	X		
Papiopio †.....	<i>Carangus</i> (small size).....	X	X	X	X	
Poopa'a.....	<i>Paracirrhites cinctus</i>		X		X	X
Pualu.....	<i>Hepatus dussumieri</i>		X			
Puhi.....	<i>Gymnothorax</i> (a generic name for eels).....		X	X		
Puhiki'i.....	<i>Paræxocoetus brachypterus</i>		X			
Uhu.....	<i>Callyodon minentus</i>		X		X	
Uku * † ‡.....	<i>Aprion virens</i>	X	X	X	X	X
Ulae.....	<i>Saurida gracilis</i>		X		X	
Ulaula * † ‡.....	<i>Etelis marshi</i>	X	X	X	X	X
Ulua * † ‡.....	<i>Carangus</i> (large size).....	X	X	X	X	X
Ulua kihikihi.....	<i>Alectis ciliaris</i>		X			
U'u †.....	<i>Myripristis murdjan</i>	X	X	X	X	X
Walu.....	<i>Hepatus xanthopterus</i>		X		X	
Weke ula †.....	<i>Mulloidæ auriflamma</i>	X	X	X	X	X



PLATE 88. EELS AND OTHER CURIOUSLY SHAPED FISHES.

[Assembled from U. S. Fish Comm. Bulletin No. 23.]

1. Bone-fish [Oio] (*Albula vulpes*). 2. Milk-fish [Awa] (*Chanos chanos*). 3. Hawaiian Herring [Makiawa] (*Etruncus micropus*). 4. Anchovie [Nehu] (*Anchovia purpurea*). 5.

(Description of Plate Continued on the Opposite Page.)

Students of the subject of fish and fish culture tell us that there are now known in the waters of the world more than ten thousand species of bony fishes. These they have divided *into* about twenty orders, which are again divided into numerous families, and still more numerous genera. Of the *important* genera, a surprising number are represented in the fish fauna of Hawaii by one or more species.

Many of the six hundred or more species attributed to Hawaii are never seen in the markets, since they dwell only in the dark abysses of the deep open ocean, often miles below its surface. They are only captured by the use of complicated apparatus operated at great expense by scientific men commissioned to study the wonders of the great ocean, and who for their work must employ specially equipped vessels, such as the United States Fish Commission ship Albatross.

Then again, fish, like birds and plants and insects, have their peculiar habitats, and require special conditions or certain kinds of food. As a result, many of the common kinds are confined in very limited localities. Out of over one hundred species of food fish that are regarded as abundant in Hawaii, only five—the aku, oio, uku, ulaula and ulua—enter into the records as being taken commercially by the fishermen on all of the large islands of the group.

Of the large number of species of fish sold in Honolulu, almost none are the same species as are sold in the markets of the mainland or in foreign countries. This is because the fish fauna of Hawaii is isolated from that of other lands. However, most of the common families of sea fish have local representatives, some of them perhaps excelling in flavor the species with which strangers from abroad are more familiar. While in general it may be said that the fish fauna of Hawaii is in a large measure derived from the fauna of the East Indies, and while it is more closely related to the fishes of Polynesia than to those of North America or Japan, it should be regarded as constituting a minor faunal group composed in the main of forms which have been isolated long enough, in most instances, to form distinct species.

ANCHOVIES AND BARRACUDAS.

A good example of this localization of species is shown by the nehu,² which is in reality a very abundant local species belonging to the genus including the widely and favorably known anchovy of commerce. So far they have only been secured from the Hawaiian Islands. They are fish of small size with a well-marked, broad, silvery lateral band. In 1900 the records for the islands shows a catch of more than ninety thousand pounds of this species for the year.

² *Anchovia purpurea*.

(Description of Plate Continued from Opposite Page.)

Lizard-fish [Kawealea] (*Trachinocephalus myops*). 6. Lizard-fish [Ulae] (*Synodus varius*). 7. Moray [Puhī] (*Gymnothorax erecodes*). 8. Moray [Puhī laumili] (*Gymnothorax undulatus*). 9. Moray [Puhī] (*Gymnothorax pectili*). 10. Moray [Puhī kapa] (*Echidna nebulosa*). 11. Trumpet-fish [Nunu] (*Aulostomus valenci*). 12. Sea-horse (*Hippocampus fisheri*). 13. Needle-fish [Ahaaha] (*Athlenes hians*). 14. Half-beak [Me'e me'e] (*Hemiramphus depauperatus*). 15. Half-beak [Ihehe] (*Euleptorhamphus longirostris*).



PLATE 89. FISHING IN HILO BAY.

The photograph shows one of the remarkable cloud effects for which the islands are noted.

The family of barracudas³ has two local forms, one of which, the kawelea⁴ is not uncommon, as it frequents the mullet ponds along the shore. They seldom attain a length of more than twenty-four inches, and are therefore but feeble representatives of the great barracuda, that excellent food fish along the California coast, which is often five feet or more in length. Our local form is voracious and destructive to mullet, and do much damage to seines with their strong teeth which are set in a large mouth—two characteristics that are useful to the novice in separating them from the more valuable mullet with which they frequently occur.

BUTTERFLY-FISH.

No one who has visited the Aquarium will need to be reminded that Hawaii can boast of a long list of beautiful creatures that might well be called the butterflies of the coral reefs.

Their compressed bodies, small size, continuous dorsal fins, small mouths, and brilliant, varied and beautiful colors are characteristics sufficient to distinguish them at once from their near relatives under a family name, *Chaetodontida*, which has reference to their distinctly brush-like teeth. The five genera found in Hawaii embrace at present about eighteen species that, owing to graceful form, bright colors and great activity, make them exceedingly popular as aquarium specimens. Their great quickness and agility enable them to maintain themselves in the struggle for existence in the close competition of the coral reef, in spite of their conspicuous habits and coloring. In the typical genus⁵ a black band usually crosses through the eye; kikakapu is the native name applied to several well-marked species which vary so widely in their colors as to defy brief description.

BLENNIES.

Representatives of the family known as Blennies⁶ are certain to be noticed by the most casual observer strolling along the beach. The little fish most commonly seen clinging to the coral rocks as the waves recede is one or another of the nine or ten species of this family. They are active and alert, and since there are in the world more than five hundred species, many of which never attain a length of two inches, it is not strange that the naturalist seldom ventures to name, off-hand, the various examples that so often form the sum total of the catch secured by a wading party. However, it may be well to know that *Enneapterygius atriceps* is the only name given the little fish with the large eyes, three dorsal fins and the whip-like pectorals that is common in the coral rocks about Honolulu.

The Hawaiians did not distinguish it as separate from its relatives. Of its next of kin two or three species of the genus *Alticus* are also quite common about the islands; they have two dorsal fins. The small dark olive *Salaris zebra* is the most abundant species. It has the body crossed by numerous alternating pale and dark-olive bands, and has a curious lash above the eye.

³ *Sphyrænidæ*.

⁴ *Trachinocephalus myops*.

⁵ *Chaetodon*.

⁶ *Blenniidae*.

BONE-FISH, CATALUFAS AND CIRRHITIDÆ.

The bone-fish, or lady-fish,⁷ have a single representative in Hawaii known as the oio.⁸ It is a silvery fish with soft flesh that resembles the milk-fish in some respects, but is distinguished by its swine-like snout.

The Catalufas⁹ are represented by but a single genus of three species. One of these, the *aweoweo*,¹⁰ is the famous "red fish" which during the month of September, 1873, entered Honolulu harbor in shoals. They were evidently young fish, as the largest were not more than three and a half inches long. This shoaling has occurred from time to time at irregular intervals. In the mind of the native the coming of the red fish presages the sickness and death of some member of the royal family. On several occasions there has been a singular sequence of events of this nature which has left its impress on the beliefs of the more superstitious among the people. The fish are esteemed as food by the natives, however, who regard their coming in large numbers in the nature of a windfall, as the fish can be readily dried and saved. The species is of wide distribution and among English-speaking people is known as the "big eye."

The family *Cirrhitida* includes among its number seven of the more beautiful and highly-colored fishes of the coral reef, and as they are almost constantly to be seen in the market and at the Aquarium, the pilikoa,¹¹ hihu pilikoa¹² and piliko 'a¹³ are well known, though they are seldom more than six inches in length.

DEEP-SEA FISHES.

The fishes of the deep sea are for the most part examples of the familiar forms that have become modified and specialized to suit the peculiar environment of great pressure, inky blackness and freezing cold which the bottom of the sea affords. Eels, soles, scorpion fish, box fish and dozens of other forms found commonly on our shores have their deep-sea representatives that are seldom seen by other than experts to whom are sent the rare examples, secured at great cost and labor by scientific deep-sea expeditions. We therefore content ourselves with the knowledge that they exist and confine our attention to the more common, if not the more interesting, species that are met with in the markets almost daily.

THE DOLPHIN.

The dolphin¹⁴ (*mahihi*) is an important food fish in Hawaii. The body is elongate, compressed and covered with very fine scales. The under jaw protrudes and the long low dorsal fin extends from the nape to the base of the tail. It is changeable in color and thus becomes a conspicuous fish either living or dead, but unfortunately its beautiful color rapidly changes after death. They attain the length of four to six feet.

⁷ *Albulidae*.⁸ *Albula vulpes*.⁹ *Priacanthidae*.¹⁰ *Priacanthus cruentatus*.¹¹ *Paracirrhites* spp.¹² *P. fosteri*.¹³ *P. arcatus*.¹⁴ *Coryphæna hippurus*.

Both known species of dolphins occur in Hawaii. As they are very large fish of the open sea and are surface swimmers, they are occasionally seen by passengers on board sailing vessels. While the name dolphin rightly belongs to a group of small whales, it has been associated with this fish. In song and story their beauty of color and grace of motion have received much attention.

EELS.

The order *Apodes*, which includes the eels and morays is well represented in Hawaii, several dozen species frequenting the coral reefs and rocky coasts. Eel-fishing is a favorite sport, as the animals are easily enticed from their hiding places in the rocks, when they may be hooked or speared.

The Hawaiian name puhi is applied to the class as a whole. Puhi-uha signifies slippery eel, and is applied to the conger-eel. Some of the larger examples attain a length of five or six feet, and are much sought after as food.

FROG-FISH AND FLYING-FISH.

Two genera of frog-fishes¹⁵ occur, but representatives of only one genus have so far been taken in the shallow water or open sea. They all have the head compressed, and the skin covered with prickles, the body oblong and much compressed. They are fantastic-looking fishes, often gaily colored, and feed among the seaweeds on the reef, where they creep about like toads. They are also capable of filling their capacious stomachs with air, which enables them to float on the surface of the water. Eight species occur on the reefs, all of which are provided with one or two whip-like lashes that protrude from the upper lip to form a "bait" over their cavernous mouths.

Flying-fish¹⁶ abound in the open sea in all tropical waters, and Hawaii's waters are in no way an exception. Five well-marked genera include the eight species, all of which are called malolo by the natives. They are most abundant during the summer months. A common species¹⁷ has the upper part of the body dark blue and the fins about two-thirds the length of the body. They, in common with their cousins, usually occur in shoals, and are a source of interest to the voyager as they leap from the surface of the sea and sail away, sometimes sustaining a so-called flight for a hundred yards or more. The most recent sport in Hawaii is flying-fish shooting. This is done from a power launch, as the fish skim over the water. The fish are a favorite food of the natives, who prefer to eat them raw at their feasts (aha-aina).

GOBIES.

Gobies¹⁸ have no near relatives among the spiny-rayed fishes, and as a family may be easily recognized. The ventral fins are inserted very close together; there is no lateral line and no bony stay to the preopercle, which gives to the gills a peculiar flabby appearance. The species are very numerous in the tropics, there being fourteen genera in Hawaii, usually with but one or

¹⁵ *Antennariidae*.

¹⁶ *Exocoetidae*.

¹⁷ *Parexocoetus brachypterus*.

¹⁸ *Gobiidae*.



PLATE 90. FISHES AT THE AQUARIUM.

1, 2, 3, 4. Taken by the use of the special photographic aquarium and reflection hood shown in fig. 6 (apparatus devised by the author). 5. View of Honolulu Aquarium at Waikiki.

two species each. This fact indicates the diversity of form found in the family. They inhabit mountain streams and brackish water, and are common in pools along the shore and in shallow water generally, but they never go far out to sea. The largest species rarely exceed eight or ten inches in length, while many of the small forms are only an inch or so long when full grown.

Oopu, in combination with specific terms, is the name applied by the Hawaiians to a great number of species of gobies. They are carnivorous in habit, and are exceedingly interesting and active little creatures. One of the common forms¹⁹ is a dirty-brown color throughout and attains a length of nine inches. They somewhat resemble the common catfish in shape and color, and are plentiful in fresh brackish and shallow water. The natives often capture them in large numbers from the streams by the use of the fish poison previously referred to. The practice is to divert the stream from its usual course so as to leave a series of small shallow pools along its bed. The poison is then freely used in the crevices and under stones where the oopu hide. In a few minutes the fish come to the surface in a stupefied condition, when the native fishermen, both old and young, join in gathering them into their baskets and calabashes.

A species known as *Eviota epiphanes* is a very small oopu common in the shallow water at Waikiki. It attains the length of about three-fourths of an inch. Another abundant and wide ranging species of oopu is *Mapo fuscus*, which is very dark in color with black marblings and brown edges to the scales.

A curious oopu²⁰ is dark greenish-olive with the back and upper parts crossed with fourteen black bars. They have the pectorals united to form a curious disk on the chest. This species is abundant in certain Hawaiian mountain streams, and is able to cling to the rock in the rush of the mountain torrent. They are strictly a fresh-water fish, attaining the length of five to seven inches, and are sometimes caught and used for food. Two closely-related oopus²¹ are common in fresh-water streams of the islands and are taken in numbers sufficient to make them common objects in the Honolulu markets. One species²² is olivaceous in color, crossed with a dozen black bars. It has a black patch below the eye, and its belly is red while its cousin²³ is olivaceous, marked with obscure dusky blotches, and has the belly pale and with a dark blotch at the base of the tail.

THE FLYING-GUNARD.

The flying-gunards²⁴ are striking fish resembling the common flying-fish in the very large wing-like pectoral fins, but differing from them in many respects, among others in having the head and body decidedly quadrangular in form and bony in structure, and by having two separate spines in front of the two dorsal fins. The tail fin ends squarely, while the tail in the flying-fish is always forked. The lolo-oau²⁵ is not very abundant, and as a result when a specimen appears in the market it is an object of considerable curiosity. Speei-

¹⁹ *Eleotris sandwicensis*. ²⁰ *Sicydium stimpsoni*. ²¹ *Awaous* spp. ²² *Awaous genericittatus*.
²³ *Awaous stamineus*. ²⁴ *Cephalacanthida*. ²⁵ *Cephalacanthus orientalis*.

mens fourteen inches in length are sometimes caught, and as their "wings" are almost as long as the body and are beautifully colored with blue and brownish-red, they are with reason pronounced by many as the most striking and fantastic of the Hawaiian fishes.

HEADFISH.

The headfish,²⁶ though much rarer, is equally striking and has been classed among the rarest and most wonderful of all animal forms. To the natives it is known as the apahu, or to some as the makua. It appears simply as a large head separated from the body and supplied with a fringed tail. They are fishes of the open sea and reach a very large size. As the flesh is coarse and tough, they are rarely brought into market except as curiosities. The cast of a very large specimen is on exhibition in the Bishop Museum. It shows the beautiful coloring of brown and silver of the living fish.

The headfish is known to the Hawaiian fisherman as the "king of all the mackerel," and as it is supposed to be under the rule of the spirits,²⁷ it is feared that the mackerel will disappear if the fish is killed. A similar fish in the Atlantic is known as the king of the herring, and the local superstition is doubtless colored by the influence of the early whalers and traders that called at the islands.

Curious fish known as the half-bills²⁸ are very common in the markets, where all three of the species that occur here may be recognized at once by the fact that the under jaw is singularly bill-shaped, while the upper jaw is normal. Of the three species, the iheihe or me-me'e²⁹ is the most abundant. They are oviparous fishes and feed on green algæ. The half-bills live in large schools, usually near shore, and are especially numerous in the channels about the islands.

HAWAIIAN HERRING.

The makiawa,³⁰ so far as is known, is the only representative of the great herring tribe³¹ to be found about Hawaii. It attains a length of about ten inches and is quite common in the market at certain seasons. It is easily identified by its herring-like shape and appearance.

The family *Kuhliidae* is conspicuously represented in Hawaii by the ahole-hole,³² a silvery, fish-shaped fish, with the edge of the first dorsal and the caudal fins narrowly edged with black. They attain a length of ten inches or more. This active fish is sure to attract notice, since it is common at the mouths of the Hawaiian streams in both brackish and fresh water, but dwells by preference in running water, where it may be found in the deeper pools. It is a good fish and takes the hook readily, resembling the fresh-water sun-fish of America in this regard. The natives sometimes capture them by use of the narcotic plant described elsewhere.

²⁶ *Ranzania nokua*. ²⁷ Akua. ²⁸ *Hemiramphidae*. ²⁹ *Hemiramphus depauperatus*.
³⁰ *Etrumeus micropus*. ³¹ *Clupeidae*. ³² *Kuhlia malo*.

THE WRASSE-FISHES.

The *Labridæ* or wrasse-fish—a New England name—includes more than twenty genera in which are distributed more than fifty Hawaiian species. Of this large family only a few examples can be mentioned. The general form of the various species, though it varies somewhat from one genus to another, is sufficiently characteristic throughout the family to render them easily identified as members of the same division. The color patterns, usually of the brightest hues of blue, green, golden, scarlet, crimson and purple, are as rich and deep as though laid on with a brush by a most lavish hand. Often, in addition to its vivid color, the pattern is one of the greatest delicacy or the most intricate design.

Most of the wrasse-fishes feed upon mollusks and have their teeth adapted for crushing shells, but as they frequent the rocky coast, the coral reefs, the kelp beds, and the open sea, their food must necessarily vary considerably. However, in all the genera the teeth in the front jaws are prominent, separate and pointed.

Perhaps the most brilliant species are among those in the genera *Thalassoma* and *Julis*, but the more delicately-colored species are among the *Stethojulis*. The a'awa,³³ omaka,³⁴ akilolo,³⁵ opule,³⁶ awela,³⁷ hinalea lauili,³⁸ lolo and hilu³⁹ and poun⁴⁰ are among the species to be seen almost daily in the markets, and often in the Aquarium.

The lantern-fishes and lizard-fishes⁴² are well represented in the Hawaiian fauna, the kawelea⁴³ and ulae⁴⁴ being common examples of the latter. Their large mouths and lizard-like shapes render them easy of identification in the markets. The lantern-fishes are for the most part denizens of the deep, and as they live away from the shores, they are seldom seen except when they come to the surface at night or in times of stormy weather.

MULLET.

The mullet is by far the most important and generally esteemed food fish of the islands. There are three genera of the family,⁴⁵ each represented by a single species that have been reported from the group, but it is the species commonly called the ama-ama,⁴⁶ that is the most abundant. It is this species which in former times received the most attention from the natives in the way of protection and conservation. So much has been done along this line that mullet ponds have been important institutions since the days of the early chiefs. In fact, the time of the building of many of the ponds extends far back into the age of fable, the Hawaiians attributing the construction of one of the ponds on Kauai to the work of the menchunes—a fabled race of dwarfs that correspond in many ways with our Brownies.

Many of the oldest mullet ponds are still in use and in an excellent state of repair. As the ponds were originally owned by the kings and chiefs, it is

³³ *Lepidaplois* spp. ³⁴ *Stethojulis* sp. ³⁵ *Gomphosus* sp. ³⁶ *Anampses* sp. ³⁷ *Thalassoma* sp.
³⁸ *Thalassoma* sp. ³⁹ *Julis* spp. ⁴⁰ *Cheilinus* sp. ⁴¹ *Myctophidæ*. ⁴² *Synodontidæ*.
⁴³ *Trachinocephalus myops*. ⁴⁴ *Synodus varicus*. ⁴⁵ *Mugilidæ*. ⁴⁶ *Mugil cephalus*.

very probable that most of them were built by the forced labor of the common people.

The ponds are found principally in the bays indenting the shores of the islands, the common method of construction having been to build a wall of lava rock across the narrowest part of the entrance to a small bay and use the enclosed space for a pond. They were also built on the seashore itself, the wall being built out from the shore in a half circle.

Ponds vary in size from small ones of less than an acre in extent to the unusually large one at Moanalua, on Oahu, which encloses over five hundred acres. There are as many as a hundred and sixty of these ponds indicated on the maps of the islands. Of this number perhaps one hundred are still in use. The catch of ama-ama from the ponds of the islands in 1905 was 430,000 pounds, valued at more than \$87,000.

The mullet that find their way to the market from these ponds are identical with those found in the markets of the United States, Japan, Chile and even the Mediterranean and as far away as India. The average weight of the mullet in the market is from one to three pounds, though they grow to two or three times that size, attaining a length of twenty inches or two feet.

They feed on organic matter, especially the minute plants contained in the mud on the bottom in the shallow water along the shore. As they naturally gather up a large quantity of indigestible matter, these fishes have the organs of the throat modified into a filtering apparatus. They take in large quantities of mud and sand and, after apparently chewing it for a time, spit out the indigestible portion.

The awa⁴⁷ and the awa-awa⁴⁸ are also reared in large numbers with the mullet in the ponds. They all enter the ponds when young through openings left for the purpose in the stone walls. Owing to the protection furnished by the walls, the mullets thrive and fatten rapidly and, sheltered from their enemies, become stupid and blundering.

CHAPTER XXVIII.

HAWAIIAN FISHES: PART THREE.

FLATFISH.

The visitor at the Aquarium is sure to be interested and delighted with the beautiful and graceful flatfish that, in general habits and appearance, resemble the butterfly-fish, but differ from them in having the dorsal fin drawn out to form a beautiful white plume-like filament often six inches or more in length. The species is known to the natives as kihikihi, but since it is a wide

⁴⁷ *Chanos chanos*. ⁴⁸ *Elops saurus*.

ranging form they are known to Europeans generally as Moorish idols.¹ They are quite common about the Hawaiian reefs, where their yellow bodies crossed by broad black bands, and the long plume-like dorsal fin render them especially conspicuous even among their brilliant and beautiful associates.

MORAYS.

The morays² include an important group of Hawaiian fish that are distinguished from the true eels, with which they are closely related, by the presence of the small round gill openings and by the absence of pectoral fins. Many of the species reach a large size and are extremely voracious and pugnacious. As they are especially abundant in holes in the coral reefs and not infrequently spring out and bite the hand of even the experienced fisherman, it is just as well for the stranger to bear them in mind when on wading expeditions. Too often it has happened that underneath the most innocent looking flat coral stone exposed at low tide there has been hidden one of these snake-like fishes. If they choose to do so they can resent any intrusion from the merely curious in an unexpected and painful manner, that is long remembered by the offender.

Six genera of morays have so far been identified from the waters about the islands. Of the forty-two species of morays found here no fewer than eighteen belong to the genus *Gymnothorax*. The pubi laumili³ is one of the most common as well as most savage of these. They are not infrequently taken with large fish in their stomachs, sometimes a fourth as long as the moray itself. It ranges in length up to three feet or more, is variously mottled and naturally is much feared by the natives.

One of the fiercest of all the eel tribe is the moray known as pubi kapa,⁴ so called because it is said to be victorious over all kinds of fish. In life it is a pale greyish-white covered with irregular dark-brown areas with crome-yellow spots; the bars between these areas, when present, are gray and brown. It is reported by the natives that this eel goes ashore in the grass at night and will wiggle back into the water when disturbed.

The members of the order *Apodes*, to which the eel-like fishes belong, are very well represented in Hawaii, there being several dozen species, that usually differ one from the other only by slight characteristics. Most of the larger species are much used as food by the Hawaiians. The flesh of the morays, however, is oily and not readily digested and on the whole is not so wholesome as the flesh of the true eels.

THE MACKEREL FAMILY.

Eight species of the mackerel family⁵ occur in Hawaiian waters, including representatives of the frigate-mackerel, little tunnies, ocean bonito, Albacores and Petos. The opelu, or true mackerel,⁶ the aku, or ocean bonito,⁷ and the ahi,⁸ all belong to different genera in the mackerel family. They all rove the sea, usually in large schools, and have a wide range. While they differ in outline considerably, in the different genera, they are all "mackerel-shaped" and are

¹ *Zanclidae*.

² *Muraenidae*.

³ *Gymnothorax undulatus*.

⁴ *Echidna nebulosa*.

⁵ *Scombridae*.

⁶ *Scomber japonicus*.

⁷ *Gymnosarda pelamis*.

⁸ *Sereno sereno*.



PLATE 91. CHOICE HAWAIIAN MARKET FISH.

[Assembled from U. S. Fish Comm. Bulletin No. 23.]

1. Big-eyed Sead [Akule] (*Trachurus crumenophthalmus*). 2. Mullet [Amaama] (*Mugil cephalus*). 3. Grouper [Hapupuu] (*Epinephelus quernus*). 4. Amber Fish [Kahala]

(Description of Plate Continued on the Opposite Page.)

marked with two well developed dorsal fins which are followed by a series of little finlets; there is also a similar series of finlets posterior to the anal fin.

Though the flesh is usually coarse and dark, it is firm and oily. The opelu especially is much valued as food, two hundred and seventy-five thousand pounds of this species being marketed in Hawaii during the year 1903. The aku is very abundant about Hawaii, particularly in the summer, and quantities of them reach the market almost daily. There is a record of a yearly catch for the islands that approaches eight hundred thousand pounds. The ahi or albacore is known from its cousins by the bright yellow color of its finlets. Though not so abundant as the other species mentioned, it is frequently taken with a hook, and large specimens are occasionally seen in the markets.

The little tunny or kawakawa⁹ is at once recognized as a mackerel, but differs from the ocean bonito¹⁰ by its having the lateral line straight and with no blue-black stripes below the line. They swarm through the high seas in shoals, especially during the summer months, and are easily captured on an unbaited hook. The writer has caught them by the dozens from the jib-boom of a sailing vessel in mid-ocean. When drawn from the water they give one terrible death shudder and are "as dead as a mackerel" instantly. They are usually twenty inches long and weigh about three pounds when seen in the market; they are a fairly good food fish. In this connection it is of interest to note that so far as the records show, the California bonito has been taken in Hawaiian waters only once.

MILK-FISH.

The milk-fish¹¹ (awa) is a silvery fish that is largely used for food in Hawaii, notably about Honolulu, where a quarter of a million of pounds of the species is offered for sale in the markets annually. Next to the mullet, it is the species most frequenting the artificial ponds into which it runs with the mullet at high tide and is retained. Although it is an excellent food, it is not considered a game fish. Like the mullet it is known by different names at different ages, all of which are combinations of the name awa. They can be recognized at once since they have but one dorsal fin, while the mullet has two. Specimens five feet in length are not uncommon in the open sea.

NEEDLE-FISH.

Three species of needle-fishes,¹² each belonging to a different genera, are

⁹ *Gymnosarda pelamis*.

¹⁰ *Gymnosarda pelamis*.

¹¹ *Chanos chninos*.

¹² *Belonidae*.

(Description of Plate Continued from Opposite Page.)

(*Scorpaenidae*). 5. Goat-fish [Kumu] (*Pseudupeneus porphyreus*). 6. Common Dolphin [Mahinahii] (*Coryphæna hippurus*). 7. Striped Surgeon Fish [Maunî] (*Hepatus sandvicensis*). 8. Cavalla [Omîlu] (*Carangoides ferdau*). 9. Snapper [Opakapaka] (*Bonaparteia violacea*). 10. Cavalla [Small = papiopio, medium size = Paupau, large = U'ua] (*Carangus ignobilis*). 11. Snapper [U'aula] (*Etelis marshi*). 12. A Squirrel-fish [U'u] (*Myripristis berndti*). 13. A Snapper [U'ku] (*Aprion virseus*). 14. Surmullet [Weke ula] (*Mulloidops auriflamma*).

met with in the ocean about the islands. Their elongate, slender bodies with long beak-like jaws that are set with a band of small sharp teeth, besides a set of wide, sharp, conical teeth, together with the dorsal fin opposite the anal fin set far back on the body, are characteristics sufficient to separate them from the flying-fish on the one hand, and the half-bills on the other, as these two families are the only Hawaiian fish with which they would be confused. Superficially they resemble the common gar-pike. They are voracious, carnivorous fishes that swim along the surface of the sea, often leaping from the water. Specimens four feet long occasionally reach the market, and are much sought after as food by certain races. Ahaaha,¹³ as they are called by the Hawaiians, are common in the market every month of the year.

PAMPANOS.

Of the more than two thousand known species of pampanos,¹⁴ at least twenty-five have been taken in Hawaiian waters. Their bodies are compressed, somewhat resembling the mackerels in form, but they are without the finlets which are so marked a characteristic in the family. As a rule, they are metallic-blue in color, varied with silver and gold, and have the lateral line in most cases armed with bony plates posteriorly. The simple mark of the family, however, is the presence of two separate spines in front of the anal fin. The *Carangida* are all rapid surface swimmers, so much so that occasionally the dorsal fin will be seen cutting through the surface of the water. They are all regarded as excellent fish, but the lae, puakahala, opelu, akule, apuu-u, and the ulua, and the curious ulua kihikihi or thread fin, are among the best known species. The ulua¹⁵ is indeed one of the most important food fish of the islands. Specimens three and even four feet in length are common enough in the markets. It dries readily and the head is especially esteemed for use in the making of fish chowder. This species is considered by many to be the most delicate and finely flavored food fish to be taken in these waters and is quite generally substituted for mullet and opakapaka on the bill of fare of the most fastidious.

TARPON.

The tarpon occurs in Hawaii and resembles the bonefish quite closely, but its dorsal fin is inserted well before the anal, a characteristic which separates its family¹⁶ from the others of the order. It is said to be a great game fish in Florida, where it is common. Tarpon have little value as a commodity in the Hawaiian markets.

The thread-fin with the long threads, sometimes twice the length of the fish, trailing from the dorsal and anal fins is a curious fish of wide distribution that is occasionally seen in the markets, and is without doubt the most striking member of this family of pampanos,¹⁷ a large family which includes local repre-

¹³ *Athlennes hiens*.

¹⁴ *Carangidæ*.

¹⁵ *Carangus ignobilis*.

¹⁶ *Elopidae*.

¹⁷ *Carangidæ*.

sentatives of all such well-known forms as the pilot-fishes, amber-fishes, the runners, mackerel-seads, big-eyed seads and cavallas.

THE PARROT-FISH FAMILY.

The parrot-fish,¹⁸ of which the islands can boast of a large assortment, resemble the wrasse-fishes¹⁹ in color, form and scales, but differ in that they have the teeth more or less fused together which gives to the mouth a heavy beak-like appearance suggestive of the bill of a parrot. They are all herbivorous fishes, some of them attaining a very large size. They are abundant about the coral reefs where they always add a touch of vivid color to the wonderful picture to be seen through an observation hood or a glass-bottomed boat. The flesh is soft and white and of a rather pasty nature. It is a favorite fish with the Hawaiians, who eat it raw at their feasts, but it is seldom cooked by Europeans.

The color pattern of this group is greatly varied and the family is broken up into many species. In Hawaii four well-marked genera occur and at least two dozen species have been found and described from the islands. The ponuhunhu²⁰ has the spinous dorsal fin with a distinct black spot between the first and second spines and the sides somewhat mottled, but without definite spots or specks. They are quite common in the markets. The uhu²¹ is a general reddish color without conspicuous markings other than a narrow violet line on the outer edge of the dorsal. They are not very abundant and as a result command an exorbitant price. The uhu uliuli²² is one of the handsomest fish of the islands. It is green in color with bars or stripes on the dorsal and spots on the scales of the lower sides and a curious rectangular patch over the snout. The blue parrot-fish²³ is a fine brilliant blue fish that in the olden time was tabu, for the use of the chiefs alone. It now sells at a ridiculously high price and is eaten raw. The pipe-fish family²⁴ is represented by three or four genera, one of which²⁵ is of interest since it includes two island species of the curious sea-horse. Both species are so rare, however, that there seems to be no generally accepted native name for the curious animal.

PORCUPINE-FISH.

Poreupine fishes²⁶ occur in the group, there being four species in all. They are more or less spherical in form and as the name implies, have the body well armed with sharp spines the bases of which are so broad as to form a coat of mail in the skin. The oopu kawa²⁷ is the species commonly on exhibition in the Aquarium. It is a sluggish fish, living at the bottom among the seaweeds on the coral reefs about the islands. They are reported as being poisonous. When disturbed they swallow air and float belly up on the water. Their power of inflation, however, is not so marked as that of the globe-fish or puffers, to which they are related. As they are seldom used for food, their principal use

¹⁸ *Scaride*. ¹⁹ *Labride*. ²⁰ *Calotomus sandvicensis*. ²¹ *Callyodon minckleyi*.
²² *Callyodon perspicillatus*. ²³ *Pseudocoriscus jordanii*. ²⁴ *Syngnathidae*. ²⁵ *Hippocampus*.
²⁶ *Diodontidae*. ²⁷ *Diodon nudifrons*.



PLATE 92. CURIOUS AND COMMON HAWAIIAN FISHES.

[Assembled from U. S. Fish Comm. Bulletin No. 23.]

1. Flying Fish [Malolo] (*Parrococcus brachypterus*). 2. Flying Fish [Malolo] (*Cypsilurus sinus*). 3. Barraeuda [Kawalea] (*Sphyrna helleri*). 4. A Squirrel Fish [Alaihi]

(Description of Plate Continued on the Opposite Page.)

is as curiosities, and they are objects of never-failing interest at the Aquarium and in natural history collections.

The name porgy was applied by the Greeks to a red fish of this family²⁸ common in the Mediterranean. Since then the name has been carried over the world by the Spanish and came to be the common name applied to a group of carnivorous shore fishes of the tropics which are everywhere esteemed as food. The single Hawaiian porgy is the mu.²⁹ In their general shape they somewhat resemble the sea-snappers, having their bass-like mouth armed with several conical canine-like teeth in front. They are greenish in color with two paler cross-bands that extend up into the dorsal fin.

THE PUFFERS.

The puffers³⁰ and sharp-nosed puffers³¹ are two families, closely related to the poreupine fish, that have ten species belonging to four genera in the Hawaiian fauna. The walls of the abdomen are capable of distention so that when inflated the fish appears like an animated glass globe with a head and a tail attached. The oopuhue, or keke,³² is the most abundant species. It is light olive-green covered over the back with pearly spots, the belly being striped with light yellow and pearly, but the colors vary greatly with age. It is an abundant fish in suitable places about Honolulu, where it frequents mullet ponds and brackish water generally. When removed from the water they swell up as tight as a drum and remain in this condition until returned to the water, where they will float on their backs in a helpless condition for some time; eventually they collapse and swim off. Cabinet specimens hardened in alcohol will remain in an inflated condition indefinitely. Specimens fourteen inches in length are common. The native name, meaning "sure death," indicates the Hawaiian belief in its poisonous character. The gall doubtless contains an active poison, said by some to have been used on spear-points. Puffers are seldom, if ever, seen in the markets, but are commonly captured in seines in the mullet ponds. They vary greatly in color with age, while in some the body is smooth and in others more or less covered with prickles.

THE REMORA.

The remoras, disk-heads or sucking-fish,³³ while not commonly met with

²⁸ Sparidae. ²⁹ *Monotaxis grandoculis*. ³⁰ Tetraodontidae. ³¹ *Canthigasteridae*.
³² *Tetraodon hispidus*. ³³ *Echeneidae*.

(Description of Plate Continued from Opposite Page.)

(*Holocentrus microstomus*). 5. Swordfish [A'u] (*Xiphias gladius*). 6. Mackerel [Opelu palahu] (*Scomber japonicus*). 7. Ocean Bonito [Aku] (*Gymnosarda pelamis*). 8. Little Tuna or Bonito [Kawakawa] (*Gymnosarda alleuterata*). 9. Pilot Fish or Romero (*Nauarches ductor*). 10. A Cavalla [Puakahala] (*Carangus affinis*). 11. Thread Fish [Ulua kikihi] (*Alepis ciliaris*). 12. Sea Perch [Aholehole] (*Kuhlia malo*). 13. Catalufa [Alalaua] (*Priacanthus alalaua*). 14. Porgie [Mu] (*Monotaxis grandoculis*). 15. A Surmullet [Weke ulaula] (*Mulloidies flammus*). 16. Goat-fish [Mumu] (*Pseudupeneus bifasciatus*). 17. A Wrasse Fish [Omaka] (*Stethojulis avillaris*). 18. A Wrasse Fish [Opule] (*Anampses curier*).

are so curious in form and habit that they are sure to attract attention when they occasionally come to market attached, barnacle-like, to the body of some shark, or turtle, or large fish. They are slender, violet-blackish colored fish that are peculiar in that they have the first dorsal fin transformed into a sucking disk, which covers the entire head and nape. The shark sucker³⁴ of Hawaii is one of two widely distributed species, but as they are neither very abundant nor used as food, their appearance in the markets is entirely owing to their interesting habits. By affixing themselves to their hosts they are carried through a much greater extent of water than their own limited swimming powers would admit. They obtain thereby a much greater supply of food than they would otherwise secure. They may be carried about for weeks by their hosts, leaving them only to secure food. This is done by a sudden rush through the water. The remora does not injure the carrier-animal in any way, and as they are of small size, rarely being more than six or eight inches in length, they do not materially impede the progress of their hosts.

THE SCORPION-FISHES.

The scorpion-fishes³⁵ are so varied in form as to render a brief characterization of the group impossible. In the more extreme examples which are sure to attract attention great changes take place in the form of the fish and their appendages. The head may be distorted with ridges and grooves, the anal spines lost and the dorsal spines variously modified. The scales may be lost or replaced by warts or prickles, and in others the ventral fins may be reduced, while in still others the pectorals are often greatly enlarged.

They are especially abundant in the Pacific and form a large portion of the fish fauna of Hawaii, where ten genera and twenty or more species occur. In general, they do not migrate, but make a permanent home about the rocks and in the coral reef. Curiously enough, they are esteemed as food in spite of the fact that some of them have a venom sac at the base of the dorsal spine, to the poisonous effect of which they owe their name.

The noho or amakaha³⁶ is perhaps as typical and as common in the market and Aquarium as any of the scorpion-fish. They are indescribably mottled and streaked with brown, claret color, sulphur-red, salmon color and near-white. The inner or posterior side of the pectorals is brightly marked with yellow varied with black, so that when swimming from the observer they look like heavy-bodied butterflies winging their way about the tide pools in the reef.

THE SEA-BASS FAMILY.

Although it is customary for the angler to talk of the great variety of sea-bass to be caught in Hawaii, he doubtless speaks from the abundance of misinformation which is current on the subject of fish and fishing, and not from a desire to misrepresent the facts. Anything that takes the hook and in the

³⁴ *Echeneis* sp. ³⁵ *Scorpenidae*. ³⁶ *Scorpenopsis gibbosa*.

least resembles a bass passes as one among this class of fishermen. As a matter of fact, there are but five species belonging to as many genera of the sea-bass³⁷ family that have so far been taken from Hawaiian waters. It is true that it requires some skill to detect the characteristics that separate the cardinal-fishes on the one hand and the catalufas and snappers on the other. If the fish in hand should prove to have three and only three stiff, strong spines in the anal fin and be bass or perch-like in form, the chances are it would prove to be a true bass. However, it would then require much consulting of authorities to prove the specific identity of the species, as the matter is further complicated by a disagreement in popular nomenclature as to whether it should be called a Jew-fish, a grouper, or a hind.

The hapu'u pu'u³⁸ is the most important and common species in the market, where specimens three feet or more in length are not uncommon. It is a dark purplish-brown fish with occasional irregular pearly spots on the sides and with black ventral fins, though in old specimens the spots disappear, leaving the fish a uniform reddish leather-brown. They are usually caught with a hook and are the only species of the bass family commonly known by a Hawaiian name.

One might naturally expect that the ocean about these islands would be inhabited by representatives of almost every type of animal to be found in the sea anywhere. However, the announcement of the discovery of the presence of the sea-devil³⁹ family close at hand will come in the nature of a surprise to many. That the creature was a new species and called for the creation of a new genus is made plain from its description, which, briefly put, characterizes it as an inky black animal with small eyes, a white mouth and a protruding chin. Any fear and uneasiness that may have been felt at the discovery of a member of this satanic family about the islands will be allayed somewhat when it is known that the only specimen of the genus ever discovered is less than four inches long and was dredged from the floor of the ocean under 500 fathoms of water.

SNAPPERS.

The snapper family⁴⁰ is represented in Hawaii by seven or eight important food fish. As has been stated, they closely resemble the sea-bass. One familiar with the characteristics of the two families, however, will be able to point out that in the snappers "the maxillary slips along its edge into a sheath formed by the broad end of the preorbital," while the sea-bass have no such sheath.

The eight species are all fairly abundant, carnivorous, voracious, gamey, excellent high-colored fish, and all are known at the market by Hawaiian names. The ukikiki⁴¹ is a fairly common red fish with diagonal golden cross-bands. It is a fine, firm, white-fleshed fish especially suitable for baking. The

³⁷ *Serranidae*.

³⁸ *Epinephelus quernus*.

³⁹ *Ceratiidae*.

⁴⁰ *Lutjanidae*.

⁴¹ *Roosevelti (Apsilus) brighami*.



PLATE 93. PARROT FISH, BUTTERFLY FISH, PUFFERS AND THEIR RELATIVES.

[Assembled from U. S. Fish Comm. Bulletin No. 23.]

1. A Wrasse Fish (*Thalassoma umbrostigma*). 2. A Wrasse Fish [Hilu lauili] (*Julis leporis*). 3. A Parrot Fish [Uhu] (*Callyodon miniatus*). 4. Blue Parrot Fish (*Pseudosca-*

(Description of Plate Continued on the Opposite Page.)

opakapaka ⁴² is light rosy-olive with violet shades, especially on the scales over the back; the ulaula ⁴⁴ is a beautiful rose-red or reddish-pink, while the uku ⁴⁵ is uniform light gray, the upper parts tinged with blue which on the head becomes dark blue. Some of the species may be procured almost every day, there being more than a hundred thousand pounds sold annually in the Hawaiian markets.

SOLES.

Of the true soles ⁴⁶ but two species were secured by the scientists of the Albatross, and they were taken only from deep water. But of the nearly-related flatfishes, especially the flounders, ⁴⁷ five genera with a half-dozen species have been recorded. By far the most plentiful flatfish is the pakii, ⁴⁸ a curious sand-colored fish with numerous eye-like markings of light grayish-brown and bluish-gray and some with blackish edges. They are mostly small in size, but are excellent when fried. In the Aquarium this flatfish loves to lie almost concealed in the sand. Both eyes have been moved by nature far over on one side of its head. It is indeed a natural wonder that well repays the trouble it often takes to discover it when it has hidden itself in the sand and pebbles for protection.

SQUIRREL-FISHES.

The squirrel-fishes ⁴⁹ are conspicuous shore fishes frequenting the rocky banks and coral reefs of the tropical seas. They are usually red or reddish in color and have eleven spines in the dorsal and four in the anal fin, the third usually being very strong. Five genera have been taken in the group, to which twenty gaily-colored species have been credited. Several of the species are abundant and are always to be seen in the market. The u'u ⁵⁰ is the common red species that lives in the rocks. The natives have an interesting way of fishing for them. One is first caught on a hook, which they take quite readily. The fish is then attached to a line and dropped in again in some place suitable to the habits of the u'u. If the rock is inhabited the resident species will come out at once, bristling with rage, to drive off the intruder. Both fish are then lifted out with a hand net; the last one caught being substituted for the decoy—and so the fishing proceeds.

The alaihi ⁵¹ are interesting members of this family, represented by seven or more species that are quite abundant about the islands. They, like their

⁴² *Apilus microdon*. ⁴⁴ *Etelis marshi*. ⁴⁵ *Aprion virensens*. ⁴⁶ *Soleida*. ⁴⁷ *Pleuronectida*.
⁴⁸ *Platophrys pantherinus*. ⁴⁹ *Holocentridae*. ⁵⁰ *Myripristis murdjan*. ⁵¹ *Holocentrus* spp.

(Description of Plate Continued from Opposite Page.)

rus jordanii). 5. A Butterfly Fish [Kikakapu] (*Chatodon unimaculatus*). 6. A Butterfly Fish [Kikakapu] (*Chatodon miliaris*). 7. Moorish Idol [Kihikihi] (*Zanclus canescens*). 8. A Surgeon Fish [Naenae] (*Hepatus olivaceus*). 9. A Surgeon Fish [Puala] (*Hepatus guntheri*). 10. A Trigger Fish [Humuhumu nukumuku apua'a] (*Balistapus rectangulus*). 11. Sharp-nosed Puffer [Puu olai] (*Canthigaster epilamprus*). 12. Porcupine Fish [Oopu kawa] (*Diodon nudifrons*).

cousins, are mostly small high-colored fish and are peculiar in the development of small spines almost everywhere over the surface of the body. The name refers to the noise they make when taken out of the water, which suggests the bark of the squirrel. The stripes on some species also add to their squirrel-like appearance.

THE SURGEON-FISHES.

The surgeon-fishes or tangs⁵² are herbivorous inhabitants of the tropical seas, notably abundant about the coral reefs and in the tide pools along the shore. They undergo great changes with age, the young often having been described as distinct genera. Hawaii has five genera and perhaps a dozen and a half species of these interesting fishes. They are mostly dark in color, with some vivid color added, and all have an armament developed on the side of the tail. In some genera this armament consists of a movable spine set with the point turned forward which can be dropped down into a sheath-like groove. In other genera one or two sharp knife-like plates are rigidly attached to the side of the tail. It is from these spines that the fishes derive their common names, surgeon-fish, doctor-fish, or lance-fish, and they form very effective weapons against their enemies, be they fish or man.

The pa kuikui⁵³ is common about Honolulu, and may be recognized by its brown color, which is relieved by an orange patch about the murderous spine on the side of the tail. The nae-nae⁵⁴ is olivaceous and has a bright spot on the shoulder. The pualu⁵⁵ is a common species in the Honolulu market. It is brown in color and has four or five golden longitudinal bands on the dorsal fin and four similar ones on the anal. The most abundant member of the extensive genus, however, is the delicious panfish known to everyone as manini.⁵⁶ They are almost daily offered for sale in the markets; their dull olive-gray bodies crossed by five narrow vertical lines renders their identity easy and certain. They are seldom more than seven or eight inches in length, but their small size is more than made up for by their delicate flavor when fried. They are fearless shore fishes, usually to be seen in pools in small schools. The young are often trapped in holes in the rocks along shore as the tide recedes, where they swim about without alarm, patiently awaiting the return to the sea. They are hardy and thrive in the Aquarium, where their stripes have won for them the popular name of convict-fish.

The kala,⁵⁷ or unicorn-fish, is an abundant member of the family. In addition to the two large pale blue, blunt, immovable spines on the tail, placed one in front of the other, it has as a special distinctive mark a long horn growing forward from the cranium above the eyes.

THE GOAT-FISH.

The surmullets, or goat-fish⁵⁸, are shore fishes of moderate size and possess the notable features of two long unbranched barbules of firm sub-

⁵² *Acanthuridae*. ⁵³ *Hepatus achilles*. ⁵⁴ *Hepatus olivaceus*. ⁵⁵ *Hepatus guntheri*.
⁵⁶ *Hepatus sandvicensis*. ⁵⁷ *Acanthurus unicornis*. ⁵⁸ *Mullidae*.

stance on the chin. These they employ for feelers, using them to stir up the sand on the bottom, as they search for the small animals upon which they feed. Their scales are large and thin, and the fish are all bright-colored, usually red or red and golden. About a dozen and a half of closely-related species are found in the ocean about Hawaii. These are divided among three important genera. Weke is the name applied by the Hawaiians to a number of the species. The name is also used in combination with more specific descriptive terms, so that weke or weke ula⁵⁹ is specifically applied to the bright red-colored surmullet of which enormous quantities are annually marketed in the islands. In the Aquarium they attract much attention as they swim along carrying their chin barbules extended in advance of them, cautiously feeling their way as they go.

The goat-fish proper⁶⁰ are represented by the moano,⁶¹ the munn⁶² and the kunn,⁶³ all of which are highly-colored common species.

SWORDFISH.

Occasionally a swordfish⁶⁴ is taken by the Hawaiian fishermen, and in this way reaches the market under the name a'u. They are fishes of great size, with the upper jaw prolonged to form a "sword," which is flattened horizontally. So far as is known, the family⁶⁵ is represented by a single species of world-wide distribution. They are mainly pelagic in their habits and are among the most predaceous and savage of the monsters of the deep. They not only transfix their ordinary prey with their formidable sword, but use it in a merciless attack on whales, which, from repeated stabs, often succumb.

Occasionally this pugnacious fish mistakes a ship's hull for an enemy and charges it, sending its sword crashing through several inches of timber. On one occasion the writer photographed a swordfish bill that had been rammed through the stern sheets of a small deep-sea-going craft. The vessel had been hauled out of the water for repairs in Honolulu harbor, when, to the surprise of the ship's master, the beaks of the swordfish were found driven deep into the hull, one of them piercing the solid pine shell to a depth of twelve inches. While swordfish are usually four to six feet in length, they may measure twelve or fifteen feet and have a sword a yard in length. The largest animals sometimes weigh as much as 600 pounds or more. The flesh of the swordfish is red in color and rich in flavor, and is everywhere prized as delicious food.

The trigger-fish⁶⁶ are rather large-size shore fishes that are partly herbivorous and partly carnivorous in habit. They are rarely used as food, and some of them are reputed by the natives to be poisonous. They are remarkable and interesting in that the first dorsal fin is composed of a short, stout rough spine with a smaller one behind it, and usually a third so placed that, by touching it, the first spine may be rigidly set or easily released, when it folds

⁵⁹ *Mulloides auriflamma*. ⁶⁰ *Pseudupeneus* spp. ⁶¹ *Pseudupeneus multifasciatus*.
⁶² *Pseudupeneus bifasciatus*. ⁶³ *Pseudupeneus porphyreus*. ⁶⁴ *Xiphias gladius*. ⁶⁵ *Xiphiidae*.
⁶⁶ *Balistidae*.



PLATE 94. GOBIES, BLENNIES, FROG FISH, TRUNK FISH AND OTHER ODD FORMS.

[Assembled from U. S. Fish Comm. Bulletin No. 23.]

1. Headfish [Apahu] (*Ranzania makuu*). 2. Trunk Fish [Moa] (*Ostracion sea*).
3. A Cirrhitoid Fish [Pilikoa] (*Paracirrhites forsteri*). 4. A Cirrhitoid Fish [Oopnkai]

(Description of Plate Continued on the Opposite Page.)

THE TRIGGER-FISHES.

back into a pocket out of the way. This gives the family the name of trigger-fish, as well as the older name, *Balistes*, which refers to a cross-bow shooter.

Hawaii has five genera with eleven species. The species of the principal genus *Balistes*, are known as humnunu, to which as occasion requires is added a second name and even a third by the natives for more specific designation.

Many of the Hawaiian species are most fantastically colored. The humnunu nukunuku a pua'a⁶⁷ has a blue band over the nose, a broad black one slanting diagonally across the body from over the forehead to the pectoral region, thence backward to the anal fin, and a wedge-shaped black band on the side of the tail; but several of its cousins outdo it in striking and unconventional colors and markings.

TRUNK-FISH.

The odd, box-like trunk-fish,⁶⁸ or coffer-fish, as they are called by some, have the body enveloped in a boney box of six sides out of which the movable jaws, fins and tail protrude. They live in shallow water, are slow of motion, but often are brightly colored.

Five species of trunk-fish have so far been recorded from Hawaii. The moa⁶⁹ are conspicuous in their dress of bright blue with golden spots, and are the most abundant of the island species. Their knowing, stolid countenances as they swim gracefully about among their associates at the Aquarium give them a "position among fishes that corresponds to that held by the owls among birds." When taken from the water these fish will live a considerable time, and they appear to be hardy enough to commend them to keepers of private salt-water aquaria.

TRUMPET-FISH.

The trumpet-fish,⁷⁰ known locally as the nunu, is not uncommon about the islands. By reason of its odd, elongated body, long head and small mouth set at the end of a long compressed tube, the nunu is sure to attract attention. The single species varies greatly in color, ranging from light yellow to dark brown, varied with five or six narrow longitudinal stripes. In spite of its odd appearance, it is a food fish of some importance, and is often exposed for sale in the markets.

⁶⁷ *Balistapus rectangularis*. ⁶⁸ *Ostraciidae*. ⁶⁹ *Ostracion sebae*. ⁷⁰ *Aulistomus valentini*.

(Description of Plate Continued from Opposite Page.)

(*Cirrhitus marmoratus*). 5. A Scorpion Fish [Nohu] (*Scorpanopsis gibbosa*). 6. Flying Gurnard [Lolo-oau] (*Cephalacanthus orientalis*). 7. A Goby [Oopu] (*Eleotris sandwicensis*). 8. A Goby [Oopu] (*Eriota epiphanes*). 9. A Goby [Oopu] (*Mapo fuscus*). 10. A Goby [Oopu] (*Sicydium stimpsoni*). 11. A Goby [Oopu] (*Awaous genivittatus*). 12. A Blennie (*Emucapterygius atriceps*). 13. A Blennie (*Alticus marmoratus*). 14. A Blennie (*Salaris zebra*). 15. Frog Fish (*Antennarius leprosus*).

CHAPTER XXIX.

INTRODUCED FRESH WATER FISH.

GOLDFISH.

Several attempts have been made by private citizens to introduce well-known food, game and ornamental fish into the Hawaiian Islands. One of the earliest, if not the first attempt of this nature, resulted in introducing the well-known goldfish¹ into the streams, ponds and irrigation ditches of Oahu, from whence they have been generally distributed to the other inhabited islands of the group. The original stock of goldfish came from China, but the date of the first shipment is not known. As early as 1867, however, they were being exported to California, and from that time to the present they have been abundant about Honolulu, and have contributed their share to the ideal beauty of the streams and the pleasure of the young angler. Since the original introduction some of the fancy varieties have been liberated at different times, with the result that there is much variation in form and color among the wild species. Goldfish are regularly offered for sale in the market in Honolulu, but they are mainly eaten by the Chinese and Japanese.

The goldfish is a native of China, and from there it was introduced into Japan at an early date. From Japan they were carried to Europe in 1611, and later to America, where many of the various artificial varieties that have been produced in China and Japan are reared with great success by fanciers. The rich golden color is found only in the domesticated species, and is retained by artificial selection. The native fish are olivaceous in color, and in the ponds and ditches about Honolulu, as in China and Japan, they readily revert to that color. In the Orient several score of forms have been produced by patient selection and breeding. Eighteen forms of so-called toy goldfish are known among the fanciers, each of them provided with a name based on its origin, history, form or color.

They are rather sluggish, hardy creatures that devour large quantities of mosquito larvæ from pools and fountains about the city. Unfortunately, the more recently introduced "mosquito fish" are reported to feed on the eggs and very young of the goldfish and mullet, as well as the mosquito larvæ and the young of the fresh-water shrimp. As a result, goldfish are not as plentiful in our streams as they were formerly.

CARP.

Carp² were introduced into the islands from America some years ago. They were first planted in the irrigation ditches near Wailuku, and from there were distributed to Hawaii and Oahu, and doubtless will be found on all the islands. They are not much used as food on account of their muddy flavor and are only used in the absence of better fish. They naturally

¹ *Carassius auratus*.² *Cyprinus carpio*.

prefer shady, sluggish water with muddy bottoms, where they feed voraciously on small water animals and vegetable matter, particularly the leaves of aquatic plants. The common carp is closely related to the goldfish and was originally a native of the rivers of China, where it has long been artificially reared by the inhabitants. From there it was introduced into Europe, perhaps three centuries ago, and has since become naturalized and several varieties produced in domestication. From Europe carp were introduced into America, and from America they were brought to Hawaii, thus completing their journey around the globe. They attain a size of several pounds and may be identified as the only scaled fresh-water fish in Hawaii that have barbules on the upper lip. A single specimen has been known to produce as many as seven hundred thousand eggs in a single season.

CATFISH.

The common bullhead catfish, or horned pout,³ was introduced about twenty years ago from California, where it had been naturalized, and was planted in ponds about Hilo, but it has not been seen since. In the meantime it has been introduced on the Island of Oahu, where it has been secured from the same ponds with the Chinese species. The Chinese catfish⁴ was introduced by the Chinese about a dozen years ago from their country. It has survived and is becoming quite common in the fresh-water ponds and finds its way to the markets, where it is sold under the name of Chinese catfish.

Since both species occur about Honolulu in the same environment, it will be well to know that the Chinese species have the dorsal and anal fins much elongated, each with many rays, and extending throughout the greater length of the trunk, while in the bullhead the dorsal and anal are much shorter, the dorsal with one hard and seven soft rays.

CHINA FISH.

Easily mistaken for the Chinese catfish in the water, is the "China fish,"⁵ which in reality is a snake-head mullet. They are long and cylindrical, and the head is covered with scales. They are carnivorous and voracious in habit, and are extremely tenacious of life, living for hours out of water when thrown on the banks of the irrigation ditches or when carried to market. Dr. A. Günther states that they are able to survive drouth by living in the semi-fluid mud or lying in a semi-torpid state below the hard sun-baked crust of the bottom of a tank from which every drop of water has disappeared.

BLACK BASS.

The first attempt to establish black bass dates from the summer of 1897, when a shipment was made from the California Fish Commission to a number of citizens at Hilo. Unfortunately, only twenty-one of these elegant sun fishes survived the journey. These were planted in Wailuku river near Rainbow

³ *Ameiurus nebulosus*.

⁴ *Clarias fuscus*.

⁵ *Ophicephalus striatus*.

Falls, but the following day a heavy freshet in the river is supposed to have carried them out to sea, as they were never seen afterward.

In 1908 Mr. W. A. Templeton, while visiting California, secured a number of large-mouthed black bass ⁶ which he brought back with him and planted in the great artificial fresh-water reservoir at Wahiawa. Under his supervision the introduction has proved successful, and this exceedingly valuable game fish is now well established in these waters and in time will doubtless be carried from Wahiawa to similar reservoirs and ponds throughout the group. As these ponds are filled with shrimp and the temperature and other conditions seem favorable, the black bass is doubtless to become a common article of food in Hawaii and will prove a worthy substitute for almost any of the native fish.

TROUT AND SALMON.

Attempts to establish trout in Hawaii have so far proved unsuccessful, though two or three attempts have been made, the first as early as 1876. It is thought by the writer that there are streams in the group, especially one or two on the Island of Molokai, that are well adapted to the trout, and that if proper precautions were observed in planting them, they would soon establish themselves. Salmon eggs were sent here for planting in 1876, but this experiment proved unsuccessful.

MOSQUITO FISH.

Work along the line of mosquito control had advanced in the Territory to a point where, on the advice of experts, it was deemed advisable to import small fish for the purpose of feeding on the larvæ of this pest that hatches in the streams, ponds and ditches of the Territory. The Legislature of 1905 made a small appropriation for that purpose, and a special collector was employed to transport to Hawaii representatives of the so-called "top minnows" or killifish from Galveston, Texas. Three species ⁷ belonging to three genera of the family *Poeciliidae* were successfully introduced into especially-prepared ponds at Moanalua, Oahu. From these they have since been spread broadcast over the group until it is now almost impossible to find slowly-moving or standing fresh water that is not inhabited by one if not all of the species. They are silvery fishes of small size, scarcely more than two inches in length. They have a wonderful appetite, devouring large quantities of mosquito larvæ, but, as was expected, they do not discriminate as closely as might be desired, with the result that they are charged with eating the eggs and young of the other aquatic animals. However, the introduction of a few into any closed body of water infested with mosquito larvæ will convince anyone of their economic value to the Territory. Their small protractile mouths, scaled heads and "minnow" shape is sufficient to separate them from other fresh-water fish, but the species are so small that their certain identification by the novice is not an easy matter.

⁶ *Micropterus salmoides*.

⁷ *Gambusia affinis*, *Fundulus grandis* and *Molienesia latipinna*.

CHAPTER XXX.

IMPORTANT ECONOMIC INSECTS: PART ONE.

The insect life of Hawaii is as yet far from being completely explored. However, through the patient researches of a number of specialists extending over a period of years, the native and introduced fauna is becoming better known, though all testify to the many insect rareties as well as pests yet to be found by almost any one who will search with patience and industry in the rich fields offered by the wonderful variety of environments to be met with in the islands.

IMPORTANCE OF THE STUDY OF INSECTS.

The study of the habits of insects by young people as a part of their school work, or on their holiday excursions, is especially to be commended, since it is sure to result in the learning of many valuable lessons that deal with the wonders of nature. Besides being of absorbing interest to old and young, such study may lead the enthusiast to follow a pursuit in life that offers possibilities of great usefulness and benefit to all.

The tourist and visitor, however, whose conception of the islands has been too literally based on some traveler's account wherein the tropical forests are portrayed as "a wilderness jeweled with a myriad brilliant-colored butterflies," is sure to be disappointed on his first expedition into the mountains of Hawaii. While they are plentifully stocked with insect life, unfortunately from some points of view it is not of the gorgeous and showy kind that one is wont to associate with tropical islands.

The few small dull-colored species the novice is able to collect on the first day's outing are usually not such as to excite much enthusiasm for Hawaii as an insect collector's paradise. But on careful study of the day's catch it will be found that many of the insects belong to species that cannot be found elsewhere in the world, and that many of them have habits of the most absorbing interest. Further and more searching study of the fauna will bring to light peculiar local representatives of almost all of the great orders of insects. When we consider the isolation of the islands, one is surprised to find represented so great a proportion of the large number of families into which the world's more than three hundred thousand known species of insects have been classified.

IMPORTANT DESTRUCTIVE SPECIES.

As there are several thousand species that are native to the islands, a few of which are touched upon in a succeeding chapter, and since there are several hundred that have been introduced by accident or design,¹ only the briefest notice can be taken in this chapter of a few of the more important economic species that, for one reason or another, are liable to attract the attention of

¹ As many as one hundred and thirty-six species being intercepted and prevented from landing at the wharf during the biennial period ending December 31st, 1914.



PLATE 95. THE STUDY OF ECONOMIC INSECTS.

1. Interior of an insectary showing breeding cages. 2. Sugar cane showing the work of the Sugar Cane Borer (*Diatraea sacalis*). 3. Office and cabinets of the Territorial economic entomologist.

the ordinary observer, or those persons whose occupations often bring them in touch with things of nature.

It is a singular fact that of the large number of species peculiar to the islands only a few are noticeably destructive to agriculture or to cultivated exotic plants. The worst enemies of the agriculturist have been introduced from abroad and are frequently cosmopolitan pests. They usually come with farm produce, ornamental plants, earth and seeds. The result is that one is liable to meet here in the islands all of the old enemies of the husbandman with which one may be familiar in his native country, and to the list may be added several other forms equally destructive that were before unknown to the observer.

The number of destructive insects in the islands has led to the adoption of the policy of controlling them whenever possible by the introduction of their natural enemies. This plan has been steadily pursued for almost a quarter of a century, with the result that probably in no other country, particularly when its size is considered, have so many beneficial insects been artificially established.

CONTROL BY NATURAL ENEMIES.

As the natural enemies of most of the insects are parasites, which as very minute insects, usually attack and feed in one way or another upon the host species which itself is often microscopic in size, this warfare is not a very conspicuous one, nor one liable to attract very much attention. However, in the struggle being continually waged to keep the enemies of agriculture in check in the islands, these often unseen and unknown insect friends are always active and have already saved millions of dollars to Hawaii.

THE SUGAR-CANE LEAF-HOPPER.

Perhaps no more remarkable example of the effectiveness of this method of control can be found than that of the introduction of the leaf-hopper egg parasites. The cane leaf-hopper had been known to plantation managers and expert entomologists in the islands for a number of years, but in the early spring of 1903 it appeared so generally throughout the cane fields and in such numbers as to prevent the growth of the cane. It was found to be a typical member of the leaf-hopper family (*Asiracida*), and proved to be a recent introduction, probably brought with seed cane from Queensland, Australia. Owing to its small size and inconspicuous color and habits, its spread was unnoticed until it could be found almost wherever cane was grown.

The sugar-cane leaf-hopper² flies readily and is attracted long distances by light; so besides traveling with the cane, it flew to new fields and from one plantation to another.

A peculiar smut that developed on the lower leaves of cane attacked by the leaf-hopper was found to grow on the "honey dew," a transparent sticky

² *Perkinsiella saccharicida*.

fluid exuded by the insect, and was one of the conspicuous signs of the subtle attacks of the troublesome bug.

As the development of the insect from the egg to the adult is not divided into definite stages, as is the case with the butterfly for example, the young when hatched resemble the adult, except they do not at first have wings. The wings are acquired, however, by a process of moulting, and in due time the insect is fully matured. The eggs, necessarily quite small are deposited along the mid-rib of the leaf, or in exposed portions of the stalk. The place of insertion is marked at first by a white spot with a waxy covering over the opening. Four to six eggs are deposited in each opening; moreover, several clusters are deposited by a single female.

As time passes the white spot, if occupied by living eggs, becomes claret-colored. When first hatched the young are almost colorless. After some effort they emerge from the nest and begin to feed. They continue to feed until they develop their wings, and finally die of old age. As a rule they do not fly when disturbed, but sidle to the opposite side of the leaf or jump to a more secluded spot.

Scientific study of their habits shows that the first injury done to the cane by them is when it is punctured for the deposition of the eggs. The puncture produces a drain on the plant's vitality and admits various diseases through the wound. But the most serious injury is that done by the young insects to growing cane.

Everything that ingenuity could devise was tried to lessen the damage done by them, but without success. The seriousness of the invasion was soon appreciated and scientific entomologists were speedily assembled in Hawaii, and from here sent out to all promising countries to look for the most effective natural enemies of this insect pest, a pest that had already cost hundreds of thousands of dollars in diminished returns from this important crop. When the entomologists went seriously to work they found a number of natural enemies of the hopper. But in choosing the most desirable and efficient one, they had to consider their effectiveness, the possibility of their transportation, the probability of their thriving, and the rate of increase to be expected when they were once established.

It was found for the work to be done that certain little egg parasites were very promising, since they completed their life cycle every three weeks the year round, and the greater part of those produced were females. With such habits it was plain that within a very few months after the original colonies were liberated, thousands of millions of descendants of the original stock would be at work searching out the spots on the cane where the leaf-hoppers had deposited eggs, and in turn depositing their own eggs in them in such a way that the young of the parasite would feed upon and kill the eggs of the leaf-hopper before they had time to develop.

When the proper data had been secured, the egg parasites were imported into Hawaii, the species carefully studied in captivity, and the young parasites

liberated on all the important plantations. Science was thus again called to the aid of the planters, as it had been many times before, and the experiment worked out has been so successful that the effects of the leaf-hopper on the cane crop of Hawaii is almost a negligible quantity. The outbreak is now under control, and the whole industry saved and restored to its normal condition.

THE SUGAR-CANE BORER.

The search for the parasites feeding on the almost equally destructive sugar-cane borer³ has been a thrilling scientific adventure. Happily, after years of search, Dr. Frederick Muir was rewarded by the discovery, and subsequently succeeded in the successful introduction into Hawaii, of parasites to prey upon this most destructive insect.

LANTANA INSECTS.

Examples of the controlling of injurious insects by introducing their insect enemies might be multiplied at length, but one more instance, of a somewhat different nature, in which insects were used to combat the spread of an injurious plant must suffice. A great many years ago (1858) the common Lantana,⁴ a native plant of the subtropical regions of South America, but elsewhere cultivated extensively as a green-house or ornamental shrub, was introduced into Hawaii as a garden plant. In course of time the mynah bird, which was likewise introduced, made the discovery that the small blue-black aromatic berries of the Lantana were edible. As a result, in a very few years this hardy plant had been spread broadcast to all parts of the group by these birds. Thousands of acres of what was formerly open pasture land became completely choked with the rank growth, while even in the lower forests it grew several feet in height, often forming an almost impenetrable, though beautiful, flowering jungle.

Although the plant was regarded as beneficial by reason of its power to force its long roots down deep into the earth, thereby loosening the soil and furnishing to it a large amount of humus as fertilizer, its inroads into pasture and tillable land became so marked and persistent as to cause it to be regarded as a serious scourge. Entomologists began to look into the natural enemies of the plant, and before long had found a number of insects and fungus parasites that naturally fed on the Lantana, preferring it to any other food.

By far the most important among these is the Lantana seed-fly,⁵ which is a small black two-wing insect, the maggot of which lives in and destroys the seed. So perfectly has it done its work that in favorable localities it is difficult to find a seed that has not been killed by this insect. This is of great importance, for if land is once cleared of Lantana it will not grow again, though unfortunately gnava often springs up to take its place.

The Lantana plume-moth,⁶ a small brown moth about a half inch in

³ *Rhabdoenemis* = (*Sphenophorus*) *obscurus*.

⁴ *Lantana Camara*.

⁵ *Agromyza* sp.

⁶ *Platyptilia* sp.



PLATE 96. SOME ECONOMIC INSECTS.
(FOR DESCRIPTION OF PLATE SEE OPPOSITE PAGE.)

expanse, is also an important species in destroying Lantana, as it lays its eggs at the base of the flower cluster. On hatching, the minute caterpillar digs a tunnel under the flowers and attacks and destroys them. The work of this species on the flowers is supplemented by the work of two species of Lantana butterflies⁷ of the family⁸ of gossamer-winged butterflies, both of which lay their eggs on the flowers so that the young worms may feed on the blossoms and fleshy seed. These caterpillars are so abundant among the Lantana of the low lands that they occur in almost every flower. The larger species⁹ has delicate tails on the hind wings; the smaller species¹⁰ is without the tails.

The Lantana leaf-miner¹¹ is a moth that is also effective, since it develops in the leaves up to the pupa or resting stage. Often as many as a half dozen of these miners occur in a single leaf and thus produce a serious drain on the plant's vitality. A second leaf pest is the Lantana leaf-bug,¹² which, being a true bug, sucks its food. The young frequent the under side of the leaf and are very destructive during the dry season. The Lantana gall-fly¹³ also does much damage to the pest host by laying its eggs in the stem of the plant. These form galls that further impair the plant's growth.

All of these insects were introduced for a definite purpose under the direction of the distinguished entomologist Mr. A. Koebele, and none of them have been observed to attack other plants. This is the first example in the world of the introduction of insects to prevent the spread of a plant. As time passes, the success of this delicate and difficult piece of scientific work is more and more fully appreciated by scientists as well as citizens. It furnishes science with another convincing example of the value of the study of entomology, and indicates the power of the subtle influences in nature with which the biologist is wont to deal.

THE MAUI BLIGHT.

In speaking of Lantana insects, it is only just to say that the Lantana blight or Lantana scale¹⁴ or Maui blight, which is the great tea pest of southern Asia, was not introduced by Mr. Koebele. It was first found at Wailuku, on Maui, in 1889. In 1904 it was noted on Lantana on the windward side of the Pali, on Oahu. Since then it has spread even into Honolulu.

⁷ *Thecla* spp. ⁸ *Lycenidae*. ⁹ *Thecla ecion*. ¹⁰ *Thecla agria*.
¹¹ *Cremastobombycia lantanella* Busck. ¹² *Theleonemia lantanae*. ¹³ *Eutreta sparsa*.
¹⁴ *Orthesia insignis*.

DESCRIPTION OF PLATE.

1. Maui Blight or Lantana Scale (*Orthesia insignis*) on Lantana. "A well known greenhouse pest of Europe and America. First observed on Maui, though not known by whom or how introduced. Apparently a powerful enemy of Lantana, but unfortunately is destructive also to a large variety of ornamental plants." 2. Excrement of American Toad (*Bufo columbianus*). The Toad feeds very largely on the Japanese beetle. 3. Florida Red Scale (*Chrysomphalus ficus*) on Citrus and Palm leaves. 4. Imported enemies of the Lantana showing: (a) seed destroyed by fly; (b) and (c) butterflies whose young eat flowers and leaves; (d) moth whose young eats the flowers; (e) injury caused by the leaf-miner; (f) moth of the leaf-miner; (g) its pupa; (h) the Lantana leaf-bug; (i) the gall and (j) the fly producing it. 5. Pineapple scale (*Diaspis bromelia*) on pineapple leaves. 6. Australian Ladybird beetles introduced into Hawaii.

where it occurs as a pest on a number of ornamental plants, most noticeeably on the species of Gardenia and Coleus.

The scale has a white body and black head, and its presenee induces the growth of a sooty mould so that everything it overruns turns black, often leaving whole fields of Lantana leaves in a blackened condition as though run through by fire. It is a decidedly benefieial parasite working against Lantana, and were it not for its unfortunate tendeney to spread to benefieial and ornamental plants, it would have been credited with a large share of the laurels due the insects that have given man the control over this plant pest.

The effect of the Maui blight on Lantana-ridden pasture land was early recognized by ranchmen, and it is said by some that they very unwisely aided in its spread to new fields and to different islands. Fortunately, as yet it has done more good than harm, though there are many who are fearful of what it may do in the future.

Of the effort of man to secure control over the Lantana in Hawaii, it can be said that the work done by scientific men in seeking out, introducing, breeding and spreading the natural enemies of this noxious plant has been singularly successful; so successful, indeed, that everywhere in the group the pest has been arrested in its invasion of the land, while in certain localities Lantana has been completely routed by its minute enemies. Brilliant and successful as has been the Lantana campaign, there is unfortunately a long list of introduced insect pests¹⁵ for which, in spite of the fact that persistent search has been made to secure them, there seems to be no known effective natural parasitic or predaceous enemy.

THE MEDITERRANEAN FRUIT-FLY.

As one of the most recent as well as the most troublesome introductions in this class, the Mediterranean fruit-fly¹⁶ may well be mentioned, as there is scarcely a fruit grown in Hawaii that is not attacked by this pest. It is about the size of a common house-fly; the body is yellowish, the eyes of a reddish-purple tint, and the back and wings variously marked with blotches and lines of black, yellow and dirty white. The home of the species is supposed to be about the Mediterranean, perhaps in Africa, from whence it has been distributed by commeree to many lands, among them Australia. From Australia the fly has doubtless been introduced into Hawaii.

The eggs are inserted by the female fly in the various kinds of fruit when they are just turning ripe. By the time the fruit is ripe the white wriggling maggot is ready to emerge. Leaving the fruit, it burrows in the ground a short distance and forms for itself a wheat-shaped pupa case from which it emerges in a few days as an adult.

The species was first noticed in Honolulu during the summer of 1910. By the summer of 1912 it had spread to all the large islands of the group and is now common wherever fruit is grown.

¹⁵ Among them many that are exceedingly troublesome.

¹⁶ *Ceratitis capitata*.

MELON-FLY.

A somewhat larger and handsomer, though similar appearing fly pest, is the melon-fly.¹⁷ It was first noticed on Oahu as long ago as 1897, and since that time has succeeded in doing for the melons and fleshy vegetables what the fruit-fly has done for the fruit of the islands. They not only infest the fruit, but the vines as well, and as there is an abundant variety of plants on which they feed, they ravage the truck gardens throughout the year.

THE HORN-FLY AND OTHER INJURIOUS FLIES.

The horn fly¹⁸ is a pest of the live stock of the islands; the damage it does is of equal rank with the fruit and melon-flies. It was introduced from California in 1897, and within a year had spread throughout the group. In the years that have passed it has bred uninterruptedly, and the annoyance caused by its blood-sucking habits has been felt by all the live stock on the Hawaiian ranches. Owing to its vicious bite, a loss of hundreds of thousands of dollars has been sustained by ranchmen through the shrinkage in weight of animals to be sent to market.

Other flies that have more or less economic importance are the stable fly;¹⁹ the horse bot-fly;²⁰ found on horses or about stables; the sheep-head maggot fly;²¹ two flesh flies;²² two bluebottle flies;²³ the sheep-maggot fly²⁴ on sheep; and warble-flies of two species²⁵ on cattle. The familiar house fly²⁶ is everywhere present and in some localities abundant, though it is kept in control by parasites²⁷ that make it their host, and to some extent doubtless by certain species of ants.

MOSQUITOES.

With the flies as members of the great order *Diptera*, should be considered the representatives of the mosquito family. Of these, three important mosquitoes, the night mosquito²⁸ and the two day mosquitoes, one²⁹ with two white stripes on each side of the thorax, and the other³⁰ with one white stripe on the thorax, are common in the islands. They are so abundant in certain localities as to be the principal source of man's discomfort in Hawaii. So far they have not themselves become inoculated with the diseases which elsewhere they transmit from one person to another, producing, in the case of one of the day mosquitoes,³¹ the dreaded yellow fever of tropical and subtropical countries. Through the introduction of natural enemies, as the mosquito fish, frogs, dragon flies and the like, in connection with the various campaigns to do away with standing water, which is their natural breeding place, all of the species have been materially reduced in numbers in Honolulu, but they are

¹⁷ *Dacus cucurbitæ*. ¹⁸ *Hematobia serrata*. ¹⁹ *Stomoxys calcitrans*. ²⁰ *Gastrophilus equi*.

²¹ *Estrus ovis*. ²² *Sarcophaga barbata* and *S. palliervis*, the latter with a red tip to the abdomen.

²³ The European bluebottle, *Lucilia sericata*, and the American species, *L. caesar*. ²⁴ *Estrus ovis*.

²⁵ *Hypoderma bovis* and *H. lineata*. ²⁶ *Musca domestica*.

²⁷ *Eucolia impatiens*, the stable fly parasite, and *Spalangia hirta*. ²⁸ *Culex fatigans*.

²⁹ *Stegomyia fasciata* (Fabr) = *S. calopus* (Meigen). ³⁰ *Stegomyia scutellaris* (Walk.).

³¹ *S. scutellaris*.

far from being under the complete control that it was hoped would be possible.

It is asserted on the best authority that mosquitoes were unknown in Hawaii previous to the year 1826, when the night flying species was brought from San Blas, Mexico, to the port of Lahaina, on Maui, by the ship "Wellington." Prior to the above date the Hawaiians had no word for mosquito. They almost immediately adopted the corruption "makika" as the native name of the insect. The day mosquitoes have been introduced during the present generation, but there is no definite record of the exact date.

SUGAR-CANE INSECTS.

While mention has been made of the sugar-cane borer and the sugar-cane leaf-hopper as the most important pests of sugar-cane, it is not to be assumed that there are no others. As a matter of fact, there are more than sixteen insects liable to do more or less damage to the growing crop. Among them are four beetles.³² The cane borer, a species which is known elsewhere, and is either an importation of man or a natural immigrant, as it is also found in the banana, pandanus, cocoanut palm and under stones in the mountains, is the most important of this order. The long-horned beetle³³ attacks the cane only accidentally, as its natural food is the decaying wood of forest trees, while a small borer,³⁴ and a nitidulid beetle,³⁵ which breeds in the parts injured by the mealy-bugs and plant lice, complete the list of beetles. There are three caterpillars,³⁶ including the sugar-cane leaf-roller.³⁷ Besides the leaf-rollers, the well-known troublesome peelua,³⁸ or grass army-worm, occurs occasionally in the cane. It is very troublesome in grass land at all seasons, occurring in millions of individuals at irregular intervals, working great havoc in pasture lands. The four-banded fly of the family *Ortaliidae*³⁹ is sometimes found about injured cane. The grasshopper family⁴⁰ has four representatives, the African mole-cricket⁴¹ being the most troublesome. They are blackish-brown insects an inch or more in length, that are peculiarly fitted for living in the ground. The front legs are modified to serve as very powerful spades and are used in much the same way that the common mole uses its fore paws. The mole cricket feeds on the tender roots of various plants, and where they are abundant become very destructive. Two species of grasshoppers, one the short-horned grasshopper⁴² which was introduced about 1878, the other the long-horned species,⁴³ the latter species appearing first in Pauoa Valley about 1898, but now present in the cane fields, as well as elsewhere, feed to some extent on the succulent growth. The black beetle-roach, cypress roach⁴⁴ or ground cockroach, does some slight damage also.

As a matter of fact, two species of leaf-hopper that occurred in the islands prior to 1892 are found in the cane fields. They are known to have

³² *Coleoptera*. ³³ *Egossoma reflectum*. ³⁴ *Haptoncus* sp. ³⁵ *Hypothenemus* sp. ³⁶ *Lepidoptera*.
³⁷ *Omiodes accepta*, and probably allied species. ³⁸ *Spodoptera mauritia*. ³⁹ Perhaps *Euresta annone*.
⁴⁰ *Orthoptera*. ⁴¹ *Gryllotalpa africana*. ⁴² *Oryza velox*.
⁴³ *Xiphidium fuscum* = *Xiphidium varipenne*. ⁴⁴ *Eleutheroda dytiscoides*.

been imported, however, as they bear no resemblance to the great order of true bugs⁴⁵ that occur in the forests. The one previously mentioned, in which the wings do not touch each other down the back, and the corn leaf-hopper,⁴⁶ having the wings folded closely together on the back, are the important forms. A gray sugar-cane mealy-bug,⁴⁷ a pink sugar-cane mealy-bug,⁴⁸ and a plant-louse known as the sugar-cane aphid⁴⁹ are also members of the same great order.⁵⁰ They are injurious locally, and though their relatives are more or less readily kept in check on other vegetation, the latter species, when it occurs on cane, hides at the base of the leaves and is almost inaccessible.

It will be seen that some of these pests bore into the stem of the cane, some eat or cut the underground roots or stems, some eat the leaves, some suck the juice from the leaves and stems, and some feed on the parts left after other species have had their fill. Yet in spite of the formidable list of enemies and the diverse lines of attack which they pursue, some of the best and most favorably located plantations are able to harvest as much as thirteen tons of raw sugar of the finest quality from an acre of this seemingly pest-ridden plant.

APHIDS OR PLANT-LICE.

The sugar-cane aphid,⁵¹ since it probably occurs throughout the islands where cane is grown, may well be taken as the type of its family.⁵² The aphids are minute insects with more than twenty species already known in the islands, all of which have been introduced.

Most of the species of plant-lice or aphids in Hawaii occur on well-known or imported plants, and were doubtless imported with their host plants. They are inconspicuous but are very injurious on account of their numbers and their juice-sucking habits. They make up in numbers for what they lack in size, and must be recognized as among the greatest pests with which the farmer, gardener and horticulturist has to contend.

The plant-lice and aphids are minute, soft, pulpy little creatures with rather long antennæ and conspicuous round eyes; they are commonly seen crowded together on the ends of stems, the under side of leaves, in buds and flowers, in clefts in the bark and sometimes even on the roots of plants. Their fore wings are longer than the hind pair and repose roof-like over the hind part of the body. While the majority of them are green in color, they vary greatly, being brown, black, red, yellow, and variegated. They are usually named after the plant on which they occur most abundantly. As a rule, though not always, they confine their attacks to a single species of plant. Among the more noticeable species in Hawaii we find the banana aphid,⁵³ the fern aphid,⁵⁴ the palm aphid,⁵⁵ the rose aphid,⁵⁶ the corn aphid,⁵⁷ the violet aphid,⁵⁸ the orange aphid⁵⁹ on citrus fruit generally, the chrysanthemum aphid,⁶⁰ the

⁴⁵ Hemiptera. ⁴⁶ *Pyrginus maidis*. ⁴⁷ *Pseudococcus saccharifolii*. ⁴⁸ *Pseudococcus sacchari*.
⁴⁹ *Aphis sacchari*. ⁵⁰ Hemiptera. ⁵¹ *Aphis sacchari*. ⁵² Aphidæ. ⁵³ *Pentalonia nigronervosa*.
⁵⁴ *Idiopterus nephrolepidis*. ⁵⁵ *Ceratophis lantanæ*. ⁵⁶ *Macrosiphum roseæ*. ⁵⁷ *Aphis maidis*.
⁵⁸ *Rhopalosiphum violæ*. ⁵⁹ *Myzus citricidus*. ⁶⁰ *Macrosiphum sanborni*.

coffee aphid,⁶¹ the bamboo aphid,⁶² and the cotton aphid,⁶³ occurring on cotton, Hibiscus, cucumber, taro, Portulaca and several other common plants.

The life history of the plant-lice is very interesting, but is exceedingly complicated. Although it differs somewhat in different species, it is always characterized by what is known as an alteration of generations. Thus several broods or generations of a species will appear during the year. Usually the young spring from eggs laid by a female capable of producing fertile eggs without the intervention of males. The females of some species give birth to living young instead of laying eggs. The true males are generally though not always provided with wings, but the true sexual female always has wings which enable her to carry her eggs to a distance and establish a new colony. Several wingless broods will follow one another parthenogenetically, when in course of time true sex individuals will appear⁶⁴ and mate, and the females go elsewhere to establish new colonies. A little study and calculation will show that millions of individuals may result from a single fertilized female in the course of a very few months.

The aphids, as well as many other insects, especially the leaf-hoppers, have the power of secreting a viscous saccharine substance called honey-dew. This they deposit on the surface of the leaves and stems of plants. It thus happens that the sugar-cane aphid and the sugar-cane leaf-hopper have been directly responsible for the increase in the production of honey in Hawaii, as the bees are very fond of this sweetish deposit and gather thousands and thousands of pounds of it annually. In fact, the bees gather so much of this substance that it has been necessary to give to this class of honey from these islands the distinctive name of "Hawaiian honey-dew honey," since honey-dew enters so largely into the composition of the local product. However, algaroba flowers furnish an immense amount of fine-flavored honey that finds a ready market here and elsewhere.

CHAPTER XXXI.

IMPORTANT ECONOMIC INSECTS: PART TWO.

SCALE INSECTS.

The family of scale insects¹ includes the mealy-bugs and scale-bugs, or bark-lice. Like the aphids, they were practically all introduced into Hawaii with some of the host plants on which they are found. They owe their name to the fact that the females of many species look like oval or rounded scales attached to the bark, stems or roots of plants. The sexes are very dissimilar. The adult males, though very rarely seen, are provided with one pair of functional wings, the hind pair being rudimentary. They have rather long an-

⁶¹ *Toxoptera aurantiae*,
¹ *Coccidae*.

⁶² *Aphis bambusae*.

⁶³ *Aphis gossypii*.

⁶⁴ Usually in the autumn.

tennæ and distinct eyes. The females are always wingless and generally, though not always, remain fixed at some one spot. In many species the female soon dies, leaving her body as a protection over the eggs until the young have hatched and begin to rove about in search of food, which they secure by puncturing the plant and sucking up the sap.

Scale insects are more numerous within the tropics than in the more temperate regions. They multiply rapidly and are very injurious to plant life. They infest a large number of fruit and ornamental trees in the islands, and are already firmly established, with representatives of most if not all the more injurious species found on the mainland, as well as from Australia and the Orient. In spite of the precautions taken to prevent their importation, along with other injurious insects, new species occasionally gain an entrance, and it is to be expected that they will continue to arrive in the future.

Like the aphids, their common name is generally derived from the plant infested by them, or at least the one on which they were first discovered or on which they are most prevalent; but it may also refer to the color or shape or some peculiarity of the insect. In addition to the sugar-cane mealy-bug already noted, we have the avocado mealy-bug,² occurring on avocado, fig grape, guava, mulberry, soursop, asparagus, etc.; the ivy scale,³ the oleander white-scale,⁴ occurring on oleander, mango, banana and avocado; the avocado scale⁵ and pineapple scale,⁶ occurring also on the Canna, Hibiscus, and a list of such plants. The last species may be readily distinguished from the Pineapple mealy-bug,⁷ which is a larger insect with a soft body that is white all over and is provided with well-developed legs. The cottony guava-scale⁸ is found on coffee, citrus fruit, etc.; the black scale⁹ on sisal and Ceara rubber; the cotton or globular mealy-bug,¹⁰ on cotton, grape, citrus fruit, mulberry and other plants; the citrus or common mealy-bug,¹¹ which is one of the common, though by no means the only species of the class infesting citrus fruit in the islands.

Other citrus scales worthy of mention are the Florida red-scale,¹² which also infests bananas, mangoes and palm trees, including the cocoanut; the green-scale¹³ and two or three other species. The large cottony-scale¹⁴ infests coffee, mangoes, oranges and ferns. The flat black-scale¹⁵ occurs on the banana, fig, pepper tree and Ceara rubber. The hemispherical scale¹⁶ and palm mealy-bug¹⁷ are species found on the palms. Others found on the plants for which they are named are the rose scale,¹⁸ the peach scale,¹⁹ the pepper-tree scale,²⁰ also found on wild guava; the bamboo scale,²¹ the croton scale,²² the pit or algaroba scale,²³ the cottony-cushion or fluted scale,²⁴ on the black wattle. The list might easily be extended, but the foregoing will be sufficient

² *Pseudococcus nipa*.³ *Aspidiotus hedera*.⁴ *Phenacaspis eugenie*.⁵ *Aspidiotus persicarium*.⁶ *Diaspis bromelie*.⁷ *Pseudococcus bromelie*.⁸ *Pulvinaria psidii*.⁹ *Saissetia oleæ*.¹⁰ *Pseudococcus flamentosus*.¹¹ *Pseudococcus citri*.¹² *Chrysomphalus ficus* = *Chrysomphalus nonidum*.¹³ *Coccus viridis*.¹⁴ *Pulvinaria mammeæ*.¹⁵ *Saissetia nigra*.¹⁶ *Saissetia hemisphenica*.¹⁷ *Pseudococcus* sp.¹⁸ *Aulacaspis rosæ*.¹⁹ *Aulacaspis pentagona*.²⁰ *Aspidiotus lantania*.²¹ *Asterolecanium mliaris*.²² *Lepidosaphes pallida*.²³ *Asterolecanium pustulans*.²⁴ *Icerya purchasi*.

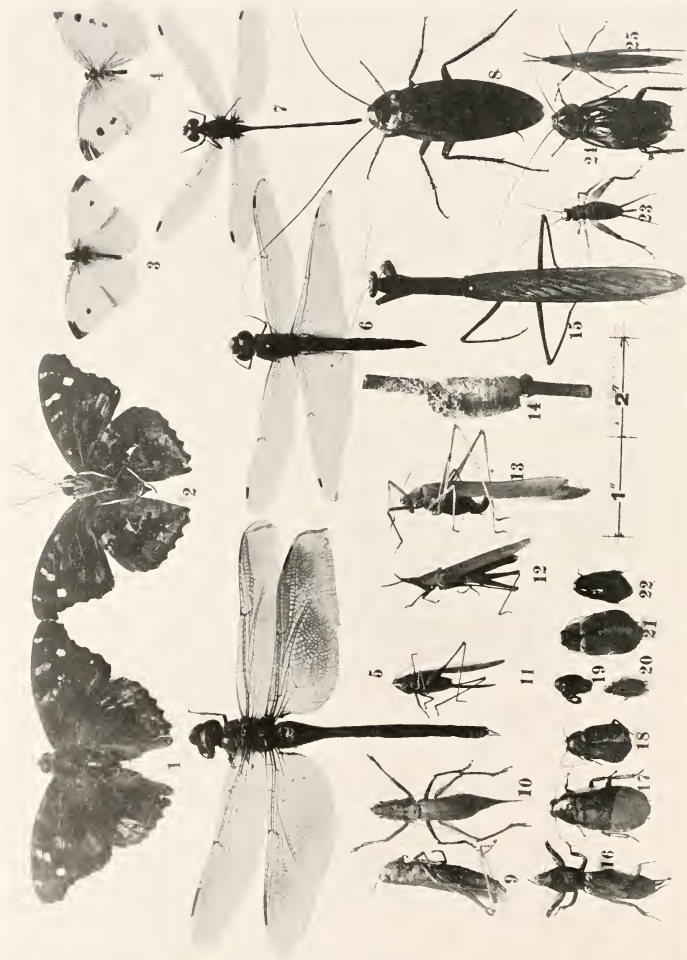


PLATE 97. CONSPICUOUS HAWAIIAN INSECTS.

(FOR DESCRIPTION OF PLATE SEE OPPOSITE PAGE.)

to show that the scale insect life of Hawaii levies a heavy tax on plant growth in the islands.

Fortunately, the experience of the orange growers of California in their successful attempts at curbing the invasion of a scale²⁵ which had been accidentally introduced from Australia and had spread with great rapidity, was turned to account in Hawaii. The plan of checking injurious insects by their natural enemies in that State, in the above instance, was so signally successful that Mr. A. Koebele, who was in charge of the work, was induced to come to the islands to put into operation the natural enemy method of warfare which has since won many brilliant battles against the injurious insect pests in the interest of the Territory.

THE LADYBIRD BEETLES.

Under Mr. Koebele's guidance, with the aid of his associates, many beneficial insects have been brought to Hawaii from the most remote quarters of the earth. Few, however, have been more generally useful in their habits than those of the ladybird beetle²⁶ family. The "ladybirds" as they are familiarly known, are small, more or less hemispherical beetles that vary greatly in color, but most often are red, yellow, black or steel blue, and are usually, though not always, mottled or spotted with bright colors. The larvæ are sometimes spotted, but more commonly are marked with warts and spines. There are more than a thousand species, some of which are found in the native fauna of almost every part of the world except Hawaii. As most of the species are predaceous, both in the adult and larval form, and are especially fond of the plant aphids, mealy bugs and scales, their introduction into the islands has been going on steadily for years. A long list has been liberated, and the individuals have established themselves to such an extent that there is scarcely an ornamental plant, fruit or shade tree in Hawaii on which these useful insects cannot be found by a close observer, at some time during the day. The more common species have suggestive, descriptive names that aid the observer in his efforts to identify the insects at sight. Among those easily recognized are the yellow-shouldered ladybird,²⁷ the ten-spotted ladybird,²⁸ the vedalia ladybird,²⁹ which was first successfully introduced from Australia into California to feed on the fluted scale, and from there brought to Hawaii as early as

²⁵ *Icerya purchasi*.

²⁶ *Coccinellidæ*.

²⁷ *Platyomus lividigaster*.

²⁸ *Ceolophora pupillata*.

²⁹ *Norius cardinalis*.

DESCRIPTION OF PLATE.

1. Kamehameha Butterfly (*Vanessa tameamea*). 2. Kamehameha Butterfly (*Vanessa tameamea*) inverted. 3. Cabbage Butterfly (*Pontia rapæ*). 4. Cabbage Butterfly (*Pontia rapæ*) inverted. 5. Dragon Fly (*Anax junius*). 6. *Pantala flavescens*. 7. *Sympetrum blackburni*. 8. *Periplaneta americana*. 9. *Orya vclor*. 10. *Brachymetopa discolor*. 11. *Xyphidium varipenne*. 12. *Atractomorpha crenaticeps*. 13. *Elimaea appendiculata*. 14. *Paratenodera siucensis*; (Egg case). 15. *Paratenodera siucensis*. 16. *Gryllotalpa africana*. 17. *Leucophaea surinanesis*. 18. *Eleutheroda dytiscoides*. 19. *Euthyrhapha pacifica*. 20. *Phyllodromia hieroglyphica*. 21. *Eleutheroda dytiscoides*. 22. *Eleutheroda dytiscoides*; (Nymph). 23. *Gryllodes poeyi*. 24. *Periphanta australasia*. 25. *Atractomorpha crenaticeps*.

1887; the steel-blue ladybird,³⁰ the ochreous ladybird,³¹ the eight-marked ladybird³² and the mealy-bug or "Brownie" ladybird.³³

THE JAPANESE BEETLE.

While the ladybirds belong to a family in the order of beetles,³⁴ and are among the most beneficial members of that great order, they are by no means so typical in appearance as is the injurious Japanese beetle,³⁵ which is an exceedingly troublesome and aggressive pest in orchards, gardens and door-yards. By reason of its ravenous appetite for the leaves of certain plants, especially roses, foliage plants, strawberries, grapes, cotton, tobacco, certain grasses and a long list of other cultivated trees, shrubs and plants, it is one of Hawaii's worst introduced pests.

They are ordinary-looking, grayish-brown beetles, a little over a half inch in length, with a broad flat head. They are night feeders, hiding by day under the loose earth about the roots of plants and under boards and rubbish. Many attempts have been made to rid the country of this pest since it first became troublesome about 1890. Perhaps the most successful enemy has been a certain fungus that has now been well distributed to all parts of the group. Like all fungi, it is a plant of low order which grows in threads.³⁶ After a certain period of growth some of these threads "fruit," producing small sacks packed full of minute granules known as spores. The spores are very light and small, and are blown about or carried by birds and insects. Some fungi are injurious, especially such species as grow on the mango and the coffee, but the one in question is beneficial, since it grows in the body of the Japanese rose beetle and, if conditions are favorable as to moisture and so on, it will eventually kill the insect. Dead beetles show the whitish or greenish fungi about the numerous joints of the body and legs. In a few days after death the spores develop and the fungus turns greenish and the disease is then readily communicated from the dead infected insects to healthy ones.

The disease can be easily distributed by simply capturing a supply of beetles and placing them in a secure box partly filled with moist earth. The box should be set in a cool, shady place and the insects fed on any of the weeds or plants of which they are fond. When they die and the greenish mold appears, the dead beetles should be mixed together with dry earth and sand and distributed about the garden or under bushes attacked by the beetles.

FULLER'S ROSE BEETLE.

Fuller's rose-beetle,³⁷ or the "Maui" or "Olinda" beetle, introduced from America, is an oval black snout-beetle about a half inch in length that, by reason of the extensive range of its food plants of native and introduced species, makes it a serious pest. The only parasite so far known is the larvæ of a certain click beetle introduced to feed upon it. Toads have doubt-

³⁰ *Oreus chalybeus*. ³¹ *Chilocorus circumdatus*. ³² *Cyclophora inaequalis*.

³³ *Cryptolarymus montrouzieri*.

³⁴ *Coleoptera*.

³⁵ *Adoretus tenuimaculatus*.

³⁶ *Mycelia*.

³⁷ *Aranicus fulleri*.

less had a beneficial effect, however, and the pest is not so serious as in former years.

Many species of smaller introduced beetles do more or less damage to various cultivated plants or stored commodities. Among the more common, or those liable to attract attention, are the rice weevil,³⁸ the coffee-bean weevil,³⁹ the rust-red flour beetle⁴⁰ on rice, the sisal weevil;⁴¹ the cadelle beetle,⁴² a whitish grub destructive to stored products, as rice; the tobacco leaf-beetle,⁴³ the carpet beetle,⁴⁴ the cigarette beetle;⁴⁵ the mango weevil,⁴⁶ supposed to have been introduced in 1903; the bean weevil,⁴⁷ the common ground beetle,⁴⁸ the algaroba bean weevil,⁴⁹ and the algaroba pod weevil,⁵⁰ both feeding on algaroba beans. In addition there are long-horned beetles of several species on algaroba, black wattle and various other trees, as well as numerous species of bark beetles—but a sufficient number have been enumerated to indicate the nature of the imported pests in this order of insects.

LEAF-ROLLING MOTHS.

Mention has been made of the sugar-cane leaf-roller⁵¹ as an injurious moth belonging to the order Lepidoptera. With it might be considered the cocoanut leaf-roller,⁵² which is especially destructive to the cocoanut leaves, and the common banana leaf-roller,⁵³ one of the four species that infest the banana plants to some extent. All three are native species belonging to a genus of twelve or more species of fair-sized, brown moths that occur in Hawaii and nowhere else, and that are peculiar in their leaf-rolling habits. The larvæ or caterpillar of all species are very similar in appearance, varying in size in proportion to the adult. They feed voraciously on the green leaves during the period of growth and fold the leaf by fastening two portions together with silken threads. When full grown, which requires three or four weeks usually, they change to the pupa within the folded leaf and remain dormant for one or two weeks.

The ragged, unsightly edges on palm leaves, especially of the cocoanut palm, is the result of the work of this leaf-roller. As it is abundant, and the largest species of the genus, it is readily collected and studied. The egg masses, with thirty to eighty eggs in a cluster, are placed along the midrib on the new leaves as they open. As from four to six broods are reared in a year, the work of defoliation continues as rapidly as the palm puts out new leaves. The mynah bird is very fond of the larvæ of the palm leaf-roller and without doubt helps to reduce their numbers.

The bean leaf-roller⁵⁴ feeds on several species of native beans, including the wiliwili, and to some extent on garden beans. In feeding they hold the leaves together with a silken thread and eat the inner surface of the leaf, leaving the outer surface undisturbed.

Some of the species of this genus, including the sugar-cane leaf-roller, are

³⁸ *Calandra oryza*. ³⁹ *Aracesus fasciculatus*. ⁴⁰ *Tribolium ferrugineum*. ⁴¹ *Pseudolus longulus*.
⁴² *Tenebroides muritanicus*. ⁴³ *Epityx parvula*. ⁴⁴ *Anthrenus scrophulariar*.
⁴⁵ *Lasioderma serricorne*. ⁴⁶ *Cryptorhynchus mangifera*. ⁴⁷ *Bruchus prosopis*.
⁴⁸ *Ompatrum serratum*. ⁴⁹ *Bruchus prosopis*. ⁵⁰ *Caryoborus gonagra*. ⁵¹ *Omiodes accepta*.
⁵² *Omiodes blackburni*. ⁵³ *Omiodes megricki*. ⁵⁴ *Omiodes monogona*.

grass feeders, while two species feed exclusively on sedges. The genus *Omiodes* have been extensively studied by economic entomologists, who find the caterpillars of the species are attacked by a number of parasites, some of which are native, but several of the most valuable have been introduced. The cane leaf-roller and the palm leaf-roller are the two most injurious species. The parasites do much good, but at certain seasons, especially in winter, and in certain localities the caterpillars get the start of their enemies, and one or two broods appear before parasites are abundant enough to check them.

Sometimes as high as ninety per cent of the caterpillars are found to be parasitized. One might ask, "Why are they not completely exterminated or, at least, why do they continue to do so much damage?" The answer seems to be that, although they have many enemies that prey upon them, they are still prolific enough to overbalance their enemies. It is difficult to estimate the damage they would do were they entirely free from their burden of parasites.

CUTWORMS.

Cutworms of various species are a serious agricultural drawback, as they attack corn, tobacco, cotton, cabbage, wheat and other useful plants, nipping the young plants off at the surface of the ground before they have fairly started. There are several species of these night marauders, but they all belong to a family of owl moths or Noctuids (*Noctuidæ*), one of the largest groups of the order *Lepidoptera*. They feed at night in the larval stage and fly by night in the adult stage, often being attracted by lights. The fact that their eyes shine brightly in a dim light and that they are seldom seen in the daytime has resulted in the popular name for the adults, while the unfortunate habit of the larvæ has given them the unenviable name of cutworms. The species are mostly small-sized, dull-colored moths. The most troublesome species in Hawaii are the widely-known and doubtless introduced black or corn cutworm⁵⁵ with the hind wings greenish; and a second species, a large native cutworm,⁵⁶ with fuscous-colored hind wings, both being plentiful on corn and other field crops. A third species known as the small native cutworm⁵⁷ is also common. They are kept in check in Hawaii to some extent by their natural enemies, which include both parasites and birds, but as there are two or three dozen native species, the caterpillars of all of which resemble each other and have similar habits, it is difficult to identify the species that feeds on the various crops and weeds, even when adult specimens are secured.

ARMY-WORMS.

The widely-known army-worm,⁵⁸ with its cousins the grass army-worms,⁵⁹ at times do much damage to grass and forage crops. They appear in great numbers occasionally, and after destroying the vegetation in the field where

⁵⁵ *Agrotis ipsilon* ⁵⁶ *Agrotis crinigera*. ⁵⁷ *Agrotis dislocata*. ⁵⁸ *Heliothela unipuncta*.
⁵⁹ *Spodoptera mauritia* and *Spodoptera exigua*.

they hatch from the eggs, they march like an army to other fields. The worm of the common species, which occurs in America and elsewhere, is an inch and a half in length when full grown and is striped with black, yellow and green. The adult moth is dull brown in color, marked in the center of each fore-wing with a small distinct white spot. The two species of grass army-worms occurring here are widely distributed, especially in the Pacific islands and continents.

THE HAU MOTH.

The hau moth ⁶⁰ is also a wide-ranging species occurring in Africa, south Asia and Fiji. It can scarcely be separated by the layman from another more local species. However, as it confines its depredations quite closely to the hau and allied plants, it can be recognized as the small brown moth which develops from the caterpillar that feeds so voraciously on the leaves of that picturesque tree. Its principal enemy is an ichneumon fly that destroys them by depositing its eggs in the body of the caterpillar.

LOOPERS.

Several species of measuring worms or span worms, belonging to the family *Hydriomenida*, occur in the islands. The koa is often attacked by them and the trees seriously defoliated, but so far as known they are not a serious economic pest. A species of the group *Plusiada*, known as the corn looper,⁶¹ or green garden looper or owlet moth, attacks wheat and corn and other plants, often fraying the leaves to a considerable extent.

The larvæ of the kolu-bush moth ⁶² are to be found in the pods which follow the beautiful little golden ball-like blossoms. They feed upon the seed and doubtless keep this thorny shrub from spreading as rapidly as it otherwise would.

THE SILKWORM.

An exceedingly useful insect, long ago introduced into Hawaii, is the silkworm.⁶³ The first specimens were imported by the missionaries with a view to encouraging the natives to take up this form of productive occupation. The experiment was given up, however, before anything definite came of it. Some say that the pious and faithful observance of the Sabbath as taught by the Christian fathers prevented the natives from gathering the fresh leaves to feed the worms on that day.

More recent experiments have proved beyond a doubt that silk of a good quality can be produced in Hawaii with as little effort as in any silk country in the world. The mulberry, especially the white mulberry,⁶⁴ does well in Hawaii. As the leaves of this plant are the favorite food of the worms, it is anticipated that silk culture will yet flourish in the islands as one of the home occupations for the employment of women and children.

⁶⁰ *Cosmophila sabulifera*.

⁶¹ *Plusia chalcites*.

⁶² *Cryptophlebia illepidia*.

⁶³ *Bombyx mori*.

⁶⁴ *Morus alba*.

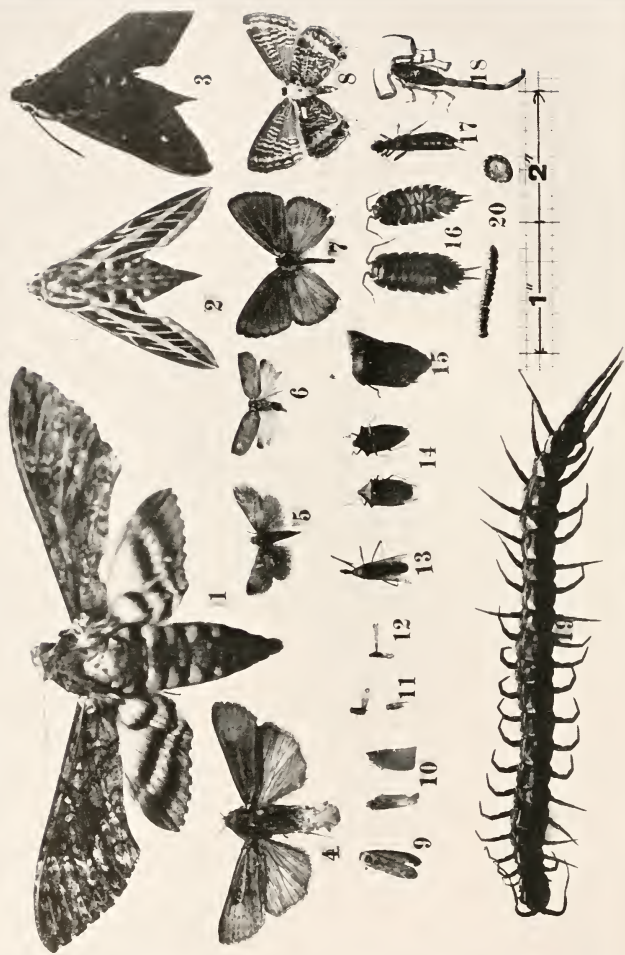


PLATE 98. SOME COMMON INSECTS AND THEIR RELATIVES.
(FOR DESCRIPTION OF PLATE SEE OPPOSITE PAGE.)

The newly-hatched larvæ of the silkworm is black or dark gray and covered with long, stiff hairs. But as the worm moults it becomes lighter and lighter in color until during the last of the larval period it is creamy white. The cocoon is spun by the worm about itself as a protection and a retreat in which to pupate. It ranges in color through several shades of white, green cream and rose, and varies greatly in size. To secure the silk the cocoons are heated in water or in an oven until the insect is killed; the end of the thread is then secured and the cocoon unwound. The adult insect is a beautiful creamy white moth with two or more distinct brownish lines across the fore wing, and with the abdomen and thorax thickly covered with wooly scales.

From two to three thousand years before the Christian era, probably five thousand years ago, the silkworm was well and favorably known in the Far East where, in China, silk culture was a well-established industry.

THE CABBAGE BUTTERFLY.

The slender green cabbage-worm in due time becomes a cabbage-butterfly,⁶⁵ and is the white butterfly commonly seen about gardens in the islands. It was doubtless introduced from America, where it has long been an introduced pest. It was first observed in the islands about 1900, and is therefore known as the imported cabbage worm. The species is kept under control in Hawaii by parasites, among them a very minute fly.⁶⁶

THE SWEET POTATO HORN-WORM.

A conspicuous insect, liable to attract attention, first in the larval state, as the large green or brownish horn-worm on sweet potato, and certain morning-glory vines, and later as the humming-bird moth that flies about our electric lights, is in reality the sweet potato sphinx-moth or sweet potato horn-worm.⁶⁷ The worm-like caterpillars often attain a length of three or four inches and are voracious feeders, stripping the leaves from the plants infested. The moth, by reason of its size and the whirring noise produced by its wings, is usually called the humming-bird moth. It measures about three and a half inches across the extended wings, and is the largest common moth in the islands.

THE COTTON BOLL-WORM.

The cotton plant in Hawaii, if it successfully survives the attacks of stem maggots, wireworms, cutworms, aphids, Japanese beetles, mealy bugs, scales and leaf-rolling caterpillars is liable at last to the attacks of the pink cotton

⁶⁵ *Pieris rapæ*. ⁶⁶ Tachinid. ⁶⁷ *Protoparce* = (*Sphinx*) *convoluti*.

DESCRIPTION OF PLATE.

1. Sphinx, or Humming-bird Moth (*Sphinx convoluti*). 2. *Deilephila lineata*. 3. *Deilephila calida*. 4. *Agrotis crinigera*. 5. *Pyralis mauritalis*. 6. *Amorbia emigratella*. 7. *Lucana boetica*. 8. *Lucana boetica* (inverted). 9. *Ethmia colonella*. 10. *Siphanta acuta*. 11. *Perkinsiella saccharicida*. 12. *Peregrinus maidas*. 13. *Zelus renardii*. 14. *Echalia grisea*. 15. *Colletichus blackburniae*. 16. Slater or Pill-bug (*Porcellio scaber*). 17. *Anisolabis annulipes*. 18. Scorpion (*Isometrus maculatus*). 19. Centipede (*Scolopendra rapens*). 20. Millipede (Species indet.).

boll-worm,⁶⁸ which is by far the most destructive enemy of the cotton plant. There seems to be no doubt but that it was introduced directly or indirectly from India within comparatively recent times. It does the damage in the caterpillar stage, when, as its name implies, it attacks and feeds on the lint and seed of the cotton in the ball before it is open, practically destroying the boll so far as its lint is concerned. The moth is about three-fourths of an inch across the expanded wings, and is soft gray-brown in color, with darker markings; the fringe on the hind wings being wider and paler brown than on the front wings.

LICE.

The various flies that annoy human beings and their domestic animals have been briefly mentioned above, but other introduced animal pests occur and are as troublesome here as elsewhere. Among them are a number of species of lice. The term "lice" is loosely applied to representatives of two orders of insects. Those occurring on poultry and wild birds are properly called bird-lice,⁶⁹ although some species infest sheep and goats also. They are wingless parasitic insects with biting mouth-parts enabling them to feed upon and live among the bird's feathers. The turkey-louse⁷⁰ and the chicken-louse are examples of this class. The family *Pedicula*, including the true lice, belongs to a sub-order⁷¹ of the great order *Hemiptera* and includes certain parasites of man and other animals. They differ from the bird-lice in having sucking mouth-parts. They live among the hair of their host animal, feeding on its blood. Three species are known that are parasitic on man; one lives in the hair on the head⁷² and two, a body louse⁷³ known as the "gray-back" and the crab-louse,⁷⁴ on the body. While the more common species elsewhere are those found on the horse or a second species occurring on the cow, they have not as yet been reported in Hawaii. Almost every animal has a species of louse, though they are not always attached to all host animals. The hog-louse,⁷⁵ for example, is reported as occurring here in limited numbers, while other species doubtless to be found here have not yet been taken.

TICKS AND MITES.

It should be mentioned in this connection that ticks are often confused in the popular mind with lice, although they more properly belong with a distinct division of the branch⁷⁶ of the animal kingdom which includes the insects, spiders, scorpions, centipedes, crabs and lobsters. In all of these the body is composed of a series of segments joined together, with some of the segments bearing jointed legs. In the order⁷⁷ to which the mites and ticks belong the abdomen is unsegmented and is united to the thorax, giving the body a sack-like appearance.

The order including the mites is represented in Hawaii, but as yet only

⁶⁸ *Gelechia gossypiella*. ⁶⁹ *Mallophaga*. ⁷⁰ *Goniodes stylifer*. ⁷¹ *Parasita*. ⁷² *Pediculus capites*.
⁷³ *Pediculus vestimentalis*. ⁷⁴ *Phthirus pubis*. ⁷⁵ *Haematopinus urius*. ⁷⁶ *Arthropoda*.
⁷⁷ *Acarina*.

nine species, all belonging to one family,⁷⁸ have been determined, six of which are already known from the British Isles. But as the largest species⁷⁹ is but a millimeter in length and has only been reported from Kona, on Hawaii, they are too small to attract attention from collectors. As they occur, however, it is well to know that the common species⁸⁰ appears to be generally distributed throughout the mountains of the group.

Most of the ticks are small eight-legged creatures, though the number of legs vary with age and the mode of life of the parasite. The chicken mite is an example that occurs in Hawaii on poultry; the dog-tick⁸¹ on the dog; the so-called red spider⁸² occurring on cotton plants, and the true itch mite,⁸³ causing an irritation of the skin of human beings known as itch, are well-known examples of the species of the order.

FLEAS.

The flea is a tiny insect belonging to the order *Siphonaptera*, and is suggestive of the household pests of which Hawaii has its full quota. As has been the case with the insects affecting the field, forage and garden plants and our domestic animals, the household pests have practically all been introduced since the islands were discovered. Fleas were among the early arrivals, and may be said to abound in certain localities, especially dry elevated places. The native name (Ukulele) for a "jumping louse" was early applied to this tormenter, which is one of the few insects it is not necessary to see in order to identify. While they occur about houses and bite the inmates and their pets, the species most commonly captured are the cat-flea or the dog-flea,⁸⁴ though the common human species⁸⁵ doubtless occurs.

PLAGUE CARRIED BY FLEAS.

One of the many brilliant medical achievements for which the closing years of the last century were especially noted, was the discovery that the flea that lives on the common rat is responsible for the spread of the dread bubonic or black plague. It has been proved over and over again that rats die of this disease and that the fleas which infest them and feed on their blood draw the minute organism causing the disease into their bodies in such a way that they can communicate the plague to other rats and to other animals, among them man, by their bite. Cases are on record where death from plague has been traced to its origin only to find that it came from flea bites. Fleas usually leave the carcass of a rat that has died of plague and at the first opportunity take up their abode on some living animal, as the cat or dog. From these pets they are easily transferred to their masters, with the result that their bite may convey the minute microscopic organism⁸⁶ that causes plague in the human body. Plague has appeared on more than one occasion in Hawaii,⁸⁷ and to all appearances has been successfully stamped out. Nevertheless, it is well for

⁷⁸ *Oribatida*. ⁷⁹ *Oribata oriformis*. ⁸⁰ *Neoliods thelepraectus*. ⁸¹ *Rhipicephalus sanguineus*.

⁸² *Tetranychus* sp. ⁸³ *Sarcoptes scabiei*. ⁸⁴ *Ctenocephalus canis* = *Pulex canis*. ⁸⁵ *Pulex irritans*.

⁸⁶ *Bacillus pestis*. ⁸⁷ Notably during the winter of 1900.

people living in the tropics to rid their premises of rats and to keep at respectful distances from pet animals that may feed upon them.

COCKROACHES.

Mosquitoes and flies as domestic pests have been mentioned as members of the order *Diptera*, and have been discussed in another connection. Cockroaches, of which there are several introduced species, are annoying pests. Two species, the American⁸⁸ and the Australian⁸⁹ cockroach, are both found in houses, most commonly infesting kitchens and pantries, attacking provisions of all kinds besides doing much damage to book bindings in the library. They emit a disgusting smell and are otherwise objectionable to everyone. They resemble one another very closely, but vary in color and appearances as they develop. The American species is about two inches in length, the latter a trifle smaller.

BEDBUGS AND OTHER BUGS.

The bedbug,⁹⁰ as everyone knows, is a nocturnal insect. It occurs the world over and, therefore, is occasionally found in Hawaii. It seems that, although it has very rudimentary wings, it has nevertheless been able to keep up with the march of human progress. They have certain characteristics that make them members of the order of true bugs.⁹¹ In the same order are placed the torpedo-bug,⁹² a green-winged, long, pointed leaf-hopper, injurious to mangoes, guava and coffee, and the more attractively-named Hawaiian kissing-bug,⁹³ which in reality is the common assassin-bug that first appeared in the islands about 1897. Since then, contrary to the character its local name seems to imply, it has maintained a reputation as a fierce carnivorous bug, feeding among other things, on ladybirds, leaf-hoppers and aphids, without discrimination between the beneficial and injurious insects.

WHITE ANTS.

The termites, more commonly termed white ants,⁹⁴ that at certain seasons fly about in large swarms and at all seasons bore into the timbers of houses, are not ants, nor are they more than remotely related to the true ants. They have been placed by many entomologists, by reason of all four wings being equal in size, form and structure, in a separate order.⁹⁵ It is true that they have certain social habits that are similar to the ant's, but their structure is very different, as anyone can see by comparing the two insects. Their communities are made up of many individuals that have a definite part of the colony work to do. Each class is fitted by nature with special reference to the task it must perform. Kings, queens, soldiers and workers live together in their many-chambered nests. Their nests are hollowed out of the timbers in which they carefully eat out the interior, leaving an outer shell in such a

⁸⁸ *Periplaneta americana*. ⁸⁹ *Periplaneta australasiae*. ⁹⁰ *Cimex lectularius*. ⁹¹ *Hemiptera*.
⁹² *Siphanta acuta*. ⁹³ *Zelus renardii*. ⁹⁴ *Calotermes marginipennis*. ⁹⁵ *Isoptera*.

manner as to exclude the light. In this hidden way they do a great many thousand dollars' worth of damage to houses in Hawaii every year. In some cases the heart of the timbers that formed the building have been so badly eaten that in time the structure has actually fallen in pieces, leaving only a sad heap of ruins as a monument to the silent industry of these destructive creatures.

SILVERFISH.

Silverfish, fish-moths, or bristletails⁹⁶ are everywhere household pests, and Hawaii is not an exception. The small, flat, silvery object without wings that scurries out of sight in the dresser drawer or on the book-shelf is sure to be one of these evildoers that cannot resist the taste of starch, no matter whether it be in clothing, book-bindings or wall-paper. In structure the silverfish represents the simplest type of insects, and is peculiar for the reason that it does not go through any marked changes⁹⁷ as it develops. It is therefore placed by entomologists in the lowest, meaning the oldest and most simple, order⁹⁸ of insects.

ANTS.

As types of the highest development and specialization in the insect world, the ants, bees and wasps are placed together in a great order⁹⁹ at the opposite end of the scale from that occupied by the silverfish. The ants, the bees and the wasps each furnish the housewife one or more pests to annoy her. Of these, the ant family¹⁰⁰ furnish a number, the most troublesome being the cosmopolitan big-headed ant¹⁰¹ that invades every nook and corner of the house and considers the food-safe and ice-box as institutions especially provided for its comfort and convenience. They will not cross water, however, so the experienced housewife places the legs of the ice-box in shallow cups filled with water and takes pains to keep the box clear of the wall. The table, safe and sideboard can be equally well protected for months at a time by tying about each leg a narrow strip of woolen cloth, which has been soaked with "ant poison," a preparation sold by the druggist for the purpose. The ants respect the poisoned string as a dead-line and rarely pass beyond it. Another common species is the big brown ant¹⁰² observed swarming on warm, still nights, when all forms issue in great numbers.

CARPENTER-BEES.

Of the bees, the blue-black carpenter-bee,¹⁰³ which resembles the bumble-bee in size and somewhat in appearance, is conspicuous and troublesome in Hawaii by reason of its habit of building its cells in the solid wood of trees, porch posts, fence posts, telephone poles and the like. It often excavates a tunnel a foot or two in length in which it lays its eggs. Each egg is contained

⁹⁶ *Lepisma saccharina*.

¹⁰¹ *Pheidole megacephala*.

⁹⁷ Metamorphosis.

¹⁰² *Camponotus maculatus*, var. *hawaiiensis*.

⁹⁸ *Thysanura*.

⁹⁹ *Hymenoptera*.

¹⁰⁰ *Formicina*.

¹⁰³ *Xylocopa brasiliatorum*.

in a separate compartment provisioned with bee-bread—a food made of the pollen from flowers mixed with nectar. It has been observed that they gather their supply of pollen principally from the bean-like plants. This bee was introduced long ago and is widely distributed throughout the group.

WASPS AND MUD-DAUBERS.

Of the wasps, the species known as the mud-dauber,¹⁰⁴ a species introduced from America, is the one causing the most annoyance about the home. It makes its nest of mud, which it delights in plastering under the eaves of houses, on the ceilings of lanais, and in similar places. Their nests usually have the form of several tubes an inch or more long placed side by side, which are always provisioned with spiders. This family of wasps¹⁰⁵ is known as the thread-waisted wasps, an allusion to the peculiar shape of the body. They have a curious habit of jerking their wings frequently in a nervous manner, which is also quite characteristic.

The paper wasps¹⁰⁶ are those that build their nests in a single circular comb suspended by a slender central support from the under side of the rafters, or from under the leaves of bushes in the yard and garden. Three closely-related species are quite common in Hawaii, but the bright yellow species¹⁰⁷ is the most savage; the browner species¹⁰⁸ is said to be less so. Children soon learn to respect the rights of these "yellow jackets," as they are commonly called, and never forget the lesson usually learned at first hand from disturbing one of the gray paper nests that are so zealously guarded by the wasp inmates against all who venture to intrude on their domain.

If unmolested, however, the little colony will sit for hours at a time on their paper home without attempting to sting anyone. After the young have grown up they abandon the nest but remain about here and there until the following February, when they organize for business and proceed to make a new nest, securing the silver-gray "pulp" used in its construction from fence-posts, boards and dead wood generally.

THE HONEY-BEE.

The honey-bee,¹⁰⁹ although not a household insect, is so intimately associated with our domestic life that it may not be out of place to direct attention to it as representing the highest group of the most exalted order of insects. As an example of social life among insects, bees have been studied by naturalists for centuries, until there is probably no other insect of which man has such an intimate acquaintance. They furnish a subject of interest about which fascinating volumes have been written, and afford an ever-present object-lesson in community life among our insect friends. By reason of their useful products they have long been of great economic importance to man. In Hawaii alone the annual output of honey is valued at tens of thousand of dollars.

¹⁰⁴ *Sceliphron cementarium*. ¹⁰⁵ *Sphegidae*. ¹⁰⁶ *Vespidae*. ¹⁰⁷ *Polistes hebraeus*. ¹⁰⁸ *Polistes aurifer*.
¹⁰⁹ *Ovis mellifica*.

THE CLOTHES-MOTH AND OTHER HOUSEHOLD PESTS.

The clothes-moth¹¹⁰ is the dread of every housewife, and any harmless little moth that ventures indoors by accident or otherwise is usually condemned to instant destruction lest a single guilty one should escape. Practical experience has proved this to be the best rule to follow. At any rate, a moth that seeks out the dark corners of the closet and bureau drawers and hides itself away in clothing is not to be trusted, nor should such places of concealment to be long neglected for fear the adult moth that is killed has already deposited her eggs. From the eggs of the clothes-moth in due time will emerge the characteristic brownish-black voracious caterpillar that feeds on the fabric and also uses the material for the construction of the husk-like case in which it assumes the chrysalis state.

Besides the clothes-moth to annoy the housewife there is the closely-related angoumois grain-moth¹¹¹ that attacks stored rice. Other enemies that occur in stored products and supplies in Hawaii are rice-weevils,¹¹² bean-weevils,¹¹³ red-rust flour-beetles,¹¹⁴ ham and cheese maggots,¹¹⁵ bamboo beetles,¹¹⁶ bone-meal beetles,¹¹⁷ bakery beetles,¹¹⁸ cigarette beetles,¹¹⁹ and the cadelle or meal-worm,¹²⁰ a small beetle that is world-wide in its distribution.

CENTIPEDES.

While discussing the more familiar household insects, allusion should be made to several other small creatures that, although they are not insects, belong with the insects to the great branch *Arthropoda*—a group that, as we have seen, has been made to include all such creatures as have bodies composed of a linear series of rings or segments bearing paired, jointed appendages that are articulated with an external skeleton.

The common venomous centipede¹²¹ is an example of the *Chilopoda* that may be recognized at a glance by the fact that each segment of the body bears a single pair of legs. The poison glands open through the claws of the first pair of legs. These are bent forward so as to act with the mouth parts. While the bite of a centipede in Hawaii is extremely painful, as many can testify, it is not dangerous, and may be counteracted by the use of ammonia, or it is said that, in the absence of that chemical, relief may be had by pounding the centipede itself into a jelly-like mass and binding it onto the bite. A centipede bite may be at once identified from the sting of any other creature by the fact that the pincer-like legs make a pair of punctures in the skin of the person "bitten." The distance between the punctures furnish a fair index as to the size of the specimen inflicting the injury.

Centipedes are predaceous in habit, feeding on insects generally, but especially on cockroaches. They usually live in moist, dark places under sticks, boards, stones, and in crevices in the bark of trees during the daytime.

¹¹⁰ *Tinea pellionella*, ¹¹¹ *Sitotroga cereatella*, ¹¹² *Calandra oryza*, ¹¹³ *Bruchus obtectus*.

¹¹⁴ *Tribolium ferrugineum*, ¹¹⁵ *Platyphila casei*, ¹¹⁶ *Dinoderus minutus*, ¹¹⁷ *Dermestes cadaverinus*.

¹¹⁸ *Lophocarenum pusilla*, ¹¹⁹ *Lasioderma serricorne*, ¹²⁰ *Tenebrioides mauritanicus*.

¹²¹ *Scutigerella repens*.

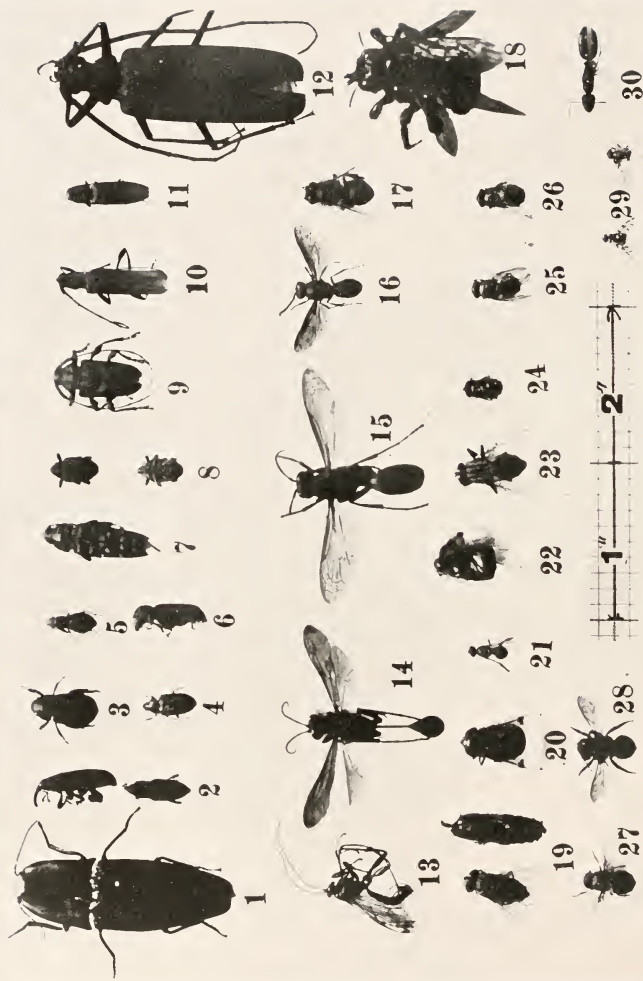


PLATE 99. COMMON BEETLES, BEES, WASPS, FLIES, ETC.

(FOR DESCRIPTION OF PLATE SEE OPPOSITE PAGE.)

but at night they become active and race about rapidly in search of food. They are most troublesome in houses during the long wet spells, for, while they naturally prefer moist situations, they come out of the ground and enter dwellings and outhouses when their ordinary hiding-places become water-soaked.

Centipedes five inches or more in length are not uncommon, and larger specimens are occasionally seen. The large species was introduced as early as 1836, and there has been at least one other small species introduced since.

The young centipedes have a curious habit of clinging to their mother's side when alarmed. The female lays her eggs in clusters on the damp ground in some obscure place, and, coiling herself round them, remains immovable until the young have hatched.

The largest centipedes known come from the East Indies, where they grow to be a foot in length. The centipedes¹²² of the Hawaiian Islands have not been exhaustively studied as yet, but all of the species so far recorded belong to genera that occur elsewhere. Four species belonging to three families were collected in the Hawaiian mountains by Dr. Perkins, three of which are described as new in the Fauna Hawaiiensis.

SCORPIONS.

At least one introduced species of scorpion¹²³ is quite common in Hawaii, where specimens frequently attain a length of three inches. The large species of the order¹²⁴ occurs in tropical Africa and southern India, where a certain big black scorpion may attain a length of eight or nine inches. The poison sting is located in the tip of the long slender tail, which is carried curled in a menacing fashion over the back.

When the scorpion comes in contact with any creature suited to its taste as food it will seize it in the vise-like grip of the pincer claw. The tail is brought into use and the sting on its tip is plunged into its prey. Small animals, insects and the like as a rule quickly succumb to the paralyzing effect of the poison. As the scorpion has no antennæ to use as feelers, it always carries its pincers well to the front.

Scorpions are night feeders and are exclusively carnivorous, feeding mainly on small insects; silverfish, moths and caterpillars being among their favorite food. Unlike the centipede, they prefer dry, dark places, and for that

¹²² Chilopoda. ¹²³ *Isometrus maculatus*. ¹²⁴ Scorpionida.

DESCRIPTION OF PLATE.

1. *Chalcolepidius erythroloma*. 2. *Rhabdocnemis* = (*Sphenophorus*) *obscurus*. 3. *Adorcetus tenuimaculatus*. 4. *Epitragus diremplus*. 5. *Aramigus fulleri*. 6. *Bostrichus migrator*. 7. *Clytus crinicornis*. 8. *Cryptorhynchus mangifera*. 9. *Coptops edificator*. 10. *Xystrocera globosa*. 11. *Simodactylus cinnamomeus*. 12. *Egosoma reflexum*. 13. *Echthromorpha maculipennis*. 14. *Pelopaeus camentarius*. 15. *Polistes hebraeus*. 16. *Odynerus nigripennis*. 17. *Apis mellifica*. 18. *Xylocopa braziliensis*. 19. *Chatogaedia monticola*. 20. *Toluceella obesa*. 21. *Dacus cucurbita*. 22. *Gastrophilus equi*. 23. *Sarcophaga barbata*. 24. *Calliphora dux*. 25. *Lucilia sericata*. 26. *Lucilia casar*. 27. *Anthomyia* sp. 28. *Megachile diligens*. 29. *Ceratitis capitata*. 30. *Camponotus maculatus*.

reason are much more liable to be found in bureau drawers, in loose papers and litter, in empty boxes and similar places about the house. When first born the tiny scorpions closely resemble their parent. They cling to her body and are carried about for a long time before they begin to shift for themselves. The sting of the species occurring in this group of islands is not dangerous, though it may be very painful for a few hours.

The false scorpions¹²⁵ are also represented by four minute species, two of which are described from Hawaii. The largest species¹²⁶ is about five millimeters in length, and, as the name of the order implies, it bears a superficial resemblance to the scorpion.

MILLIPEDS.

The natural order,¹²⁷ including the so-called thousand-legged worms or millipeds, is well represented in Hawaii. The largest species,¹²⁸ which is about two inches in length when full grown, is a comparatively recent introduction, coming presumably from California. So far, it has been reported only from the vicinity of Honolulu, where the sluggish, dark, reddish-brown creature may be seen curled up in damp places, under boards, flower-pots or, less frequently, crawling along the road in the early morning. They differ from the centipede in having the body round instead of flattened and they are also provided with two pairs of legs for each segment of the body. However, the total number of legs falls far short of a million. They are perfectly harmless and may be handled without fear. Their food seems to be vegetable matter, such as tender roots, fruits and succulent plants, and perhaps any decaying organic matter.

The class *Diplopoda*, so far as it has been studied in Hawaii, is represented by at least sixteen species belonging to five families and four orders. Of this list fourteen are described as new and about one-third of the number recorded occur on Oahu. Two introduced species, one the large worm-like milliped mentioned above, and the second a smaller tan-colored animal with two brownish stripes down the sides, are commonly met with. They have the power of emitting a curious characteristic odor. The other members of the class are usually confined to the mountain forests, and are probably peculiar to Hawaii.

SOW-BUGS OR SLATERS.

The curious little oval silver-gray creature found in large numbers in damp places, under boards and stones, is usually an introduced species known to many as the pill-bug, slater, sow-bug or wood-louse.¹²⁹ But of the order *Isopoda* there are nine of ten species belonging to five genera, in the islands, several of which are native. The minute armadillo-shaped arthropods of this order occurring at higher elevations on the islands closely resemble the more common widely-distributed species. Their positive identity, therefore, requires more than casual observation. All of the species are nocturnal in habit and unless

¹²⁵ *Pseudoscorpiones*. ¹²⁶ *Chelifer hawaiiensis* ¹²⁷ *Diplopoda*. ¹²⁸ *Sp.* undet. ¹²⁹ *Porcellio scaber*.

disturbed are not seen in the daytime. Decaying vegetable matter is supposed to furnish them with their principal supply of food.

SAND-HOPPERS.

The species of sand-hoppers belong to a family¹³⁰ in the order *Amphipoda*, to which order also belong the fresh-water shrimps. By some they may be mistaken for the pill-bug. Though they are distantly allied to the pill-bug, since they are true crustacea, they are easily identified as belonging to a different family, as they have the body narrowed and flattened from side to side, instead of broad and flat, and all proceed by a hopping movement when alarmed. The common sand-hoppers live near the edge of the sea and are aquatic in habit. There are species, however, which are found high up in the mountains in damp situations and in the cups at the base of the leaves of a number of plants such as the ieie vine, ki plant and in similar places. Three species belonging to two genera have been reported from the mountains of Oahu, and there are doubtless species occurring on all the islands of the group.

SPIDERS, MITES AND TICKS.

Zoölogists usually place the spiders together in an order¹³¹ of the Arthropods, where, with certain other orders, including such animals as the scorpions, the harvest-men or "daddy-long-legs," the mites and ticks and similar creatures, they unite to form a class.¹³² This class is made up of several well-marked orders, but the spiders are generally taken as the type for the group, as they show clearly the difference between the class to which the insects¹³³ belong, and the class which they represent. There are several important characteristics common to the spiders, among them the possession of eight legs, the absence of antennæ or feelers, and the division of the body into two main divisions,¹³⁴ that at once separate them from the insects, which have, as a rule, six legs, antennæ and the body divided into three parts, namely, the head, thorax, and abdomen.

HOUSE-SPIDERS.

While there are more than a hundred species of spiders in Hawaii, many of them spinning webs, they are for the most part so small and inconspicuous that they rarely attract the special notice of the housewife. The jumping-spiders¹³⁵ and the big brown house-spider,¹³⁶ a member of the family of hunting spiders,¹³⁷ and the well-known garden spider should, however, be mentioned as exceptions to the rule.

The jumping-spiders are small or medium size with a short blackish body and short stout legs. They occur on plants, fences and about houses, and attract attention by their peculiar appearance, bright marking and quick-jumping movements that differ from those of the web-weaving and hunting

¹³⁰ *Talitridæ*. ¹³¹ *Araneida*. ¹³² *Arachnida*. ¹³³ *Insecta*. ¹³⁴ The cephalothorax and abdomen.
¹³⁵ Family *Attidæ*. ¹³⁶ *Heteropoda regia*. ¹³⁷ *Clubionidæ*.

families. Since they spin no webs to annoy one, their comical stare and knowing ways in a measure make up for the stinging bite they can administer when their liberty is interfered with.

The garden-spider¹³⁸ is doubtless an importation. It is the large species, with the abdomen conspicuously marked with creamy yellow and black, that occurs in the shrubbery about the house and garden, where it makes its bulky, oddly-woven nests. It is common from sea-level up to 4000 feet elevation, and is also found in America and Australia.

The big brown spider¹³⁹ or house-spider is often three or four inches across, and to the tourist, at least, they present a most formidable appearance. They are common in houses all over the islands, as well as in all tropical countries, and are often looked upon as household pets. They are perfectly harmless. In many families their long residence and evident appreciation of friendly attentions from the members of the household has given them an enviable place among the domestic pets. They feed on cockroaches, moths, flies, silverfish and other insects, in an evident desire to be useful as well as interesting, and seldom leave their accustomed resting-place during the day-time. At night they become alert and active in search of food. As they never spin webs, the mother spider is forced to carry the white lozenge-shaped egg-sack about with her between her legs until her eggs have hatched. Mr. E. M. Ehrhorn found that it required about thirty-five days for the young spiders to hatch and leave the egg-sack, and that 197 out of 207 eggs hatched.

THE HAMAKUA SPIDER.

An investigation of the habits of spiders found in the cane fields, at the time of the leaf-hopper outbreak already referred to, resulted in finding that out of the one hundred and five species of spiders recorded in the islands, at least twenty occur in the cane fields. However, only fourteen species were found feeding on insects infesting the cane. The most useful species¹⁴⁰ in the cane fields is variously known as the Kohala spider, the Hamakua spider and the Puunene spider. In some sections it is very abundant, so that as many as fifty of its roundish white nests have been found on a single leaf of cane.

Some of the species met with in the mountains spin very large, firm webs. It is not uncommon to find these stretched across the path, suspended on strong stay threads twenty-five feet or more in length. As a rule, however, the species peculiar to Hawaii are not conspicuous in size or habit, the great majority being less than five millimeters in length.

CHAPTER XXXII.

NATIVE INSECTS.

In the foregoing chapters some of the more important injurious insects have been passed in review. We now turn to consider some of the salient fea-

¹³⁸ *Argiope arava*. ¹³⁹ *Heteropoda regia*. ¹⁴⁰ *Pagiophalus atomarius*.

tures of the native fauna, since it is one of considerable general as well as biologic interest.

CHARACTER OF THE NATIVE FAUNA.

The number of species even in the limited and precinctive area of the islands is so great that it is not possible to do more than indicate in the briefest way the character and extent of the various orders represented in the group, and to assure those who take especial interest in the subject of entomology that they will find in Hawaii an extensive literature already prepared and an interesting field before them for study and investigation.

The stranger in the islands, with only a few days to spend in the collecting of specimens, is fortunate in that two of the most favorable localities for gaining a bird's-eye view of the native insects in their native environment, are also two of the most accessible. They are the mountains back of Honolulu, particularly the higher slopes of Tantalus, and the region in the vicinity of the Volcano Kilauea, on Hawaii.

Dr. Perkins, the veteran naturalist of the islands, whose active life in the field of entomology has been largely spent in bringing together the material on which a monumental work, in three volumes, known as *Fauna Hawaiiensis* is based, has published short papers¹ setting forth briefly the more important and interesting forms that may be met with in the localities mentioned. These succinct papers will serve the collector as a field guide to each locality and aid him in his search for the rarer forms to be found in these favored precincts.

The student will early learn to appreciate the importance of careful and intensive study of circumscribed localities, since each island, valley, mountain, and even limited areas and often certain peculiar plants, have their peculiar forms. It will also be noted that such influences as elevation, moisture and dryness play important parts in the distribution of species and the establishment of their vertical and horizontal range.

INSECTS OCCURRING ON MAMAKI.

The work on the life histories of various groups of Hawaiian insects that has been carried on by the individual members of the local Entomological Society has added material of the greatest interest to our increasing store of knowledge concerning the habits of the native insect fauna. This is especially true in the group of *Lepidoptera*, wherein Professor Otto Swezey, in his study of moths and butterflies, has done much to clear up many obscure relations existing between that order of insects and those insects preying upon them in their early stages of development. The bearing of these inter-relations in their effect on the native vegetation has often proved to be of great biologic interest.

In his investigation of the insects associated with the mamaki (a native Hawaiian shrub, from which kapa was formerly made), he has indicated the

¹ Insects of Tantalus, Perkins, Proc. Haw. Entom. Soc., Vol. 1, pt. 2, pp. 38-51. Insects of Kilauea, Perkins, Proc. Haw. Entom. Soc., Vol. 1, pt. 3, pp. 89-99.

way to a field of fascinating and practical study that others, not wholly consumed with the desire to add new species to the fauna, nor equipped for serious systematic research, will find of value and interest.

During a period of two or three years in connection with other field collecting, mostly confined to the Island of Oahu, he gathered and studied material from which he reports the taking of more than seventy-five insects and their parasites from this single species of plant. He enumerates nine species that appear to be found on mamaki and on no other plant. Thirteen species feed extensively on its leaves, one bores into the green twigs and one lives on the bark. Of those attacking the dead or dying shrub, eighteen occurred in the trunk and branches, and two feed on fungus, on or beneath the bark. The insects which visit mamaki in search of prey were divided into five species of *Coleoptera*, four species of *Hemiptera*, eight parasites besides other miscellaneous insects, as ants, earwigs and rove beetles.

The problems of insect life are so interesting and so varied in Hawaii that the repetition of the investigation referred to above would well repay any observer on Oahu, while the insect fauna varies to such an extent on the different islands that the work, if repeated on Hawaii or Kauai, for example, would have all the novelty of original research.

Some of the more minute and scarcer groups of Hawaiian insects have not as yet been systematically studied. The larger and more important orders that have been reviewed by specialists are constantly having new genera and species added to them as a result of more detailed study. This makes generalizations based on the data available less accurate than one could wish. Nevertheless, some of the main facts selected for a popular resumé of the orders as discussed in the Fauna Hawaiiensis, supplemented by the papers on various phases of the subject that have appeared from time to time since their publication, may be of general interest.

ANTS, BEES AND WASPS.

The great order,² including the ants, bees, wasps, small four-winged parasites, and gall-forming and plant-eating wasp-like insects, is well represented in Hawaii. The order is divided into two sub-orders, one the boring,³ the other the stinging⁴ *Hymenoptera*. In the former sub-order, among other characteristics, the tip of the abdomen in the females is provided with an organ suited to boring the hole into which the egg is deposited. In some species this instrument is used to drill holes in trees, in others it is used to thrust the egg into the body of some other insect where it develops. Many of the species are very minute; often their existence is accidentally discovered during the process of rearing other insects in breeding jars. At such times the tiny parasite often emerges from the body of its host and appears in the jars as a microscopic insect with four wings. These are known as parasitic *Hymenoptera*, and are of great biologic importance in keeping their host species in

² *Hymenoptera*.

³ *Terebrantia*.

⁴ *Aculeata*.

check. Dr. W. H. Ashmead, in his treatise on the Hawaiian forms, discusses fourteen families belonging to this suborder, to which he refers one hundred and twenty-eight species as belonging to sixty-nine genera. Eighty-seven of the species were described by him as new. To this number several species have since been added, but as the very largest Hawaiian species do not exceed twenty millimeters, and by far the greater number are less than five millimeters in length, and as a great many have been described from a single specimen, we may infer that, in spite of their interesting habits, they are too small to attract much attention from the layman.

The stinging *Hymenoptera* includes about two hundred well-marked species. Of these a large number are peculiar to the islands. As the majority of the species are fair-sized, handsome insects, they have been more extensively collected. The group includes the ants, digger-wasps, the true wasps and the bees. To the twenty species of ants ⁵ listed by Prof. A. Forel as occurring in Hawaii, six species have since been added, the majority of which are new arrivals. As a matter of fact, there appears to be but one or two endemic species of ants in the islands. Most of those found here are slightly-varied forms of widely-distributed species. Only one species (*Ponera perkinsi*) is definitely stated to be Hawaiian. It occurs in small colonies of a dozen or so in moist localities high in the mountains.

Ants occur commonly in great numbers about houses, and everywhere attract attention owing to their so-called instinctive powers. They invariably live in organized communities or colonies, and exhibit as great a variety of habits and customs as do the people living in the islands, for the people, like the ants, have been brought together in Hawaii from many foreign lands. The ants found here live under boards and stones, and in the ground, and are as industrious and thrifty as those King Solomon observed, to find that they, having no guide, overseer or ruler, provided meat in the summer and gathered food in the harvest.

The home life of ants for obvious reasons has not been as fully studied as has that of the bees, but the division of labor in the colony is known to be even more complex. Their habits furnish an interesting and ever-present field for study and observation by old and young.

The digger-wasps, or Fossores,⁶ may be readily distinguished from the true wasps by the fact that their wings, when at rest, lie flat over the back and the legs are arranged for walking or digging. There are about thirty-five species so far reported from Hawaii, the most common being the introduced mud-dauber ⁷ belonging to the thread-waisted wasp ⁸ family. They are to be seen building their nests about lanais and outbuildings. When the nest is completed the eggs are deposited and the cell provisioned with spiders. The truly native species are reported to prey entirely upon flies. The principal genus, *Crabro*, represented by fifteen species, is distributed in the mountains of the larger islands.

⁵ *Formicidae*.⁶ *Sphecina*.⁷ *Peloporus carmentarius*.⁸ *Sphegidae*.

Of the true wasps,⁹ the family¹⁰ including the social wasps is represented by two or three species, one of which¹¹ is widely distributed about the islands.

The family embracing the solitary wasps¹² is represented by a large number of species belonging to the genus *Odynerus*. Eighty-six species were reported in the Fauna Hawaiiensis, and a dozen or more species have been added since. Excellent keys to the species occurring on the different islands have been prepared by Dr. Perkins, who reports sixty species from Oahu, eighty-four from Maui, Molokai and Lanai, and thirty-two from Kauai. Fourteen species have been found on Tantalus, including some of the rarest, while Kilauea as a locality has yielded twenty-one species. On a single day's collecting in Iao Valley, Prof. Swezey secured eleven out of sixteen species known to occur in that particular locality, which is about half of those so far reported from the Island of Maui.

In this genus the abdomen is joined to the thorax by a very short peduncle. The shape of the body and the coloration of the abdomen of many species so closely resemble those of the social wasps, known elsewhere as yellow-jackets, and hornets, that it is quite common to hear these names applied to the conspicuously-marked species. But as a rule, the Hawaiian *Odynerus* are much more somber in color than are species from elsewhere.

The habits of the Hawaiian species, like those of the genus occurring in other lands, varies greatly. Some species burrow into the stems and pithy parts of plants, others into dead wood, while a few build single cells of mud, which they attach to leaves of trees. Many of the species build their nests in the porous cavities in the lava rock; others make their nests in the ground.

The black rock-wasp,¹³ one of several species common about vertical ledges of rock, attaches its egg by a slender thread at the back of some small hole in the rock. It then fills the hole with caterpillars that have been paralyzed by its sting. In storing the food for its young it is usually particular to select only the young caterpillar of a single species. Many of these, as we shall see, are leaf-rollers in that they protect themselves from their enemies and the sun in the caterpillar stage by folding the leaf together about them. The wasp, after locating the young caterpillar in its hiding-place, alights on the leaf nearby. The young caterpillar then becomes excited and creeps out of its hiding-place and falls to the ground, whereupon the waiting wasp will pick it up, sting it, and carry it away to its storehouse cell. When the cell cavity is full, the ingenious insect plugs up the end of the hole with mud, through which in due time the young wasp will emerge. The habit of storing their cells with the larva of moths and butterflies is very common among the solitary wasps, and as they are active during the year they do much to keep these insects in check.

The keyhole wasp¹⁴ is a black wasp with dull-blue iridescent wings clouded with brown, that is common about houses, where it employs at least a part of its time in plugging up keyholes. They are interesting and intelli-

⁹ *Diptera*. ¹⁰ *Vespa*. ¹¹ *Polistes aurifer*. ¹² *Eumenidæ*. ¹³ *Odynerus* spp.

¹⁴ *Odynerus nigripennis*.

gent creatures, and are excellent material for the student who has the time and a taste for experimenting with animals. For example, they are greatly disturbed by a change in the color of objects near where they are working. If a piece of red cloth is tied over the door knob they have great trouble in finding the keyhole when they return with mud, but if the cloth is removed in their absence they have no trouble in locating it.

The Hawaiian solitary bees, of which there are at least sixty species, belonging to the genus *Nesoprosopis*, are not readily identified by the layman, nor are they easily separated in the field from the wasps. Like the genus of wasps just discussed, they vary greatly in habits. Some nest in the ground, some in dead standing timber and various unusual places, and are distributed from the coast to above the upper forest.

Of the typical or long-tongued bees,¹⁵ we find five species so far occurring in Hawaii. Of these the conspicuous carpenter bee¹⁶ and the useful honey bee¹⁷ have already been mentioned. The three remaining species belong to a single genus¹⁸ and are characterized as leaf-cutting bees. The common name is given them owing to their curious habit of making the thimble-shaped nests for their young out of neatly-cut circular pieces of fresh leaves, which they pack away in cells, often in holes in the woodwork, or in curled-up leaves of the cocoanut palm. Leaves when mutilated by these bees look as though small gun wads had been cut from them. The work of the wad-cutting bee is often mistaken for that of the Japanese beetle, which, while it feeds on the leaves, does not cut out the leaf in a regular pattern.

THE BEETLES.

Coming to the great order of beetles,¹⁹ we find it represented in the Hawaiian insect fauna by more than forty families, embracing hundreds of pre-invasive and introduced species. All of the members of this extensive order are easily recognized in the adult stage, as they have a pair of horny wings that meet in a straight line down the back, beneath which is a single pair of membranous wings neatly folded away. The earwig²⁰ is the only other order occurring in Hawaii that at all closely resembles them, and the earwigs are easily recognized by the presence of a pair of forceps-like appendages at the posterior end of the body.

In general it may be said that a great per cent of the beetles found in Hawaii are species that occur in no other place. Most of the species are small, many of them being almost microscopic in size, and as a rule the individuals of a species are not numerous, hence they are difficult to obtain. The collector soon learns that their habits vary greatly in the different families and even among the species of the same genera, so that in searching for specimens every possible situation must be examined. The water, earth, sand, crevices in the solid rock, under decaying animal and vegetable matter, under stones, in the

¹⁵ *Apis*. ¹⁶ *Xylocopa brasiliatorum*.
²⁰ *Euplexoptera*.

¹⁷ *Apis mellifera*.

¹⁸ *Megachile*.

¹⁹ *Coleoptera*.

wood, stems and bark of trees, on the leaves, flowers, and in the seeds of plants, in moss, in fungi, in fern stems—in fact, a thousand possible places are all liable to be inhabited by some rare and interesting beetle.

That many species, especially among the long list of those introduced since commerce was established with Hawaii, are injurious to man and to his interests, has been touched upon in a former chapter. That many forms work to man's economic benefit has also been hinted at. Of most of the peculiar native species little is really known of the place they occupy in the economy of nature.

The larvæ, commonly called grubs, seldom display conspicuous characteristics, and exhibit nothing to indicate the diversity of form assumed by the adults. They are mostly dingy-white, brownish or occasionally even black in color. The head is always horny and usually provided with jaws suited to biting and grinding their food. The pupa stage follows the larva and varies greatly in length of time. Whether it is passed in a cocoon or not, the embryo beetle lies inactive with the appendages all plainly shown, each enveloped in its own peculiar covering. From this they emerge in due time to take up the active life of the adult.

Passing to a consideration of a few of the more interesting or more important families, we find that of the great division known as the predaceous beetles, the ground beetles,²¹ with legs suited to running and with thread-like, tapering antennæ, are represented by more than two hundred small species, many of them belonging to genera peculiar to the islands. They vary greatly as to habits, the most of them, however, undoubtedly feeding on insects. They are found under stones, beneath dead wood, in moss, in trees, under bark, at the base of leaves and on the ground, scurrying about. Two small species of predaceous diving-beetles²² belonging to this division, but to different genera, occur in fresh water all over the group; they appear to be nowhere abundant.

The diving-beetles can be distinguished at once from the six species of water scavenger-beetles,²³ some of which occur in pools and running water, and some in rotten wood and decaying vegetation. The water scavenger-beetles all have club-shaped antennæ (which are often concealed beneath the head) and very long palpi. As a matter of fact, these aquatic scavenger-beetles belong to the extensive division of the beetle order known as clavicorn beetles, in which the antennæ are club-shaped—that is, they grow gradually thicker towards the top. Hawaii has twenty or more families belonging to this group, including such well-known families as the carrion-beetles,²⁴ with but a single introduced species so far found; and the rove-beetles,²⁵ with upwards of one hundred species. They may all be fairly well recognized by their short wings and long, narrow abdomen. They are mostly carnivorous, and rove about in search of food. Insects constitute a large part of their food, especially insect larvæ, but many feed on rotten wood, some on fungi and others on flowers.

The twenty species of small hemispherical lady-bugs, or ladybird beetles,²⁶

²¹ *Carabidæ*. ²² *Dytiscidæ*. ²³ *Hydrophilidæ*. ²⁴ *Silphidæ*. ²⁵ *Staphylinidæ*. ²⁶ *Coccinellidæ*.

discussed elsewhere, are practically all introduced species, brought to Hawaii on account of their well-known predaceous habits. The dermestids,²⁷ the common forms introduced and which destroy household stores and goods, have also native species of small size. The histyerid beetles²⁸ have several introduced species and an important Hawaiian genus with thirty or forty species of very small square-shaped beetles that occur about decaying matter in the mountains. The nitidulids,²⁹ a family composed of small flattened beetles with the wing covers more or less truncate, exposing the abdomen, suggesting the rove-beetles which have a much longer abdomen, are quite common; one hundred and forty species, all of which feed on decaying animal and vegetable matter, and are often found about flowers, occur in the mountains.

Several other families made up of small-sized individuals and a limited number of species, belong in this division, and may occasionally be captured by the careful collector.

The group known as the serricorn beetles, since the antennae are usually saw-like, is well represented by three families, the most extensive and common being the click-beetles,³⁰ snapping-bugs or skip-jack beetles. If disturbed they curl up their legs and apparently drop dead, usually landing on the ground on their backs. With a sudden click, they will spring up in the air and turn over. If they strike the ground on their feet they will run; if not, the clicking performance is repeated again and again. The adults are usually dull-colored, but some are of fair size and quite common. The larvae are commonly known as wire-worms. Eighty-five species or more belong to the genus *Eopenthes*, a genus that includes some beautiful iridescent species that numbers among them some of the most attractive beetles in the islands. The checkered beetles,³¹ with three widely-distributed species, and the metallic wood-borers,³² including two introduced species, conclude this part of the order.

Beetles with the antennae arranged so that the outer joints are prolonged internally in a manner to present flattened surfaces to each other, are grouped under the lamellicorn beetles, and are represented in Hawaii by such well-known families as the stag-beetles³³ or pinch bugs, so called on account of their large mandibles. The rare genus *Apterocyclus*, including the seven species of the family occurring in Hawaii, is found only on the Island of Kauai.

All of the eight or more species of Scarabaeids³⁴ belonging to the foregoing section, and including such widely-distributed forms as the Japanese beetle,³⁵ have been introduced. Other members of this extensive family, including such classic forms as the May beetle, tumble-bugs, dung-beetles, skin beetles and the like, may accidentally gain admittance here from time to time, as two dozen species of beetles were prevented from landing in 1912 only through the rigorous insect inspection in force in Hawaii.

The group³⁶ including the long-horned beetles³⁷ is well represented by

²⁷ *Dermestidae*.
³³ *Lucanidae*.

²⁸ *Histeridae*.
³⁴ *Scarabaeidae*.

²⁹ *Nitidulidae*.
³⁵ *Adoretus tenuimaculatus*.

³⁰ *Elateridae*.
³⁶ *Phytophaga*.

³¹ *Cleridae*.
³⁷ *Cerambycidae*.

³² *Buprestidae*.

more than sixty species of that family alone. The list of species includes some of the most highly-colored as well as striking forms of Hawaiian beetles. As these are all wood-boring beetles in their larval state, many of the species most commonly seen have been introduced, but in the group including the three genera *Clytarus*, *Callithmysus* and *Plagithmysus* we have several species that are peculiar to single islands and some that apparently occur only on certain kinds of trees. Such habits indicate the long establishment of the family in the group.

The division of the beetle tribe embracing the darkling-beetles,³⁸ which includes among other common species the red-rust flour beetle;³⁹ the oedemerids,⁴⁰ with one species, and the anthicids,⁴¹ with two coast and salt marsh species, is made up of representatives of introduced families, except in the case of the cistelid family,⁴² a family including ten species belonging to two genera that are regarded by entomologists as certainly indigenous.

The family *Cioida* is of doubtful position, but is represented in Hawaii by forty-two species, twenty-nine of which belong to the genus *Cis*, the remaining fourteen to *Apterocis*. A few of the species are found on the large fungi common on koa trees, but the majority occur attached to dead limbs or under dead bark. As the very largest species does not exceed two and a half millimeters in length, they may easily escape detection.

The family *Anobiida*, with the introduced cigarette beetle⁴³ and the book-worm,⁴⁴ has upwards of 134 species occurring in Hawaii. One genus⁴⁵ has at least fifty species in the Hawaiian fauna. Another genus⁴⁶ has at least seventy Hawaiian species. Most of the species in the family are black or fuscous and none exceed five millimeters in length. The family *Lycida* includes two, and the *Bostrychida* several, common introduced species. The bamboo beetle⁴⁷ belongs to the latter family and is rare; but a similar beetle⁴⁸ is fairly abundant.

The division of the *Coloptera* known as snout-beetles⁴⁹ is one in which the head is prolonged into a beak. The largest and most important family of this division is the curculios,⁵⁰ or weevils, of which there are about one hundred and fifty species. The great majority of them are peculiar to the islands. The antennæ are placed at or beyond the middle of the snout, and are curiously elbowed, each terminating in a solid club. All parts of plants are subject to the attacks of the maggot-like larvæ, and in many instances, especially in the case of the introduced species, they do considerable damage. The snout-beetle,⁵¹ found on rubber trees, sisal, etc.; the bean weevil,⁵² rice weevil,⁵³ the sweet-potato weevil,⁵⁴ all are excellent examples of the family, but a native genus⁵⁵ has several larger but rare species, the largest being fourteen millimeters in length. The large genus *Oodemas* has upward of forty-five species, all of which are rare. The family *Anthribida* and the engraver

³⁸ *Tenebrionida*. ³⁹ *Tribolium ferrugineum*. ⁴⁰ *Oedemerida*. ⁴¹ *Anthicida*. ⁴² *Cistelida*.
⁴³ *Lasioderma serricorne*. ⁴⁴ *Anobium paniceum*. ⁴⁵ *Xyletobius*. ⁴⁶ *Mirosternus*.
⁴⁷ *Dinoderus minutus*. ⁴⁸ *Schistoceros cornutus*. ⁴⁹ *Rhynchophora*. ⁵⁰ *Curculionida*.
⁵¹ *Pseudolus longulus*. ⁵² *Bruchus obtectus*. ⁵³ *Calandra oryzae*. ⁵⁴ *Cylas formicarius*.
⁵⁵ *Rhyncogonus*.

beetles⁵⁶ are associated with the weevils. The latter family is represented by a limited number of rare species. These are small beetles that live under the bark of forest trees. It is said that with the engraver beetles the female lays her eggs in the side of the channel which she cuts in the wood under the bark, and that the larvæ when hatched cut channels at right angles to those of the mother, thus forming the curious engraver's pattern.

We come now to the remarkable Hawaiian snout-beetle family,⁵⁷ which, so far as known, is peculiar to the islands. The 136 species so far described are all referred to a single genus.⁵⁸ None of the species exceed four millimeters in length. They may be at once recognized as members of this family and differing from the weevils, owing to their long many-jointed antennæ, which are placed at the base of the beak and close to the eyes.

Most of the species are found about dead and dying forest trees, but some occur in fern stems, and one or two are found in the stems of the maiden-hair fern,⁵⁹ while one species was found by Prof. Swezey to be a leaf miner.

THE TWO-WINGED INSECTS.

Passing over the order including the fleas,⁶⁰ as they have been mentioned in another connection, the next order embraces the two-winged insects⁶¹ of which the house fly, the fruit-fly, the melon-fly, the lantana-fly and the mosquito may be taken as conspicuous introduced examples that play important roles on both sides of the balance sheet of insect economy in the islands. The life histories of any of the foregoing species may be easily and profitably worked out in the class-room.

The larvæ are usually footless, whitish creatures called maggots that revel in all sorts of filth, as stable manure, decaying fruit, in fresh and stagnant water, in the earth, about roots of plants and a variety of unsuspected places. The larvæ and the pupæ of the mosquito are known as wrigglers, and in this stage are a favorite food for certain species of fish introduced for the express purpose of preying on them.

The list of Hawaiian flies prepared by Mr. P. H. Grimsham in 1901-2 indicated 188 species as belonging to the fauna. Since then a number of species have been added, so that, native and introduced, there are more than two hundred kinds of flies known to occur in the islands. Some of them are beneficial, others are troublesome, but the great majority of them are rare mountain forms seldom met with.

More than twenty-five families are represented by from one to several species, among them the fungus-gnats,⁶² the moth-like flies,⁶³ the mosquitoes,⁶⁴ the window flies,⁶⁵ the long-legged flies,⁶⁶ of which there are a few interesting native species; the big-eyed flies,⁶⁷ parasites on leaf-hoppers; the syrphus flies,⁶⁸ the flesh flies,⁶⁹ the typical flies,⁷⁰ including the horn fly, blue-bottle fly, house fly, sheep-maggot fly and stable fly (the latter now believed by

⁵⁶ *Scolytidæ*. ⁵⁷ *Proterhinidæ*. ⁵⁸ *Proterhinus*. ⁵⁹ *Pteris*. ⁶⁰ *Siphonaptera*.
⁶¹ *Diptera*. ⁶² *Mycetophilidæ*. ⁶³ *Psychodidæ*. ⁶⁴ *Cnecidæ*. ⁶⁵ *Scenopinidæ*.
⁶⁶ *Dolichopodidæ*. ⁶⁷ *Pipunculidæ*. ⁶⁸ *Syrphidæ*. ⁶⁹ *Sarcophagidæ*. ⁷⁰ *Muscidæ*.

certain investigators to be the carrier of infantile paralysis); the horse and ox bot-flies,⁷¹ the fruit and vegetable flies;⁷² but by far the most numerous in point of peculiar species are the small vinegar flies or pomace flies.⁷³ Of these there are at least forty-five species peculiar to the islands. They are attracted to decaying fruit and vegetable matter in great numbers, especially to pine-apples, where the species⁷⁴ is mistaken by many people for fruit-flies on that account.

The curious louse-flies,⁷⁵ which have very flat bodies and live like ticks on the bodies of birds⁷⁶ and occasionally on mammals, are represented in the islands by species that are sure to arouse the curiosity of anyone observing them.

BUTTERFLIES AND MOTHS.

The Hawaiian Islands possess very few butterflies, but have a very large number of moths. The moths and butterflies are all included in one order, *Lepidoptera*, owing to the fact that all of the members of this order are alike in having all four of the wings covered with minute scales. They all pass through complete metamorphosis; that is, the egg when hatched becomes a caterpillar, the caterpillar changes to a pupa, and the pupa, after a quiet period, turns into the adult winged insect. The mouth parts of the adult, when fully developed, are fitted for sucking nectar from flowers, but the mouth parts of the caterpillar are fitted for chewing, and it is in this stage that they do great damage to various kinds of plants. The amount of damage done in Hawaii is considerable, but a great part of it is done by introduced species, as has already been pointed out. However, the moths and butterflies have many natural enemies, and enemies have been introduced to aid in keeping them in check.

Without doubt the struggle for existence here had much to do with the production of forms that are protectively colored with reference to their enemies and their surroundings. When we realize that the order is represented in Hawaii by more than seven hundred species,⁷⁷ the great majority of which⁷⁸ are peculiar to the islands, we can realize the length of time and the amount of specialization involved in the production of this interesting portion of our fauna. With so large a list of species the collector is surprised to find so few individuals of a species and that the majority of those found are so minute.

For convenience the *Lepidoptera* have been divided into the *Macrolepidoptera* and the *Microlepidoptera*. To the *Macrolepidoptera* belong the few species of butterflies, (all with club-shaped antennæ), and the larger moths, making fifteen families⁷⁹ in all. Of this list but few are sufficiently marked

⁷¹ *Estridæ*. ⁷² *Trypetidæ*. ⁷³ *Drosophilidæ*. ⁷⁴ *Drosophila ampelophila*. ⁷⁵ *Hippoboscidæ*.

⁷⁶ As the puco and iwa. ⁷⁷ 733 according to Prof. Meyrick and Lord Walsingham in 1907.

⁷⁸ 661 species.

⁷⁹ According to Meyrick, the Hawaiian *Macrolepidoptera* belong to four super-families, and fifteen families, as follows: (a) *Caradrinina*—*Caradrinidæ*, *Plusioidæ*; (b) *Notodontina*—*Notodontidæ*, *Sphingidæ*, *Hydriomenidæ*; (c) *Papilionina*—*Pieridæ*, *Nymphalidæ*, *Lycaenidæ*; (d) *Pyrastidina*—*Phycidæ*, *Galleridæ*, *Crambidæ*, *Pyrastidæ*, *Pyralididæ*, *Pterophoridæ* and *Oracodidæ*. These families are again divided into more than sixty genera.

as to habit or appearance to make their recognition at all easy or certain, even by the professional entomologist, without reference to cabinet specimens, schemes of classification and tables, based often on minute and obscure characteristics. Some of the species, however, warrant notice on account of their size or abundance, though the very largest island species of the order—a beautiful green sphynx moth⁸⁰—does not exceed three and a half inches in expanse. It has four dull-colored cousins occurring on the different islands that are almost as rare. Like the foregoing species, the humming-bird moths are also members of the hawk-moth⁸¹ family. Two species occur here. The one with the rosy, spotted abdomen,⁸² known as the sweet potato horn-worm, is fairly abundant from September to December, while the species with the yellow-spotted abdomen is rarer, though both species are widely distributed in America. The commoner species has been mentioned among the economic insects.

Coming to the typical butterflies with knobbed antennæ,⁸³ we have the so-called four-footed butterflies,⁸⁴ represented by at least five species. Only one of them, however, the Kamehameha butterfly,⁸⁵ is native. Fortunately it is the most common species, especially in the lower forest zone. It can be recognized as differing from the three introduced species of the angel-wings, or vanesseds, by its larger size and having the body reddish-brown, while the body of a similar species⁸⁶ is black.

These bright butterflies with their wings of varied rusty brown, red, rose, black and white add a welcome touch of color to the forest green that is sure to delight every mountain Rambler. The larvæ are conspicuous caterpillars found principally on the mamaki. They fold the margin of a leaf together to form a shelter, crawling out of it to feed. As they grow in size, they are known to form new retreats from time to time.

The monarch or milkweed butterfly⁸⁷ is represented by an introduced species, identified by its having the upper surface of the wings light tawny-brown, with the border and veins black, and two rows of white spots on the outer borders of all four wings. It is much the largest butterfly found in Hawaii. It is fairly common on the lower levels, where it feeds in the larval stage on the introduced milkweed.

The family of gossamer-winged butterflies⁸⁸ are represented by four species of the "blues," one of which, Blackburn's butterfly,⁸⁹ is peculiar to the group and is quite plentiful at proper seasons in the mountains on all the islands up to 4000 feet. All of the species are about an inch across the expanded wings. The native species can be identified at once by the light bluish-green, unspotted under-surface of the wings, and by the upper-surface being dark colored, edged with blue. One of the introduced species⁹⁰ is very abundant, its larvæ feeding on *Crotalaria* and other bean-like plants growing on the lower levels. The two remaining species of *Lycana* have recently been pur-

⁸⁰ *Deilephila smaragdita*.

⁸¹ *Sphingidar*.

⁸² *Sphinx conovalis*.

⁸³ *Papilionia*.

⁸⁴ *Nymphalidae*.

⁸⁵ *Vanessa tameamea*.

⁸⁶ *Vanessa atlanta*.

⁸⁷ *Anosia erippus*.

⁸⁸ *Lycenidae*.

⁸⁹ *Lycana blackburni*.

⁹⁰ *Lycana batia*.

posely introduced from Mexico to feed on the flowers and leaves of the *Lantana*.

The white cabbage butterfly ⁹¹ is the representative of the third family ⁹² of the butterflies occurring in Hawaii. Here, as in America, they are an introduced species, and, as elsewhere, they are common in gardens, especially about cabbage, where their larvæ, as cabbage-worms, bore into the cabbage heads and devour the leaves.

In the genus, to which the introduced black cut-worm ⁹³ found feeding on garden and farm crops, sugar-cane and weeds belongs, there are enumerated at least two dozen native species. They are for the most part fair-sized, somber-colored, night-flying moths. Fortunately, the native species prefer to inhabit the higher forested areas, rather than the lower agricultural zone. However, there are several species belonging to the genus *Agrotis* as well as species of such genera as *Leucania*, *Heliothis*, *Spodoptera*, belonging to this extensive family ⁹⁴ and to the related family ⁹⁵ that furnish a number of forms that infest the grass and the crops of cultivated lands on the lower levels. One species, ⁹⁶ with silver commas on the forewings, is an introduced troublesome general feeder that is liable to attack almost any useful plant.

The super-family *Notodontina*, with its three families and ten genera, furnish a number of species of considerable economic importance. One genus ⁹⁷ in this division has perhaps thirty species that are among the more abundant and showy moths met with in the islands. Their caterpillars of different species often occur in large numbers on guava, koa, ferns and various other plants and trees.

Coming to the fourth super-family, ⁹⁸ with seven families and thirty-two genera in the Hawaiian fauna, we find the various species of the genus *Omiodes* represented by the cocoanut palm leaf-roller, ⁹⁹ among the most troublesome native moths. A genus ¹⁰⁰ belonging to the same family ¹⁰¹ is represented by at least fifty-six native species of attractive moths that have the forewings very narrow and often conspicuously marked with spots, blotches and wavy designs of various colors. As the range of the genus seems to be between two and ten thousand feet in the mountains, species are usually secured from high, moist regions. They feed almost exclusively on moss and lichens, in which the larvæ are said to spin curious silken tunnels for themselves.

Up to the time Dr. Perkins began his work in the islands but thirty-five species belonging to the grand division of *Microlepidoptera* were known from Hawaii. Lord Walsingham, after working over the material assembled by Dr. Perkins, recorded four hundred and forty-one species. The labor involved in adding so many species of insect life to the fauna, by the efforts of a single naturalist, can be appreciated better when we realize that the great majority of these minute creatures do not exceed a half inch in length.

⁹¹ *Pieris rapæ*. ⁹² *Pierida*. ⁹³ *Agrotis ypsilon*. ⁹⁴ *Caradrinida*. ⁹⁵ *Plusiada*.
⁹⁶ *Plusia chalcites*. ⁹⁷ *Scotorythra*. ⁹⁸ *Pyralidina*. ⁹⁹ *Omiodes blackburni*. ¹⁰⁰ *Scoparia*.
¹⁰¹ *Pyraustida*.

On the wing these tiny moths fly with a rapid, confused flight and alight with the wings folded closely together over the body. As a rule they are protectively colored and secrete themselves in crevices in the bark, and beneath the dead leaves in the forest, with such skill as to defy detection even by the practiced eye.

While their habits vary greatly, many of the species develop to the adult stage within the tissue of leaves, and in this way come to be called leaf-miners.¹⁰² Usually each species of the leaf-miner group infests some particular kind of plant or at least closely allied plants. So constant are these creatures in their leaf-mining habits that an expert entomologist can often tell the species of insect infesting the plant by the characteristic mine that it makes. Some species produce galls on certain plants, others feed on fruits, live in silken tunnels in dead grass and leaves, on the bark of dead trees; some produce webs in koa trees, and so on until it has been found that almost every imaginable habitat has been occupied by them.

Although the great majority of the species belonging to the *Microlepidoptera* are found in the mountains, there are many, both native and introduced, that may be seen about residences, in gardens or doing damage to field crops of various kinds. Perhaps the species most liable to attract the attention of ordinary observers are the morning-glory leaf-miners,¹⁰³ both of which are introduced in Hawaii. The destructive cotton boll-worm¹⁰⁴ is also an abundant introduced species that bores into the seeds of the cotton. The clothes moth;¹⁰⁵ the tobacco leaf-miner,¹⁰⁶ boring into potatoes and into fruits and stems of tomatoes, are two common species in Hawaii. The corn moth,¹⁰⁷ feeding in the kernels of corn stored in cribs, and in rice, is also a common pest. Thus the list might be indefinitely extended and made to include many species of more or less interest or importance. The species are so minute, however, and are so much like one another, that their determination is necessarily the work of a specialist. But from the standpoint of the native fauna, especial mention should be made of the large, variable Hawaiian genus *Hypomocoma*, in which more than one hundred and seventy-five native species have been identified by Lord Walsingham. This list has since been extended by local entomologists. The larvæ make for themselves many styles of cases or cocoons which are located in such places as on the bark of trees, on rocks, dead twigs, or dead wood. A peculiarity of the genus is the variable form, size, color and construction of the cases which are made by the different species.

THE DRAGON-FLIES AND THE NERVE-WINGED INSECTS.

The dragon-fly may very properly be taken as a type of the order including the nerve-winged insects,¹⁰⁸ in which all four wings are membranous and furnished with numerous veins and usually with many cross-veins. Entomologists have differed among themselves as to just what the limits of the

¹⁰² *Tineida*. ¹⁰³ *Bedellia somnulentella* and *B. minor*. ¹⁰⁴ *Gelechia gossypiella*. ¹⁰⁵ *Tinea pellionella*.
¹⁰⁶ *Phthorimæa operculella*. ¹⁰⁷ *Sitotroga cerealella*. ¹⁰⁸ *Neuroptera*.

order should be, but in the case of the Hawaiian fauna the order, as treated by Dr. Perkins, has been made to include insects familiarly known as lace-winged flies or hemerobians,¹⁰⁹ the dragon-fly,¹¹⁰ the book-lice¹¹¹ and the white ants or termites.¹¹²

To this super-order have been referred at least 116 species of insects. About one-half of this number is made up by the lace-winged flies. They are slender-bodied, delicate insects of small size, the largest measuring scarcely more than an inch in length. They all have dainty membranous wings of various colors as gray, brown, yellowish-brown, hyaline, iridescent, and often pale green, the last color being the one most liable to attract attention.

The lace-winged flies are forest dwellers and nocturnal in habit. The common lace-winged fly¹¹³ is quite frequently met with in gardens and shady localities, and may be easily captured.

Of the dragon-flies,¹¹⁴ at least one genus,¹¹⁵ with twenty-six endemic species, may be regarded as of very long standing in the islands. The members of this genus are all fond of the mountain forests and seldom occur at lower levels. They have very slender bodies, with both pairs of wings shaped nearly alike. So extraordinarily fragile, delicate and dainty are their wings that they are often called Hawaiian damsel flies. Their gentle and airy manner as they flit from leaf to leaf make them among the most attractive of the Hawaiian forest insects. There are from seven to ten species on each island, but at least two of them¹¹⁶ occur throughout the group. As a matter of fact, the species of the genus are related to one another in such a way as to indicate that they all have originated from a single ancestral species that doubtless came to Hawaii in very remote times.

The nymphs of some if not all of the species belonging to this genus develop in the cups formed at the base of certain leaves in the forest, and can live with a very scant supply of water. Living specimens confined in collecting bottles continue active for several hours.

They are aquatic and predaceous in habit in every case, and are sure to attract attention with their rapid darting movements, their strong legs and jaws, and conspicuous eyes. The adults often flock to mountain pools during dry seasons, as they prefer moist localities. As a result, their dead bodies are often seen floating on the surface of the water.

Of the three other genera of *Odonata* found in Hawaii, the big blue dragon-fly¹¹⁷ is the most conspicuous and abundant through the allied species; the strenuous dragon-fly¹¹⁸ is common enough, but so strenuous indeed that it is difficult to capture specimens. The yellow dragon-fly¹¹⁹ is the common species seen in the open country everywhere, but notably in the streets and gardens of Honolulu. At the proper season as many as twenty may be seen at one time hovering over a square rod of lawn.

Another species of pinau,¹²⁰ as all dragon-flies are called by the Hawaiians,

¹⁰⁹ *Hemerobiidae*. ¹¹⁰ *Odonata*. ¹¹¹ *Psocida*. ¹¹² *Termitidae*. ¹¹³ *Chrysopa microphylla*.
¹¹⁴ *Odonata*. ¹¹⁵ *Agriion*. ¹¹⁶ *Agriion xanthomelas* and *A. pacificum*. ¹¹⁷ *Anax junius*.
¹¹⁸ *Anax strenuus*. ¹¹⁹ *Pantala flavescens*. ¹²⁰ *Tramea lacerata*.

are common in the open country on the lowlands. Still another species¹²¹ is found in the forest and deep valleys and has doubtless long been a resident of the islands.

The three genera¹²² above mentioned are strong fliers and liable to have been natural immigrants at a less remote time. The nymphs feed voraciously on the larvæ of mosquitoes, and are of value in the struggle to keep them under control.

The small common white ant,¹²³ found about buildings, was doubtless introduced. This species and the peculiar Hawaiian species¹²⁴ found in the native forests are, so far, the only representatives of the white ant family¹²⁵ in the islands. But as indicated in a previous chapter, they do much damage.

Quite recently two species belonging to the ant-lion family¹²⁶ have been found in the islands. One of the species¹²⁷ occurs on Oahu; the other, and by far the more common, on Hawaii.

The remaining families¹²⁸ are so small as to hardly attract attention at all, though the Psocids, or "book-lice," are represented by twenty-five or more species, and the list of species could easily be extended by further systematic study.

THE TRUE BUGS.

The order *Hemiptera* includes many well-known insects with mouth parts fitted for sucking the juices from fresh vegetation and blood from animals. They are well represented by the true bugs, plant-lice, scale insects, aphids and a number of allied families.

Mr. G. W. Kirkaldy, who devoted much time to the portion of the Hawaiian fauna belonging to this order, estimated that there were at least five hundred endemic, migrant and introduced species in the islands, of which number about three hundred and sixty were peculiar to the group.

As a rule they are represented by small and, in many cases, by rare and inconspicuous species, but as many are well-known pests, the families of great economic importance have been studied by entomologists. As the more important economic species in the various families have been dealt with in another connection, it only remains to mention a few representative examples distributed among the eighteen families recorded from the group, and to note that but twelve of these families have species belonging to the endemic or native fauna.

In the sub-order, including the true bugs,¹²⁹ the first pair of wings are thickened at the base, ending with thinner extremities that overlap on the back. In this division are found insects that live on the land, in the water, and on the surface of the water in marshy places.

Of the land species, two representatives of the chinch-bug family¹³⁰ are

¹²¹ *Sympetrum blackburni*. ¹²² *Anax*, *Tramea* and *Pantala*. ¹²³ *Caloterme marginipennis*.

¹²⁴ *Caloterme castaneus*. ¹²⁵ *Ternitidae*. ¹²⁶ *Myrmeleonidae*. ¹²⁷ *Formicaleo perjurus*.

¹²⁸ *Psocidae* and *Embiidae*. ¹²⁹ *Heteroptera*. ¹³⁰ *Lygaeidae*.

of recent introduction. The red-bug family¹³¹ has a single introduced species; the family *Mydodochida* has a number of species, among them the several members of the Hawaiian genus *Nysius*—insects less than six millimeters in length. The curious Lantana bug,¹³² purposely introduced, is the only representative of its family¹³³ in the islands. The damsel-bugs,¹³⁴ so called for want of a better name, are well represented by several Hawaiian species belonging to a large genus.¹³⁵ The assassin bugs¹³⁶ have won their popular name on account of their predaceous habits. A dozen species, most of them of fair size, and usually of wide distribution, occur in the islands. The large assassin bug,¹³⁷ or kissing bug, is thirteen millimeters in length, and is doubtless an American species that first appeared in Hawaii about 1897. The minute, slender-bodied *Mirida* are represented by several species of small insects, belonging to a number of genera, none of which are liable to be seen by casual observers.

Conspicuous among the few species of insects that live on or within the water in Hawaii is the representative of the family of water-boatmen.¹³⁸ It is represented by a small oval, gray and black mottled species¹³⁹ that has the body flattened above and swims on the ventral surface. This peculiar habit is of value to the novice in identifying them, since in this they differ from the next family, in which the various species all swim on their backs.

When the water-boatmen swim through the water they are almost completely enveloped in air which gives them a silvery appearance. If they stop swimming or lose their hold on the bottom they quickly come to the surface, as their bodies enveloped in air are much lighter than the water. They occasionally float on the surface of the water, or slowly paddle about with their oar-shaped legs. When they choose they can leap from the water into the air and fly away. They feed principally on other insects and lay their eggs upon water plants.

The back-swimmers,¹⁴¹ like the foregoing family, are represented by a single species¹⁴¹ that happens to be one of wide distribution. The favorite attitude of the back-swimmers is floating on the surface of the water back down, with their long oar-like legs stretched outward and forward ready for making a stroke. When disturbed they will dart out of the way, usually by going rapidly to the bottom, there to remain hidden for some time. Other minute bugs,¹⁴² with minutely-spotted wings in the adult and with a red edge to the abdomen in the immature stage, that walk about on the water, especially in stagnant, weedy pools, are very common. They belong to a totally different family¹⁴³ of insects from either of the two species just described, and in turn may be easily confused with rarer species of bugs and flies that frequent similar places.

¹³¹ *Pyrhocoridae*. ¹³² *Teleonimia lantanae*. ¹³³ *Tingitidae*. ¹³⁴ *Nabidae*. ¹³⁵ *Reduviidae*.
¹³⁶ *Reduviidae*. ¹³⁷ *Zelus renardii*. ¹³⁸ *Corixidae*. ¹³⁹ *Arctocoris blackburni*. ¹⁴⁰ *Notonectidae*.
¹⁴¹ *Buenoa pallipes*. ¹⁴² *Microvelia vagans*. ¹⁴³ *Gerridae*.

PLANT-LICE.

The sub-order¹⁴⁴ to which the plant-lice, the jumping plant-lice, the lantern-flies and similar insects belong, is made to include a number of odd bugs with suctorial mouth parts. Though they differ widely in form, they usually agree in that when the wings are present they are of the same thickness throughout. When at rest their wings are held slanting, roof-like, at the sides of the body.

LEAF-HOPPERS.

The tree-hoppers¹⁴⁵ if represented in the fauna are included only as recent introductions; one species¹⁴⁶ was taken as long ago as 1908. The leaf-hoppers,¹⁴⁷ better known as jassids, are slender, minute, inconspicuously-colored insects which, like the lantern-fly family¹⁴⁸ and closely-allied families, are represented in the Hawaiian fauna by a very few species. The sugar-cane leaf-hopper¹⁴⁹ is by far the most destructive member of a family¹⁵⁰ to which have been referred ten genera, including thirty species of Hawaiian insects. They are arboreal in habit, favoring the higher elevations. They average about four millimeters in length and are extremely difficult to identify specifically.

In a synopsis of the family of Aphids or plant-lice,¹⁵¹ Prof. D. T. Fullaway enumerates twenty-one species belonging to eight genera as occurring in the Hawaiian fauna. A large number of these are of economic importance, and have had notice in a chapter devoted to that phase of the local insect life.

The *Aleyrodida*, which formerly were included with the scale-bugs and mealy-bugs,¹⁵² are represented by six known species, while the coccids have close to one hundred species in the fauna, almost all of which have been brought to Hawaii within the last one hundred years. Of this number only two are thought by specialists to belong to the native insect fauna.

THRIPS.

The thrips¹⁵³ are microscopic insects so small that they rarely attract the attention of even observant persons. Under a hand lens or the microscope the adults show their four long narrow wings, of nearly equal size, to be fringed with long hairs. These are laid horizontally on the back when at rest. However, in many of the Hawaiian species the wings have been reduced to functionless pads. Thrips are to be found in various places, as in flowers, lichens and moss, and on the underside of stems, leaves and stalks of grass, plants and shrubs. Their mouth parts show them to be intermediate between the sucking and biting insects, and, as one would expect, they are known to feed on other insects and upon vegetation. Four families are represented by twenty or more species, the most of which are black, brown or chestnut-brown in color.

¹⁴⁴ Homoptera, ¹⁴⁵ Membracidae, ¹⁴⁶ Centropygus sp., ¹⁴⁷ Tettigoniidae, ¹⁴⁸ Fulgoroidea,
¹⁴⁹ Perkinsiella saccharicida, ¹⁵⁰ Jassididae, ¹⁵¹ Aphidae, ¹⁵² Coccidae, ¹⁵³ Thysanoptera.

One species¹⁵⁴ found here in the mountains is common in greenhouses in Europe and America. The mango thrip,¹⁵⁵ occurring in Hawaii, is a species belonging to the same genus. Other species occur on cultivated plants.

GRASSHOPPERS, CRICKETS, COCKROACHES AND EARWIGS.

The order *Orthoptera*, as treated in the Fauna Hawaiiensis, is made to include such well-known insects as the grasshoppers, crickets, cockroaches, earwigs, and other forms with conspicuous mouth parts formed for biting, and with the lower lip divided in the middle. The mode of growth in each individual is by increase in size without any abrupt change in form except that the wings, when present, are only developed in the final condition of growth. In several forms the wings are rudimentary and not suited for flight.

The *Orthoptera* are all insects of comparatively large size, and many of them, on account of their voracious appetites, are very destructive to cultivated plant life.

The earwigs¹⁵⁶ are elongated, dark-colored insects bearing at the posterior end of the body a pair of curious pincer-shaped organs. They are common insects in Hawaii, occurring commonly in gardens and cultivated ground, as well as far up in the mountains. They are fond of concealing themselves in places difficult to enter. The name "earwig" is said to be due to a belief that the creatures are fond of creeping into the ears of persons while asleep. This curious and apparently groundless superstition is current in Hawaii, as well as in almost every other country these creatures inhabit. They are mainly carnivorous in habit and generally regarded as beneficial insects.

Ten species belonging to four or five genera are reported as occurring in the islands. Most of the species are of undoubted recent introduction, some of them very recent, while one which inhabits the mountain forests of Kauai,¹⁵⁷ and a rarer species¹⁵⁸ from Oahu, may have developed from early natural immigrants.

The cockroaches,¹⁵⁹ with at least sixteen species belonging to thirteen genera, are well known in Hawaii, where certain species are abundant household pests. They are all easily recognized by the common characteristics of the order that are well exhibited by familiar species. They all feed at night and fly from the light with a rapid scurrying gait which is peculiar to them. Only one species¹⁶⁰ is believed to be truly endemic. It is found only in the mountains among the leaves of native plants. The other species frequent the inhabited areas to such an extent as to preclude the possibility of their belonging to the native fauna, even though, as in one or two instances, they have never as yet been taken outside of the islands.

The two larger common house roaches,¹⁶¹ of which the American species is the larger, have already been mentioned; but six or seven species are liable to occur about buildings, often in company with them.

¹⁵⁴ *Heliothrips hamorrhoidalis*, ¹⁵⁵ *Heliothrips rubrocinctus*, ¹⁵⁶ *Dermaptera*, ¹⁵⁷ *Anisolabis pacifica*.

¹⁵⁸ *Anisolabis littorea*, ¹⁵⁹ *Blattodea*, ¹⁶⁰ *Phyllodromia obtusata*.

¹⁶¹ *Periplaneta americana* and *P. australasia*.

Two species of praying mantes,¹⁶² or mule-killers, belonging to two different genera, have been introduced. One, the Australian mantis,¹⁶³ occurs on Kauai; the other, known as the Chinese praying-mantis,¹⁶⁴ on Hawaii, where it was first taken in 1900. These curious-looking insects, with pious faces and front legs clasped meekly together, are not so pious as they appear. They are insect feeders with a desire for food that is seldom satisfied. They are harmless to man and beast, though the curious form of their body gives them a formidable and menacing appearance.

The short-horned grasshoppers¹⁶⁵ or locusts are now represented by two or three introduced species. In these the antennæ are shorter than the body, and the ovipositor of the female is made up of four short separate parts.

The green species with the long, sloping head, suggesting a dunce-cap, which is known as the Australian grasshopper,¹⁶⁶ was accidentally introduced from that country about 1887 and has since become common on Oahu and Kauai, and perhaps other islands. A more typical species with a square head¹⁶⁷ was introduced probably from Australia also, and has since become quite common about Honolulu.

The long-horned green hoppers¹⁶⁸ always attract attention by reason of the extreme delicacy and great length of their antennæ, which always exceeds the body in length.

The common meadow grasshopper¹⁶⁹ is well established all over the islands in open pasture land and on mountainsides, and serves as a common type of a group of insects represented by at least thirteen species and four genera. Two of the genera—the one mentioned above and one with a single species,¹⁷⁰ also common on the plains, about rice fields, and the lower mountains—are introduced. The other two genera, one with ten species¹⁷¹ and one with a single species,¹⁷² are endemic. As the single large, green native species, belonging to the last genus, has only been secured from Olaa, any rare green or brown grasshoppers, with long antennæ, taken elsewhere in the mountains of the group can with safety be referred to the larger genus by the novice.

The crickets¹⁷³ all differ from both the long-horned and the short-horned grasshoppers in having the wing covers flat above and bent sharply down at the edge of the body, suggesting the lid of a box, instead of meeting in a ridge above the body like a roof. As a rule, the males have a very different appearance from the females—a difference so marked that in one instance the sexes were placed in separate genera. There are in Hawaii about forty species of crickets belonging to ten genera. Of that number, three dozen or more are recognized as peculiar to Hawaii, and for the most part confine their range to the native forests on the different islands. Sixteen of the native species are placed in a single genus with a brown mountain cricket¹⁷⁴ as the most widely-distributed, abundant and easily-captured species. They are fond of the wet

¹⁶² *Mantodea*. ¹⁶³ *Orthodera persiana*. ¹⁶⁴ *Tenodera sinensis*. ¹⁶⁵ *Aceridiodea*.

¹⁶⁶ *Atractomorpha crenticeps*. ¹⁶⁷ *Oxya velox*. ¹⁶⁸ *Locustodea*. ¹⁶⁹ *Xiphidium varipenne*.

¹⁷⁰ *Etimara appendiculata*. ¹⁷¹ *Brachymetopa*. ¹⁷² *Canocephaloides hawaiiensis*. ¹⁷³ *Gryllodea*.

¹⁷⁴ *Paratriginidium pacificum*.

woods and damp gulches, and are usually found on the ground. They sing all day long and most of the night, with a plaintive chirp that is an audible sign of the moist virgin forest. Their chirp can usually be heard a long way, and as they occur in localities frequented by tree snails, their song is often spoken of by the layman as the chirp of these tree-dwelling animals.

The leap of these insects is worthy of remark, as during the first leaps they can cover several feet in a single bound. But after a few jumps they lose their strength and make for cover on a run. The habits and appearance of the remaining species of the genus, and of the remaining mountain genera varies greatly, some being arboreal, some hiding beneath the bark of trees, and some frequenting peculiar species of trees or plants.

The introduced species, including the curious mole-cricket,¹⁷⁵ elsewhere referred to, and two species of the true crickets, one of which ¹⁷⁶ is common and well established, the other ¹⁷⁷ a more recent introduction, occur about houses and gardens, especially in Honolulu. The familiar chirp of the true crickets adds a homely note to the music of the soft tropical evening in Hawaii, and all agree that their song more than repays the slight damage they may do to vegetation and to stored food.

WINGLESS BIRD-LICE.

The wingless bird-lice ¹⁷⁸ are minute parasitic insects with biting mouth parts that live among the feathers of birds. They are to be found on both the native and introduced birds of Hawaii. The list includes upwards of twenty species taken from a dozen species of the common birds and doubtless falls far short of a complete enumeration of the bird-lice to be found in the group, since, of the twenty species recorded, seventeen are described as new to science. While the rule is for each species of birds to have its own peculiar form, it is not unusual to find several species of bird-lice infesting a single bird. The beautiful red iwi,¹⁷⁹ for example, is infested with three genera representing three species, and the Chinese dove with two.

SILVERFISH AND SPRING-TAILS.

The spring-tails ¹⁸⁰ are included in an order of insects that are entirely without wings in all stages of growth. Five species so far reported from Hawaii are minute silvery, yellowish or pale-colored creatures usually less than two millimeters in length. They are provided with a curious tail-like organ which is bent under, when the insect is at rest, that reaches almost to the head. This organ, when suddenly straightened, throws the insect into the air like a rocket to land several feet away, presumably in a place of safety. The species so far secured have been taken from the high mountains under bark and from other sheltered places, but their general habits are unknown.

Coming to the most primitive order of living insects,¹⁸¹ familiarly known as bristle-tails, fish-moths or silverfish, we find the order represented by

¹⁷⁵ *Gryllotalpa africana*. ¹⁷⁶ *Gryllus innotabilis*. ¹⁷⁷ *Gryllus* sp. ¹⁷⁸ *Mallophaga*. ¹⁷⁹ *Vestiaria coccinea*.
¹⁸⁰ *Collembola*. ¹⁸¹ *Thysanura*.

several species peculiar to the islands. At least one or two among them, especially the common silverfish,¹⁸² were introduced. They are all active insects that live in obscure places and, like the spring-tails, they never exhibit any trace of wings. The silverfish has a distinctly segmented body, covered with minute hairs or scales, which terminate in two or three bristle-like appendages. The four native species so far reported belong to two families and have all been described from specimens collected in the native forest. The native species from Oahu¹⁸³ occurs also on both Maui and Kauai, and is about thirteen millimeters in length. Doubtless there are other species to be discovered, as the mountains of the islands mentioned are the only localities from which these interesting insects have as yet been reported.

CHAPTER XXXIII.

LAND AND FRESH WATER SHELLS.

The land shells of the Hawaiian Islands have been more extensively collected and minutely studied than any other group of animals in the islands, and it is doubtful if any single group of animals in the world has contributed more really striking material for systematic study or received more attention from students of evolution.

LAND SHELLS.

The first Hawaiian land shells to be examined by Europeans were specimens secured by Captain Dixon from a shell lei or necklace which was procured in the islands on the occasion of his memorable visit. He carried the specimens back to England and described the first species as *Turbo apcx-fulva* in the report of his voyage round the world, which was published in 1789. From that time to the present land shells from Hawaii have been eagerly collected by almost every one with a taste for general natural history.

Almost every boy in Hawaii has at one time or another made his collection of land shells, and a long list of scientific men and energetic collectors, past and present, have given much time and thought to the collection and study of this most interesting group of mollusks.

While there are perhaps fifteen well-established families with as many as thirty-five genera represented in the entire land and fresh-water shell fauna of the islands, it is the beautifully and conspicuously-colored tree-dwelling forms, commonly known as "tree snails," that are most generally sought for by the shell enthusiasts. Moreover, they are the forms upon which most of the important systematic and philosophic work of the past has been based. According to Mr. E. R. Sykes, who published an extensive paper on the subject of the Hawaiian Mollusca as late as 1900, at least three hundred and twenty-two of

¹⁸² *Lepisma saccharina*.

¹⁸³ *Machilis heteropus*.

¹ *Achatinellidae* (see page 433).



PLATE 100. COLOR VARIETIES EXHIBITED BY TWO COMMON SPECIES OF LAND SHELLS.

1. *Achatenallastrum varia* and varieties. 2. *Apex mustelina* and varieties.

the approximate five hundred species and varieties of Hawaiian land and fresh-water shells then known, were placed in the one family¹ which, according to his view, was made up of nine genera. Of that number the four genera, *Achatinella*, *Amastrea*, *Leptachatina* and *Auriculella*, contain the great bulk of the species. These names occur so often in the literature on the shells of the group, and are represented by such extensive and handsome series in the various noteworthy collections in the islands, that the remaining genera of the family and the long list of genera belonging to other Hawaiian families too often appear to be lost sight of.

VARIATIONS.

The super-genus *Achatinella*, for example, is represented by upwards of one hundred species,² the majority of which grade through such a perplexing variety of shades and forms that it is usually impossible to fix the exact limits of the species. Indeed, Rev. E. W. Thwing collected from various sources and published no fewer than three hundred and fifty-eight descriptions that have been applied by different authors to the various forms in the above genus alone.

With so long a list of names founded on such variable characteristics as size, shape, locality, color pattern, banding and other variable markings to be considered for the most part as synonyms, the amateur collector although he may be provided with the literature on the subject—a literature which includes more than two hundred titles—finds himself involved in an almost endless confusion of names. What is worse there is such a diversity of opinion among the authorities on the minute points involved in the classification of the shells in this important genus, that for the present, at least, the student in desperation is reduced, as a rule, to simply keeping his shells, gathered from various localities carefully separated—usually labeling them by valleys, ridges, side ridges, spurs and in some cases indicating the particular bush or tree from which they were taken, in the hope that some day the subject of nomenclature will be definitely settled.

Nevertheless, this tendency to wide divergence in form and color in the various groups and species furnishes to the true shell collector his chief source of interest and relaxation at home and a worthy excuse for any number of all-day rambles in the mountains. This point can better be appreciated by taking one or two fairly typical examples.

COLOR VARIETIES.

Extending over both sides of the mountains back of Honolulu, from Niu Valley to and including Makiki Valley, are distributed the species and varieties of what for convenience is known to some authors as the *Fulgens* group. To this group seven described species have been referred. But each of the so-called species ranges through a series of varieties sufficient in the opinion of

² The exact number varying with different authorities.

some to unite it very nicely with other species in the group. Under one species³ are described no fewer than forty-two color varieties! Some are bluish-gray, others ashy-chestnut with black bands. Some are with two bands, others have three. Others are white or yellowish at the base, reddish-gray above, with a dark spiral line between. Others, again, are smaller and more elongatedly ovate. Still others are thinner than the typical varieties. Some have the spire more convex and colors less streaked, and so on, to the end that almost every specimen collected is found upon close examination and comparison to vary, much or little, from its next neighbor. But, unfortunately for the collector, this remarkably variable species, name and all, in the opinion of a second authority, is reduced to the rank of a synonym under the name of one of the other species⁴ in the *Fulgens* group of our first authority, and in company with a species⁵ from Waimea Valley, at the extreme opposite end of the Koolau range that has been carefully referred by our first authority to an entirely separate group, the range of the species is thus made to extend over this chain of mountains from end to end!

With such confusion in almost every species, it is little wonder that all those who collect Hawaiian land shells—and there are those in Honolulu who have private collections numbering into scores of thousands of specimens—are looking patiently forward to the completion of the work* by the more

NOTE:—Since the manuscript for this chapter was written, Volumes XXI (1911) and XXII (1912-1914), and a more recent supplement to Volume XXI, of the *Manual of Conchology* have appeared. Both volumes are splendidly illustrated with colored plates and include synonymy and descriptive text treating fully the Hawaiian terrestrial *Amastriidae* and the tree-dwelling *Achatinellidae*. This review of these interesting families of land mollusks by Dr. Henry A. Pilsbry, with the assistance of a number of local collectors, has been anxiously awaited by students and conchologists generally. The volumes are in every way praiseworthy, and are indispensable to those who are interested in this section of the Hawaiian fauna.

Volume XXI is devoted to the sub-family *Amastrina*, which in the subsequent volume is elevated to full family rank (*Amastriidae*). It is made to include seven Hawaiian genera, namely: *Leptachatina*, with 117 species and a number of sub-species; *Carelia*, with eleven species and nine sub-species and varieties; *Pterodiscus*, seven species, two sub-species; *Planamastira*, two species; *Armsia*, one species; *Amastira*, 114 species with numerous sub-species and varieties; *Laminella*, fourteen species and six sub-species and varieties, the last genus being arboreal in habit.

Volume XXII treats fully of the true *Achatinellidae*, recognizing three well-defined genera, namely: *Newcombia*, *Partulina* and *Achatinella*. The *Partulina* are further divided into four (*Perdicella*, *Partulina*, *Balderianina*, *Eurnella*), and the *Achatinella* into three (*Bulinella*, *Achatinellastrum*, *Achatinella*) sections. The genus *Newcombia* includes nine species and three sub-species; *Partulina*, fifty-one species and a number of sub-species, varieties and forms; and *Achatinella* forty-one species with a very large number of sub-species and minor forms. In the appendix to Volume XXII, and the supplement mentioned, as many as two score of species and sub-species are described, in addition to the large numbers of new species described in the text of the volumes. They are divided quite equally among the various genera in proportion to the number of forms already known, and represent graphically the progress made during the period (1911-1915) of publication towards a more complete systematic knowledge of the land shell fauna of the group. The rapid increase in new species indicates that the possibility of collecting new forms is by no means exhausted. A comparison of the text and synonymy of these later volumes with the earlier (1900) work of Mr. E. R. Sykes will show the sweeping changes that have taken place in the nomenclature during the period of fifteen years.

It is to be hoped that the remaining families of Hawaiian air-breathing mollusks (*Pulmonata*) may receive a similar review by the author of these epoch-fixing volumes at an early date.

³ *Achatinella plumata*.

⁴ *Achatinella buddii*.

⁵ *Achatinella casia*.

recent and most painstaking authorities, the renowned Dr. H. A. Pilsbry, of the Academy of Natural Sciences of Philadelphia, and the local specialist, Dr. C. Montague Cooke, of the Bishop Museum. It is hoped that their conclusions as published from time to time, since they are based on extensive field collections and the examination of the hundreds of thousands of shells now in museum collections, will at least settle once and for all the question of "which is which" in the shell fauna of these islands.

But we cannot afford to pass without comment in this connection the interesting investigation of my friend and colleague, Dr. Cooke, on the distribution and variation of a single species⁶ of *Achatinella* from Nuuanu Valley, published by the Bishop Museum.

For his purpose he selected a shell from Nuuanu Valley that, as a recognizable species, seemed to be fairly abundant and is commonly regarded as occurring only in that single valley. The northwest side of the valley was carefully explored and about three thousand shells collected, over half of which belonged without question to the single species under investigation. Beginning at the upper end of the valley, at the famous Nuuanu Pali, the habitat studied included the main ridge on the left and the sub-ridges and valleys that extend into the main valley of Nuuanu from one hundred to three hundred yards at almost right angles to the main ridge. On account of the sedentary habits of the land snails, these ridges, owing to the deep valleys that separate them one from another, form isolated habitats. Of the twenty-three sub-ridges the upper seventeen were all found to offer a very uniform environment as far as food, moisture and elevation were concerned. All were found to be inhabited by the particular species of land shell being studied. In some instances the sub-ridges were further sub-divided into special localities so that the area of none of the localities was over one hundred and fifty yards in diameter. Specimens were found to favor the more open localities between one thousand and fourteen hundred feet elevation.

With the data and material at hand Dr. Cooke was able to describe twenty-five well-marked color varieties, all of which were more or less closely connected by intermediate specimens. When we remember that the species in its various forms is distributed over an area only a few hundred yards wide at most, by two or three miles in length, it is clear that much scientific interest must attach to such studies. Among many other interesting facts it was found that the shells varied not only from one ridge to another, but from one colony to another. In fact, the specimens secured from a given limited locality often varied among themselves to a remarkable degree.

It was the early appreciation and observation of facts such as these, and a desire to find the law that underlies such facts, that led my friend, the distinguished evolutionist, Rev. John T. Gulick, in his early youth to begin a systematic collection of land shells. Later, through the inspiration of Darwin's great book on "The Origin of Species,"⁷ he set to work in earnest, with

⁶ *Achatinella multizonata*.

⁷ Published in 1859.



PLATE 101. FRESH WATER FAUNA OF OAHU.
(FOR DESCRIPTION OF PLATE SEE OPPOSITE PAGE.)

the result that he soon published a considerable amount of valuable data based on Hawaiian land shells, the object of which was to show that isolation, segregation and variation were exceedingly important and until then almost neglected factors in the theories advanced in efforts to explain the formation of natural species.

In the study of so small and apparently unimportant a subject as a land snail, Dr. Gulick's philosophic mind found abundant material for the elucidation of such profound subjects as the variation of species as related to their geographical distribution illustrated by the *Achatinellida* (1872); diversity of evolution under one set of external conditions; divergent evolution through cumulative segregation; intensive segregation; divergent evolution and the Darwinian theory; the inconsistencies of utilitarianism as the exclusive theory of evolution, and lastly the preservation and accumulation of cross-infertility (1890-97). All of these were contributions to knowledge of the most far-reaching significance.

IMPORTANT FAMILIES REPRESENTED.

Scarcely less in numerical importance when compared with the genus *Achatinella* are the one hundred and fifteen or more species of the genus *Amastrea*, representatives of which are distributed over all the large islands of the group. The *Leptachatina*, with an equally extended list of species, is likewise distributed; and so the enumeration could be extended, but it is not the intention in this place to attempt more than to encourage the beginner to enter this fascinating field of study, where so much has already been accomplished and where yet so much remains to be done before this remarkably rich and varied fauna will be completely understood.

In the gathering of these "jewels of the forest" the collector will find many forms occupying a great variety of habitats, so that bushes, grass, trees (including their leaves, trunks and limbs), the ground, dead leaves, the rocks in the streams, the streams themselves—in short, almost every conceivable place, but particularly the moist regions of the mountains—is liable to have its shell inhabitant. The great majority of those species found on the ground, however, are more liable to belong to some of the fourteen families other than the *Achatinellida*, but they will not be found entirely devoid of interest for

DESCRIPTION OF PLATE.

1, 2, 3. Chinese Snail (*Viviparus chinensis*). 4, 5. Melania (*Melania mauritensis*). 6, 7. *Melania mauritensis* (Badly eroded). 8, 9, 10, 11. *Melania newcombi*. 12. *Neritina vespertina*. 13. *Neritina cariosa*. 14. Pipipi (*Nerita picta*) on rocks at low tide. 15. Operculum from *Viviparus chinensis*. 16. *Limnaea* (*Limnaea oahuensis*). 17. Shrimp [Opae] (*Macrobrachium grandimanus*). 18. Dragon Fly [Pinau] nymph (Introduced). 19. Brackish water Crab (*Mictograpus messor*). 20. Native Dragon Fly [Pinau] nymph. 21. Shrimp (*Macrobrachium grandimanus*). 22. Water Beetles (*Hydrobius semicylindricus*). 23. *Limnaea* (*Limnaea binominis*). 24. Fresh water Clam (*Spharium* sp.). 25. Water Beetles (*Ethanthes pacificus*). 26. Sow-bug (*Porcellio scaber*). 27. Waterboatman (*Acetocoris blackburni*).

that reason. As many of them are scarcely an eighth of an inch in length, they require that careful search and much patience be expended in collecting them.

Among the more conspicuous of the various families, not included in the extensive divisions of the *Achatinellidae*, are the *Succineidae*. There is but the single genus⁸ in the family, with perhaps thirty species known from the islands: the larger number being found on the Island of Hawaii. They are delicate thin-shelled mollusks with a slightly spiral shell, the last whorl of which is large and flattened, giving the empty shell the appearance of a twisted finger-nail. The majority of the species prefer damp situations, usually under luxuriant foliage, though there are species that vary their habitat somewhat. Another family⁹ with very fragile spiral shells is represented by perhaps a dozen species of the genus *Limnæa*. At least half the known species are from Oahu. The best representative of the genus is the small shell¹⁰ found floating on the surface of the water in taro and rice ponds about Honolulu. Other forms occur in the cool mountain water at high elevations; a horn-colored species¹¹ found on the rocks beside the waterfalls at the head of Manoa Valley furnishing a good example. *Erinna newcombii* is the only known Hawaiian species of this related genus; it was reported only from the Hanalei river, on Kauai, until the author collected specimens from the Limanui stream.

A very minute cap-shaped shell¹² found in various streams on the under side of decaying leaves, especially the leaves of kukui and hau, also belongs in this group, although there is little in the shape of the tiny paper-like shell to suggest such a relationship. While they are fairly common and are quite generally distributed, on Oahu at least, they are very seldom seen even by expert collectors.

The conspicuous and abundant long spiral fresh-water shells common in the lower portion of the streams on Kauai, Oahu, Maui and Molokai are sure to belong to one family.¹³ The six known species are all placed in one genus.¹⁴ The species¹⁵ with the entire surface roughened is the more widely distributed, being taken on all of the islands mentioned. The smooth species¹⁶ has so far been collected on Oahu and Kauai, but both species often occur together in the same stream.

Some years ago the Chinese introduced an edible snail¹⁷ which has become firmly established in the taro and rice ponds of Kauai, Oahu, Maui and Molokai, and doubtless on the other islands. Large specimens may be collected, often two inches or more in length, but as a rule they are seldom so large. They are, however, easily the largest species of land or fresh-water shells in the group and belong to a family¹⁸ without other representatives in the islands.

The small globular snails¹⁹ with short spires occurring in damp woods have as many as a dozen or more known species. They are the only representatives of the operculate shells in the land fauna; but as the largest

⁸ *Succinea*.

⁹ *Limnæidae*.

¹⁰ *Limnæa oahuensis*.

¹¹ *Limnæa binominis*.

¹² *Ancylus sharpi*.

¹³ *Melaniidae*.

¹⁴ *Melania*.

¹⁵ *Melania mawaensis*.

¹⁶ *Melania newcombii*.

¹⁷ *Vitiparus chinensis*.

¹⁸ *Vitiparidae*.

¹⁹ *Heliciniidae*.

examples are less than a quarter of an inch in diameter, they are seldom taken by other than a specialist with a taste for collecting the small "pin head" groups of Hawaiian mollusks.

Occurring in similar localities with the species mentioned above are found the beautiful spiral, translucent, shining *Opeas*. A common species²⁰ occurs on all the islands, but as there are but four species belonging to the two genera in the family,²¹ they are not regarded as important.

The streams, particularly towards their mouths, are liable to be inhabited by one or more of the five or six species of *Neritina* found in the islands. A large flat black species with an orange mouth and roughened shell²² is found higher up in certain streams, adhering to stones. They are gathered for the markets, the finest specimens perhaps coming from Pelekunu Valley, on Molo-kai. All of the species are liable to be found on any of the islands, their occurrence apparently depending on the habitat. The several fresh and brackish-water members of this family²³ adhere to stones and other objects in the water, and all are eaten by the Hawaiians.

A very common coiled snail shell²⁴ that grows to be three-fourths of an inch in diameter, is common all over the island, but especially plentiful about Honolulu, where they occur under boards and flower pots, or in moist weather may be found slowly creeping about over the grass, fences, walks and shrubbery. They are the largest representatives of the *Helix* family²⁵ in Hawaii, and as this species is widely distributed, it is doubtless an introduced form. Specimens are abundant in scattered and isolated places on Oahu, indicating that it is by no means a new arrival.

During a period of drought the animal draws back into the coils of the shell and secretes a whitish paper-like false operculum over the aperture. They will live in this condition for many months, but in the rainy season they become active again.

The curious black slug,²⁶ about two inches in length with a pale line down the center of the back, is also an introduced species that at times is very plentiful about Honolulu. They are nocturnal in habit, coming out at night from moist places where they remain hidden during the day. Slugs often leave a trail of slime or mucous behind them as they creep along. They are supposed to feed upon decaying vegetation. Although an introduced species, it serves very well to represent the family of true slugs,²⁷ of which there are five or six species known from the mountains on the different islands. They are not abundant, however, the most common native slug²⁸ on Oahu being a small species that occasionally occurs in the mountains of Kauai and Maui.

While the species of several families of Hawaiian shells²⁹ are too minute to be often seen or to admit of a brief characterization, they are, nevertheless, sure to occur in the material gathered by a careful collector. Probably between seventy-five and one hundred species of Hawaiian shells are placed in the

²⁰ *Opeas junceus*. ²¹ *Stenogyridæ*. ²² *Neritina granosa*. ²³ *Neritidæ*. ²⁴ *Eulota similis*.
²⁵ *Helicidæ*. ²⁶ *Veronicella* sp. ²⁷ *Limacidæ*. ²⁸ *Agriolimax bevernoti*.
²⁹ *Zonitidæ*, *Philomyxidæ*, *Endodontidæ*, *Pupidæ*, *Tornatellinidæ*.

various families here grouped as being too small to be illustrated or to receive notice in a book of this character.

The tiny fresh-water clams³⁰ are represented, so far as known, by a very minutes species³¹ and a still smaller form³² on Oahu, Molokai, Kauai, and perhaps other islands of the group. Both of these forms are very small, the larger being less than two-tenths of an inch in diameter.

EARTHWORMS.

The worms of the islands have never been exhaustively studied. A dozen species of earthworms³³ representing three genera are enumerated by Dr. F. E. Beddard, who examined and reported on the material collected by Dr. Perkins. The species occurring in cultivated grounds appear to have been transferred to the islands by man. The leeches³⁴ have not been studied. Two species are quite common in the streams of Oahu, and there are doubtless other species on the different islands. But in general the fresh-water streams of Hawaii have received but little attention from zoölogists, doubtless owing to the fact that they are known to be very sparingly inhabited by animals of any considerable size, save a few fish and fresh-water shrimp. Of recent years, however, frogs, tadpoles, mosquito fish and dragon-fly larvæ have added a welcome touch of life to the streams.

CHAPTER XXXIV.

SHELLS FROM THE SEA-SHORE: PART ONE.

PLEASURE OF COLLECTING SHELLS.

A ramble by the sea-shore usually results in gathering shells, seaweed, fragments of coral and such odd remnants of life as are cast up by the waves, and it is from the desire to know more of the natural history of such objects that many a person has been led into the systematic study of the life of the sea and thereby become a life-long student of nature. To one with a taste for such pursuits, the sea-shore of the Hawaiian Islands furnishes a never-failing and ever-changing lure. Winter or summer, day or night, one may wander up and down the beach or wade in the shallow water for miles, knowing that he can never grow too old nor become too full of knowledge to enjoy nature's open school by the sea-shore.

The class of objects most liable to attract the novice are the dead shells strewn here and there along the sandy beach. Little by little one comes to realize that there are many different kinds of shells, and that realization usually is the starting point of the collection of shells, for one soon appreciates the necessity of specimens for comparison; and the pleasure of adding little by little to the storehouse of one's treasures by one's own efforts is a pleasure that has in it all of the joys of discovery, knowledge and possession.

³⁰*Cyrenidae*.

³¹*Spharidium* sp.

³²*Pisidium*.

³³*Terriicola*.

³⁴*Hirudinea*.

Persons coming to Hawaii imbued with the idea that the shores of all coral-wreathed islands in the tropics are piled high with large and showy shells, such as adorn the curiosity dealers' windows throughout the country, and that are often labeled "from Hawaii," or more often the "Sandwich Islands," are sure to be disappointed. Such shells are usually gathered from islands far to the south of Hawaii. They are labeled "from Hawaii," not so much from a desire to give their proper locality, a thing the collector soon learns to appreciate as a matter of very great importance, as to make of them mere "curiosities," something rare and strange to sell to the unsuspecting. For that reason it is better to collect such specimens as one can gather, even though they are not as large or brilliant as those one can buy, and exchange such duplicates as are gathered with associates, be they schoolmates, traveling companions or professional collectors.

The first expedition, perhaps a stroll along the bathing beach at Waikiki, is an auspicious one if two dozen different kinds of small beach-worn shells are gathered; for with shells, as with almost all forms of life, only the most resistant types can withstand the grinding action of the waves. If the same beach is visited the following day, a week later, or when opportunity offers, without doubt other species will be found; thus the little collection grows.

The enthusiast soon learns that different environments, as sandy beaches, rocky coasts, coral reefs, sheltered bays and the open coast line, are inhabited by different groups of mollusks and that in due time their shells are cast upon the shore. The pleasure and the profit in visiting the same localities and different localities under varying conditions at different seasons, again and again, soon comes to have a fascination that only those who have become enthusiasts themselves can understand in others.

THREE TYPES OF MOLLUSCA.

So far as the writer knows, no one has ever succeeded in gathering a complete collection of all the shells that may be collected from the waters about the islands, or even from the shore of a single island. A complete collection would number many hundreds, if it were made to include all of the many-celled animals without a backbone and with unsegmented bodies, without paired, jointed appendages and with or without a hard shell, that are included in the great phylum Mollusca.

Such a group would include three widely different types of animals. The squid, the octopus and their kind,¹ in which the head is well developed and in which the front part of the foot surrounds the mouth and is remarkable for its bearing a series of lobes or tentacles—called the "arms" in the octopus—form one class.

The snails, slugs, whelks and periwinkles form a second class and are called Gasteropods. They are usually, though not always, with spiral shells, but they may be without shells at all. The name gasteropod means stomach-

¹ *Cephalopoda*.



PLATE 102. TWO MOLLUSKS USED BY HAWAIIANS AS FOOD.

1. An Octopus or Devil Fish [Hee] (*Octopus* sp.) as seen at the Aquarium. 2. Hawaiian gathering Pipipi (*Verita picea*) from the rocks at low tide.

foot, and is an allusion to the fact that the entire lower portion of the body is thickened and flattened to form a broad muscular foot adapted to their clinging and crawling habits. In the common and more typical forms, the aperture, which is the opening into the spiral shell, is closed when the animal is retracted, by a small horny or shelly plate called the operculum, but both the spiral shells and the operculum are absent in certain gasteropods.

The third division² includes such creatures as the mussels, clams, scallops and oysters, in which a right and left valve or shell can be plainly recognized. For this reason they are commonly spoken of as bivalves. The living animal has broad, flat gills on each side of the body to which water is brought through a tube called the siphon. The food, consisting of minute plants and animals, is strained out of the water as it passes through the incurrent and excurrent tube. The bulk of the soft part of the animal is called the foot and is suited for digging.

MUSSELS, CLAMS, SCALLOPS AND OYSTERS.

While there are a number of species of bivalves in the waters about the islands, perhaps not more than fifteen or twenty species are common on Oahu. Of these the one most frequently met with is the common mussel,³ which in many places, as at Diamond Head and Pearl Harbor, almost pave the shore below the low-tide mark. They are from an inch to two inches in length; the right and left valves are equal, slightly ridged, and are covered with an epidermis which varies from black to light yellow. The hinge has minute teeth, and the beak is at one end of the hinge-line. They live attached to rocks, shells, piles or other objects by a number of threads called the byssus. A species occurring in Europe is much esteemed as food. The Hawaiians use the nahaweie, as they are called, but so far as the writer knows they have never been gathered for market.

A method formerly employed by the natives in preparing this common mollusk for food should be of interest to sea-shore campers. A spot was found where the mussels were exposed at low tide, and over the bed of shells, drift-wood was piled and a fire lighted. The heat caused the shells to open and at the same time roasted the fleshy part within, rendering it very palatable. The natives also gathered them from the shallow water and placed them in wooden calabashes in which water was heated by means of hot stones. In a few minutes the animal would be thoroughly cooked. The water was then drained off and a pinch of sea salt added to bring out the flavor of the food.

The *Mytilus*, or edible mussel, is readily separated from the two or three common species of *Perna*, especially a small black form⁴ which it somewhat resembles, by the more compressed form of the shell and by the several tooth-like notches along the straight hinge-line. The *Perna* are further marked by conspicuous flaky lines of growth which are important characters in the various common forms. One species, the papaua of the natives, common at

² *Pelecypoda* or *Lamellibranchiata*.

³ *Mytilus edulis*.

⁴ *Melina* = (*Perna*) *californica*.

Kiwalao, is cream color with black teeth. A third species is dark-brown in color, with the hinge-line somewhat elongated and marked with fan-like lines radiating from the beak.

A species of the pearl oyster family⁵ occurs at Pearl Harbor. The common species "pa" is often three or four inches or more across. The hinge-line in the common pearl oyster⁶ found here is long and straight, without teeth, and is produced to form wing-like projections of the shell at either side of the beak, which is much nearer the middle of the hinge. Without doubt it was the presence of this shell with the iridescent interior, occurring at Pearl Harbor, on Oahu, that gave that sheet of water its name. Although they belong to the same sub-family,⁷ they are not the famous pearl shell⁸ of the South Pacific islands. However, a pearl-bearing species is found in Pearl Harbor and at certain other places about the group in the deeper water offshore, and pearls were found to some extent by the natives, but the pa was chiefly used by them for making fishhooks and to some extent in making the curious shell-eyes for their wooden gods.

Fine specimens of the chest or ark shell,⁹ locally known as kupukele, are to be found living in the water and bedded in the solid rock in certain localities in the uplifted coral reef about Pearl City. They, in common with other species of the family,¹⁰ have the beak near the middle of the hinge. The hinge-line is strong and straight and is furnished with fine interlocking teeth. The outside is fluted with pronounced squarish riblets. A second species¹¹ found washed up on the sand beaches is oblong in shape, and in the dead shell the whitish surface is marked with many fine riblets which in old age become broken up into squarish points by the lines of growth. The inside of the shell within the pallial line is also roughened by lines radiating from the beak.

The true oysters, the scallops and the saddle oysters differ from other bivalves in that they have but one, instead of two, adductor muscles for pulling the shells together. They lie on their sides instead of standing on edge as other bivalves do, and the under valve becomes flattened or otherwise modified in consequence.

There is a large species of extinct oyster¹² to be found in the uplifted beds about Pearl Harbor, but there also occurs a smaller living species¹³ seldom more than two inches in length. On account of its sharp edge it is called piocoe by the natives. It makes a rough, rude, irregular foliated shell, the edge interlocking by numerous notch-like folds. They are too small and scarce to be used extensively for food. Nevertheless, they, and their extinct cousins, indicate that a commercial species could be grown in the islands if the proper kinds were introduced and proper care taken in their planting, despite the fact that efforts in this field have so far proved unsuccessful.

⁵ *Ariculida*.

⁶ *Margaritifera fimbriata*.

⁹ *Arca*.

¹⁰ *Arca*.

¹¹ *Arca candida*.

⁷ *Ariculina*.

¹² *Ostrea retusa*.

⁸ *Aricula margaritifera*.

¹³ *Ostrea rosacea*.

ATTEMPTS AT OYSTER CULTURE.

In 1871 the first attempt was made to introduce the Eastern oyster¹⁴ into Hawaii. Again in 1883, Mr. Allen Herbert purchased three hundred Eastern oysters in San Francisco and planted them in Kalihī Bay, but heavy freshets in the stream covered them with mud. In October, 1893, another attempt was made. This time one thousand Eastern and three thousand California oysters¹⁵ were secured in San Francisco and planted in ponds at Ewa in shallow water. In a very short time the California oysters died. The Eastern oysters thrived better, and by 1895 Mr. J. F. Colburn undertook a more extensive planting. More than thirty-eight thousand oysters were planted in that year, but they did not thrive, and by 1901 only a few living shells could be found.

Next to the oysters come the pretty scale-like golden saddle oyster (pipi) or *Anomia* shells. The common species¹⁶ are irregular in form and the valves are unequal. The lower and usually the flatter valve is remarkable for the hole near the hinge through which a plug-like peduncle passes by which the shell is attached to other shells or rocks. Fine specimens occur about Ford's Island, at Pearl City, and are to be found in suitable places in other localities.

The scallops or pectens,¹⁷ of which two or three species are quite common, as well as a related genus,¹⁸ are more regular and symmetrical in the growth of the shell. They are usually flushed with rose color and ornamented with radiating ribs. The wing-like ears together with the symmetrical outline of the shell renders the genus¹⁹ an easy one to identify, and as the species are fond of sandy bottoms and shallow water their shells are scattered here and there along our beaches. The shell of Hinnites is irregular in growth. As they are usually attached to some submerged object, they are less commonly found on the shore.

Coming to the clam-like mollusks of the islands, first place should be given to the olepe²⁰ by reason of its being the most important shell-bearing food mollusk of the group, though the present day Hawaiians apply the same name indiscriminately to a number of edible bivalves that are in no way closely related to the common species. Full-grown specimens of the olepe are two inches or more in length and are creamy white in color. They are slightly flattened, but are rounded in front and angular and slightly folded posteriorly. The shell is beautifully sculptured with wavy lines which become more and more pronounced as the shell advances in age. They are fond of burying themselves in the soft mud at the mouths of rivers and have long been an article of food especially prized by the Hawaiians. A smaller, smoother, more delicate milk-white species²¹ known by the same name by the natives is often found in large numbers on the sandy beaches on the windward side of Oahu.

A small, round, white clam²² also occurs in Pearl Harbor, both as a living

¹⁴ *Ostrea virginica*. ¹⁵ *Ostrea lurida*. ¹⁶ *Anomia nobilis*. ¹⁷ *Pectinidae*. ¹⁸ *Hinnites giganteus*.
¹⁹ *Pecten*. ²⁰ *Tellina rugosa*. ²¹ *Tellina dispar*. ²² *Cadokia* = (*Lucina*) *ramulosa*.

and a fossil species. It has its firm shell sculptured with a large number of radiating riblets, and the margin minutely roughened or erenulated.

The genus *Cytherca* is represented by a heart-shaped clam²³ that is similar to the Venus clam but is much rounder and thicker. Like it, the hinge has three strong teeth, but the species has its surface beautifully marked with radiating blotches of brown. These markings, however, often disappear from beach-worn specimens, or in old age, leaving the pure white shell slightly roughened with minute hair-like growth lines. The markings are responsible for the common name tent or encampment shell.

In Hawaii, as elsewhere, one of the commonest forms of clam shell everywhere along the beach is a species of Venus²⁴ or round clams. Its stout white shell is beautifully roughened by prominent concentric bands which are broken up into numerous rectangular spaces by the radiating rib-like lines.

The typical species of Cardium or heart shell²⁵ found on Oahu is easily identified by its heart shape when both valves are joined, and by the strongly convex valves, which are deeply ribbed, the ribs interlocking on the margin of the shell. In addition to the center teeth there is also a strong tooth at the extreme end of the hinge line. The inner surface shows the furrows of the rib lines, and even in beach-worn specimens it is of a delicate pink color.

Several species belonging to the family of rock oysters²⁶ are found on the beaches, as they are fond of attaching themselves to various objects, especially the dead and growing coral. At first glance they may be mistaken for oyster shells, but their thick, heavy, solid, foliated shell is somewhat spiral at the tip and the unequal valves are united by teeth, two in the left, or attached valve, and one in the upper, or lid valve. The name of the genus²⁷ has reference to their gaping appearance. Some of the specimens are four inches in length and the two valves together often weigh a pound. The inside of the shell may be white or colored, especially about the margin, with rose, lavender or brown. As they are very thick and strong, they long withstand the grinding of the sea and sand, and fragments lie along the shore which are worn down perfectly smooth. Other specimens are much roughened by numerous small holes drilled in the shell by various worms which enter them for protection. They are sometimes used as food by the natives, either cooked or raw, and are known to them as kupakala.

GASTEROPODS, INCLUDING SNAILS, SLUGS, WHEELKS, COWRIES, ETC.

In a book of this character it is obviously impossible to give more than the briefest mention of some of the more common and interesting of the several hundred species of gasteropod mollusks that have been reported from the Hawaiian Islands. However, it is hoped that by reference to the accompanying figures and the brief description given of the more common species occurring in the waters about the islands, that many of the shells found along the shore

²³ *Lioconcha hieroglyphica*.

²⁴ *Venus reticulata*.

²⁵ *Cardium orbiter*.

²⁶ *Chamidae*.

²⁷ *Chama*.

may readily be placed in their proper genera by those who do not have access to more minute description. To make the illustrations more useful to those whose collections are made mainly from the beach, the majority of the specimens shown are in the beach-worn condition in which they are liable to occur. They were selected from material collected on four holiday excursions, one to Waikiki and Diamond Head, one to the dredger-dumped material from Honolulu harbor, one to Pearl Harbor and one to Kahana Bay. Ninety-two species belonging to forty-one genera were collected in this way. Of this number sixteen species belonging to fifteen genera are included in a list of forty-five species reported by Mr. D. Thaanum as commonly found on shore and in the shallow water about Hilo. Mr. Thaanum's collection, which includes the land and fresh-water shell collection made by the Kuhns brothers, is one of the largest and most systematic private collections in the islands. The marine collection numbers upwards of two hundred and fifty species belonging to ninety of the one hundred and twenty or more genera commonly included in a list of Hawaiian gasteropods.

As an example of the unusual reward to be had for more exhaustive collecting in a given locality for a single group of shells, it is interesting to report that Mr. J. M. Ostergaard has been able, in a few years, to secure from the dredging from Honolulu harbor and other sources, thirty of the forty species and sub-species of the beautiful *Cypraea*, or cowry family, so far listed in the literature of the subject as occurring in the Hawaiian Islands.

The univalve or gasteropod mollusks are by far the largest division of the Mollusca. Some are free swimming animals, living far from land out in the open seas, but the greater number inhabit shallow water, usually about the low-tide mark; while others dwell in brackish water, in fresh water and on the land. The typical gasteropod—and it is only this division that can be considered in any detail here—is normally a crawling animal bearing a coiled shell. They all move slowly by the continual contraction and expansion of the muscular foot. Many of the common marine forms have interesting habits, and may be kept alive with very little trouble in a simple salt-water aquarium. In a small aquarium one should be careful not to overstock. Two or three healthy, happy specimens are less trouble and far more interesting for the purposes of observation and study.

In general it will be found that the species that have the base of the aperture rounded as in *Littorina*, *Crepidula*, *Nerita* and the like, are herbivorous in habit, feeding on seaweed, moss and minute aquatic plants. Shells in which the aperture is deeply notched or prolonged into a canal, as in *Nassa*, *Strombus*, *Mitra* and *Cypraea*, are usually carnivorous or flesh-eating species and are perhaps more difficult to supply with their accustomed food on that account.

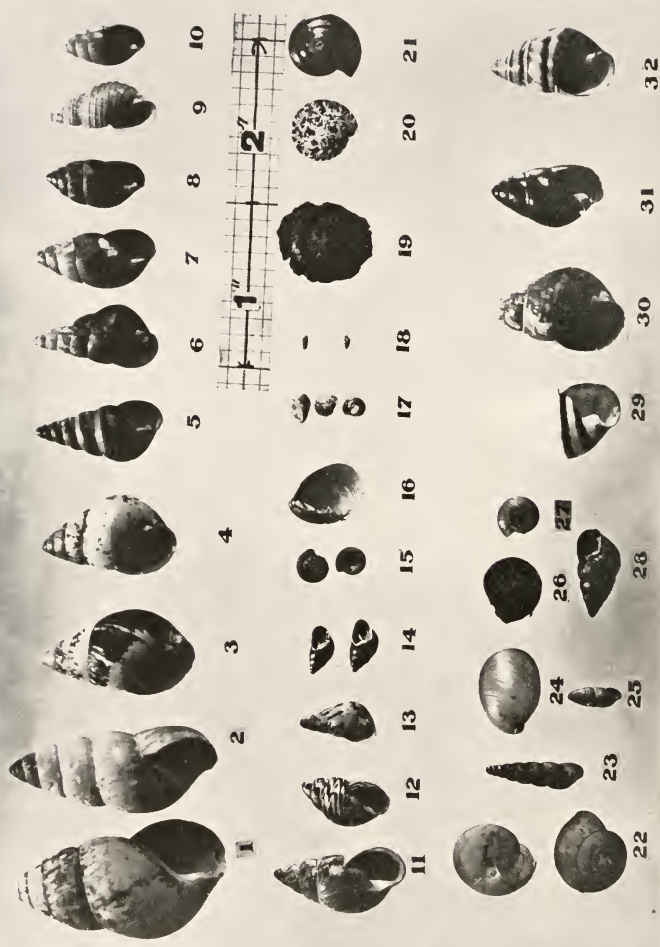


PLATE 103. IMPORTANT GENERA OF LAND SHELLS.
 (FOR DESCRIPTION OF PLATE SEE OPPOSITE PAGE.)

SPINY ROCK SHELLS.

The extensive family²⁸ known as the spiny rock shells is represented in Hawaii by ten genera with perhaps twenty-eight or more species. The typical genus *Murex* is seldom found on the shore, but the genus *Purpura*, named in allusion to a purple dye formerly secured from certain species, has three species, one of which is quite common. These, together with the castor bean-pod shells,²⁹ the banner shells³⁰ and the rattle shells³¹ shown in the plates, will be sufficient to give an idea of the more common forms belonging to this family.

Of the rattle shells there are several small species known from Hawaii. The mulberry shell³² is appropriately named from its appearance. It is quite generally distributed, but is not conspicuous, since it is less than an inch in length. To these, and in fact to the great majority of shells of the same general shape, the Hawaiians gave the class name pupu. It seems that the number of species was so great that the natives applied specific names to only a few of the more important ones.

TRITONS.

The triton family³³ is represented in the islands by a dozen or more species belonging to the typical genus³⁴ and as many as eight or more of the frog-shell³⁵ group, which differ from their consins in having a pronounced ridge or varix on each side of the shell, which forms a thick ridge on the opposite sides making the shell distinctly two-edged. They live on the coral reef, and all but one of the species has been taken from Honolulu harbor.

The fine triton trumpet³⁶ is seldom taken on shore. But as they grow to splendid proportions and are the largest shell that occurs in Hawaii and were used by the ancient Hawaiians as a war trumpet, they are worthy of special mention. They are said to attain a length of eighteen inches, but specimens a foot in length are more commonly seen. Such shells are treasured as a real possession by the old Hawaiian fishermen, for they know how scarce they are and how hard they are to secure, living or dead.

The hard shell has a peculiar resonant quality. When the tip of the spire is cut or ground away and the shell used as a bugle (pu), it emits a peculiar

²⁸ *Muricidae*. ²⁹ *Ricinus*. ³⁰ *Vexilla*. ³¹ *Sistrum*. ³² *Sistrum morus*. ³³ *Tritonidae*.
³⁴ *Triton*. ³⁵ *Ranella*. ³⁶ *Triton tritonis*.

DESCRIPTION OF PLATE.

1. *Amastre violacea* var. *waitauensis*. 2. *Carelia sinclairi*. 3. *Laminella gravida*. 4. *Laminella gravida*. 5. *Amastre turritella*. 6. *Laminella sanguinea*. 7. *Amastre rubricunda*. 8. *Amastre textilis*. 9. *Neurornbia canaliculata* var. *waitauensis*. 10. *Leptachatina* sp. 11. *Partulina dubia*. 12. *Perdicella fulgurans*. 13. *Laminella venusta*. 14. *Auriculella* sp. 15. *Endodonta* sp. 16. *Succinea* sp. 17. *Helicina* sp. 18. *Pupa* sp. 19. *Pterodiscus rer*. 20. *Endodonta* sp. 21. *Philonesia baldwini*. 22. *Eulota similis*. 23. *Opeas pyrgiscus*. 24. *Succinea* sp. 25. *Leptachatina chrysalis*. 26. *Pterodiscus discus*. 27. *Philonesia* sp. 28. *Amastre frosti*. 29. *Achatinella* (*Aper*) *lorata*. 30. *Partulina confusa*. 31. *Bulimella bacca*. 32. *Achatinellastrum plumata*.

foggy sound that carries for a long distance. In former times it was a convenient instrument with which to summon the laborers from their slumbers, or, in more strenuous times, to cheer the faithful on to victory at arms. The gracefully tapering shell is variegated with buff, brown, purple and red in a very rich and characteristic pattern. The outer lip is toothed, and whitish, with double streaks of brown which soon fade into the ruddy aperture.

The more common species, especially in Honolulu and Pearl Harbor, is the hairy triton³⁷ known as pupu ole. It may be recognized by its bristly olive-colored epidermis. On beach-worn specimens this peculiarity disappears, leaving the whole exterior of the shell streaked with revolving bands and folds. In the tritons, as with most shells, as age advances the lip thickens and changes take place between young and old specimens which confuse even those who profess to considerable knowledge of the science which deals with the shell-bearing animals.³⁸

The quilted triton³⁹ is a smaller, more solid species, seldom more than two inches in length, and is far from being the most common triton in the islands. It exhibits considerable variation in coloring and other characters, but is usually light or dark brown with the ribs and tubercles lighter, and there is sometimes an ill-defined whitish band on the large or body whorl. The nodulated teeth and the mouth of the shell are whitish and thickly enameled. The interior of the aperture is orange-red.

SPINDLE SHELLS.

The spindle-shell⁴⁰ family has a typical Hawaiian form in a graceful white species⁴¹ in which the long canal equals, or exceeds, the spire in length. The species is fond of mud-flats, where it burrows in the soft deposits. For this reason it is a common shell in harbor dredgings. The chick-pea shells⁴² and the genus *Peristernia* are common shells that are grouped in a sub-family⁴³ of the spindle shells, but to the ordinary observer, unacquainted with all the details of classification, they appear to have little in common with the more typical forms.

WHELKS.

So far as is known, the whelk⁴⁴ family, which includes the fulgur shells commonly figured in books on sea shells, are represented in Hawaii by only a few small species. The family as a whole is described as thick, ovate or pear-shaped shells with a short canal and with the columella (the pillar around which the whorls or turns of a spiral shell revolve) without plications or folds. The sub-family⁴⁵ to which the island species belong is characterized as small heavy shells, usually less than an inch in length, with teeth on the outer lip and the columella rough and thickened. The pisa shells⁴⁶ and the tankard shells⁴⁷ belong to this group. They are few in number and difficult to place even by skilled collectors.

³⁷ *Triton pileuris*. ³⁸ Conchology. ³⁹ *Triton tuberosus*. ⁴⁰ *Fusidæ*. ⁴¹ *Fusus nova hollandiæ*.
⁴² *Latirus*. ⁴³ *Peristerniinae*. ⁴⁴ *Buccinidæ*. ⁴⁵ *Pisanina*. ⁴⁶ *Pisania*. ⁴⁷ *Cantharus*.

DOG WHELKS.

The dog whelk⁴⁸ family has four species occurring in the islands, all belonging to the one genus⁴⁹ of fish-basket shells. The name is given them from the resemblance of certain species to the tapering narrow-mouthed wicker baskets used in Europe by the fishermen in the fish and lobster business. The small notch at the base of the aperture is an important characteristic. They are predatory⁵⁰ in habit and are usually found near the shore. The largest species⁵¹ is whitish, more or less blotched with yellowish-brown, and has the spire tipped with pink. The various species of the genus seem to intergrade to a remarkable degree. To the common small, light-yellowish or orange-brown specimens with a pale central band is given the name *Nassa hirta*. The one with narrow red revolving lines and irregular broad bands, a variable species, is called *Nassa gaudiosa*, while *Nassa splendidula*, smaller than the foregoing, is white, shining and distinctly granose, caused by the crossing of the longitudinal ribs by deeply incised lines.

MITRE SHELLS.

The mitre shells collected in the islands are usually included in the great genus which is typical of the family,⁵² according to the best authorities, although this large genus is variously divided by other specialists. Three or four additional genera, including the small "gutter-tile" shells,⁵³ which approach the cone shells in general form; the little turret shells,⁵⁴ of which there are four or five species, and a small, slender representative of the genus *Thala* are regarded as forming good genera, but they all have characteristics that are common to the true mitre shells, and all may be known by their sharp spire and the conspicuous and strongly marked folds on the columella. However, their size and the character of the body of the shell varies greatly, especially in sculpture and marking. There are more than two hundred species of mitre shells in the tropics, and some of them are of large size and great beauty. Of that number more than three dozen species, most of them less than an inch and a half in length, have been reported as occurring in the waters about these islands. Of a possible twenty-six species, seventeen of the genus *Mitra* have been collected from Honolulu harbor by the author.

The living shells are gregarious⁵⁵ and avoid the daylight by hiding in the masses of coral on the reefs or by burrowing in the sand. At night, however, like many of their marine associates, they creep out to feed. Their heavy, hard shells will long resist the action of the waves, so that they are to be found among the small pebbles on the shore. On almost every ramble by the sea the careful collector may gather one or more species of these attractive shells.

By reference to the accompanying plates they can readily be identified as *Mitra*, a name given out of a fancied resemblance to a priest's mitre; but to

⁴⁸ *Nassidae*.⁴⁹ *Nassa*.⁵⁰ That is, feeding on other animals.⁵¹ *Nassa papillosa*.⁵² *Mitridae*.⁵³ *Imbricaria*.⁵⁴ *Turricula*.⁵⁵ Inclined to gather in companies.

describe the various species accurately, in a way to be of use in identifying the beach-worn specimens, is obviously a task beyond the scope of this volume.

MARGIN SHELLS.

The margin shell ⁵⁶ family includes small shells related to the cowries and mitres. They are pear-shaped, porcelainous in appearance, and are marked by the large body whorl. The aperture is usually nearly the whole length of the shell, and the outer lip has a narrow thickened margin which may be toothed or smooth within, but the columella is distinctly plicated much as in the mitre family.

Since the largest of the four species of margin shells so far collected in Hawaii is less than a fourth of an inch in length, they are liable to be secured only by those accustomed to close observation. The largest species ⁵⁷ is smooth, pale rosy-white, with two brownish bands, and has the outer lip slightly thickened in the middle. It is the only species belonging to the genus taken here, but is, of course, too small for satisfactory photographic illustration. The typical genus of margin shells ⁵⁸ embraces perhaps two hundred and fifty species. Of this number a dozen or more are Polynesian, three being credited to this group, two of which have been taken on Oahu. They have the outer lip conspicuously thickened, with the inner margin smooth, ridged or toothed in different species.

OLIVE SHELLS.

The olive shells are rare in Hawaii. The family ⁵⁹ is so far represented by four species, none of which seem to be common. Only the beautiful conoid harp-shell ⁶⁰ is commonly collected. This species, which shares the Hawaiian name pu with the triton shell, belongs to an important sub-family ⁶¹ in which the species differ from those in the typical sub-family ⁶² in several important respects, among them being the conspicuous and characteristic longitudinal parallel ribs on the shell. These ribs, together with the general harp-like shape of the shell, amply justify the common name. The color scheme is brown in many shades, and the pattern, resembling the banding of an agate, makes of the harp shell an object greatly admired.

The typical olive shells are smooth, solid, highly-colored, and agree with the group just described in having the outer lip simple and the aperture obliquely notched below. The red-mouthed olive ⁶³ is a typical species. It has a deep orange-red aperture, and the pale creamy ground is variously banded with chestnut, but the general color scheme varies greatly. The species is said to inhabit muddy sand in deep water, where it attains a length of two or three inches. A small species of olive ⁶⁴ less than an inch in length, is white within and without, and is marked with two wide and one narrow rich orange bands. It is a common wide-ranging species and together with a third undetermined species has been collected by Mr. Thaunum on Hawaii.

⁵⁶ Marginellide.

⁵⁷ *Erato sandwicensis*.

⁵⁸ *Marginella*.

⁵⁹ *Olividae*.

⁶⁰ *Harpa conoidalis*.

⁶¹ *Harpinae*.

⁶² *Olivinae*.

⁶³ *Olivca erythrostoma*.

⁶⁴ *Olivca carneola*.

DOVE SHELLS.

The little "dove shells" belong to a tropical family⁶⁵ to which more than eight hundred species have been referred by conchologists. Of that number fifteen or more species belonging to two genera have been reported from these islands. Among so many similar forms the characteristics distinguishing the species are often obscure and confusing. This is especially true in the present family, as the largest species are scarcely an inch in length, while the great majority are less than half that size. However, they are all solid shells of varying form with short anterior canals. The inner lip anteriorly is usually tuberculated; the outer lip as a rule is thickened and variously roughened on its inner margin. The most abundant and best known representative of the family in the islands is the little Niihau shell.⁶⁶ It is a trifle over a third of an inch in length and varies greatly in the markings and sculpture of the shell, but usually has the base of the columella stained with chocolate. These pretty bead-like shells, especially those from the Island of Niihau, were formerly used by the Hawaiians in making shell necklaces or leis. Necklaces made from them are still manufactured for sale and are much prized by tourists.

A slightly larger, and perhaps more typical form, is shown in *Columbella turturina*. It is white, variegated with clouds of yellowish-brown. The columella and teeth of the outer lip are usually stained with violet. The zebra dove shell⁶⁷ has a higher spire and the white ground is so curiously marked with zebra-like chestnut markings that it always attracts attention along the beach in spite of its small size.

A genus of "grey" shells⁶⁸ with three species, one of which Mr. Thaanum includes in his manuscript list of Hawaiian shells as occurring on Hawaii, and which also occurs on Oahu, is included in this family, though it is admitted that they bear but little resemblance to the typical genera. They are all longitudinally ribbed, the ribs broken up into nodules by revolving lines. The form *Engina farinosa*, a yellowish-brown shell with indistinct dusky bands, is found on Hawaii and doubtless elsewhere in the group.

CHAPTER XXXV.

SHELLS FROM THE SEA-SHORE: PART TWO.

THE CONE SHELLS.

The cone shells¹ are sufficiently characterized by their common name to need no further general description than to say that in addition to being cone-shaped, the aperture is long and narrow, the lips are straight and parallel and are always without teeth or ridges. Perhaps four hundred species are

⁶⁵ *Columbellidae*.⁶⁶ *Columbella varians*.⁶⁷ *Columbella zebra*.⁶⁸ *Engina*.¹ *Conidae*.

known to occur in the tropical waters of the globe. Of this number one hundred and thirty-three are enumerated by one authority as occurring in the Eastern Asiatic province in which the Hawaiian Islands are included. Twenty-five species and well-marked varieties have been recorded from this group. Specimens of all but three of the Hawaiian species Mr. Thaanum reports having personally secured, chiefly in the vicinity of Hilo, while the writer has secured a similar number of species on the Island of Oahu. In the little collection of common beach shells secured on the four excursions mentioned are ten species ranging in size from tiny shells less than a half inch in length to heavy solid specimens three and a half inches long. Unfortunately most of the beach specimens secured are badly worn, in some cases past positive identification. The great weight of the dead shell in proportion to its size makes its progress over the wave-swept reef much slower and the grinding much more severe than would be the case with a lighter shell that might be caught up and laid down again high on the sandy shore, well out of harm's way, by a single wave.

The cones are fond of the coral reefs and hide in holes in the rocks on the reef and along the shore. They are carnivorous animals, and move slowly about seeking their food, which is usually obtained by means of curious poison fangs by which they paralyze their prey.

The most common and without doubt the most beautiful of the cone shells found in the dredgings from Pearl Harbor and Honolulu harbor is a species identified as *Conus quercinus*. The shell itself is a delicate tan color and is ornamented with numerous parallel revolving pen-lines of brown. Over this in fresh specimens is a thin rich-brown epidermis. They appear to prefer the muddy brackish water conditons at the harbor mouth to a life on the coral reef in the open sea. A more ordinary type of marking is found on the spotted cone shell.² It is about two inches long and has the creamy white ground irregularly covered with chocolate spots about the size of a pin-head. These spots are somewhat thickened towards the ends, thus forming three ill-defined bands about the shell.

The Hebrew cone³ is so called from a fancied resemblance of the large deep-chocolate colored markings on the white ground to the characters used in the Hebrew alphabet. It is an inch and a half in length and is a reef-dwelling species, found usually on sandy shores with fragments of broken shells and other debris.

The largest species is the lettered cone,⁴ which bears row after row of oblong brown characters on its white surface. A yellow undercolor groups these rows into indistinct bands. Specimens seven or eight inches in length are not uncommon, especially on the coast of Molokai, and a number of very large specimens come up in the dredgings of Honolulu harbor.

Unfortunately the worn specimens of any of the cones can seldom be identified without reference to perfect examples. The local collector should have no trouble, however, in identifying any shell he may secure by use of

² *Conus pulchellus*.³ *Conus hebraeus*.⁴ *Conus litteratus* var. *millepunctatus*.

the labeled specimens in the extensive collection of Hawaiian shells at the Bishop Museum.

Leis were occasionally made by the Hawaiians of certain species of cone (leho) shells, but as a rule they were too scarce to be much used, although there is a string several feet in length in the Bishop Museum and the author has two such leis in his private collection.

AUGER SHELLS.

The auger shells⁵ are most appropriately named, for the long, tapering, many flat-whorled spire at once characterizes them, while the small aperture, notched in front, renders them easily placed in the single genus to which about two dozen Hawaiian species belong. These hard, sharp-pointed shells were of much use to the Hawaiians in various ways. They were formerly used as drill points in their crude but ingenious rotary drills. There they served their true purpose of an auger, but the hard, sharp outer lip was equally effective as a tool when used as a scraper. They made excellent stoppers for the small-necked gourds that once were used for the storage of water.

Even the fragment of the crenulated auger shell⁶ washed ashore is sufficient for the identification of this large species in which the whorls are obtusely nodulated below the suture.⁷ Fresh specimens are cream-colored, streaked with chestnut between the nodules, and with three revolving rows of chestnut spots on the body-whorl and two rows on the remainder of the spire. Adult specimens are five inches in length. The spotted auger shell,⁸ when fully adult, is almost as large as the foregoing, but is orange-brown with a row of large white spots just below the suture and a second row below the middle of the body-whorl. The largest species occurring in Hawaii is *Terebra maculata*. Specimens in the writer's collection vary from three to nine inches in length. Large shells were much sought for by the natives, as they were fond of the animal and used the chisel-like edge of the shell in scraping out the wooden hulls of their canoes.

Perhaps the Gould auger shell⁹ is the commonest species found on our Hawaiian sand-rimmed bays. It is a smaller species and one of a large number of this group of shells which is peculiar in that it has what appears to be a double suture about the spire. This band is slightly nodulated, while the body of each whorl is longitudinally plicated. The shell is creamy-white banded with very pale chestnut, and has three bands on the body-whorl. The cancellated auger shell¹⁰ is smaller and has the narrow nodulous band white. To the unpracticed eye it is otherwise very similar to the preceding form.

A fifth form which is fairly common on sandy shores is *Terebra aciculina*. It is about an inch and a half in length, varies in color from deep chocolate to pale ash color, and is white-banded at the suture, as well as on the free edge of the body-whorl. Perhaps twenty species of auger shells can be secured in

⁵ *Terebridae*.

⁶ *Terebra crenulata*.

⁷ The line where the whorls of the shell unite.

⁸ *Terebra oculata*.

⁹ *Terebra gouldi*.

¹⁰ *Terebra cancellata*.



PLATE 104. COMMON MARINE BIVALVES.

1. Hawaiian Edible Mussel [Nahawe] (*Mytilus edulis*).
 2. Ham Shell [Hihiwai] (*Modiola* = (*Perna*) *californica*).
 3. Papania (*Perna* sp.).
 4. Papania (*Perna* sp.).
- (Description of Plate Continued on the Opposite Page.)

Hawaii by a careful collector, but as many of them are small and rare, their description would be out of place here.

CONCH SHELLS.

The typical conch shell family¹¹ has but nine species reported from Hawaii, the most common species being the little spotted conch,¹² the puleho of the Hawaiians. They are found usually in the shallow water along shore, hidden away during the day under a coral rock or in crevices in the growing reef. The species is less than an inch and a half in length, and can hardly be made to agree with one's notion of this family founded, usually, on the fine large conch shell that everywhere, a generation ago, adorned the mantel, held the honored place in the curiosity cabinet or served a useful and ornamental purpose as a door brick in the homes of people not given to the pursuit of natural history. Nevertheless, if the species were compared it would be found that they differ mainly in size and color. They have the same solid shell, with a well-developed spire, the thickened, expanded outer lip similarly lobed; the columella without plaits and the posterior canal well developed. The living shell has a strong muscular foot adapted to leaping; a peculiarity which makes them interesting inhabitants for an aquarium. The shell of the common species, when the epidermis is removed, is creamy white, spotted and maculated with chocolate and orange-brown, and has the aperture white. *Strombus hellii* is a smaller yellowish-brown species regularly ribbed and crossed by spiral striae. *Strombus samar* is larger and the outer lip has three large teeth, and the interior of the aperture radially ridged.

The only species of spider shell¹³ so far found in the islands is five or six inches in length. They are stromb-like, but have the outer lip exaggerated by long curved fingers that make the mollusk look like a huge spider traveling on seven legs.

THE COWRY FAMILY.

The cowry¹⁴ shells are all so well known to everyone who visits the seashore that a description seems unnecessary. The living animal is interesting, since from the long, narrow, centrally-located aperture emerges the curious, often brilliantly-colored, foot and mantle. The latter when fully expanded almost envelops the smooth, glossy shell. The young shells almost always show a short spire, but as they mature the spire is usually enveloped by the growth of the body whorl.

¹¹ *Strombidae*. ¹² *Strombus maculatus*. ¹³ *Pterocera aurantia*. ¹⁴ *Cypræidae*.

(Description of Plate Continued from Opposite Page.)

5. Pearl Oyster [Pa] (*Margaritifera fimbriata*). 6. Ark Shell (*Arca* sp.). 7. *Arca can-dida*. 8. Hawaiian Oyster [Pioeoc] (*Ostrea rosacea*). 9. Jingle Shell (*Anomia nobilis*). 10. *Anomia nobilis* (young). 11. Scallop (*Peeten* sp.). 12. Scallop (*Peeten* sp.). 13. Purple-hinged Scallop (*Hinnites giganteus*). 14. Tellen Shell [Olepe] (*Tellina rugosa*). 15. *Tellina dispar*. 16. Hawaiian Cytherea (*Cytherea* = (*Lioconcha*) *hieroglyphica*). 17. Venus Clam (*Venus reticulata*). 18. Lucina Shell (*Cadokia ramulosa*). 19. Heart Shell (*Cardium orbiter*). 20. Rock Oyster [Kupakala] (*Chama* sp.). 21. Rock Oyster (*Chama* sp.).

Of a possible two hundred living species there are more than three dozen forms of these interesting mollusks reported as occurring in Hawaii, all of which are known as *leho* by the natives. With possibly one or two exceptions, however, they cannot be said to be abundant or common in the islands. Reference has been made in another connection to the large number of species belonging to this family that have been secured in Honolulu harbor. In the small collection of common beach forms, in the lot before me from Oahu, no fewer than ten recognizable species occur. Of that number three or four are sufficiently common to be liable to occur in almost every collection.

By far the most abundant species is the snake-head cowry.¹⁵ It is seldom more than an inch and a quarter in length, and is often found along rocky coasts or in coral heads in shallow water. It is reddish or blackish-brown with unequal snow-like spots on the back. The extremities are tipped with white, the base gray; the teeth are strong and white. These and other species of cowries, especially the money cowry,¹⁶ a small yellowish species, and another small form ornamented with white and brown spots, a saffron base and pale violet extremities, known as *Cypræa helvola*, were used by the Hawaiians to some extent in making their leis.

The hump-backed cowry¹⁷ when full-grown is more than three and a half inches in length. Its brown color is varied by light brown or white spots of irregular size, while the sides and base are dark brown or almost black. The teeth are prominent and the edge of the shell is much thickened and angular. This fine shell is said to be the strongest and heaviest of the genus. It is one of the large sea shells in which the native children, like the children of many other lands, could hear the sound of the sea. It is a choice food of the Hawaiians and is often to be seen offered for sale in the market. Its shell was much used in making their ingenious squid-hooks. As a part of the hook the shell served as bait, and was attached to a stone sinker of similar size and shape, so that the flattened surfaces were together. Between the shell and the sinker there was fastened a stick, to the lower end of which was attached a hook of bone or, in more recent years, of iron. About the hook was usually fastened a bunch of leaves, which kept the point hidden from the eye of the cautious animal. The squid has a great fondness for this particular species of cowry. They seize the hook by wrapping their arms about the shell, when they are easily captured. "Humpbacks" (*leho*) were always in great demand among the fishermen for that reason. The flesh-colored cowry,¹⁸ a large species ornamented with four or five deep flesh-colored bands and with a red animal, was also sometimes used as squid bait. The squid if captured under certain conditions by this species of shell, was supposed to be a very valuable remedy in the healing of the sick.

¹⁵ *Cypræa caput-serpentis*.¹⁶ *Cypræa moneta*.¹⁷ *Cypræa mauritiana*.¹⁸ *Cypræa carneola*.

The following, translated by Dr. N. B. Emerson, is a portion of ancient pule repeated by the native doctor (kahuna) fisherman as the baited hook was lowered to capture a squid to be used for curative purposes:

“Here is the cowry,
A red cowry to attract the squid to his death.
Here is the spear, a mere stick,
A spear of lama wood for the squid that lies flat.
O Kanaloa of the tabu nights,
Stand upright on the solid floor!
Stand upon the floor where lies the squid!
Stand up to take the squid of the deep sea!
Rise up, O Kanaloa!
Stir up! agitate! let the squid awake!
Let the squid that lies flat awake, the squid that lies spread out.”

Two large species related to the more familiar tiger cowry¹⁹ (the largest of the family, and common in collections) have spots extended over the base. The Arabian cowry²⁰ has the base tinged with brown. If the spots are crowded and run together, the sides thick, and the base milky or bluish-white, with a dark blotch near the middle of the shell, it is the closely-related species *Cypræa reticulata*. All three species occur in the group, and, like most of the larger forms, were used as food by the Hawaiians. A small form usually about an inch in length, that is ashy-fulvous, without spots, and has the teeth white and the extremities saffron-red (that is usually collected in the group), is Isabella's cowry.²¹

A curious species of cowry, occurring quite commonly in the islands, belongs to the group in which the shell is covered with little nodules. It is a wide-ranging form, known as the Madagascar cowry,²² and is a species in which the ridges on the outer lip are alternately large and small. The list of rare or occasional species could easily be extended into a small volume.

Five minute white or pinkish species of the coffee-bean shell²³ have been reported from Hawaii. As the largest of them are less than half an inch in length, they are seldom seen by amateurs. They are all cowry-shaped, rather roundish and curiously cross-ribbed shells that can at once be identified by their resemblance to the larger members of the family.

EGG SHELLS.

The egg shells²⁴ are so seldom seen on our beaches that a description of the species seems unnecessary, farther than to say that in general form they resemble the cowries, are whitish or dull in color and the extremities are usually drawn out to form two canals. They differ from the family mentioned above in having the inner or columella side of the aperture smooth. The shells occur throughout Polynesia, where in many of the islands they are much prized as personal ornaments.

TUN SHELLS.

The tun shells,²⁵ or wine jars, as the name given to the family signifies,²⁶

¹⁹ *Cypræa tigris*. ²⁰ *Cypræa arabica*. ²¹ *Cypræa isabella*. ²² *Cypræa madagascariensis*.
²³ *Trivia*. ²⁴ *Oculida*. ²⁵ *Doliida*. ²⁶ An allusion to their capacious size.



PLATE 105. SOME OF THE LARGER COMMON SEA SHELLS.

1. "Purple" Shell [Pupa] (*Purpura aperta*); so called by reason of a purple dye secured from certain species. 2. Pupa (*Purpura* sp.). 3. Hairy Triton [Pupa ole] (*Triton*)
 (Description of Plate Continued on the Opposite Page.)

are represented in Hawaii by two species, there being but fifteen species described. The partridge tun²⁷ is the more common, though a specimen is a real prize. It is fairly typical of the family. The tun is a large shell with a stout spire and swollen body-whorl that is banded by strong spiral ribs. The shell is marked with crescents and irregular lines of white on a rich brown ground color, suggesting the breast of a partridge. They are said to attain a length of fifteen inches, but the specimens found on the beach are seldom more than a third that size. The black-mouthed tun²⁸ is much rarer. It is dirty white in color and has the outer lip dark brown.

CAMEO SHELLS.

The helmet or cameo shells²⁹ are active predatory mollusks that live along sandy shores in the warm seas. There are perhaps three dozen species and sub-species, of which five or six are known to occur in the waters about Hawaii. They all agree in being thick, heavy shells with short spires. The aperture is long and ends in a recurved channel. The typical horned helmet³⁰ occurs in the islands. Although it is a rare shell here, it is of more than ordinary interest since it is one of the shells used elsewhere in the manufacture of cameos, cutting a white figure on an orange-brown ground. It is the giant of the family, reaching a foot in length. The shell is yellowish-white tinged with yellowish-brown, and is studded over the back with three rows of tubercles. Blotches of dark brown occur on both the curiously expanded lips and on the knobs.

The more common form on Oahu is *Cassis vibex*, which has four short spines at the base of the lip and is seldom more than three inches in length. It is a fleshy-ash color, obscurely banded and varied with light and dark chestnut. The lip on its outer margin is marked with chocolate spots. A variety³¹ also occurs that is smaller, thicker and has small elongated tubercles on the shoulder.

MOON SHELLS.

In the family of moon shells, or naticas,³² the shell is more or less globular or ear-shaped and the aperture differs from that of the preceding families in

²⁷ *Dolium perdix*. ²⁸ *Dolium melanostoma*. ²⁹ *Cassida*. ³⁰ *Cassis cornuta*.
³¹ *Cassis vibex erinacea*. ³² *Naticidae*.

(Description of Plate Continued from Opposite Page.)

pilcaris). 4. Quilted Triton (*Triton tuberosus*). 5. Spindle Shell (*Fusus nova-hollandia*). 6. Chocolate-lined Cone (*Conus quercinus*). 7. Lettered Cone (*Conus pulicarius*). 8. Hebrew Cone (*Conus hebraeus*). 9. *Conus lividus*. 10. *Conus miliaris*. 11. Auger shell sp. (*Terebra* sp.). 12. *Terebra gouldi*. 13. *Terebra oculata*. 14. *Terebra aciculina*. 15. Hermit Shell (*Cassis vibex* var.). 16. Hawaiian Top Shell (*Trochus sandwicensis*). 17. Hump-backed Cowry [Leho] (*Cypræa mauritiana*). 18. *Cypræa reticulata*. 19. Turban Shell (*Turbo chrysostomus*). 20. *Turbo intercostalis*; showing the operculum in place. 21. *Cypræa sulcidentata*. 22. Worm Shell [Pohokupele] (*Fermetus* sp.). 23. *Fermetus* sp. 24. Kannaoka (*Fermetus* sp.). 25. Partridge Tun [Paonionio] (*Dolium perdix*). 26. Umbrella Shell [Opihi kapuailio] (*Helcioniscus exaratus*). 27. Conoid Harp Shell (*Harpa conoidalis*).

that it is smooth and without canals. The outer lip is smooth and sharp. The inner lip is turned back in some species so as to conceal the umbilicus,³³ as may be plainly seen in one of the species of the genus here shown. The shells, placed in the two hundred and twenty-five or more species in the different genera, vary greatly in shape. Examples of the same species often vary through a long series of color patterns, rendering the ten or more species that occur here difficult of determination, even in the hands of specialists and when aided by a large series of shells.

The living animal is remarkable for the very large foot, which is used to crowd the creature through the sand in search of other mollusks, mostly bivalves, upon which they feed. Their habits are interesting, and as living specimens may occasionally be secured from the sand where their favorite food is abundant, they may be studied to advantage in a small aquarium partly filled with sand and stocked with other living shells.

SLIPPER SHELLS.

Perhaps the most abundant shells along the coast of our islands are the various species of slipper shells,³⁴ cup-and-saucer limpets,³⁵ the horse-hoof shells³⁶ and their allies, all of which are placed in the one family³⁷ including the various cap-shaped or limpet-like shells. They usually have a more or less spiral apex, and the interior is often provided with a septum or internal plate of variable shape.

The living animals are found adhering closely to stones and shells, and as they spend most of their lives in one spot the shell is usually irregularly shaped to fit some particular spot on rock or coral. They feed on the minute free-swimming animals that come their way. In due time they die and add their shells to those light particles of debris cast up at high tide. Representatives of four genera, including the nine or ten species usually found in the islands, are shown. From these the main characteristics for the genera may be determined.

HORSE-HOOF SHELLS.

Of the horse-hoof shells, four species occur about Honolulu and Hilo. *Hippomyx antiquatus* has the apex posterior of the center and is rudely and closely laminated with more or less distinct radial striae. When alive it has a hairy epidermis. *Hippomyx barbatus* is more compressed, is strongly radially striated, and has a brown hairy epidermis. *Hippomyx imbricatus* has the interior stained with chestnut.

WORM SHELLS AND EULIMAS.

Without doubt the most curious of the shell-bearing mollusks are those included in the worm shell family,³⁸ in which the twisted shell might be mistaken for the tube of some marine worm, as they much resemble them in that

³³ The name given to the cavity in the central base of the shell when the columella or axis is hollow.

³⁴ *Crepidula*. ³⁵ *Crucibulum*. ³⁶ *Hippomyx*. ³⁷ *Calyptorhida*. ³⁸ *Vermetida*.

they are similarly twisted and are attached to stones, coral and shells in much the same way. In early life they are spiral in form and crawl about as free moving animals, but later they become attached and take on various contorted shapes. While the species are not numerous, their irregular growth, sculpture and coloring render them difficult to characterize, but the general form and appearance may be made out from the figures shown. The caecum shells³⁹ are also represented in the islands by one or two species. They are minute shells which, as adults, are curved cylindrical tubes that are closed at one end by a septa.

The eulimas⁴⁰ are all small, white, polished slender shells in which the spire is often curved to one side. Three genera occur here; *Eulima* is the most important. It includes fifteen of the seventeen species commonly reported from Hawaii. Some of the species belonging to the family are known to live in or upon the sea-cucumber (oli). *Eulima major* is an inch in length and is one of the larger species found in the islands.

PYRAMID AND SUN-DIAL SHELLS.

The pyramid shells⁴¹ have slender spires of many whorls. The columella lip may have one or several folds. *Pyramidella terebellum* is smooth, creamy white, with three or four narrow spiral lines on the body, and two on the spire whorl. *Pyramidella sulcata* is longitudinally streaked with pale orange-chestnut, usually forming a series of revolving dots; the columella has three plicated folds. *Pyramidella mitralis* is whitish clouded and banded with pale brown; is strongly ribbed, usually forming little knobs at the sutures.

The family *Turbonellida* is represented in Hawaii by four small species which resemble the species in the preceding family, except that they are usually more pronounced in their sculpturing and usually have the columella without folds.

The curious spiral sun-dial shells⁴² are easily recognized by their top-like shape and angular aperture and wide and deep umbilicus. Although they resemble *Trochus* to some extent, they are never pearly in texture. Six species belonging to two genera have been recorded from Hawaii. They are seldom taken in beach specimens, but their beauty of form and color make them especially prized by professional as well as amateur collectors. *Solarium perspectivum* has the umbilical crenulations brown; in *Solarium cingulum* they are white. The genus *Torinia* differs from the foregoing in some respects, but mainly in having the spire more elevated and the edge of the whorls rounded. *Torinia variegata*, here shown, occurs occasionally on Oahu. It is reddish-brown, variously marked with white and brown, the margin of the umbilicus crenulated and the center of the umbilical wall with a crenulated mid-rib.

VIOLET SNAILS.

Shells of the three beautiful species of violet snails⁴³ are often found on

³⁹ *Cacidae*.

⁴⁰ *Eulimidae*.

⁴¹ *Pyramidellidae*.

⁴² *Solariidae*.

⁴³ *Ianthinidae*.

the beaches of all the islands after a heavy gale. They float on the surface of the ocean, usually in large companies. They are supported by a raft-like structure formed by a large mass of cells filled with air. All the species recognized by Tyron were gathered at Kahana Bay, on Oahu, on the beach on the same collecting trip. The base of the thin shell is always deep violet, while the spire is almost white, tinted with violet. The large violet snail⁴⁴ is an inch or more in diameter. It is slopingly-convex, is slightly angular on the edge, and has the outer lip very slightly sinous. *Lanthina globosa* is inflated with a short spire, the whorls are rounded, and the outer lip is slightly more sinuous in the middle. The third species⁴⁵ is much smaller and more conical, the whorls forming an obtuse angle on the outer edge, and there is a deep incision on the outer lip. The species are all said to feed on small surface-swimming animals, especially minute jellyfish.

LADDER SHELLS.

The staircase shells, or ladder shells,⁴⁶ are usually white and polished. The numerous ribs across the whorls are prominent and look like the steps of a ladder, whence they derive their name. They live in the ocean below the low-water mark. They are carnivorous in habit and are fairly common about Hawaii. Ten or more of the many species known, have been reported from the group. The chief characteristics center about their size, the number of whorls and the size and number of the ridges. *Scalaria lamellosa*, which is representative, has seven or eight whorls, is a fleshy color with a more or less definitely darker band at the suture and above the basal rib.

HERALD'S HORN SHELLS.

The family *Cerithiidae*, a name derived from that given to the principal genus,⁴⁷ is represented by almost fifty species of small shells belonging to four genera. They are all long, many-whorled, spiral shells, with both anterior and posterior canals, and have the lip more or less dentate. They live on the rocks and among the marine vegetation. The species figured⁴⁸ are found in dredging from Honolulu harbor. They will serve to aid the amateur in placing such shells as may be gathered in the proper family, but the specific characteristics for the twenty or more species that may be collected are too minute for consideration here.

PERIWINKLES.

Of the familiar periwinkle⁴⁹ family two or three species are everywhere abundant on rocky coasts, where they are to be found usually at or above the high-tide mark. They feed on algae and inhabit brackish and salt water. The species⁵⁰ most common at Waikiki are flesh color or nearly white and have the aperture orange-brown, and may be easily identified as distinct from a species⁵¹ common at Pearl Harbor, which is larger. The latter are gray to red-

⁴⁴ *Lanthina fragilis*. ⁴⁵ *Lanthina exigua*. ⁴⁶ *Scalaria*. ⁴⁷ *Cerithium* = Herald's horn.
⁴⁸ *Cerithium columna* and *Cerithium obeliscus*. ⁴⁹ *Littorinidae*. ⁵⁰ *Littorina obesa*.
⁵¹ *Littorina scabra*.

brown in color, are usually banded with chocolate, and have the aperture often streaked with the same color. Two other genera⁵² belonging to this family also occur about the shores of the islands. They are small shells seldom seen by amateur collectors, and differ so much in appearance from the more common forms that their relationship is not easily understood. The *Fossaridae* is a small family closely allied with the family just considered, the chief differences being in the soft parts. The family *Planarida* is a small family, the common species⁵³ being nearly smooth, light yellowish varied with orange, brown and chestnut, is little over a quarter of an inch in length and varies greatly in form and color. The *Rissoidae* include another group of shells to which a dozen or more forms from Hawaii have been referred. Of this number five or six small species may occasionally be taken among the very small shells on the shore, but they are too tiny to be of interest to anyone except the professional collector.

SEA SNAILS.

The sea snails⁵⁴ include such well-known shells as the small black species commonly found clinging to the lava rocks along the shore near the upper tide-mark. They are all fond of seaweed and are nocturnal in their habits. the thick body whorl and small spire give them a characteristic form, but they may be identified also, by the character of the operculum, which is peculiar in that it has a process jetting out from beneath that fits under the toothed or wrinkled columellar lip, when the animal retires within its shell.

Of the six species of *Nerita* reported from Hawaii, the black form with a white aperture and with fine spiral grooves on the shell is most abundant on the sea-shore of Oahu. It is commonly known as pipipi.⁵⁵ The native Hawaiians are very fond of them and often spend hours gathering the little black shells from the rocks at low tide. The fleshy part is easily picked from the shell with a pin after they have been heated in warm water or in the imu—the native underground oven. A similar species,⁵⁶ which is without teeth on the outer lip, and a larger variegated species⁵⁷ showing fine growth lines and with the shell flecked, spotted or banded with white, yellow, orange, red or black on a varying ground color, are fairly common about the islands. Both these latter species, and doubtless others, were used by the natives in bracelets worn as an emblem of mourning for the ali. A specimen in the author's collection is shown on the accompanying plate. They were often polished or cut in various shapes.

A genus⁵⁸ belonging to this family, which has four or five Hawaiian species, is not easily separated from their cousins just described. They are somewhat thinner shells and are usually found under stones or clinging to the rocks just below the low-water mark, most commonly in the brackish water

⁵² *Modulus tectum* and *Risella* spp.

⁵³ *Planaxis lineatus*.

⁵⁴ *Neritidae*.

⁵⁵ *Nerita picea*.

⁵⁶ *Nerita* sp.

⁵⁷ *Nerita polita*.

⁵⁸ *Neritina*.

at the mouths of streams. The wi⁵⁹ is found only in fresh water. It is the largest species of the genus in the islands, being more than an inch in diameter. It is black in color and the shell is curiously granular over the surface. One species⁶⁰ commonly found at Waikiki is horn color, while a second species⁶¹ from the same locality has distinct growth lines. The black epidermis is marked with numerous minute yellowish spots, sometimes scarcely visible; the outer lip of the aperture is bluish in color.

TURBAN SHELLS.

The large family of turban shells,⁶² to which belong the typical turban shells,⁶³ the pheasant shells⁶⁴ and the star shells,⁶⁵ is represented in Hawaii by perhaps a dozen and a half species. Not more than a third of that number are liable to be collected, however. Only two species appear in the collection of beach specimens before me from the shores of Oahu. The larger one⁶⁶ is brownish or white marbled with chestnut; the smaller one is dirty white strongly tinged with green and variously marked on the body whorl with dark brown. The characteristics employed in descriptions of the species in this family are confusing, and much skill is required in order to make the identification of the species certain.

TOP SHELLS.

Of the top shells,⁶⁷ only two of the ten or a dozen species which have been recorded from Hawaii occur in the little collection of shore shells that serves as the basis of this brief account of the common mollusks of Hawaii. Of these, the Hawaiian top shell⁶⁸ is by far the most common. It is a shallow-water species occurring at Pearl Harbor, Hilo and elsewhere about the group where slightly brackish water may be found. The second species⁶⁹ was collected only at Kahana Bay and appears to be a rare form.

LIMPETS.

Several species of limpet-like shells may be easily collected from the rocks between the tide-marks, or may be found cast up on the sand beaches along the shores of all the islands. While the keyhole limpets⁷⁰ are represented by one or two species, they are by no means as common as the species belonging to the old-world limpets,⁷¹ from which they differ by having a small hole through the apex of the shell. The families and species of this sub-order of conical, cup-shaped shells are separated in the main by obscure and difficult characteristics that render them almost beyond definite determination by amateur collectors. Two species belonging to the keyhole limpets⁷² are occasionally collected, especially at Hilo, and Honolulu harbor.

To the old-world limpets belong the opihi⁷³ of the natives. It is a favorite food with the Hawaiians, and fine specimens may often be secured alive in the

⁵⁹ *Neritina granosa*. The native name hikiwai is applied to all the brackish and fresh water forms of *Neritina*. ⁶⁰ *Neritina respertina*. ⁶¹ *Neritina cariosa*. ⁶² *Turbinida*. ⁶³ *Turbo*. ⁶⁴ *Phasianella*.
⁶⁵ *Astrarium*. ⁶⁶ *Turbo chrysostomus*. ⁶⁷ *Trochida*. ⁶⁸ *Trachus sandwicensis*. ⁶⁹ *Trachus* sp.
⁷⁰ *Fissurellidæ*. ⁷¹ *Patellidæ*. ⁷² *Glyphis granifera* and *Submarginula oblonga*.
⁷³ *Helcioniscus exaratus*.

markets. This knee-cap or umbrella shell is roughly though evenly ribbed without and pearly white within. They attain a diameter of two inches or more and are usually completely covered with a growth of sea-moss. As they are fond of the dash of the spray, they usually cling with great tenacity to the moss-grown rocks along the more exposed portion of the sea-coast. Like their relatives, they feed on algae of various kinds, but are commonly found sticking tight to the rocks, although they are known to move about in search of food.

Experiments have been made on certain European species of limpets for the purpose of showing how difficult they are to dislodge from their resting places. It was found that it required one thousand nine hundred and eighty-four times the weight of the living animal to detach it from the rocks.

CHITONS.

The chiton shells⁷⁴ are also represented in the sea-shore fauna and, like the members of the preceding family, they are found adhering firmly to the rocks. The shell is remarkable in that it is composed of several separate overlapping plates suggesting a "coat of mail," a name often applied to various species. Specimens may be taken from under stones on the shore at Pearl Harbor and about Hilo, but as there are more than two hundred and fifty living species in the world, more than one of which occurs in Hawaii, the beginner can hardly hope to definitely identify his material. Specimens are of unusual interest, however, as they are believed to be a very primitive type of mollusk and are known to occur elsewhere in very ancient geologic strata.

One of the prettiest shells to be picked up occasionally on the sea-shore in the islands is the beautifully-banded bubble shell,⁷⁵ the body whorl of which is characteristically marked by two delicate pink bands that are set off from the white ground by well-defined blackish bands. Another species,⁷⁶ with a greenish body, is often found well concealed on mossy rocks along our coasts. The thin pale-green shells are so delicate, however, that they are seldom found except living and attached to the rocks. Although related to the preceding⁷⁷ family, they are held separate from it as *Scaphandrida*.

SEA SLUGS.

The sea slugs,⁷⁸ and especially the sea hares,⁷⁹ are curious naked mollusks occasionally found cast up on the shore, entangled in the seaweed or else caught in tide-pools along the shore. The numerous species vary in size from small animals up to creatures several inches in length. They also vary in form and color to such an extent that they are not easily recognized as members of the great phylum to which the more ordinary shell-bearing animals belong.

⁷⁴ Chitonidae. ⁷⁵ Hydatina amplustræ. ⁷⁶ Smaragdinella viridis. ⁷⁷ Bullidae.

⁷⁸ Order Nudibranchiata. ⁷⁹ Aplysidae.

CHAPTER XXXVI.

PLANTS AND ANIMALS FROM THE CORAL REEFS: PART ONE.

Of the many groups of animals living on or about our tropic shores, the fishes and mollusks have received attention in other chapters. There remains for consideration some of the more common and striking of the many varied forms of plant and animal life that are sure to awaken the interest of any one who visits the shore or, better still, is so fortunate as to spend even a few hours wading in the shallow water that covers the fascinating coral reefs.

THE COMMON CRABS.

Of the various orders of the larger animals yet to be considered, the crabs and their marine relatives are perhaps the most conspicuous and at the same time the most omnipresent. Some one of the tribe inhabits almost every rod of the sand beach and almost every loose stone along the shore furnishes a shelter for one or more of these active, interesting, curious creatures.

Nearly every child is familiar with some of the more common shore forms and perhaps can call them by their native names and tell something of their many peculiar habits. But few, indeed, even of those who are skilled in such matters, can name the rarer of the odd forms of crab-like animals that inhabit the ocean and are liable to be captured by almost anyone who will take the trouble to turn over a stone, stir up the sand and mud, or break up the masses of living and dead coral along the shore.

As the number of marine species belonging to this huge class far exceeds any other group of marine animals, we can do little more than point out the main characteristics of the class by calling attention to a few of the common forms. The body of an animal of this class is typically made up of a number of hard plates or rings variously arranged, but always forming an outer hard or thickened shell or skeleton. The skeleton plates are usually so arranged as to divide the animal into a variable number of segments. Each segment ordinarily bears paired, jointed legs or swimming organs.

The wide variation in form and plan among these creatures can be gathered from the examination of such animals as crabs, crawfish, prawns, shrimps, mantis shrimps, sand-hoppers, fish-lice, whale-lice, acorn and stalked barnacles, and a long list of less known denizens of the deep, all of which belong to this grand division of the animal kingdom of which the lobster is taken as the typical form.

THE LOBSTER.

The so-called Hawaiian lobster,² the ula of the native fishermen, is the large species of marine crawfish so abundant in the Hawaiian market. Those familiar with the large pincer-clawed American lobster³ will appreciate at once that the local species is quite a different creature. By zoölogists the

¹ *Crustacea*.² *Panulirus japonicus*.³ *Homarus americanus*.

Hawaiian species is placed in a separate family and is known as the rock lobster.⁴ The large size, enormously long, stout antennæ and spiny carapace of the ula, and the absence of the pincer-claw, are among its most conspicuous characteristics and serve to separate it at once from the fifteen or twenty species of crabs, lobsters, shrimps and prawns that find their way into the markets.

The ula is caught in lobster traps, or more commonly by stringing a net about the reef and leaving it during the night. As lobsters are active at night, they become entangled in the net when they come out of their hiding places among the rocks to seek food. Although they appear large and showy in the market stalls, their color is such that they harmonize perfectly with the rocks and seaweed where they make their home. They are, therefore, very difficult to detect on the reef, and are not often seen by one unfamiliar with their appearance or habits.

They feed upon both fresh and decayed fish, various invertebrate animals, and to some extent on seaweeds. The lively demand for them, owing to their excellent food qualities, brings large numbers of them fresh and sprawling into the markets every day. The ulaapapa⁵ is also a large species of crawfish-like animal, quite common in the markets, that is a favorite food of the native people.

PRAWNS.

Prawns⁶ of several species and brackish and fresh-water shrimps⁷ are common in the fish stalls and are of excellent quality.

Turning to the short-tailed Crustacea, or the crabs, a dozen species at least are offered for sale. The papai, the aama, and the alamihi are the more common forms, while such crabs as the kukuma, the papa and the papai lanai are less abundant. The alamihi is a notorious scavenger on the coral reefs about Honolulu. The kumimi is regarded as poisonous by the Hawaiians. They are fairly common along the shore, and they and their close relatives are quite generally avoided by experienced crab catchers.

The common black rock-crab⁸ is the species usually found hidden under stones at low tide. A similar dark-colored, but more active, species prefers the dash of the spray along rocky shores, while a pale sand-colored crab⁹ lives in burrows that it makes for itself in the sandy shore just above high tide. Other forms live their lives hidden away in the coral heads; and so the list might be extended almost indefinitely, as more than three hundred species belonging to the short-tailed¹⁰ and the long-tailed¹¹ Crustacea are enumerated by Miss Mary J. Rathbun in her report on this section of the Hawaiian marine and fresh-water fauna. As eighty of the species are described by her for the first time, the brief characterization of the common forms is too difficult a

⁴ *Palinuridae*. ⁵ *Scyllarides squammosus*.

⁶ *Aloalo*; this native name is most commonly applied to the mantis-shrimp.

⁷ *Opae*.

⁸ *Grapsus grapsus tenuicrustatus*.

⁹ *Ocypode ceratophthalma*.

¹⁰ *Macrura*.

¹¹ *Brachyura*.



PLATE 106. SMALLER COMMON SEA SHELLS.

1. Spotted Purple Shell (*Ricinus ricinus*). 2. Banner Shell (*Vexilla vexillum*). 3. Mulberry Shell (*Sistrum morus*). 4. Kolealea (*Peristernia chlorostoma*). 5. *Peristernia*
 (Description of Plate Continued on the Opposite Page.)

task to be undertaken here. The reader is referred to the accompanying plates for the names of a number of the more common shore species.

HERMIT CRABS.

Mention should be made of the species of hermit crabs¹² that occur in such abundance along our shores. They are especially interesting, since they do not have the long, hard tail of the shrimp or lobster, nor a short one that can be doubled underneath as is the case with the ordinary crabs. Instead they have a soft fleshy tail that requires to be covered and protected. Apparently aware of this defect in its organization, the hermit crab, be it large or small, old or young, invariably thrusts itself for shelter into some empty sea shell. Once established in its shell house, it is subsequently never quite ready to leave it, except to exchange its abode for a larger one when it finds its quarters too cramped for comfort, owing to its own growth: or, occasionally, for a new home that in weight and design is more closely in accord with its notion of what a domicile should be. For these reasons they may be styled the professional house-hunters along the shore. Once sheltered and protected in the empty shell of some mollusk, they become aggressive and are always on the lookout to better themselves. Occasionally one will forcibly eject the living animal or another crab from the shell it chooses.

This house-hunting process may be easily seen by placing a few hermit crabs in an aquarium together with a variety of empty shells and a liberal supply of food. With a full stomach the necessity for a larger house is soon felt. But if the process becomes too tedious to watch, the crab may be ejected by force, when, if care is taken not to injure the two or three pairs of rudimentary feet, by means of which it retains possession of its borrowed dwelling,

¹² Sub-order *Onomura*.

(Description of Plate Continued from Opposite Page.)

chlorostoma var. 6. Tankard Shell (*Cantharus* sp.). 7. *Cantharus* sp. 8. *Cantharus* sp. 9. Fish-Basket Shell (*Nassa hirta*). 10. Mitre Shell (*Mitra* sp.). 11. *Mitra* sp. 12. *Mitra* sp. 13. *Mitra* sp. 14. *Mitra tabanula*. 15. Dove shell (*Columbella turturina*). 16. Zebra Dove Shell (*Columbella zebra*). 17. Niuhau Shell (*Columbella varians*). 18. Spotted Coneh [Pu leholeho] (*Strombus maculatus*). 19. *Strombus maculatus*; var. 20. Madagascar Cowry [Leho pupuu] (*Cypraea madagascariensis*). 21. Money Cowry (*Cypraea moneta*). 22. Isabella Cowry (*Cypraea isabella*). 23. *Cypraea semipicta*. 24. Snake-head Cowry (*Cypraea caput-serpentis*). 25. *Cypraea carnicola*, var. 26. Moon Shell (*Natica melanostoma*). 27. *Natica marochiensis*. 28. Horse-hoof Shell (*Hipponyx antiquatus*). 29. *Hipponyx barbatus*. 30. *Hipponyx imbricatus*. 31. Slipper Shell (*Crepidula aculeata*). 32. Eulima Shell (*Eulima* sp.). 33. *Eulima major*. 34. Pyramid Shell (*Pyramidella terebellum*). 35. Sun-Dial Shell [Pupu puhii] (*Solarium perspectivum*). 36. Ornament Shell (*Torinia variegata*). 37. Violet Snail (*Ianthina fragilis*). 38. *Ianthina exigua*. 39. *Ianthina globosa*. 40. Ladder Shell (*Scalaria* sp.). 41. Pupu adapii (*Scalaria lamellosa*). 42. Horn Shell (*Cerithium columna*). 43. *Cerithium obeliscus*. 44. Small Periwinkle (*Littorina pincta*). 45. Mottled Periwinkle [Kolealea] (*Littorina scabra*). 46. Measure Shell (*Modulus tectum*). 47. Sea Snail Shell [Kupee] (*Nerita polita*). 48. A wrist ornament made of Kupee shells; often worn as an emblem of mourning. 49. Little Sea Snail (*Neritina neglecta*). 50. Pipipi (*Nerita picea*). 51. *Neritina cariosa*. 52. *Neritina respertina*. 53. Wi (*Neritina granosa*); a fresh water species. 54. Top-shell (*Trochus* sp.). 55. *Patella* sp. 56. *Patella* sp. 57. Pupu moo (*Ischnochiton* sp.). 58. Bubble-shell (*Hydatina amphistrua*). 59. Little Emerald Shell (*Smaragdinella viridis*).



PLATE 107. THE REEF AT LOW TIDE.

The native fishermen have just captured a squid; in the background Koko Head, an extinct crater, is shown.

it will immediately seek shelter in the nearest shell at hand. The crab will back into its new home, inserting its tender abdomen into the shell until the aperture is plugged by its claws and the hard part of its body.

Often at low tide during the day a dozen or more of these active creatures will be found carefully hidden away under some loose stone on the reef. When disturbed they start off in all directions, each sheltered in a different species of shell and each carrying its own borrowed house on its back like a snail. Not infrequently other animals, as barnacles, oysters and sea-anemonies take up their permanent residence on the shell occupied by a hermit crab and are in this way carried about by them.

BARNACLES.

There is little in the appearance of adult barnacles to suggest that they are in any way related to their crab and lobster cousins. Such is the case, nevertheless, and by zoölogists they are looked upon as furnishing an excellent example of degeneration through quiescence, for when they hatch from the egg they are free swimming animals that closely resemble the young¹³ form of the crabs and shrimps, with but a single eye. Later on they have six pairs of swimming feet, a pair of compound eyes, and two well-developed antennæ, and are still free swimming animals. But when the creature makes the final change to the adult condition, it attaches itself by means of a cement-like substance to a stone, shell, pile or floating log, or to the bottom of a ship, and gives up all attempts at locomotion. It then loses its compound eyes and its feelers, and develops a protecting shell. The swimming feet become modified into grasping organs and henceforth it abandons any attempt to look and act like other Crustacea and devotes its energies to fanning such food as comes its way into its mouth, with its legs. There are two main groups of the order,¹⁴ including the barnacles, that are liable to attract attention on the sea-shore. One family¹⁵ includes the stalked species familiarly known as goose mussels or goose barnacles, a name derived from an ancient belief that if one fell from its support it turned into a goose. They usually occur hanging by the long stalk¹⁶ to the bottoms of ships, to floating timber or submerged wood of any kind. The sessile barnacles,¹⁷ acorn shells, or piceæ as they are called by the natives, are everywhere abundant along the shore. The entire animal is enclosed in a tent-shaped shell composed originally of six pieces, which is capped by an operculum made up of four valves.

Unfortunately, the shore forms have not as yet been fully studied. A dozen species of barnacles were enumerated by my friend, Dr. Pilsbry, from the material gathered by the ship *Albatross*. But one of these, a species of acorn barnacle¹⁸ belonging to the typical genus of that family, was secured in shallow water. The remainder were deep-water or off-shore forms, most of them occurring in water two or three hundred fathoms deep. Of the twelve species secured, eight proved to be undescribed. A careful study of the shore

¹³ Nauplius. ¹⁴ *Cirripedia*. ¹⁵ *Lepadidae*. ¹⁶ Peduncle. ¹⁷ *Balanidae*. ¹⁸ *Balanus amphitrite*.

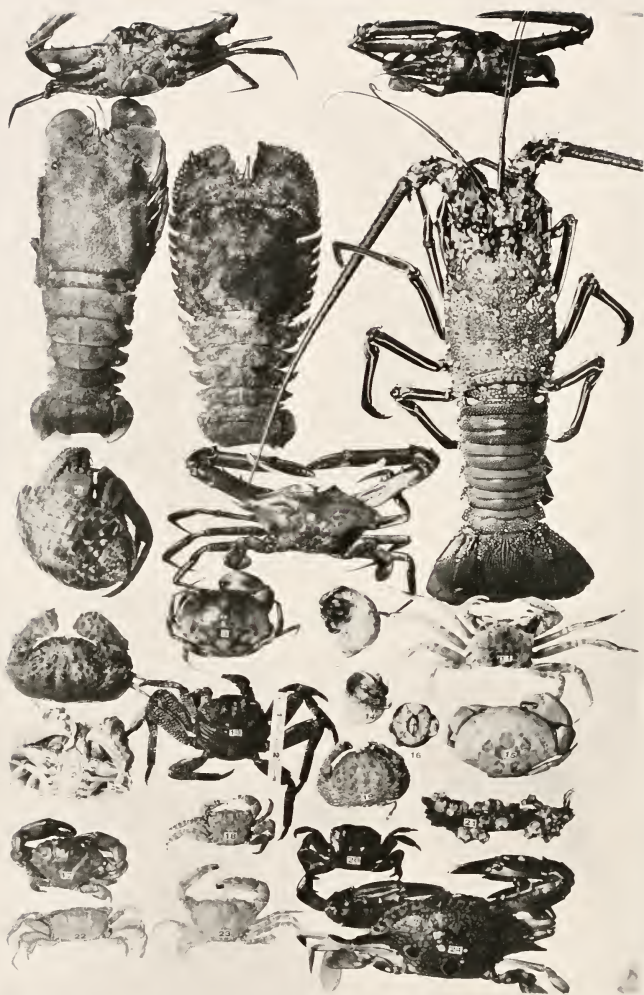


PLATE 108. COMMON CRABS AND BARNACLES OF THE CORAL REEF.

1. *Podophthalmus vigil* (female). 2. *Podophthalmus vigil* (male). 3. *Scyllarides squammosus*. 4. *Parribacus antarticus*. 5. *Panulirus japonicus*. 6. *Dardanus gemmatus*.

(Description of Plate Continued on the Opposite Page.)

fauna would doubtless add many new forms to the list of Hawaiian species. For example, a large flat white species apparently undescribed, perhaps a coronet barnacle,¹⁹ attaches itself to the skin of the sea turtle. Moreover, there are doubtless examples of the truly parasitic species that are still more degenerate in form and habit and occur as parasites feeding on the larger crustaceans.

COMMON CORALS.

The fragments of coral occasionally cast up on the sand beach are sufficient to awaken in everyone a desire to know more of the life and habits of the living creatures that produce the curious stony structure, and this desire has tempted many to explore for themselves the wonderful reefs for which the islands are so celebrated.

The public long ago accepted, apparently without question, the assertion of a worthy poet²⁰ that the coral animal was an insect. Zoölogists, however, have long known that it is not an insect, but a polyp—a very different creature, indeed—belonging to the great phylum,²¹ including all such animals as hydroids, corals, sea-fans, sea-pens, jellyfish, sea-anemonies and their allies.

There are, of course, many kinds of polyps, varying through a great variety of shapes and sizes, but they all conform fairly well to a general plan of body structure, a little more complex in its organization than that of the sponge. They have a more or less typical cylindrical body, with an interior cavity connected with the outside world by a single large opening at the free end. This opening is surrounded by a circle of arm-like processes or tentacles, hence the name polyp, meaning "many-footed." The tentacles are continuations of the body wall and composed of the same tissues. The fresh-water Hydra, a minute animal less than an eighth of an inch in length,²² is usually figured as the type of the whole great phylum. But for our purpose the common type of sea-anemonie, of which there are many species living on the rocks and along sandy shores or attached to piles and wharves, may be taken as an enlarged example of a single polyp. The chief difference between the two is that the animals known as the coral polyp usually live in enormous colonies and form skeletons of lime,²³ whereas the sea-anemonies are solitary, or at most gregarious, and secrete no hard skeleton. Both the anemonies²⁴ and the calcareous corals,²⁵ however, are included in the same class.²⁶ Though belonging to different orders, they seem to have the same general food habits.

¹⁹ *Coronula* sp. ²⁰ Alexander Montgomery. ²¹ *Cœlenterata*.

²² This interesting animal has not so far been reported from the fresh water pools and streams of Hawaii.

²³ Calcium carbonate. ²⁴ *Actiniaria*. ²⁵ *Madreporaria*. ²⁶ *Anthozoa* or *Actinozoa*.

(Description of Plate Continued from Opposite Page.)

7. *Podophthalmus vigil* (male). 8. *Calappa hepatica* (male). 9. *Carpilius convexus*. 10. *Calcinus elegans*. 11. *Ocyropsis ceratophthalma*. 12. *Calappa hepatica* (female). 13. *Grapus grapsus tenuicrustatus*. 14. *Calcinus lateris*. 15. *Carpilius maculatus*. 16. *Chelonobia testudinaria*. 17. *Elisus larimannus*. 18. *Metopograpsus messor*. 19. *Calappa hepatica*. 20. *Metopograpsus messor*. 21. *Balanus amphitrite*. 22. *Macrophthalmus telescopicus*. 23. *Thalamita integra*. 24. *Portunus sanguinolentus*.

SEA-ANEMONIES.

The food and general habits and life history of the sea-anemonies may be studied with profit by placing the living examples of any of the common shore forms, with the bit of rock to which they are usually attached, into an aquarium. When disturbed they contract into an almost unrecognizable mass, but when unmolested they expand into beautiful aster-shaped, flower-like, brilliantly-colored animals, so that a collection of living species is a veritable sea flower-garden. That they are not flowers, however, may be shown by attaching a small piece of meat to a thread and dropping it into the circle of petal-like tentacles. Almost instantly the long tentacles close over the food and shift it to the mouth, where the juices are extracted and the flesh digested.

As a rule, sea-anemonies settle where food is most liable to be carried to them by currents of water. Sometimes they attach themselves to other animals, as crabs, and in this way are carried about from place to place. That there are a large number of species about Hawaii is apparent to the most casual observer, but as far as the writer knows, they have never been studied and classified.

Turning now to the stony corals,²⁷ so important as reef builders, we find that though they are much more minute as individuals, they are more liable to develop into large colonies. Thus a single cabinet specimen of coral often represents, as a life work, the combined involuntary secretion of myriads of these patient and persistent animals. Interesting and beautiful as the bleached skeletons of the stone corals are, the living animals in their habitat on the growing reef are infinitely more fascinating to study. In the different species the expanded animals cover the skeleton with their soft bodies, giving to them a variety of colors as varied and as delicate as those in the rainbow.

THE GROWING CORAL REEF.

Those persons who for the first time see a growing coral reef through a glass-bottomed boat, or, failing that, through a water-box with a glass bottom, are invariably lost in admiration. Though they are privileged to repeat the experience again and again, they never tire of viewing the peaceful, brilliant scene beneath the wave. There, with the living and dead coral as a background, are mingled in wild and ever-changing confusion a multitude of nature's curious plants and singular animals. All are garbed in the most wonderful, striking and varied colors imaginable, and as they swim in and out among the corals or tranquilly wave to and fro with the rise and fall of every wave, they form a veritable vision of delight that time and distance cannot dim.

To have visited Hawaii without visiting some of these tropical submarine gardens is to have missed a golden opportunity, but to live in Hawaii, often within the sound of the surf that breaks over her fringing coral reefs, and not to have first-hand knowledge of their wonders, is to be remiss indeed.

²⁷ *Madreporaria*.

The coral reefs of the Pacific have been much studied by oceanographers, zoölogists and geologists who have sought to wrest from them something of the history of the formation of the islands in this vast ocean. The geologic significance of the Hawaiian reefs has been pointed out in another connection.

While but few have ever attempted to list the various species of corals found here, their study was first undertaken seriously long ago. In 1840-41 the renowned geologist James D. Dana, whose epoch-making book on the coral islands is a scientific classic, visited Hawaii and examined the reefs, as a member of the scientific staff of the United States Exploring Expedition. As a result a dozen of the more common shallow-water forms were described as new by him in a portion of the report of that expedition, published in 1846. Since then others have added to the list, but it remained for my friend, Dr. T. W. Vaughan, to give the subject the attention it deserves. As a result of his labors, based primarily on the collections secured by the Albatross expedition in 1902, but supplemented by a large collection of shallow-water coral secured by members of the staff of the Bishop Museum, we now have available for the specialist a handsome monograph in which representatives of fifteen families, including thirty-four genera, to which, according to that author, are referred one hundred and twenty-three species, varieties and forms. Of that number more than three-fifths are described and figured for the first time. Some idea of the richness of the coral fauna of any given locality can be gathered from the fact that the reef and shallow waters along the south side of Oahu, but especially at Waikiki, yielded examples of thirty-four of the species enumerated.

While a single species²⁸ of mushroom-like coral was brought to the surface by the dredges of the Albatross from the great depth of eleven hundred and fifty fathoms, the great majority of the forms, seventy-seven in number, occur in water from one to twenty-five fathoms in depth. Of the fourteen genera that occur in this shallow water zone throughout the group, ten were collected on reefs of Oahu from Pearl Harbor to Diamond Head. Representative specimens of the common genera from this locality are here figured. The figures will aid in the generic determination of such forms as are most liable to be collected, but definite identification of the species and the almost numberless forms of certain species is in many cases almost impossible, even when the type specimens can be seen.

The genera occurring in the shallow water about Oahu may be regarded as the living representatives of the reef-building forms that for thousands perhaps millions of years have been building the lime rock that fringes the islands.

Of the several genera *Porites*, the pohaku puna of the natives is the most abundant and is represented by the largest number of forms. The *Pocillopora* are perhaps next both in size and abundance, and like the preceding genus, they range through an extensive list of varied forms. *Moutipora* is next in abun-

²⁸ *Bathyaetes hawaiiensis*.



PLATE 109. COLLECTING ON A REEF.

1, 2, 3. Showing the use of the water-glass and collecting outfit. 4. A heart urchin (*Brissus carinatus*) with spines removed. 5. A cluster of *Mytilus* shells attached to each other by the curious hair-like byssus.

dance, while such genera as *Pavonia*, *Favia*, *Leptastrea* and *Cyphastrea* occur in isolated places here and there in certain favorable localities.

The mushroom coral,²⁹ or huahua akai, forms a remarkable group of solitary corals that are fairly common, especially in holes or reef pools on the outer edge of the reef. They take their name from their resemblance to the inverted head of an expanded mushroom. They are remarkable and beautiful objects, and make handsome souvenirs of a day's visit to a coral reef. The "sea mushroom," or in fact any of the corals, can be easily cleaned if they are placed in a bucket of fresh water before they have been out of the sea-water long enough for the animal to die and begin to dry up. Each day or so the water should be changed and the macerating animal washed out by a stream of water from the hydrant. When thoroughly cleansed the coral should be placed on a clean board in the sun to bleach.

Perhaps the most strikingly beautiful of the stalked corals is a species³⁰ which so far has only been found on Oahu, growing on the edge of the small coral islands in Kaneohe Bay. When alive the animal is a rich red-orange color and has the top of each short branch surrounded by a single orange-yellow polyp that when expanded is three-fourths of an inch in diameter. On the approach of danger the animal can completely withdraw within the cup in which it lives.

So far as known, the brain corals³¹ have never been taken in Hawaiian waters. They, together with many other forms offered for sale in the curiosity shops of Honolulu, doubtless come from the islands of the south Pacific or from the Philippines.

THE EIGHT-RAYED CORALS.

While the Aleyonarians are seldom seen by the reef collector, it is a matter of interest to know that of the sixty-eight species of the "eight-rayed corals" taken by the Albatross on its epoch-making cruise about the islands, thirty-nine were described as new to science in Dr. C. C. Nutting's reports on the material. He states that of the three orders of *Aleyonaria* discussed in his paper, the first,³² including the colonial forms, usually typified by the organ-pipe coral, are represented by only five species.

SEA-PENS AND SEA-FANS.

The order³³ including the sea-pens and similar forms where the colonies are arranged bilaterally and symmetrically on an axial stem, have sixteen species in the off-shore fauna. The sea-fans, sea-plumes and their allies form the most abundant order.³⁴ Like the other orders of the class, they all have eight-rayed polyps. The beautiful horny tree or bush-like growth to be seen in museums, however, gives but little idea of the appearance of the living animal. Forty-eight species are included in the list of Hawaiian species, but

²⁹ *Fungidae*.

³⁰ *Dendrophia mannii*.

³¹ *Meandrina*.

³² *Aleyonacea*.

³³ *Pennatulaceæ*.

³⁴ *Gorgonacea*.

they so very seldom reach the sea-shore that their presence in the islands would be unknown but for the work of such expeditions as that of the Albatross.

JELLYFISH.

Those who have been boating on the beautiful Pearl Harbor lochs are almost sure to have seen large numbers of the curious swimming-bells of the jellyfish³⁵ floating gracefully about through the water. If one is captured it will sting the hands like a nettle. For this reason the pololia, as it is known to the Hawaiian fishermen, is let severely alone by those who have once experienced the stinging, itching sensation, which is the result of a poison injected by myriads of little stinging cells. These stinging cells or lasso cells are common to many forms of Cœlenterata, and are very effective in protecting these apparently helpless animals from their enemies. Other species of large jellyfish are occasionally seen as they slowly swim at the surface of the ocean, or are rarely found stranded on the shore by the receding tide, but not more than a half dozen species all told are known from the islands.

HYDROIDS.

The *Hydromedusa* resemble the members of the foregoing family, differing mainly in being smaller in size, and in the fact that the medusæ or heads found floating at the surface, in most cases, are in reality budded off from small animals,³⁶ which form colonies and are permanently fixed at the bottom of the sea. The young medusæ after leaving the hydroids or stems, begin an independent free-swimming career. In the course of growth they pass through a series of stages and finally become sexually adult. The eggs of the female medusa do not, as a rule, develop into medusæ, but into hydroids, so that there is an alteration of generations. As the hydroids seldom grow in water more than a few hundred fathoms deep, the medusæ are usually found in shallow water offshore, though there are pelagic forms that are exceptions to the rule. Only a few species of the free-swimming forms have so far been reported from Hawaii. The common form,³⁷ a new species, is a very small bell-shaped animal with from twelve to fourteen lash-like tentacles suspended from the edge of the bell.

Dr. Nutting visited the Hawaiian Islands on the cruise of the Albatross, and subsequently devoted much time to a study of the hydroids collected about the islands. He found the fauna very rich, varied and interesting, but as the material examined was that secured in water from ten to five hundred fathoms deep, the littoral fauna is yet to be studied. His list enumerates forty-nine species, twenty-nine of them proving new. As the species are placed in twenty-seven genera belonging to eleven families, the great variation in the forms will be apparent. The shore species are often called moss animals,³⁸ since many of them are pretty feathery, plume-like creatures, so closely re-

³⁵ *Scyphomedusa*. ³⁶ *Zoophytes* or *Hydroids*. ³⁷ *Solmaris insculpta*.

³⁸ This name is more properly applied to the *Polyzoa*.

sembling sea-mosses that it is with difficulty that the untrained observer is convinced that they are really animal colonies. Some of the genera³⁹ are well-known animals and occasionally figured in general reference books. The Hawaiian species in every case are rarer forms that can only be recognized by experts when aided by elaborate descriptions.

In this connection mention should be made of certain colonial hydroids⁴⁰ that secrete masses of carbonate of lime out of which the animal protrudes like a coral polyp. They are usually pink or orange-colored, and are often called corals. Several species are found very plentifully on our coral reefs. On close examination it will be seen that they differ in structure from the true corals. The solid-looking masses with lobed processes, or bosses, are the most common,⁴¹ though fine branching examples⁴² also occur. In both families the whole surface can be seen, with the aid of a lens, to be covered with small pore-like openings. If a vertical section is examined, indistinct layers can be seen running parallel with the outer surface. Only the surface is alive, the inner mass being composed of the dead skeletons. Thus these animals secrete lime and build up a coral-like skeleton in much the same way as do the true corals, which are polyp colonies and quite different in their organization, though secreting similar masses of lime.

Zoölogists often cite this peculiar fact as an example of "convergence," meaning thereby that two animals of different types have become adapted to similar conditions of life and come to superficially resemble each other. Other animals, as whales and fishes, birds and bats, show similar evidence of convergence. Indeed, it has not been uncommon for naturalists to place totally different animals in the same group on account of their resemblance. The Hawaiian *Hydrocorallina* have not been fully studied as yet, and there appears to be no list of even the common species.

THE PORTUGUESE MAN-OF-WAR.

Sea-bathers occasionally make the acquaintance of the Portuguese man-of-war,⁴³ which is perhaps the best known member of a third family⁴⁴ of the jellyfish tribe. It floats, by means of an air sack, on the surface of the sea. Its stinging power is tremendous, producing a maddening, scalding pain which lasts for hours. As the stinging tentacles are long and thread-like and float out loosely in the water, the beautiful "blue bottles" are things that can be more safely admired at a considerable distance. On the windward shore of all the islands they are often stranded by thousands by the ebbing tide, where they dry down to a mere bubble in a few hours.

SEA MONEY.

Another common form⁴⁵ is a flat coin-shaped disk with fine radiating white lines. About the edge are innumerable fine tentacles. The animal,

³⁹ *Sertularia*, *Campanularia* and *Plumularia*. ⁴⁰ *Hydrocorallina*. ⁴¹ *Milleporidae*.
⁴² *Stylasteridae*. ⁴³ *Physalia utriculata*. ⁴⁴ *Siphonophoræ*. ⁴⁵ *Porpita pacifica*.



PLATE 110. SMALL CRABS AND CRAB-LIKE ANIMALS FROM THE REEF.
(FOR DESCRIPTION OF PLATE SEE OPPOSITE PAGE.)

tentacles and all, is less than two inches in diameter and is a beautiful blue color. When stranded the soft parts soon disappear, leaving a white disk about the size of a dime, which is often appropriately called "sea money." There is also another form⁴⁶ that is fairly common at times. It somewhat resembles the Portuguese man-of-war in that it is surface-swimming and bears on its upper surface an oblique sail. It differs from the man-of-war most noticeably in having short rather than long pendant tentacles.

A curious transparent balloon-shaped little animal⁴⁷ with two long retractile tentacles, with odd tag-like appendages attached, has also been taken in Hawaiian waters. It belongs to a fourth family,⁴⁸ which also includes an odd transparent, many-ribbed cylinder-shaped animal,⁴⁹ four or five inches in length, one end of which is rounded, the other truncated and occupied entirely by the immense mouth. As these animals are jelly-like, they seldom, almost never, reach the shore. For that reason they are rare curiosities when once they are secured. It is a matter of interest to know, however, that as many as twenty species of jellyfish or medusæ-like animals have been reported by Dr. A. G. Mayer as occurring in the collections made by the Albatross.

MOSS-ANIMALS.

Mention has been made of the sea-mats or moss-animals.⁵⁰ They are usually found attached to stones, forming an incrustation which, upon examination, seems to be made up of very minute cells each perforated by a small pore. Besides the encrusting forms there are branching forms that resemble hydroids, but unfortunately our fauna has not yet been studied, so that the species are not known.

Allied to the Polyzoa, and by most authors placed in the same phylum,⁵¹ are the very rare, but very interesting, lamp shells⁵² or arm-footed animals. The shells of these animals are so like the common clam shells in general form that they were once classed as a division of the mollusks, but they may be distinguished from them by the fact that their valves are unequal in size, and that they are attached by a small stalk which passes out through a hole in the apex of the larger valve. While it is to be presumed that species occur offshore, the only examples⁵³ that have come under the writer's immediate observation were a few delicately-colored specimens a half inch in diameter, secured in a small collection of shells brought up in dredging operations in Honolulu harbor, and

⁴⁶ *Vellela pacifica*.

⁴⁷ *Hyromphora fusiformis*.

⁴⁸ *Ctenophora*.

⁴⁹ *Boreo* sp.

⁵⁰ *Polyzoa*.

⁵¹ *Molluscoidea*.

⁵² *Brachiopods*.

⁵³ *Terebratulæ sanguinea*.

DESCRIPTION OF PLATE.

1. *Macrobrachium grandimanus* (immature). 2 and 3. *Crangon* = (*Alpheus*) *locris*. 4. *Macrobrachium grandimanus* (mature). 5. *Actæa affinis*. 6. *Platypodia eudourii*. 7. *Metopograpsus messor*. 8. *Palæmon pacificus*. 9. *Pseudosquilla ciliata*. 10, 11, 12. *Leptodius sanguineus*. 13. *Etisus levinianus*. 14. *Nerocila australasie*. 15. *Leptodius sanguineus*. 16. *Lophozozymus dodone*. 17. *Actæa speciosa*. 18. *Phymodius nitidus*. 19. *Xanthias canaliculatus*. 20. *Carpilodes Monticulosus*. 21. *Trapezia cymodoceæ intermedia*. 22. *Trapezia digitalis*. 23. *Rhymodius unguiculatus*. 24, 25. *Simocarcinus simplex*. 26, 27. *Perinea tumida*. 28. *Domoeia hispida*. 29. *Hippa adactyla*.

a few shells of apparently the same species, gathered on Laysan Island. They are of more than ordinary interest, since they represent a group which was very abundant in early geologic times and of which a few type-forms have persisted, almost unchanged, to the present day.

SEA-SQUIRTS.

The sea-squirts or ascidians form a class⁵³ that is well represented on the reef and the sea-bottom offshore. To look at the shapeless sack-like mass of a leathery or gelatinous texture having two openings through which, in the living creature, currents of water enter and leave the body, no one would for a moment believe that they could claim even a remote relationship with the typical vertebrate animals. Nevertheless, they are placed by modern zoölogists in a phylum⁵⁴ with several other unusual animals thought to form a group⁵⁵ more closely allied to the typical vertebrates than to any of the many varied types of invertebrate animals. In order to trace the affinities, however, the larval condition of the sea-squirt must be studied, as they are strangely degenerated animals in the adult form. They begin life as a free-swimming tadpole-like larvæ which approaches somewhat to the vertebrate type of structure. That is, they possess a notochord,⁵⁶ a central nervous system, gill slits, and certain other fundamental characteristics. As they attain the adult condition, however, radical changes in form and structure take place. They usually find a suitable location and become attached, remaining for their life-time in one place, firmly adhering to various objects, as a shell, a coral, a rock, or a bit of seaweed. The pelagic free-swimming sea-squirts or salpa I have never seen in Hawaii, but there are both simple and compound ascidians in abundance about the islands. Among the compound fixed types, the colonies, as they are called, are produced by budding from a single parent animal. They commonly form jelly-like incrustations in which a whitish star-like pattern can be seen. They abound on the under side of submerged objects, or on seaweeds. But the simple forms, being much larger, are sure to attract the notice of the naturalist on the reef. On being lifted from the water, attached to a stone or coral, they squirt a small stream of water from the openings as they contract.

THE BALANOGLOSSUS.

A curious soft-bodied worm-like animal,⁵⁷ whose claim to a place among the *Chordata* rests upon the fact that an outgrowth of the intestine extends into the proboscis, where it forms a solid rod which, in its origin, suggests the notochord in more typical forms, occurs in the sand in shallow water along our shores; in pockets in the reefs, as, for example, in the reef at Kahala, Oahu. Specimens may be secured by passing the sand through a sieve, or dredging it

⁵³ *Tunicata*, ⁵⁴ *Chordata*, ⁵⁵ *Protovertebrata*.

⁵⁶ A dorsal longitudinal rod of supporting cells that corresponds to the primitive backbone.

⁵⁷ *Balanoglossus*.

up on the tines of a rake. They are much sought by zoölogists owing to their primitive chordate characters, but uninformed collectors would place them at once among the worms. If specimens are carefully collected and placed in a jar of sea water and sand, they make interesting exhibits in the schoolroom or laboratory.

CHAPTER XXXVII.

PLANTS AND ANIMALS FROM THE CORAL REEF: PART TWO.

The Hawaiian reefs abound in representatives of the phylum,¹ including such odd and diverse animals as the starfish, sea-urchins, brittle-stars and the sea-cucumbers. The curious bleached white skeletons of the sea-urchins, with the beautiful lace-like pattern pierced in fine holes over the biscuit-shaped shell or test, are among the objects picked up with shells and seaweed on the sand beach. They are hardly to be recognized, however, as the remains of the spiny sea-urchin so often stepped on by incautious bathers. They are the "hedge-hogs" of the sea, since the numerous calcareous plates forming the shell are covered in the several species with variously-shaped spines. These spines serve the inna, as the sea-urchins are called by the natives, as a means of protection, and in certain species they are used to assist in boring the burrows often inhabited by them in the solid rock below low-tide.

SEA-URCHINS.

The common forms are a black species,² or inna eleele, and a whitish form,³ inna keokeo. They both are very plentiful on the coral reefs about Honolulu and are gathered and eaten by the natives. If one is taken alive from its hiding place beneath the loose stones on the outer edge of the reef and examined, the spines will be found to move on a ball-and-socket joint. The tubercles on the test forming the attachment for the spines are arranged mainly in five broad bands extending from the top round to the bottom or oral side. Alternating with these are five narrow bands bearing fewer tubercles, but pierced by the small holes arranged in rows as referred to above. Through these holes pass numerous curious tube-feet, each provided with a sucker on the end. These are therefore the walking bands.⁴ The vent is situated in the summit or aboral side of the test. The membrane on the bottom or flat side surrounds the mouth, from which protrude the tips of five pointed teeth. If the membrane is removed a curious conical structure will be seen commonly called Aristotle's lantern.

One of these animals dropped into a salt-water aquarium will prove an interesting object. Placed in water, the tube walking feet expand and the creature will slowly glide along, or if placed on its back it will right itself.

¹ *Echinodermata.*

² *Echinometra* sp.

³ *Echinometra* sp.

⁴ Ambulacral zones.

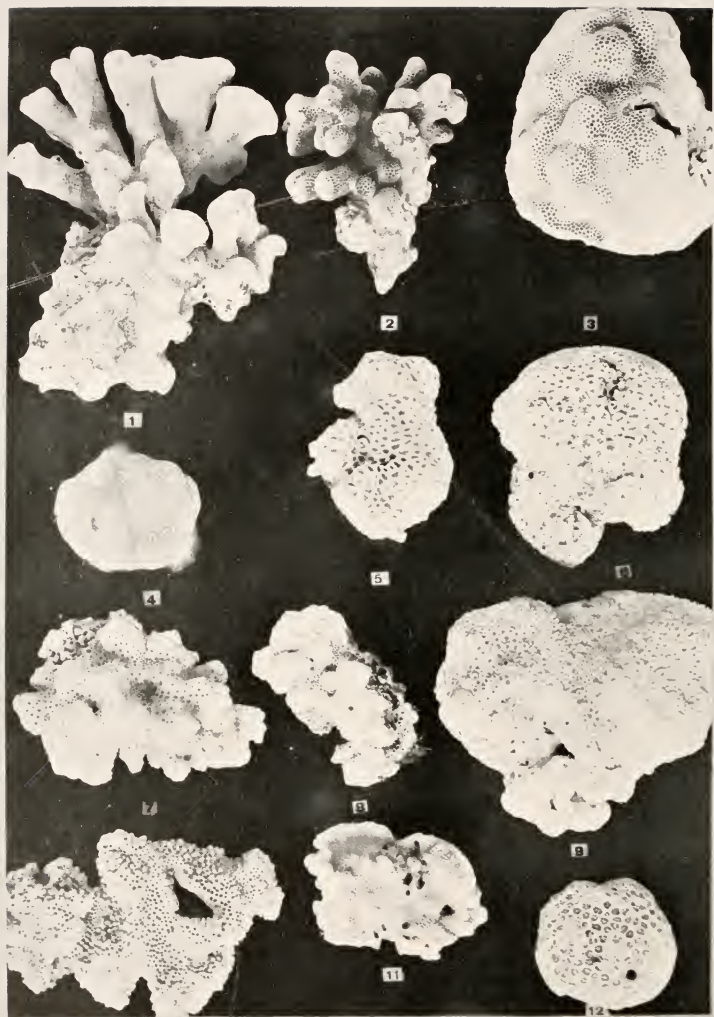


PLATE 111. COMMON CORALS AND CORAL ROCK.

1, 2, 3, 4. [Akoakoa—the general name of coral]. *Porites* spp. and varieties; the species are variable in form and a large number of forms have been enumerated. 5. *Coelastrea tenuis*. 6. *Leptastrea* sp. 7. *Cyphastrea ocellina*. 8. *Leptastrea hawaiiensis*. 9. *Leptastrea agassizi*. 10, 11. *Montipora* spp. 12. *Coelastrea* sp.

They are said to feed on seaweed and also on dead fish and decaying matter of various kinds. The large purple-black species,⁵ with long, slender, awl-shaped spines, prefers the deeper water in the holes toward the outer edge of the reef. With it occurs a similar species⁶ in which the long spines are banded gray and black. Both species are known as Wana, or sea eggs, and are much sought for by the Hawaiians, who are very fond of them.

The spines of the wana are both sharp and brittle and inflict a serious wound. If the native fisherman is so unfortunate as to be injured by one he will bite the wound savagely in order to grind the spine into fine fragments so that the pieces will come out later on with the pus.

The beautiful club-spined⁷ urchins are quite common at certain places on the reef, and are often on exhibition in the Aquarium in Honolulu. They are as large as the preceding species, but are a reddish-brown color, and the spines are heavy and blunt and imperfectly triangular.

A curious rough rock urchin,⁸ the haukeuke, has the spines short and blunt over the back, but long and dull-pointed about the edge. They are fond of the rough sea and adhere to the black lava rocks exposed to the full dash of the waves.

A large heart-shaped urchin,⁹ covered with fine short brown hair-like spines, is known as the sea biscuit or heart-urchin. Other forms are occasionally collected in shallow water, but the majority of the Echinoidea are found in deeper water offshore. The number of species inhabiting the Hawaiian waters is not determined, but it is known to be a rich fauna, there being a number of rare species.

STARFISHES.

While the true starfishes¹⁰ are fairly common in the deeper water offshore, they are not very abundant on the coral reef. As a matter of fact, it is a great find to collect a specimen of any size from the reefs about Oahu. It is necessary to understand at this point that in the typical starfish the arms are usually, though not always, five in number and that, as a rule, they are not sharply marked off from the central disk, as is the case with the brittle-starfish,¹¹ two or three species of which are plentiful in shallow water. In the true stars the feet are located in a definite groove, while in the brittle stars the grooves are not present.

The connection of the feet with the water-vascular system is very interesting. On the back between two of the arms may be seen a curiously roughened plate¹² that in reality is a sieve through which the water is strained before it enters the system. Connected with this sieve-like body is the stone-canal. It runs downward and connects with the ringed-canal which encircles the mouth; from this canal five radial canals, one for each arm, pass outward just above the ambulacral grooves. The radial-canals give off side branches

⁵ *Diadema paucispinum*.

⁶ *Echinothrix desori*.

⁷ *Heterocentrotus* sp.

⁸ *Podophora pedifera*.

⁹ *Brissus carinatus*.

¹⁰ *Asterioidea*.

¹¹ *Ophiuroidea*.

¹² Madreporite.



PLATE 112. CORALS AND REEF ROCK.

1. *Stephanaria* sp. 2. *Pocillipora* sp. 3. *Fungia* sp. 4, 5, 6, 7, 8, 9. *Pocillipora* spp. and forms. 10, 11. Dead coral rock showing worm holes and other marks of disintegration. 12. *Stephanaria* sp.; beach worn specimen. 13. *Porites* sp.

to connect with the bulb-like sacks¹³ that in turn connect with the tube-feet. Sea water is forced into this system of tubes and by the expansion or contraction of the little sacks, the feet are thus extended or withdrawn.

The favorite food of the starfishes is said to consist of the common bivalves, but it is asserted that there is no animal that it can catch that it will not devour. On the oyster beds, especially along the Atlantic coast, they are very destructive. They wrap themselves about the oyster and in so doing literally turn the stomach inside out through the mouth. In a little while the bivalve is forced to relax its muscles and allow the shell to open. The edge of the stomach is then inserted between the valves of the shell and the soft parts of its prey are thus digested outside the starfish's body. The habits of our Hawaiian species have not as yet been studied, though it would not be a difficult matter to do so.

Large specimens of an eight-rayed starfish¹⁴ are occasionally captured at Pearl Harbor. They are often a foot and a half in diameter, are cream-colored above, mottled with burnt sienna and chocolate, and are white below. A similar but very small species is to be found abundantly in the coarse green sponges in Kalihī bay and at Pearl Harbor. A small, stiff, irregularly-developed pink leather-like species,¹⁵ without spines, is occasionally found crowded into small holes in the coral reef. It is remarkable for its powers of reproducing new and complete animals from the broken fragments of the old one; a single specimen in the laboratory has been made to produce a dozen or more complete animals from the fragments broken from the parent, while the parent disk has gone on and reproduced all the lost parts.

A curious five-sided form, ten inches or more in diameter, has also been taken in the shallow water in Pearl Harbor, but of recent years the dredging operations have apparently driven the large species away. My friend Dr. Walter K. Fisher was on the great Albatross expedition and has described fifty-two of the sixty species taken on that cruise as new to science. They are placed in twenty families and are distributed into no fewer than forty-six genera. As can be imagined, the collection represents a most astonishing variety of starfish forms. But as the collection was made in water from ten to a thousand fathoms down, his splendidly-illustrated monograph is an index to what is in the great deep offshore, rather than a guide to the forms liable to be gathered by hand by the wading naturalist.

THE BRITTLE-STARFISH.

The brittle-stars¹⁶ have long serpent-like arms attached to a relatively small and usually rounded disk-shaped body. They differ from the true stars in a number of ways. It is important to note that the digestive system does not extend into the arms, but is confined in the central body, and that they have no grooves on the under side of the arms, such as exist in the typical starfish. The arms are long and very flexible and are used almost entirely as the organs of locomotion.

¹³ Ampullæ.

¹⁴ *Luidia hystrix*.

¹⁵ *Linckia* sp.

¹⁶ *Ophiuroidea*.



PLATE 113. MISCELLANEOUS MARINE ANIMALS.

1, 2, 3, 4. Common Tunicates. 5. Marine worm [Koe] from the coral rock. 6. Flatworm. 7. Portuguese Man-of-war [Pololia] (*Physalia utricula*). 8. Marine worm (*Gephy-*
(Description of Plate Continued on the Opposite Page.)

The common blue-black brittle-star,¹⁷ known to the Hawaiians as pea, is sure to give the unsuspecting person a start as it scrambles out of some hole in a dead block of coral lifted from the water and held in the hands for closer inspection. Like the true starfish, the brittle-stars are inclined to be gregarious. Often a dozen or two will be gathered under a single head of coral, or a stone half buried in sand in a hole in the coral reef. As they go scurrying off in all directions they look so weird and snake-like that one instinctively shrinks from taking them up in the hand, though they are known to be perfectly harmless.

They can be kept for a short time in an aquarium, where their habits can be studied to advantage. Their food, however, is difficult to provide, since it consists of marine organisms and decaying organic matter lying on the mud and sand on the sea bottom. It is scooped into the mouth by special tube-feet, two pairs for each arm. The stomach is a simple sac that cannot be pushed out of the mouth. A small pink species¹⁸ with remarkably long, slender arms, with short bristle-like spines, is occasionally found in holes in coral rock, but is exceedingly difficult to secure, owing to the arms being very easily broken.

The term "brittle-star" is derived from the habit of these animals of breaking off their arms on the slightest provocation. By so doing they can readily escape from their enemies. The loss of two or three arms is of no serious consequence, since new arms are speedily regenerated. The new growth, however, may be easily recognized, as it seldom is as large as the portion it replaces. This remarkable power of regenerating lost members is a common one in the animal kingdom, worms, crabs, lizards and the like furnishing interesting examples.

Zoölogists include the basket-stars,¹⁹ with branching arms, in the same class with the brittle-stars, but they have never been taken by naturalists on the Hawaiian reefs.

SEA-CUCUMBERS.

Every Hawaiian child is familiar with the loli, and most of them can tell at a glance the species that are used as food and those that are to be left lying on the reef or unmolested in the holes in the coral rock where they commonly seek attachment or shelter. They are known to Europeans by various names, as sea-cucumbers, trepang or bêche-de-mer, but whatever the name, whether they are fresh from the sea or dead, or for sale in the markets, they are the same repulsive, uninteresting-looking objects.

They are all included by zoölogists in one class²⁰ of sausage-shaped,

¹⁷ *Phioema* sp. ¹⁸ *Ophiotrix* sp. ¹⁹ *Cladophiura*. ²⁰ *Holothuroidea*.

(Description of Plate Continued from Opposite Page.)

rea) from the dead coral. 9. A *Cocentrate* (sp. indet.) from Honolulu harbor. 10. Sea-squirt (*Tunicate*). 11. Marine worm from a piling in Honolulu harbor. 12. Portion of the tube of a ship worm (*Teredo*) in a piece of timber. 13. Hue. 14. Sea-anemonie. 15. Sea-squirt. 16. Sea-anemonie.



PLATE 114. COMMON MARINE PLANTS AT WAIKIKI.

leathery marine animals with the mouth at one end of the body, which is sometimes surrounded with tentacles which may be expanded or withdrawn. They appear to bear but little resemblance to their cousins, the sea-urchins, or their second cousins, the starfish, but if one is closely examined it will be found to resemble the sea urchins in certain fundamental features, especially in possessing a ringed canal about the mouth which gives off tubes that run up and backward to supply water to the tube-feet when they are present. While they are far from being star shaped and are without the long, sharp spines of the typical sea-urchins, they appear to trace their ancestry back to a generalized starfish-like animal, and for that reason they are all included in the one great phylum.²¹

An energetic collector may secure a half dozen species on a single expedition on the reef at low tide, but if one turns to Dr. Fisher's very comprehensive paper based on the Albatross collection, the list of Hawaiian species will be found to be a much more extensive one.

Of the forty-four species of sea-cucumbers enumerated by this careful naturalist, nineteen are described for the first time. The fauna is placed in four families, including twenty-one genera in all. Perhaps a dozen species are liable to be gathered from the tide pools on the reef, but as they are difficult to describe in popular terms, they are even more difficult to identify. A few forms, however, may be recognized by their popular names or simple descriptions.

To all of these animals the Hawaiians applied the class name *loli*, but several species were recognized by definite specific names, such as *loli kai*, which grows about six inches long and is eaten raw or cooked; *loli pua*, the large black species often fifteen inches in length, which was also eaten, and *loli koko*, which is red inside and was not eaten by the natives.

The names thus applied by the Hawaiians are fairly accurate and constant throughout the group. As the definite detection of the characters which separate the species in most cases can only be made out by the examination of the calcareous deposits in the skin of the animal, their classification is a far too difficult problem for the average collector. But to collect specimens of many of the species is an easy task, since they are sluggish, inactive creatures which lie buried in the sand or seek shelter underneath stones or in the crevices in the coral reef. The large, dark-brown, blackish species with ambulacral feet scattered all over the body,²² commonly found in lava rock pools, is perhaps as well known as any of the group owing to its size when adult. A reddish, heliotrope-purple or brownish-purple species²³ frequently found in company with the large black one just mentioned, and a brown or reddish-brown species²⁴ of large size with a whitish ventral surface, are also common in shallow water. A well-known species²⁵ on the Honolulu reef is about three inches long and variously colored, the tentacles being straw color, the

²¹ *Echinodermata*.

²² *Holothuria atra*.

²³ *Holothuria cinerascens*.

²⁴ *Holothuria nobilis*.

²⁵ *Holothuria pardalis*.



PLATE 115. COMMON HAWAIIAN SPONGES [UPI].

dorsal surface brownish straw color, varied with lighter, the ventral surface lighter than the back. The species may or may not have two rows of dorsal spots.

A curious and striking worm-like sea-cucumber²⁶ is common at Pearl Harbor, Kaneohe Bay, and at other points in similar places in the shallow water on sandy and coral bottoms. Large specimens are two or three feet in length and an inch and a half in diameter. They vary greatly in coloration, but are usually reddish-orange spotted with brown, the brown forming mottlings and irregular bands. They have fifteen or more greenish tentacles an inch or more in length. These animals may be seen by the hundreds in favorable localities at certain seasons, as they slowly creep about in the algæ on the bottom, in shallow quiet water. On being lifted to the surface they completely collapse, as the water which fills the entire animal runs out, leaving only the thin contracted bladder-like skin.

Another very common variegated olive-brown species,²⁷ varied with whitish circles and blotches over the back, takes little care to conceal itself during the day and is quite plentiful, usually in lava rock pools. A fair-sized, dark-greenish species²⁸ mottled with dark brownish-green is also quite common, especially in the large tide pools on the outer edge of the reef near Honolulu.

The food of most sea-cucumbers consists of minute particles of organic matter extracted from the sand and mud, taken into the alimentary canal. The species mentioned above as common in Pearl Harbor may be seen in the process of feeding. The plume-like tentacles round the mouth are stretched to their full length. When they have gathered sufficient food particles from the water they are alternately curved round and drawn over the mouth and the food-charged water forced into the central mouth opening.

The tube-feet, when present, are the organs of locomotion: by them the animal is pulled along on its ventral surface. Several of the species, but especially the loli koko, have a disgusting habit, when disturbed, of exuding a mass of long white sticky fibers that adhere tenaciously to any object, and in which the enemies of the animals are entangled. These threads are part of the respiratory apparatus known as the gill tree, but the threads themselves are termed Cuvierian organs. When the loli becomes excessively irritated it contracts the muscles of the body wall to such an extent that the thin wall of the intestine is ruptured and a portion of the long, coiled intestine is pushed out. The animal is only temporarily inconvenienced by this experience, however, as in a short time, after a brief period of quiescence, nature refurnishes it with an entire new set of digestive organs.

CRINOIDS.

While the beautiful and rare sea-lilies or Crinoids are never found on the reef, it is a matter of general interest to know that they belong in the great

²⁶ *Opheodesoma spectabiles*.

²⁷ *Actinophyga mauritiana*.

²⁸ *Stichopus tropicalis*.

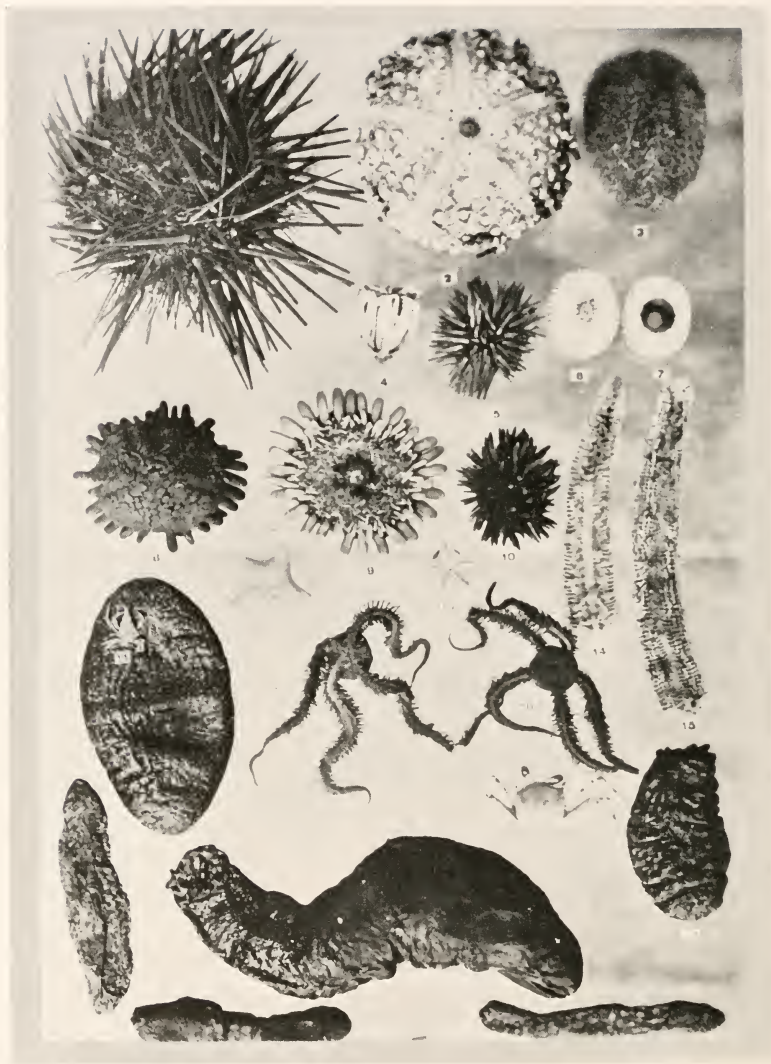


PLATE 116. STARFISH, SEA-URCHINS AND SEA-CUCUMBERS.

1. Sea Egg or Sea-urchin [Wana]. 2. The same with the spines removed. 3. Sea-beaver or Heart-urchin. 4. Aristotle's lantern: the masticating organ of a sea-urchin. 5.
(Description of Plate Continued on the Opposite Page.)

phylum including the starfish, sea-urchins and sea-cucumbers. A dozen species of this class²⁹ of animals, often known as feather-stars, or when fossilized as stone-lilies, were collected by the Albatross. They were placed in eight genera assigned to four families of the non-stalked forms. In the hands of Dr. A. H. Clark, the American authority on the erinoids, they all proved to be species heretofore unknown. Although it is thought that the collection secured represents only a small portion of the entire erinoid fauna of the islands, it should be remembered that all of the species were collected from water more than a hundred fathoms deep. The lower range of their distribution about the group, for want of fuller knowledge, is placed at about the one-thousand-fathom line. Although the species are peculiar to Hawaii, they all belong to wide-ranging genera.

SEA-WORMS.

The great group of worm-like creatures is at best not an especially attractive one to collectors of animals, and the general naturalist is very liable to pass them by without much attention. Yet there is such a variety of marine forms that make their home on or in the living and dead coral, and in the sand and mud along the shore, that they are at least worthy of passing notice.

Of the various groups of flat-worms, a division³⁰ collectively termed Planarians is well represented. As they are very curious in form, being broad and flat, they are usually sufficiently out of the ordinary to attract attention when seen gliding from the under side of some object picked up on the reef. Many of them are brilliantly colored and have an easy, graceful gliding motion, enabling them to move smoothly over the surface of shells, seaweeds or stones.

The Nemertinea have a superficial resemblance to the flat-worms. They may be recognized by their soft, extensile bodies and their long thread-like proboscis, an organ which can be completely withdrawn within the animal. They are often conspicuously colored and of varying form; some are fragile, others are very slender and of great length.

By far the most important group on the reef, however, is that which includes the bristle-worms³¹ and their allies, all members of the phylum,³² including the common earthworm, the leeches and similar forms. They can be placed in the phylum without much difficulty by the fact that the body is divided into numerous similar parts called segments.

They occur in various places, some living in canals in the dead coral rock.

²⁹ Crinoidea.

³⁰ Turbellaria.

³¹ Polychata.

³² Annelida.

(Description of Plate Continued from Opposite Page.)

Ina keokeo (*Echinometra* sp.). 6. Aboral view of the shell or test of *Echinometra*. 7. Oral view of the same. 8. Rough Rock Urechin [Haukenke] (*Podophora pedifera*). 9. Oral view of the same. 10. Ina lili (*Echinometra* sp.). 11. Crab (*Simocarcinus* sp.). 12. Starfish (not Hawaiian). 13. Oral view of the same. 14. Arm of a Starfish [Pea] (*Ludia hystrix*). 15. Same as No. 14. 16. Sea-cucumber [Loli]. 17, 18. Brittle Starfish (*Phoema* sp.). 19. Sand Crab (*Ocypode ceratophthalma*). 20, 21, 22, 23, 24. Sea-cucumbers [Loli].



PLATE 117. MARINE PLANTS AND PLANT-LIKE ANIMALS.

some forming tubes for their habitations, while still others are noted for making paper-like tubes. Some species burrow beneath the sand and mud; others fasten their tubes to stones or coral and cover them with sand or bits of shell.

Another group of worm-like animals³³ may easily be found by breaking up old coral rocks in which they are able to drill round holes. In the common forms³⁴ the anterior part of the body can be drawn into the posterior part. They are tough and leathery, blunt at the tail, and taper gradually to the end of the proboscis.

SPONGES.

It is a matter of regret that the many species of sponges³⁵ that occur on our reefs and to moderate depth in the water about them have never been systematically collected and studied. This need not prevent one from admiring and examining them, however, not only on their own account, but on account of the large number of worms, crustacea, starfish and other animals that enter them for protection.

There is scarcely a stone of any size on the reef that is without one or more of these curious creatures attached to it. Red, black, white, yellow and purple sponges are common, but almost every color one can suggest is represented. Many of them are shapeless encrusting masses; still others have a definite form, so familiar as to render their identification complete at a glance. Still others look more like weird plants than animals, and it is not strange they are often mistaken for such, when we consider their irregular plant-like growth. Although they were once claimed by botanists as part of the plant kingdom, they are now generally regarded as representatives of the simplest form of the many types of many-celled animals³⁶ as distinguished from the single-celled animals,³⁷ which are nearly all microscopic.

Sponges are free swimming animals for only a very short time, at an early stage of their development. They soon become attached to some object, and not infrequently modify their form so as to conform with the shape of the object to which they adhere. For this reason they seem to have no fixed shape of body, as individuals of the same species vary greatly.

The sponge is a very simply-organized animal and lives a very simple life indeed. Their food is the minute organisms in the water. Currents are created in the animal by means of minute flagella which wave to and fro in the tiny tubes that lead into the animal through small pores scattered over its body surface. The food is digested out of the water before it is allowed to pass out again through the large holes³⁸ distributed over the animal at irregular intervals. Sponges are of considerable interest to zoölogists, as they are the lowest types in which cells are found differentiated for certain purposes, as skeleton cells, reproductive cells, and so on.

Sponge culture has never been attempted in Hawaii, though the subject has been occasionally discussed. While none of the species now growing on

³³ *Gephyrea*.

³⁴ *Sipunculoides*.

³⁵ *Porifera*.

³⁶ *Metazoa*.

³⁷ *Protozoa*.

³⁸ *Osculum*.

the reefs have any great commercial value, it is not improbable that the fine soft species of commerce, suited to our climate and conditions, could be introduced and grown here.

Anyone who sees the living sponge will realize that the familiar bath sponge is only the bleached skeleton of the animal from which all of the soft part has been macerated and washed away, leaving only a substance known as spongin—a substance very like silk in its composition.

The division of the sponges is made not on color or shape nor habits, but on the differences in their skeletons. Two principal classes are recognized: one where the skeleton is composed of limy spicules³⁹; the other class includes species with glassy⁴¹ spicules or with horny⁴² fibers. To the non-calcareous class belong the majority of the larger sponges on the Hawaiian reefs.

SEAWEED.

It is a very natural transition in this connection to pass from the curious sponge animals, that so often resemble plants, to the consideration of the flora of the coral reef, since these curious marine representatives of the vegetable and animal kingdoms occur together, often in the most intimate relation, about our shores. In fact, many of the species of seaweed are attached to various species of sponges, and even more frequently sponges will be found growing on the larger forms of algae.

The examination of the heaps of curious bright-green, brown, purple or red plants cast ashore by the sea, particularly after a heavy storm, gives to the beach ramble a charm in any quarter of the globe, but in Hawaii, with its hundreds of miles of ever-varying coast line, the gathering of the sea-mosses holds out allurements to the lover of the beautiful in nature that few can long resist.

HOW TO COLLECT HAWAIIAN ALGÆ.

To gather and preserve these bright-colored flowerless plants is so easy and so fascinating a task that tourists who visit the islands, as well as old and young people who call Hawaii home, can find no more pleasant diversion than making a collection of the more common forms.

The first step in reef collecting of any kind is to find out the time each day when the tide will be low and arrange to be on the reef two or three hours before extreme low water, so that the tide may be followed out. However, algae hunting, as well as reef collecting generally, may be greatly facilitated if the collector can have the use of a boat, a fine-toothed long-handled rake and a water box with a glass bottom. Still more ambitious collectors will want to use a dredge, though dredging about a coral reef is very difficult work. Those who are not able to dredge or wade, will find the sea-coast at high tide furnishes specimens of most of the species to be gathered first-hand farther out.

The collector will want a light canvas bag, or wicker basket, and a small

³⁹ Calcareous.

⁴⁰ Non-calcareous.

⁴¹ Silicious.

⁴² Spongin.

assortment of bottles and containers of odd sizes. A good quantity of old newspapers will also be useful. A lens, a stout knife, a pair of forceps, and a wading costume that protects the arms and legs from the sun are very important parts of the field equipment, but nothing is more necessary than a pair of stout shoes to protect the feet when wading over the rocks on the rough coral reef.

The Hawaiian tides are so uniform and slow that there is no danger to be feared from their sudden return, so the collector can work in safety and at his leisure, always taking time to gather the finest specimens to be found in the given locality. A little practice with the lens will enable the beginner to discover the fruiting bodies on the different algae. If they ever attempt the task of naming their specimens, the importance of having perfect specimens will be appreciated; still, an imperfect example is not to be despised, since it will be of value in giving a clue to the nature of the flora of a given locality.

The specimens may be roughly dried in a shady place or salted down, or, better still, mounted and pressed while they are fresh. To do this the plants should be carefully washed and sorted in sea water, as they retain their colors better than when washed in fresh water.

The next step is to "float out" the specimen in fresh or salt water on a piece of substantial, tough, unglazed paper of the proper size. Several methods of "floating out" the specimens may be employed. A good way is to take a shallow dish or enameled pan and lay in the bottom a square piece of galvanized iron that is a trifle smaller than the pan. If the corners of this mounting table are turned down so as to make legs a quarter to a half inch long, the apparatus will work much better.

Place the floating table in the pan and cover it with water and lay upon it a piece of mounting paper that has been moistened on both sides. The specimen to be mounted is then laid on the paper and held in place with the left hand, while with the right hand, needle points and tweezers are used to smooth the branches of the specimen out on the paper. The specimen, mounting table and all, is then gently lifted out of the water and the card laid to one side to drain. When the paper is fairly dry, the specimen and its mounting sheet is placed on a sheet of blotting paper, a piece of thin muslin cloth, free from starch, spread over it and a second dryer laid over the cloth. The specimens are piled up in this way, one on top of the other, until the lot is finished, when they are placed between two flat boards, to which a little weight is added, and left to dry thoroughly. Specimens that do not adhere to the mounting sheet may be fastened in place with narrow strips of gummed paper.

The collector will soon learn that algae, like land plants, favor certain localities, and moreover that they have their special seasons of growth. So that to gather all of the attached or fixed algae⁴³ in a given locality will require many expeditions over the same locality at different seasons. It is not improbable that almost every collecting ground would yield as many as fifty

⁴³ For there are many microscopic species that are free swimming plants.

species, and there are some of the more favorable localities in the islands where with close and persistent work a more extended list can be secured.

It is impossible to give in a few pages a systematic survey of so extensive a group as the Hawaiian algae. A few of the more common forms found at Waikiki are figured. These will serve to show how curious and interesting these plants are. But as not a few of the species to be gathered about the islands are as yet unnamed, the collector who is not a botanist may feel sure that he can render good service to science, and at the same time afford himself a pleasant recreation by making a carefully collected and well-labeled collection from almost any locality. The label should note such facts as the season, depth, character of the bottom, whether in brackish or salt water, exposed to tide-rush or surf or in quiet pools, and other observations of interest.

While Hawaiian algae have been studied to some extent for years, and several important collections have been made, no one, so far as the writer knows, has ever given more than a guess at the probable extent of the flora of the Hawaiian reefs. The literature begins with a list published more than thirty years ago by Mr. J. E. Chamberlain, which gave the names of one hundred and twelve species of marine algae common in Hawaii. In 1900 Miss J. E. Tilden spent some months in Hawaii collecting the fresh-water and marine algae, and subsequently published a list of one hundred species in Thrum's Annual. But as the list published was only a small part of "the several hundred species collected," many of which were not described, it is to be hoped that this authority will be induced to make a more exhaustive review of the material.

Miss Minnie Reed has also made extensive collections of the algae of the islands in connection with her especially interesting investigation of the economic seaweeds of Hawaii and their food value—for limu, as the fresh and salt-water algae are called by the natives, has always had an important place in the native bill-of-fare. As many as seventy-five species of edible algae were known to the Hawaiians by name. As this list of edible species is referred by botanists to thirty-eight genera, some idea of the variety of forms of the useful species can be gathered.

Almost every day at low tide native women and children may be seen on the reef gathering the daily supply; and at least a dozen species are offered for sale in the markets, along with other Hawaiian delicacies, the favorite species being limu kohu,⁴⁴ limu eleele,⁴⁵ limu oolu⁴⁶ and limu lipeepee.⁴⁷

Seaweed has also had an important place among the native medicinal plants. But Europeans, as a rule, seldom regard this product of the sea as a marketable or an edible commodity. Nevertheless, thousands of dollars' worth of Hawaiian limu is consumed by the natives, and even a greater quantity is imported by the Oriental population.

⁴⁴ *Asparagopsis sanfordiana*.

⁴⁵ *Entiromorpha* spp.

⁴⁶ *Chondria tenuisssima*.

⁴⁷ *Laurencia* spp.

In addition to the long list of marine species there is an extended list of fresh-water limu, many species of which were also used for food by the natives living at some distance from the sea.

But important as limu is as a food for man, its importance as a food for the myriads of animals of the coral reef that feed on it exclusively, or at one stage or another of their existence, is far greater. It is perhaps in this indirect way that it has its most significant bearing on the food supply in Hawaii, and it is the ecological relation of these curious plants and animals to their environment, that is of such absorbing interest to the student of natural history.

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The author takes this final opportunity to again express his indebtedness to those who have preceded him, and through their published works, made this popular synoptical view of nature in Hawaii possible.

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GLOSSARY AND COMPENDIUM.

NOTE.—The black-faced numbers indicate that the subject is illustrated upon the page cited. In such cases the subject may be referred to only in the explanation of the plate, or it may also be referred to in the text. Scientific names used in the text have been segregated and appear as an INDEX to SCIENTIFIC NAMES. Vernacular names in English are entered twice as Crow, Hawaiian, and Hawaiian Crow; Hawaiian names are entered but once. The work is so fully indexed that it will serve as a synonymy of the common names in current use. Frequently, where Hawaiian and English names are given as Alae (Hawaiian gallinule), both names should be consulted for additional information on the species. The important subjects treated are indexed very fully with the object of rendering the volume useful to teachers and students as a collateral reference book. Notes, explanation of terms, etc., appear in small type, and are alphabetically arranged, usually without reference to the text.

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Aahumamo. A yellow feather robe worn by the king or high chief.

Aahnula. A royal cloak usually adorned with red feathers.

Aaka. A name given to the dry wood of the bastard sandalwood (*Mycoporum sandwicense* Gray). When dry this wood becomes very fragrant and when burned gives off the odor of sandalwood, hence the name. The living tree is known as Naio, which *see*. The wood is very durable and was much used for house posts.

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"Ababai" (*see* Papaya)

Abbreviations—sp.=species; spp.=two or more species belonging to the same genus; s^o. indt.=an undetermined species; = the same as; = when following a scientific name and before a locality—of or from.

Abdomen of insects, etc., (409). The hind body; the posterior one of the three parts of a perfect insect.

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Abortion was commonly practiced among the ancient Hawaiians and was accomplished in various ways, as by the use of sharp pointed bamboo instruments, jumping, etc.

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Accidental. Said of a species that only occasionally occurs in the islands and is not considered as an established species. (*See also* occasional visitors.)

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Alia. A cord braided from the husk of cocoanut, or from human hair; or strings made from the intestines of animals.

Ahaaha (Needle-fish), 350, 349, 364

- Aha-aina (feast), 355
- Ahakea. Name of a species of yellowish wood (*Bobea* spp.) used for rims of canoes, poi boards and paddles. The tree in the forest is conspicuous by reason of its light green foliage.
- Aha-moa. The name of an assembly collected at a cock-fight.
- Ahanui, 206, 224
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- Akaakai (Bullrush), 198, 199.
- Akai, 227
- Akai. Name applied to the different species of the genus *Wikstroemia*. The shrubby plants have a tough bark furnishing a strong native fiber and contain an intoxicating narcotic which was employed by the natives to poison fish in fresh water as ahuahu was used in salt water.
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- Alaa. A name applied to the species of the genus of trees *Nideroxylon*. The sap of the more common species (*N. Sandwicense* Benth. & Hook.) was used as a bird lime.
- Alaalaa=(Fig. 9), 482
- Alaalabee. The spawn or eggs found in the 'squid.' It was eaten, with kukui nuts as a relish.
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- Alahee. The name of a tree (*Plectranis odorati* Benth. & Hook.): from its wood instruments were made for tilling the soil. (*See* Oo.) The leaves were also used to produce a black dye. A shrub or small tree with glossy leaves and fragrant, sweet-scented flowers common on all islands, but especially on Molokai.
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- Alaneo. The name of a cloak, or royal robe, made of the feathers of the mamo only.
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- Alii. One who rules or has authority over men.
- Aalii or Alii. The name of a small hard wood tree (*Dodonaea viscosa* Linn.) common on all islands up to the 4000 foot level. The wood is used to some extent for fence posts; the leaves were used for medicine by the natives.
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- Annual plant (276). Flowering and fruiting the year it is raised from seed; then dying.
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- Antennæ (407). Organs occurring in pairs on the head of insects, crabs, etc., and serving as feelers or tentacles. They vary greatly in size, shape and function.
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- Arbor (201). A bower formed by trees, shrubs or vines usually trained over a lattice work to form a shelter from the sun.
- Arboreal (245). Tree like: the size and shape of a tree.
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 Astringent (217). A substance which binds or contracts the tissues and canals of the body.
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 Au. The handle or helve of an ax. They were often made of hau wood.
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 Auamo. The stick or pole used to carry burdens when balanced across the shoulder. *See* plate 12.
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 Auau. The stalk of loulou (*Pri-hardia* spp.) made into a spear.
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 Aulima. The name of the stick held in the hand when rubbing to produce fire. The name of the stick rubbed is *aunaki*. The action of rubbing is *hina*.
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 Awa drinking. The root of the awa plant produces a numbing effect on the mucus membrane of the tongue, and is thought to allay thirst by its pleasant aromatic flavor. The Hawaiians recognize six or seven varieties of awa all of which are regarded by botanists as forms of the one species. Awa from Puna, Hawaii, was considered of the best quality. In former times the drink was used almost exclusively by the chiefs. Later, it came to be a prevalent habit among old natives, and awa drinking is still quite common throughout the group in native settlements. The object of drinking is primarily to produce stupification. The drink is made from either the fresh or drv roots. The regular drink was one cup full from a coconut cup, cut lengthwise of the nut. The plant is an upland growth and is found where the ground is both damp and shady. It was, and is, planted by the natives in suitable localities. The ground is loosened and a joint or cutting set in, after the native method of planting sugar-cane. After a time it is hilled and left to grow without further care. It continues to grow and spread its roots abroad. Roots 20 years old are enormous in size—sometimes being all two or three men can carry. *See* awa.
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 Awikiwiki. Name of a leguminous vine (*Canavalia galeata* Gaud.) common on all islands. According to Andrews the "berries" were used as a medicine, operating as an emetic and cathartic. The species bears 4 to 8 large seeds in a pod.
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 Barbados cherry (*Molipigia glabra* Linn.). A well established, though not a common fruit in Honolulu gardens, coming originally from the West Indies. It is a small bushy shrub with dull green, opposite, ovate leaves. The rose-colored, five-parted flowers spring from the axils at the base of the leaves; they are followed by a cherry-sized, rich, red fruit, with acid pulp surrounding a hard seed. The fruit may be used for jam and preserves.
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 Barbels [fish] (372). A small, slender, elongated process appended to the mouth of certain fishes (*Barbules error*).
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 Basalt. The term basalt is used, in a somewhat comprehensive way, for dark compact igneous rocks that appear to be nearly homogeneous owing to the smallness of the crystals which are usually so minute as to be identified only under the microscope. There is usually a considerable range in chemical composition, but the basalts are relatively poor in silica, but rich in lime, magnesia and iron. They are classed as basic rocks and are sometimes highly so. *See* Hawaiian Igneous Rocks.
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- Bhel or Bael fruit (*Egle* sp.). This small, strongly-spinose tree with alternate tri-foliate leaves is not uncommon in Honolulu gardens. It is distinguished from the nearly related *Citrus* genus by the hard gourd-like rind of its fruits which, when ripe, is yellowish-brown and 3—4 inches in diameter.
- Big-headed ant, 403
- "Big-eye" (Fish), 354
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- Biologist (385). One skilled in or a student of the science of life and living things, in the widest sense.
- Bird-catchers were an important class in old Hawaii who captured birds for their feathers. In addition to several well-known bird-limes (which *see*), they employed nets and spears. They recognized two seasons for catching birds: one from March to May, the other from August to October. These correspond with the flowering season of the ohia lehua. The trees in the lower woods flower in the spring; those higher up in the fall season. The birds they sought move from place to place, wherever flowers and food is plentiful. The bird-catcher of former times said prayers and made offerings to his gods that the birds of the forest might be gathered into his gum-traps and held fast. It is reported that Kamehameha I was the first to appreciate the importance of protecting the birds. He reprov'd his bird hunters for taking the lives of birds they caught.
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- Birds as pets. It was quite the custom with bird catchers to keep the o-o, iwi and apapane alive in special cages to use as decoys in bird catching. They were fed, daily, on the nectar of their favorite flower and in time became very tame.
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- Bracts (201). The small leaf or scale from the axil of which the flower or its stem proceeds.
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- Brain corals, 479
- Brake, Common, 223
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- Brazilian plum (*Eugenia Brasiliensis* Lam.) or Spanish cherry is widely known as the grumichama of Brazil. It was probably first introduced by Don Marin, but fine trees may be seen in the garden of Mrs. Mary E. Foster, introduced by Dr. Hillebrand. The deep purple fruit is the size of a cherry; the leaves are oval or obovate 3 inches long by 1½ broad and occur scale-like along the branches. The edible fruit has a very agreeable flavor.
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- Breccia. A rock composed of angular fragments cemented together by nature. It is to be compared with conglomerate in which the fragments are rounded.
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- Cannibalism. Dr. W. D. Alexander has asserted in his History of the Hawaiian People that cannibalism was regarded with detestation and horror. On the same subject the Rev. Sheldon Dibble, author of a much earlier History of the Sandwich Islands, states: "The practice was not common, and it is due to the Hawaiians to say that those few instances that did exist were looked upon by most of the people with horror and detestation."
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- Carambola (*Avicennia Carambola* Linn.) has long been cultivated in the islands. It doubtless came from China or India. It may be identified most readily by its acid fruits which are about the size of a lemon, yellow in color, acutely five-angled, with a thin skin and watery pulp. The fragrant fruit is used when half grown for pickles; when ripe for preserves. The flowers are rosy purple; the tree usually 15—20 feet high, has alternate odd pinnate leaves. It is said to produce three crops a year.
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- Cashew nut (*Anacardium occidentale* Linn.). The kidney-shaped nut consisting of a kernel inside a very hard shell is borne upon a swollen pear-shaped yellow edible stalk. When roasted the kernels are also edible. The small spreading tree is a native of the West Indies, but occurs sparingly in Honolulu gardens. One of the first trees introduced was planted by Mr. Henry Davis in his garden in Punahou, Honolulu. The flowers are pink and sweet-scented; the leaves light green, oval in shape and with a rough leathery texture.
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- Caterpillar (385). Usually the larvæ of a moth or butterfly, but also applied to the same stage of development for other insects.
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- Cats. Cats were an early introduction into Hawaii. A breed of bob-tailed cats is common—the tail having a curious corkscrew kink at the end.
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 Chocolate, or cacao (*Theobroma Cacao*). Is a small evergreen tree from 16—40 feet high in its native wild state in tropical America. Its fruit is a somewhat pear-shaped pointed pod, 10 furrowed, from 5—10 inches long and contains numerous large irregular seeds embedded in a sweet pulp. These seeds are very nutritive and agreeable in flavor and are used both fresh and dried as articles of food. They are roasted, ground into a paste, mixed with sugar and flavoring matter to make the chocolate of commerce. A few experimental trees are growing in Hawaii. They may be recognized by their large pointed leaves, the wine-colored new growth and the small flowers with inflexed petals hanging from the trunk and branches, and by the pods.
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- niha, Haena, Koloa, Lawai, Elele, Hanalei, Makaweli, Waimea, Kekaha: on MOLOKAI—Kaunakakai, Kawela, Kamalo, Kalaeloa, Pukoo, Honomuni, Pauwahu, Waialua, Halawa, Lepau, Wailau, Pelekuna, Kalawao, Kalaupapa: on LANAI—Mannalei, Manele.
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 Climate. While the Hawaiian language does not have a word which is the equivalent of our word climate, the language is rich in weather words. The dictionary gives 86 words pertaining to clouds, 82 to precipitation, 139 to wind movements, 23 to temperature, 11 to optical meteorology, 18 to electric meteorology, and 12 general weather words.
 Climate, changes in. Abundant evidence exists to prove that the climate of the islands has undergone changes in the past sufficient to seriously affect the plants and animals. (*See* Diamond Head, Geology of, Forests, Deforestation, etc.)
 Clinkstone. A name applied to phonolite because of its metallic, clinking sound when struck. It is a common product of Hawaiian volcanoes and was used by the natives in making stone adzes, etc.
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- Cock-fighting. At Pau o Keokeo, on Hawaii, immense crowds of Hawaiians gathered to witness the cock-fights in former times. The pens still stand as they were in the time of Umi—three and a half centuries ago.
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- Cocoon (309). The silky envelope which the larvæ of many insects spin as a covering for themselves in the resting (chrysalis) stage.
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Diphthongs. A diphthong is a union of two vowels pronounced as one syllable. In uttering a diphthong both vowels are sounded but are so blended as to be considered as forming one syllable. In scientific nomenclature proper diphthongs occur frequently and are usually indicated by the union of the letters involved. In the present volume the italic *a* and *æ* used in the Latin names occurring in the foot-notes and the explanation of plates are so similar in appearance that as a convenience, in the varification of spelling, those words formed with an *a* have been here collected. Those occurring in the description of the plates are: *Borhaavia diffusa*, *Clermontia cœrulea*, *Cœlastrea tenuis*, *Cœlenterata*, *Crangon* = (*Alpheus*) *lœvis*, *Ipomœa* spp., *Echalia grisea*, *Parexocetus brachypterus*, *Phiœma* sp., *Phœnix dactylifera*, *Scævola* Kœnigi. Those occurring in the foot-notes for the text are: *Bœhmeria nivea*, *Cœlenterata*, *Cœlophora* spp., *Exocœtida*, *Exocœtus volitans*, *Ipomœa* spp., *Cœlenerida*, *Cœstridæ*, *Cœstrus*, *Parexocetus brachypterus*, *Phiœma*, *Phœnix dactylifera*, *Pœciliidæ*.

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Districts: On OAHU—Honolulu, Ewa, Waianae, Waialua, Koolauloa, Koolau-poko. Honolulu, with about one-fourth the population of the whole group, is the capital city. On KAUAI—Waimea, Koloa, Lihue, Kawaihae, Hanalei (including Napali); on MAUI—Lahaina, Wailuku, Makawao, Hana; on HAWAII—Kohala (divided into North and South Kohala), Hamakua, Hilo (divided into North and South Hilo), Puna, Kau, Kona (divided into North and South Kona); on MOLOKAI—Undivided.

Divergence (433). Differentiation in action or character.

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- Dyes for tapa, 69
- Dye stuff. The Hawaiians had an extended list of materials which served as dye stuff for ornamenting their tapas. Among the plants so used were akoa, awapuhi, haa, niu, holei, mao, na'u, noni, ohia, olema, koa, pili (charcoal of), walahee, etc. Other dyes were made from earth, charcoal, ashes, red ochre, etc.
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- Egg fruit (*Lucuma Ricica* Gettn.). A native of Brazil and of rare occurrence in Hawaii. The fruit is described as being "about the size and shape of an egg and tastes like the yolk sweetened."
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- Ehuawa. A species of sedge (*Cyperus laevigatus* Linn.) from which a strong cord was made; but its chief use was in the manufacture of the fine Niihau mats. It is common in shallow sweet and brackish water.
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- Embalming. Sometimes the human body was
partially embalmed by being salted and dried.
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- Emerald shell, 470
- Emerge (382). To come out of the covering;
to come forth, as a butterfly from a cocoon.
- Emergency diet, 69
- Emerson, Jos. S., 342
- Emerson, Dr. N. B. (Ethnologist, Hawaiian
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- Emoloa, 224
- Encampment shell, 446
- Endemic (193). A species peculiar to the islands;
'autochthonous' is often used in the same
sense. Peculiar to and hence characteristic
of a given locality.
- Endemic fauna. Dr. Perkins estimates that nine-
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- Entomologists (383). One versed in or engaged
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- Epidermis [Mollusca] (450). The outermost
covering of the body of an animal.
- Erect [Bot.]. Said of plants when they grow
upright from the root.
- Erosion by the sea, Example of, 142
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- Executions were anciently in the form of assas-
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rude and barbarous manner by assault
usually at night. Often the victim was
attacked from the rear and done to death
by strangulation or by breaking the back.
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- Exotic (381). Not native; introduced from a
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Fires, Forest. Forest fires of a more or less destructive nature occasionally occur. They were also known in ancient Hawaii. Fire was used to some extent by the natives to clear land in the forest for native crops.

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First fruits. When the first fruits of any crop were ripe they were offered to the family gods on the proper day of the moon.

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- Fish gods. Several species of fish arrive in large numbers on the coast every year in their respective seasons. The fish first secured was always carried to the fisherman's heiau and there offered to the fish god whose influence, it was thought, had driven the school of fish to the land. It is suggested that the natives, at some remote date, had seen the fish pursued through the islands by sharks and that the occurrence may have led them to respect the shark as a powerful god of the fishermen.
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- Fish-hooks, Bone, ivory, tortoise shell, 242
- Fish-hooks were made of shell, bone, tortoise-shell and ivory; iron was substituted in most cases at an early date. But few fish-hooks [he makau] are now made in the ancient style.
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- Fishing torch. Torches were made of kukui nuts strung on a rush, or on a cocoanut mid-rib and bound together with ki leaves. They would burn in almost any kind of weather. The natives believed that when the torch burned poorly, the fishing would be poor, but if it burned bright the fishing would be good. The light from the torch blinds or dazzles the fish. Sometimes a fire is made on the bow of the boat to aid in fishing. Often the blinded fish may be killed with a club.
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 the east end of Maui, at Hana, at Kawai-
 hae, Keauhou and Punaluu. In some sec-
 tions they determined the location of villages
 as they furnished a dependable supply of

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Grindstone, or more properly whetstones (pohaku hookala) were made from hard, more or less gritty rock. They were used in ancient times for sharpening stone implements and in modern times may occasionally be seen in use for whetting knives, etc.

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Guava. The genus *Psidium* is represented in Hawaii by several species and varieties, all introduced from the West Indies, South America and China. The common guava (*P. Guajava* var. *puriferum* Linn.) is the yellow fruited form common everywhere by the roadside. The sweet red species (*P. Guajava* Linn.) is also common and has a sweet, firm, red pulp. A white lemon-shaped form is also common in certain localities: it has a white, sweet pulp. Another variety of early introduction known as waiawi has small pear-shaped fruits with yellow flesh and numerous large seeds. The strawberry guava (*P. Cattleianum* Sabine) is a very different species with round red fruits. A variety (*P. C. lucidum* Hort.) with small, round, yellow fruit is also cultivated.

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Haae. The name applied to a beer made of sugar-cane after it is fermented and foaming.

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 Hawaiian igneous rocks (analyses of): Various samples analyzed by Dr. Washington exhibit the following variations in chemical composition given in per cent.
 Class DOSALANE, including specimens of Andesite, Angite, Basalt, etc., contains: SiO_2 from 58.06 to 45.61; Al_2O_3 from 18.21 to 15.98; Fe_2O_3 from 8.25 to 2.23; FeO from 11.60 to 2.01; MgO from 4.85 to 1.59; CaO from 11.85 to 3.29; Na_2O from 6.12 to 3.50; K_2O from 2.80 to 0.80; TiO_2 from 5.35 to trace; H_2O from 0.27 to none; P_2O_5 from 0.72 to trace; MnO from 0.36 to trace; SO_2 from 0.20 to none; S from 0.05 to none; CuO from 0.05 to none; Sp. Gr. from 3.03 to 2.94.
 Class SALFEMANE, including specimens of Basalt, Pele's Hair, etc., contains: SiO_2 from 56.79 to 47.61; Al_2O_3 from 16.09 to 12.10; Fe_2O_3 from 9.65 to 3.09; FeO from 11.97 to 2.61; MgO from 9.40 to 1.90; CaO from 10.25 to 5.92; Na_2O from 5.95 to

- 2.98; K₂O from 1.80 to 0.30; H₂O from 1.19 to none; TiO₂ from 3.97 to none; P₂O₅ from 0.76 to trace; MnO from 1.72 to 0.10; SO₃ from 2.54 to none; CuO from 0.48 to none; S from 0.02 to none; Cr₂O₃ from trace to none; Sp. Gr. from 2.93 to 2.74.
- "INFERIOR ROCKS", including specimens of tuffs, ashes and decomposed rocks, contains: SiO₂ from 50.00 to 4.54; Al₂O₃ from 41.35 to 12.10; Fe₂O₃ from 40.87 to 7.82; FeO from 8.20 to trace; MgO from 11.75 to 0.37; CaO from 13.39 to trace; Na₂O from 5.23 to trace; K₂O from 1.77 to trace; H₂O from 1.87 to none; TiO₂ from 8.99 to trace; P₂O₅ from 1.25 to none; MnO from 1.13 to trace; CO₂ from 5.56 to none; SO₃ from 0.55 to none; CuO from 0.14 to none; S from 0.14 to none; FeS 1.40 to none; CoO from 0.04 to none; sp. Gr. from 2.80 to 2.77.
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 Hei [Cat's cradle], which *see*
 Heiau. Usually meaning a large temple of idolatry among the Hawaiians, but it was also the name of the house for the gods in every man's regular establishment, as well as for the small secret enclosure in the large temple.
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 Hepaticæ. In 1877 D. D. Baldwin enumerated 73 species. Dr. C. Montague Cooke and others have added several species since, bringing the total up to near one hundred.
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 Hog plum (*Spondias lutea* Linn.) or golden apple
 of Jamaica or Jamaica plum is rare in Ha-
 waii although cosmopolitan in the tropics. It
 is a tall tree with yellow ovoid fruits some-
 times 2 inches long, and odd-pinnate leaves
 in panicles 6 inches to a foot long.
 Hogs, 287
 teeth bracelets, 82
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 Hoi (Black mamo), 335
 (Yam), 213
 Hoilo. The season of the year answering to win-
 ter in the northern latitudes. The opposite
 season or kau was the hot summer season.
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 Honohonowai (often contracted to 'honohono').
 The name of the day-flower (*Commelina*
 nudiflora Linn.), a representative of the
 spider-wort family, sometimes called spider-
 wort, bearing small blue irregular flowers.
 Growing on alluvial banks and moist places
 throughout the group. This American plant
 with jointed, creeping, often branching stems,
 bearing parallel nerved leaves with sheathing
 petiole is much used as feed for livestock.
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 Host. An animal or plant upon which a para-
 site habitually lives.
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 Hu (*see* Top spinning)

- Huahekili (Hua=egg, hekili=thunder). A "thunder egg": a hailstone. It generally thunders during hailstorms in the mountains of Hawaii.
- Huahua akai, 479
- Huakai. Hua, foam of the sea, hence a sponge.
- Hualalai, 152
Eruption of 1801, 152
Position of, indicated, 148
- Hue, 490
- Hukaa. A general name for pitch, resin or gum from a tree.
- Hula. A term applied by Hawaiians to music, singing and dancing. The dance took many forms, usually, however, a few danced while others sang and played instruments. The hula god was Laka (*see* plate 15).
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- Ie kuku (*see* Tapa beaters)
- Iheihe (Half-beak), 350, 349, 358
- Ihi. The name of the pigweed (*Portulaca oleracea* Linn.), the roots of which were used in native medicine as a mild cathartic.
- Ihi (Purslane), 196
- Iholena. A variety of banana which was permitted to be eaten under the *kapu* system.
- Iholena, 259
- Iiwi, 334, 329, 430
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- Iiiliopai, Heiau of, 140
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- Iiilipoi (*error see* Iiiliopai)
- Iikala. The name of the rough shark skin fastened over a coconut shell to form a drum.
- Iiki. A kind of varnish made of kukui bark, etc.
- Ilima, 192, 203, 209
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- Iliohe (Fleabane or horse-weed), 212, 287
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- Immigrant. A species occurring elsewhere but having reached the islands by natural means.
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food fish, 348
- Imu. A place for baking made by heating stones under ground (*see* plate 4).
- Imu, 210
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- Ina, 485
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liilii, 496
- Inamona. The meat of the kukui nut, roasted and pounded up with salt, used as a relish at table.
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8 m.; Maui-Lanai [Auau], 7 m.; Hawaii-
Maui [Alenuihaha], 26 m.; Oahu-Kauai
[Kaieie Waho], 63 m.; Kauai-Niihau
[Kumukahi], 15 m.
- Inter-island channels (*see* Depths of)
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- Invisible double, 49
- Io (Hawaiian hawk), 323, 327, 336
- Ioli, 291
- Ipecac, Wild, 212
- Ipu. The general name for all kinds of gourds,
calabashes, etc., and for containers of any
kind made from them.
- Ipu, 209
hula (Gourd drums), 78
nui, 209
- Ipu Lono. The name given to a certain class
of small heiaus built in order to induce rain
in time of drought. The same term was ap-
plied to a sacred calabash kept in private
houses in which offerings were made to the
family gods.
- Irish potatoes, 284
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 Iwa (Man-o'-war bird), 310, 77
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J

Jack fruit (*Artocarpus integrifolia* Linn.). A tree belonging to the breadfruit genus, and having a milky juice. The leaves are 4-6 inches long and are variously shaped. The fruits, which are usually oval, are often enormous, occasionally weighing 50 pounds. They occur on both the trunk and branches. The green rind resembles the breadfruit in being covered with rough six-sided knobs. The pulp is seldom eaten owing to the offensive odor. This tree should not be confused with the durian (which *see*) .

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 Jambosa (*see* Ohia ai)
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 Jingle shell, 456
 Job's tears, 198, 207
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 Judd, Dr. A. F., 286
 Judd street cave, 129
 Jujubi (*Zizyphus Jujuba* Lam.). Occurs in Hawaii, having been introduced originally from China. The small tree is characterized by thorny branches and triple-nerved leaves, which are alternate, 1-3 inches long, green above and nearly white beneath. The small axillary flowers are followed by the fruits, which are about the size of a cherry and yellow-green when ripe and bitter to the taste; they make excellent preserves. Several varieties are grown in China and India and more than one occurs in Hawaii: one is known as the Chinese date.

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K

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 Kaeo, the high point on Niihau, 101
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 Kahili (fly-flap), 60
 "Kahili" Lobelia, 224
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 Kahoolawe was for a time used as a place of exile for state offenders. The only article of food produced on the island at that time was sweet potatoes, in a small quantity.
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- Kahoalii (*see* Opelu tabu)
 Kahu, 57
 Kahuku Point, 109
 Kahului Bay, 138
 Distances from (*see* Overland Dis-
 tances)
 Kahuna. A general name applied to such per-
 sons as have a trade, an art or practice or
 profession. Some qualifying term is gener-
 ally added, but in Hawaiian antiquities the
 word *kahuna* without any qualifying term
 refers to the priest or person who offers
 sacrifice.
 Kahuna(s), 54
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 Kahuna lapaau (Medicine men).
 Kailua Bay, 211
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 Kalia. A common tree (*Elaeocarpus bifidus* Hook.
 and Arn.). Its flowers are stung by an
 insect (*see* plate 56) which causes them to
 be deformed. The red growth is sure to
 attract attention.
 Kalia, 202
 Kaliuama, 131
 Kaluha (Nut grass), 196, 212
 Kamaa (Sandals). Sandals made of lauhalu
 leaves, etc., were worn when traveling on
 rough lava and similar places in the open
 country.
 Kamakahala. A name applied to several species
 of Hawaiian plants belonging to the same
 genus (*Labordea* spp.), but especially to the
 yellow flowered species on Molokai and Oahu.
 Leis made of these sweet-scented flowers were
 tabu to the common people, being reserved
 for the use of the high chiefs alone.
 Kamakua peak, 133
 Kamalo, Cloud cap over, 142
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 Kamehameha V., 266
 Kamole. The name of a plant (*Polygonum*
glabrum Willd.) common about taro patches
 and running water extending its rang along
 the water courses and swampy land well into
 the mountains.
 Kamole, 212
 Kanae valley, 144
 Kanaka (Pacific islander), 25
 Kanaloa, 49
 Kanapi. Hawaiian for centipede.
 Kanawau, 224
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- Kiawe** (Algaroba tree), 240
- Kigelia (*see* Sausage tree)
- Kihikihi, Moorish, 370, 361
- Kiholo. The name of a large kind of a hook formerly made of wood, used to catch shark and other large fish.
- Ki, 190, 59, 67, 221, 251
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- Kilauapueo=Kilua
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- Killer, 301
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- Killifish, 378
- Kilohana crater, 105
- Kingfisher. A stray pair has been reported by Prof. H. W. Henshaw from Hilo. The skin of one of them is now in the Bishop Museum. They were evidently ocean waifs, as the pair mentioned constitute the only record of the occurrence of the species in Hawaii.
- 'King of the herring,' 358
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- Kipi, 332
- Kipu kai, 199
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 range, small cones in, 149
 Soil of, 149
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 statue of Kamehameha I., 44
 Kohola (Humpback whale), 302
 Kohola. A reef, a dry place; hence a whale from his spouting water like the water on the reef. The flesh of the whale was forbidden to women under the *tabu* system.
 Kokio. The name of a native tree belonging to the *Malvaceae* occurring on Molokai (rare) known as the native red cotton owing to its showy red flowers. The bark was used by the natives as a dye for fish nets.
 Kokio, 281
 Koko (plant), 283
 (Calabash net), 68, 76, 59, 61
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 Head, 472, 115, 121
 Kokolan, 220, 227
 Kolea. A name applied to almost all of the several species and varieties of the genus *Suttonia* common on all islands.
 Kolea, 226, 324
 Kolea (Pacific golden plover), 310
 Kolealea, 470
 Koloa maoli (Hawaiian duck), 323
 Koloa, Spouting horn at, 108
 Kolokolo kuahiwi, 230
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 Kona coffee, 279
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 View of, from Olympus trail, 206
 Konane was a checker-like game played usually on the flat surface of a slab of sandstone or lava rock in which a varying number of small depressions were dug out to form the stations. Small black and white stones were used for the counters in the game (*see* Hawaiian checkers).
 Kookolau=Kokolau
 Kookoolau=Kokolau
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 mountains, Early appearance of, 229
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 range, Erosion of shown, 112, 130
 range, mountains in the, 112
 range, Structure of the core of, 125
 Kopa. A shrub (*Kadua* spp.) the fruit of which is made into beads.
 Kopiko. Name of a tree (*Straussia* spp.) the wood of which was used for the *Kua* or anvil in making tapa; it is also a good firewood.
 Kopiko, 202, 220, 226
 Kou, 198, 59, 61, 63, 201
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 Kua kuku (Wooden tapa anvil), 64
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 Kuhns Bros., D. B. and J. M., 447
 Kuhns, D. B., 12
 Kukaepuaa, 286
 Kumquat (*Citrus Japonica* Thumb.) or kin-kan, is a native of China, or Cochinchina, but it has long been known in Hawaii. The fruits are small, round or oval, and are orange-like in appearance. In America it is coming to be prized as a preserve: the sweet rind and the pulp may be eaten raw. The Chinese make excellent preserves of the fruit. Only the attacks of insect pests prevent this fruit from more general cultivation in the islands. The rich green dense foliage makes a truly ornamental as well as useful tree.
 Kumquat, 265
 Kumu (Goat-fish), 362, 349, 373
 Kupakala (Rock oyster), 456, 446
 Kupaoa. A plant (*Raillardia scabra* D. C.) used to scent tapa.
 Kupaoa, use of, 71
 Kupee (sea snail shell), 470
 Kupee, Wrist ornament of, shells, 470
 Kupipi, 349
 Kupikipikio, Map showing, 118
 Kupua. A sorcerer: a person of extraordinary powers of body or mind. Sorcerers, wizards and witches are frequently spoken of in Hawaiian antiquities in their *kaos* and *meles* as things that existed and were fully believed in.

Kupoupon, 349
Kupukele, 444
Kusaie banana, 259
Kuula, a fish god (*see* Shark god)

L

Laa. A general name for what grew out of the ground, but often used as the name of medicine. The ancient Hawaiian medicines were numerous, and consisted mostly of mixtures of leaves of trees, bark, roots, etc. Some were exceedingly nauseous, while other were very acrid, but the physicians depended more on their enchantments, their invocations to the gods and to the sacrifices offered, than to the virtue of their medicines as such.

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Lahna Island, 88
La-i (Lauki), 210
Laie, 131, 211
Laka, Goddess of the hula, 82
Lake, Green, on Hawaii, 160

Lama. The name of a forest tree (*Mabu Sandwicensis* A.D.C.) common on all the islands of the group. Its very hard wood was much used in building houses for the gods and always occurred as an altar piece in the worship of laka, the goddess of the hula. The reddish-yellow berries and thick, leathery, dull green alternately arranged leaves are conspicuous characters.

Lamb tree, The, 281
Lamellibranches, 443
Lamellicorn beetles, 417
Lamp-shells, 483
Lamps [Kukui] of stone, 70, 62

Lanai. A bower, a shed, a piazza, a porch. The term is in very general use in Hawaii being applied to any form of an open structure intended for shelter.

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of hau, 201
Position of, 100

Lananuu (*see* Oracle)

Lance-fish, 372

Lanceolate (227). Shaped like a lance.

Land belonged to the king, 54
and the king, 55
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Lapalapa, 224

La Perouse, Compe de Jean Francois (Navigator), 97

La Platte tobacco, 192

Largo banana, 259

Larvæ (299). The early stages in the development of any animal in which it is unlike the parent in appearance.

Lasso cells, 489

Last eruption on Mani, 147

human sacrifice (*see* Sacrifice)

Lateral band or line (351). Along the sides of a fish is a line of peculiar scales called the lateral line.

Lateral craters on Mani (indicated), 134

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 Rise and fall of, 167
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- Lavas of Hawaii and their Relations. Under the above title Dr. Whitman Cross discusses the Hawaiian rocks in an exhaustive and able paper (Professional Paper 88, U. S. Geol. Survey, 1915) to which the technical student of Hawaiian lavas is referred for detailed information bearing on the composition, classification and theoretic problems involved in a study of this subject.
- Law of custom, 55
- Laysan albatross, 92, 294, 312
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 -miner beetle, 419
 -hoppers, 388, 427
 -hopper, Sugar-cane, 381
 -hopper, Sugar-cane, Parasites of, 382
 rolling moths, 395
- Leaflets. One of the divisions or blades of a compound leaf.
- Leahi (*see* Diamond Head), 115
- Lealoa, 115
- Leaping place of ghosts (*see* Jumping off places)
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- Lechoso (*see* Papaya)
- Ledyard, John (With Capt. Cook), 153
- Leechee (*see* Lichi)
- Leeches, 440, 497
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- Leho, 455, 458
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- Lehua, 101, 216
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 of human hair, 79
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 Seeds for, 204
- Lelan. The name of a native banana of fine flavor.
- Lele (Alter), 259
- Lemon, 263, 264
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 guava, 264, 263
 Silvery, cause of, 265
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- Length, Width, Area and Population of Hawaiian Islands (U. S. Census 1910): HAWAII—90 by 74 miles, area 4015 square miles, population 55,382; MAUI—46x30 miles, area 728 square miles, population 28,625; OAHU—46x25 miles, area 598 square miles, population 81,993; KAUAI—25x22 miles, area 547 square miles, population 23,952; MOLOKAI—21x8 miles, area 261 square miles, population 1791; LANAI—97 square miles, population 131; Midway population 35; total population, 191,909.
- Leper Settlement, 135
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 View in, 136
- Leprosy. This disease was introduced from abroad prior to 1853, probably about 1840. The policy of segregation was entered upon in 1863, the disease having become widespread by that date.

- Lesser gods, 49
 Lettered cone, 460, 455
 Lice, 400
 Lichee (*see* Lichi)
 Lichen (226). Plants of low order appearing in crusts, scaly patches and bush-like *for as* on trees, rocks, the ground, etc.
 Lichens are found everywhere in the group on rocks, trees and the bare ground. Bailey (Thrum's Annual, 1887) records 136 species. The list could doubtless be extended by careful study.
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 Limu. The class name for seaweed (*see also* Pumice).
 Limu, 500-503
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 koku, 502
 lipeepee, 502
 oolu, 502
 Linear (204). With parallel margins; narrow.
 Lip [Mollusca] (452). The inner or the outer side of the aperture.
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 Lobed (197). Cut into small lobes or rounded points.
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 -horned grasshopper, 388, 429
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 voyages. Provisions for, 29, 67
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 Lotus, 285
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 Loulu. The name of the native palm (*Prithardina*) of which ten species are now recognized by O. Beccari as belonging to the Hawaiian flora.
 Loulu hiwa, 236
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 Lucina shell, 456
 Luenma (*see* Egg fruit)
 Lycopersicum (*see* Tomato)
 Lycopodiaceæ (*see* Club-mosses)
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 Madagascare cowry [*Leho puupuu*], 470, 459
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 Maggot (405). The larva of a fly, but often ap-
 plied to other worm-like creatures.
 Maggots, 405, 419
 Mahihi, 344, 354
 Mahimahi (Common dolphin), 362
 Mahiole. A war cap: a helmet (*see* plate 6,
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 tapa, 76
 Makua, 358
 station, Barking sands at, 122
 Malabar, 221, 249
 Malay archipelago, 210, 249
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 Male children, How regarded, 46
 Malo. A strip of tapa cloth girded about the
 loins of men; in former times the malo was
 the only dress worn by men when at work
 (*see* plate 5, fig. 1).
 Malo, David (Native Hawaiian Antiquar-
 ian), 329
 Malo, Feather, 57
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 Malolo (Flying fish), 366, 349, 355
 Malpighia (*see* Barbados cherry)
 Mamake=Mamaki
 Mamake, 212, 217
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 Mamamo, 349
 Mamani, 226
 Use of wood of, 226
 Mamanu=Mamano
 Mamero (*see* Papaya)
 Mammalia (295). The highest group of animals
 containing those forms that suckle their
 young.
 Mammea (*see* Mammee apple)
 Mammee apple (*Mammea Americana* Linn.) or St.
 Domingo apricot is well known in Hawaii,
 having doubtless been introduced from the
 West Indies where it is a native. The fruits
 are 3 to 6 inches in diameter, round, russet-
 colored or brown, with a yellow juicy pulp
 which may be eaten raw without flavoring—
 as the taste does not have to be acquired.
 Its nearest ally in Hawaii is the *Garcinia*.
 The tree, 20 to 40 feet high, has rigid leath-
 ery leaves.
 Mamo, 332
 Black, 332, 333, 335
 feathers, use of, 75
 Oahu, 335
 Mana flats, 103
 Sands at, 108
 Mandarin orange (*Citrus nobilis* Lour.) is some-
 times called the kid-glove orange, owing to
 the ease with which the ruddy, orange-yellow,
 loose, baggy rind may be removed. The
 fruits, small, slightly flattened and rough, are
 seldom more than two inches in diameter.
 The dense, low, thornless tree is a favorite
 with the Chinese.
 Man-eater shark [*Niuhu*], 344, 345
 Maneo (*see* Papaya)
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 Fungus disease of, 242
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 -thrip, 428
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 weevil, 395

- Mangosteen (*Garcinia* spp.). There are about forty species known from tropical Asia and Africa; two or more occur, rarely, in Honolulu gardens. The dried juice of various species forms the yellow resinous pigment and purgative drug known as gamboge. All the known species have a yellow juice, opposite coriaceous leaves and a fleshy fruit with a thick rind.
- Mangosteen, 246, 269
- Manienie (Introduced), uses of, 208, 286
- Native, 208
- Manila hemp, 280
- Manini mango is a small variety introduced by Don Marin, perhaps one hundred years ago. It is said to be the first mango introduced into Hawaii.
- Manini (Fish), 349, 372
- Mano, a shark. There are many species of sharks, etc., which Hawaiians call by the general name mano. They were all tabu to women to be eaten only under penalty of death.
- Mano (Hawaiian eel-shark), 340, 349
- kihikihi (Hammer-head shark), 340, 346
- Manoa valley, General view of, 270
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- Man-o'-war [Iwa], 310, 312, 314
- Gular pouch of, 310
- Nesting habits of, 317
- birds on the nest, 36
- Man-of-war, Portuguese, 490
- Mantis, Praying, 429
- shrimp, 468
- Mantle [Mollusca] (457). An outgrowth of the dorsal body wall.
- Manufacture of poi, 66
- of salt, 129
- of tapa, 69
- of (*see* object in question)
- Many celled animals, 499
- Mao. A kind of shrub (*Abutilon incanum* Don.) used in dying tapa. The plant is common in low rocky districts. The name is also given to the wild cotton.
- Mao (Cotton), 203, 281
- Mapele. Name of a tree (*Cyrtandra* spp.) formerly much used in building a heiau in the worship of the god Lono.
- Mapulehu valley, 135
- Heiau in, 140
- Map of Ford's Island, 110
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- Topographie of Kauai, 104
- Topographie of Maui, 134
- Topographie of Oahu, 110
- Margin shells, 452
- Marin, Don Francisco de Paula (Early Horticulturist). Arrived in Hawaii 1791, died 1837.
- Marine animals, Miscellaneous, 490
- bivalves, Common, 456
- Marine gardens. It was not uncommon in old Hawaii for the natives to have marine gardens, reserved for the growth of certain favorite species of limu. Choice species were occasionally transplanted from one locality to another by them. The care of these gardens as well as the gathering of limu was the work of Hawaiian women and children. Limu was the third most important article of diet in former times.
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- Marker at Kealakekua Bay (old copper), 84
- Market-fish, Choice, 362
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- made by women, 73
- Makaloa, 72
- Niihau, 57, 72
- uses of, 72
- used as sails, 48, 72
- Materials for tools, 74
- Maternal relation, The loose, 45
- Ma'u. The name of a fern (*Sadleria pallida* Hook. & Arn.) with a trunk 2-3 feet high, very common about Kilauea. It was eaten in time of scarcity and is the species said by some authorities to be referred to in the name of the crater pit Halema'uma'u.
- Maua. A tree (*Xylosma Hawaiianse* Seem.) found in the forests of Kauai and Oahu where it is conspicuous by reason of the reddish color of the young leaves. On Maui and Hawaii, etc., a second species (*X. Hillebrandii* Waw.) occurs known by the same native name.
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- Mauna. A mountain; the inland region of an island.
- Mauna Kea, 144, 149, 151
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- Maxillary [fish] (369). The jaw bone.
- May beetle, 417
- Mayer, Dr. A. G. (Zoölogist), 483
- 'May-pops' (*Passiflora foetida* Linn.) have long been cultivated as a garden and veranda vine on account of their passion-flower blossoms which are followed by bright red, nearly globular fruits, nearly an inch in diameter. Children amuse themselves by popping the green and red seed pods. The fine green leaves are three-pointed.
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- Menckhues, Work of, 359
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- Menzie, Archibald, 153
- Mesh gauge, 75
- Mesquit, 242
- Metallic wood-borer beetle, 417
- Metamorphosis (403). The alternations, or transformation which an insect, or more generally, an animal undergoes in its development.
- Meter. The unit of length of the French metrical system is the meter (abbreviation m.) which equals 39.370432 inches. The centimeter is the hundredth part of a meter (0.3937 inch); hence one inch equals very nearly 2.54 centimeters. The millimeter (mm.) is the thousandth part of a meter and equals very nearly 1/25 of an inch. One inch equals 2.54 mm. The metric system is much used by the scientific men of all countries as an international unit of measure.
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- Mid-rib (210). The middle or main rib of a leaf.
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- Migration, Remarkable record of bird, 322
- Migratory. Said of a species that makes regular or periodic visits to the islands from other lands.
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- Millimeter (*see* Meter)
- Millipede, 398
- Millipeds, 408
 Characteristic odor of, 408
- Milo, 201, 203
 in the native temples, 203
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- Milu. The god of the under world. His abode was that of the deepest realm of misery, where those who were consigned to his care must live on lizards and butterflies.
- Mimosa seed, Uses of, 207
- Mina (*see* Mynah)
- Mineral dyes used, 69
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 Moo. A general name for all kinds of lizards: hence Mookaala a species common about rocks in dry regions; Mookaula a species occurring about dwellings, etc.
 Moo (Lizards), 297
 Mookaala (*see* Moo)
 Mookaula (*see* Moo)
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 Mosses. In 1877 D. D. Baldwin published a list of 92 species of Hawaiian mosses. Other investigators have added species since bringing the total up to more than one hundred species.
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 Mountains: ON OAHU—Kaala (Waianae Range) 4030 ft., Palikea (Waianae Range) 3111 ft., Konahuanui 3105 ft., Lanihuli 2775 ft., Tantalus (Puu Ohia) 2013 ft., Olymplus (Awawaloa) 2447 ft., Round Top (Calakaa) 1049 ft., Punchbowl (Puowaeana) 498 ft., Diamond Head (Leahi) 761 ft. ON HAWAII—Mauna Kea 13,825 ft., Mauna Loa 13,675 ft., Hualalai 8269 ft., Kohala Mts. 5489 ft., Kilauea 4000 ft. ON MAUI—Haleakala 10,032 ft., Puu Kukui 5788 ft., Eke 4500 ft. ON KAUAI—Waialeale 5250 ft., Hoary Head (Haupu) 2030 ft., Kihohana Crater 1100 ft. ON MOLOKAI—Kamakou 4958 ft., Mauna Loa 1382 ft., Olokui 4600 ft. ON LANAI—Highest Point 3400 ft. ON KAHOOHLAWE—Highest Point 1472 ft. ON MOLOKINI—Highest Point 160 ft. ON NIHAU—Highest Point 1300 ft.
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 Mourning customs were various. Wailing was always indulged in. Some knocked out one or more of their front teeth; others cut their hair in odd ways; some tattooed their tongues; others burned their bodies in different places. Clothing, as well as moral restraint, was often discarded; houses were burned and general anarchy was liable to prevail.
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 Murder was not uncommon in ancient Hawaii, the object usually being theft. Professional robbers lurked along the highways. Many of them were expert in their vocation, entangling their victim with a rope and leaping upon him so as to break his bones. Murderers when apprehended were usually stoned to death.
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Nahaweie (Hawaiian edible mussel), 456, 443

Naieo (*error see* Naieo)

Naio, 222, 226

Nakuina, Mrs. Emma Metcalf (Hawaiian Scholar and Antiquarian), 12

Names (*see* Nomenclature), 318

Nana uli (diviners) or soothsayers were a class supposed to be able to predict future events, as changes in the weather, the death of important persons, wars and the like from certain events, as the appearance of the sky, arrival of certain fish, tidal waves, etc.

Napakā (*error see* Naupakā)

Napali cliffs, 107

Nape (368). The upper or back part of the neck, usually written 'the nape of the neck.'

Napkins, Hawaiian, 62

Napoopoo, 182

Narcotic (207). Generally producing sleep or stupor, though variously applied.

Narwhale, 301

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Naturalist (335). Usually one who is devoted to the study of the natural sciences.

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Na ukewae (Laysan albatross), 310

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Nauplius (373). An early stage in the development of the crab-like animals in which the larva has six legs and a median eye.

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Needles, Spanish, 196

Nehe, 199

Nehu (Anchovie), 350, 349, 351

Nemertinea, 497

Nene (Hawaiian goose), 310, 323

Nerita, 465

Neritina, 465

Nerves [Bot] (213). The name applied to the ribs or veins of a leaf when simple or parallel.

Nerve-winged insects, 423

Nesting habits of the Man-o'-war bird, 317 (*see* species in question)

Nestlings (*see* species in question)

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heron, Black-crowned, 310, 325

-mare, How interpreted, 49

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view of Mokuaweoweo, 186

Niho. A tooth, especially a whale's tooth; hence Nihopalaoa, an ivory ornament, worn pendent from the neck, made from the ivory of the whale or walrus. Originally this ornament was worn only by high chiefs (*see* plate 10, fig. 1).

Nihoa (Bird Island), 88, 96, 98

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Niu. The name of the cocoanut tree. Under the tabu system females were forbidden to eat the nuts under penalty of death.

Niu (*see also* cocoanut), 201, 236

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Noah's ark shell (Ark shell), 456

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Nocturnal (309). Active at night, appearing at night.

Noddy tern, 310, 311, 318

Nohu (Scorpion fish), 374, 168

Nohu, 92, 199, 368

Nohuanu, 229

Nomenclature. The systematic naming of things. Scientific knowledge is based primarily on the classification of facts. Classification in general consists in observing objects and placing those which are alike in one or more characters in the same group under a common name. As the study of living objects has advanced, and the number of species being increased through research, the detail of providing a separate and definite name for each living thing has become an enormous task. This labor is largely performed by specialists, who working as botanists, zoologists, entomologists and the like, are guided in the naming of objects in their respective fields, by certain more or less definite rules known as the rules, or canons of nomenclature. By these rules scientific or technical names are applied which are intended to serve the double purpose of providing a definite name for the animal or plant, and at the same time, one which will indicate its relation to other similar groups and to still other groups

from which it differs more or less in important characters. Natural classification attempts to indicate the relation of groups to other groups of varying degrees of similarity. In this scheme of classification and nomenclature a number of terms are quite generally applied, in the biological sciences, with the general meaning of which every person should be acquainted. The classification of the domestic cat is a familiar example and one that serves well to indicate the important points in the whole scheme of classification and nomenclature in force among both botanists and zoologists.

The many varieties or breeds of domestic cats indicates the variation liable to occur within a given species. The lion and the tiger differ more widely in their characters and for that reason are given different specific names, but they, together with the common cat (as well as numerous other species), are all grouped together as species belonging to one GENUS (Felis). The genus Felis and other genera, in which are placed less common cat-like animals, are grouped together in a larger group—the FAMILY (Felidae). This important group, together with the members of the dog family form a still larger group—the ORDER (Carnivora). These families, as an order, are included with other orders to form a CLASS and so on, as indicated in the following diagram:

Kingdom—Animalia.

Phylum—Chordata.

Class Mammalia.

Order—Carnivora.

Family—Felidae.

Genus—Felis.

Species—*Felis domestica*.

The name of the animal is generally understood to be its generic name followed by its specific name. To this, under varying rules, is usually added as authority for the name, the family name of the person first publishing an accurate description of the animal or plant. Variety names are added under the same general rule; the names of the sub-species or variety following that of the species as *Asio accipitrinus sandvicensis* (Blox.). The name indicating that the Hawaiian owl is a variety of the short eared owl of America and that it was first described by Bloxham. The name of the authority being enclosed in parenthesis (Bloxham) indicates, to the student of nomenclature, that the species has been changed from the original genus to which Bloxham referred it in the original description.

Non-calcareous sponges, 500

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 Silk, 248
 Objects of geologic interest on Oahu, 129
 of recent manufacture, Hawaiian, 60
 of worship, 49
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 Observations, notes, comments, where
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 Obsidian, commonly called volcanic glass, is a vol-
 canic rock, in various conditions closely re-
 sembling bottle-glass in appearance and tex-
 ture. It belongs to the trachyte group of
 rocks, but is of rare occurrence in the islands
 in the typical form. Specimens variously
 colored, as black, brown, greenish and bluish-
 white have been found by the author on vari-
 ous islands of the group. Pel's hair and
 pumice (which *see*) are forms of this rock.
 Occasional visitor (Birds). Said of a species
 that occurs in small numbers at irregular
 intervals.
 Occupations of Hawaiians, 63
 Ocean boneto [Aku], 344, 366, 361
 -borne plants, 195
 Ocean Distances: HONOLULU to San Fran-
 cisco 2100 miles; San Diego, 2260 miles;
 Portland, 2360 miles; Panama, 4720 miles;
 Tahiti, 2440 miles; Samoa, 2290 miles; Fiji,
 2700 miles; Auckland, 3810 miles; Sydney,
 4410 miles; Hongkong, 4920 miles; Yoko-
 hama, 3400 miles; Guam, 3300 miles; Ma-
 nila via N. E. Cape, 4890 miles; Victoria,
 B. C., 2460 miles; Midway Island, 1200
 miles.

- Island, 88, 94
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 in time of war, 51
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 Ohe, 224, 203, 209
 Ohekapala (*Ohe*=bamboo and *kapala*=to print).
 A piece of bamboo carved for the purpose of
 printing tapa (*see* tapa making).
 Ohelo berries, 258, 227, 256
 papa, 255
 Tall, 220
 Ohia, 190, 220, 215, 216, 226, 228
 Ohia ai. A useful fruit tree (*Jambosa malaccensis*)
 usually known as *Eugenia malaccensis*
 Linn., bearing the mountain apple. The
 wood was also used in house building, etc.
 Ohia ai, 216, 256
 ha, 220
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 wai (*error see* Oha wai)
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 Kukui nut, use of, 62
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 Oio (Bone-fish), 350, 349, 354
 Okeleha. The name given to an intoxicating
 liquor formerly distilled by natives and for-
 eigners from *ki* roots. Its manufacture in
 illicit stills continues in the back country sec-
 tions.
 Okolehau, 210
 Okupukupu, 228
 Old age among Hawaiians, 45
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 Government Nursery, 238
 'Stump leg' (plover), 322
 -world limpets, 466
 Olea (*see* Olive)
 Oleander, 252
 poisonous, 252
 white scale, 391
 Yellow, 252
 Olena. The name of a plant (*Carenum longa*)
 the root of which was used in dyeing yellow.
 It resembles the *avapuhi*, which *see*.
 Olepe (Tellen shell), 456, 445
 Olinda beetle, 394
 Olive (*Olea Europa* Linn.), although seldom fruit-
 ing in Hawaii, the 'oil tree' is nevertheless
 well established, and is grown usually as an
 ornamental tree. The dull, whitish green,
 small, thick, lanceolate opposite leaves are
 characteristic of this low-growing tree. It
 has been cultivated from the earliest times in
 Syria and Palestine and in remote antiquity
 was distributed throughout the whole Medi-
 terranean region. In recent times it has
 been successfully planted in America, Aus-
 tralia and elsewhere. The wild olive (*O.*
Oleaster) was once sacred to Pallas and its
 leaves were used for victors' wreaths among
 the Greeks and Romans—hence 'the olive
 branch.' Many cultivated varieties of *O.*
sativa are recognized.
 Olive shells, 452
 Olivine (*see* Chrysolite)
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 how grown, 73
 Method of preparing, 64
 Nets of, 73
 use of, 73, 77, 79, 81, 203
 Olowalu valley, 138
 Olympus trail, Ferns along, 206
 Omaka. The foreskin in males removed in cir-
 cumcision as formally practiced among the
 Hawaiian. Also the nipple of a female.
 The surgical instrument used in circumcision
 was usually a sharp splinter of bamboo.
 The operation was resorted to chiefly as a
 sanitary measure.
 Omaka (Wrasse fish), 366, 349, 359
 Oman (Hawaiian thrush), 334
 Omilu (Cavalla), 362, 349
 Ono, 349
 Onomea, Arch at, 150
 gulch, 176
 Ornament of braided hair, 60
 Oo. An instrument anciently and in a modified
 form still used by Hawaiians in cultivating
 the ground. It was made of hard wood as
 alahae, ulei, kauila, uhiuhi, etc., and was
 long and flattened at one end to form a
 digger.
 O-o a-a, 337
 O-o (Bird), 330, 333
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 Opae (Shrimp), 436
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Opens, 439

Opehu. The opehu and aku were two kinds of fish that were sacred and tabu by turns for six months at a time. On January 13th each year a human sacrifice was offered together with the fish aku. The Kahoali, a man personifying the god of that name, is said to have plucked out and ate the eye of each. By this ceremony the tabu was taken from the aku and the opehu in turn became tabu for six months.

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Operculate land shells, 438

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Opibi, 466

“Opium” tree [Opiuma], 198

Opu. A protuberance with an enclosure as the belly, stomach, bladder, etc. The Hawaiians supposed the seat of thought, intelligence, etc., also the seat of moral power to reside in the small intestines; hence *opu* or *naau* was used by them for what we call the heart.

Opule (Wrasse fish), 366, 349, 359

Oracle [Lanauun]. A tall framework of poles in the temples shaped like an obelisk. It was four to six feet square and hollow. In it the priest stood to get in direct communication with his god that he might learn the will of the god on important matters.

Oral and aloral view of sea-urchin, 496

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Ornaments, 38

Feather, 75

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Human teeth as, 70

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Ornament shell, 470

Ornithologist (329). One who is devoted to the study of birds.

Osculum explained, 499

Ostergaard, J. M., 447

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O-u, 337

holowai, 337

Outline of head of Maui (*see* map of), 134

Outfit for reef collecting, 478

Otaheite gooseberry (*Phyllanthus distichus*, Müll.)
Although extensively cultivated in the tropics

for its acid fruits, which are used for pickles, it is rare in Hawaiian gardens. This low growing tree with large pinnate leaves belongs to the very large tropical genus *Phyllanthus*, commonly represented in the islands by the variegated *Phyllanthus roseo-pictus*, much used as a hedge plant. It is a native of Java. The fleshy green fruits, an inch or more in diameter, occur in long clusters. A related species with finely pinnate leaves (*Phyllanthus emblica* Linn.) is rare in Hawaii. A single tree may be seen in the Mausoleum grounds in Nuanu Valley. The round fruits, $\frac{3}{4}$ inch in diameter, are slightly flattened and six-ribbed.

Ovary [Bot] (260). The part of the pistil which contains the future seeds.

Ovate (203). Like the section of an egg with the broader end of the leaf next to the stem.

Overland Distances: ON OAHU—From Honolulu P. O. to Diamond Head 5.9 miles. Koko Head 11.8 m., Makapuu 14.8 m., Waimanalo (by the Pali) 12 m., Pali 6.6 m., Kaneohe 11.9 m., Waiahole 18.9 m., Kahana 26.4 m., Kahuku Mill 37.2 m., Waialua 28 m., Kahuku Ranch (via Waialua 39.4. *By Rail* from Honolulu Depot—To Punaloa 6.23 m., Aiea 9.37 m., Pearl City 11.76 m., Wahiawa Station 25.20 m., Ewa Plantation Mill 18.25 m., Waianea Station 33.30 m., Kaena Point 44.50 m., Waialua station 55.80 m., Kahuku Plantation 69.50 m., Punaluu 80.50 m. ON KAUAI—Nawiliwili: to Koloa 11.0 m., Hanapepe 20.0 m., Waiawa 31.5 m., Niihola 44.8 m., Hanamaulu 3.3 m., Waialua River 7.7 m., Kealia 11.9 m., Kilanea 23.6 m., Hanalei 31.8 m., Wainiha 34.8 m. ON MAUI—from Kahului: to Spreckelsville 4.0 m., Paia P. O. 7.2 m., Haiku 11.0 m., Huelo 20.2 m., Nahiku Landing 49.9 m., Hana P. O., 55.6 m., Kipahulu Mill 66.2 m., Waikuku 3.8 m., Waikapu 5.9 m., Maalaea 10.3 m., Kihei 12 m., Makawao 11.6 m., Olinda 18.5 m., Haleakala (crater edge) 26.6 m., Haleakala summit 28.6 m., Olowalu 19.9 m., Lahaina Court House 25.5 m., Waihee 7.3 m., Kahakuloa 16.3 m., Napili 29.8 m. ON HAWAII—from Foreign Church (Kohala) to Hamakua boundary 4.5 m., Kukuiahae Mill 11.0 m., Mana 7.7 m., Honoipu 7.25 m., Mahukona 10.5 m., Mahukona to Court House 9.2 m., Kawaihae to Waimea Court House 11.8 m., Mana 19.5 m., Kohala Court House 15.0 m., Kealakua to Kailua 12.0 m., Kiholo 27.6 m., Kawaihae 42.0 m., Honanua 4.0 m., Hookuna 7.7 m., Kahuku Ranch 36.5 m., Volcano to Halfway House 13 m., Pahala 23 m., Punaluu 27.6 m., Honapo 32.6 m., Waiohinu 37.1 m., Kahuku Ranch 43.1 m. From Hilo Court House 13 m., Pahala 23 m., Punaluu 27.6 m., Road 9 m., Pahoa 20.0 m., Pohoiki 28 m., Kapoho 32.0 m., Furneaux's 13.2 m., Mount View 16.8 m., Volcano House 31.0 m. ON MOLOKAI—from Kaunakakai: to Meyers, Kalae, 5.0 m., Kalaupapa 9.0 m., Kamalo 9.0 m., Pukoo 15.0 m., Laialua 25.0 m.

Oviparous fishes, Example of, 358

Ovipositer (429). An organ by which many insects place their eggs in places suited to their development.

Owalii, 227

“Owl” fish [Moa], 375

Owl, Hawaiian short-eared, 336

Owlet moths, 396

Owls, Sacred. In time of danger the appearance of an owl was regarded as a favorable omen. Kukanahi was the god of owls.

Ox hot-fly, 421

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 Pahee was a game in which short blunt darts of
 polished hard wood from two to four feet in
 length were thrown along the ground be-
 tween two darts laid down at a certain
 distance.
 Pahoehe and a-a shown, 162
 Examples of in Kilauea, 184
 flows in Kilauea, 166
 flows on Mauna Loa, 155
 Pahu. The pahu was originally a hollow cocoa-
 nut stem or other tree with a shark skin
 drawn over one end and used as a drum (*see*
 plate 11, fig. 1).
 Pahu hula, 57
 Paiai, 66
 Painted fish, 359
 Painters' brush (a composite), 262
 Painui, 206, 224
 Pakii, 349, 371
 Pakuikui, 347
 Palagonite. A volcanic rock closely allied to
 basalt having a somewhat vitreous structure;
 the craters of Diamond Head, Punchbowl,
 etc., are largely composed of this rock.
 Palahala. A paste made from the fern amaumau
 (*Sadleria cyanthoides* Kaulf.) which was
 used as a gum in repairing tapa.
 Palaoa, 79, 301
 Palapalai, 221
 Palani=Palawi
 Palawi, 349
 Pali, Eruptive center beyond, 220
 Height at the, 114
 road (1214 feet), 125
 The, 125, 114
 The, a wind gap, 125
 The, View near, 112
 Pallial line. The line or mark made by the
 mantle in certain Mollusca on the inner side
 of the shell.

- Palmate (262). Said of a leaf when the leaf, or
 the divisions of the leaf, spreads from its
 stalk like the open hand.
 Palm blossoms, Bees feeding on, 232
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 Bottle, 240, 237
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 Palolo-Manoa trail, View on, 218
 Palolo. Sticky mud. A bluish-white clay of the
 islands.
 Pamoho=Okupukupu
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 Pandanus, 204, 252
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 Pan-Hawaiian Island, 290
 Panicles (227). A loose branching cluster of
 flowers.
 Panini, 269
 Pantheon, The Hawaiian, 49
 Papa hee malu (surf board), 80
 holua, 57, 86
 holua slides on Oahu, 86
 Papa, wife of Wakea. They were regarded as
 the founders of the Hawaiian race.
 Papai lanai, 469
 Papaia (*see* Papaya)
 Papain is a ferment obtained from the half-ripe
 fruit of the papaya. It differs from pepsin
 in that its proteolytic action goes on in the
 neutral or alkaline solutions. It is also called
 papayin, papayotin, and carican.

- Papala, 214
 Papaua, 456, 443
 Papaw, 262
 Papaw (*see* Papaya)
 Papaya. The common name for both the tree and fruit of *Carica Papaya* is derived from the Carab "abahal" which doubtless is a corruption of the American name papaya since the species is known to be of South American or West Indian origin. The papaya has so long been in cultivation in the tropics that it is known under at least a dozen common names, variously spelled, some of which are used interchangeably even by the same authors. Papaya seems preferable as the distinctive English name, although papaia is a common spelling. Other current English names are tree-melon, pawpaw (which *see*), papaw, melon zapote, lechoso, maneo, and mamero.
 Papaya 264, 262
 Property of the juice of, 263
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 Paper mulberry [Wauke], 67, 69, 217
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 Papiopio (Cavalla), 362, 349
 Papipi. The prickly pear. Also called panini.
 Para grass, 286
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 plant, Example of a, 204, 225
 Parasites (381). An animal that lives in or on or at the expense or by the exertion of another species.
 Parasites, Egg, 382
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 -fish, Common [Uhu], 370
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 Parthenogenesis (390). In some animals in which fertilization normally occurs, the ova may develop in the absence of the male element; hence virgin reproduction.
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 Paste (*see* Varnishes)
 Pa'u, Feather, 57
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 Pa'u. The principal garment of a Hawaiian female in former times, consisting of a number of tapas, generally five, wound around the waist and reaching about to the knee (*see* plate 11, fig. 3).
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 Pears. Pears (*Pyrus communis*) occasionally fruit in the islands in the higher altitudes. They are of fairly rapid growth and produce a fruit of good quality. They thrive best at from 4000-5000 feet elevation.
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 Peculiar. A species occurring only on the islands of the group (*see* endemic).
 Pectoral fins (347). Situated on the side of the body, usually just behind the head.
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- Perennial (205). Living on from year to year, as distinguished from an annual.
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- Petiolate (254). Said of a leaf when born on its own leaf-stalk.
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- Phylodendron (*error see* Philodendron)
- Phylum (*see* Nomenclature). One of the large branches of the animal kingdom.
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- Piiku. A drink made from the leaves, branches and fruit of the kukui tree and used for medicine.
- Piihi (Stick-tight grass), 196, 286
- Pikopiko. The name of the ink or sepia in the squid. When emitted it clouds the water a murky brown, enabling the animal to escape.
- Pilali. The gum of the kukui tree, but also a general term for a gum.
- Pili, 192, 59, 209, 286
- Pilikai. The name of a stout woody climber (*Argyrea tiliaefolia* Wright) with pale purple flowers the seeds of which were used as a cathartic for children.
- Pilikoa 'a, 354
- Pilikoa (Cirrhitoid fish), 374, 354
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- Pinnate [leaves] (244). When the small leaflets are arranged along the side of a common stem.
- Pintail duck, 328
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Plumeria (*error see* Plumieria)
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- Pod (201). Generally applied to any sort of a seed capsule, but more correctly the pod of a bean-like plant.
- Poetry, Examples of Hawaiian, 41, 42, 459
- Poets, Hawaiian, 41
- Poha, 257
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- Pohaku. The general name for stones, rocks, pebbles, etc. Large stones were called pali pohaku; lesser ones pohoku uuku; rough lava, aa; smooth lava, pahoehoe; small smooth stones, ihile, and sand, one.
- Pohaku kui poi, 57
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- Pohakupele (Worm shell), 460
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- Popolo (*Solanum nodiflorum* Jacq.) is well established in Hawaii. Its small black tomato-like fruits and the tomato-like appearance of the foliage renders it easy to identify. It thrives on waste land, about fences, and by the roadside. The fruit and leaves were much used by the ancient Hawaiians and doubtless possess certain medical properties not appreciated by Europeans.
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 Predaceous- (426). Living on prey, preying on other animals.
 Preliminary to a battle, 51
 Preopercle [fish] (355). A ridge usually occurring just forward of the large bony flap covering the gills.
 Preorbital [fish] (369). A bony prominence before the eye.
 Price of Natural History of Hawaii (*see* distributors)
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 Pritchardia (*see* Loulu)
 Procumbent (230). Trailing or creeping on the ground.
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 Prostrate (199). Lying flat on the ground; not erect.
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 Psidium (*see* Guava)
 PTERIDIUM AQUILINUM [Kilanapueo] =
 Pteris aquilina [Kilua]
 Pteris aquilina = PTERIDIUM AQUILINUM [Kilanapueo]
 Pua. The Hawaiian for a flower. Puaa, a hog.
 Puaiohi, 330
 Puakahala (Cavalla), 366, 364
 Puakala (Mexican poppy), 198, 204
 Puakeawe, 225
 Puakeawe = Pukeawe. A shrub (*Cyathodes tanceiancia* Cham.) common on the mountains of the group (*see* text). Dr. Emerson states that it was with the smoke of this bush that the ancient kapu-chiefs are said to have smudged themselves before mingling with the people on equal terms. *Cyathodes* is sometimes made a sub-genus in the genus *Styphelia*.
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 Pukamole=Kamole
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 Pule, Ancient, to the corwy, 459
 Puleho, 457
 Pulu. Any soft substance, as for example, the mass from which the tapa was made; hence the name of the material that grows on and is collected from certain large ferns (*Cibotium* spp.) and used to some extent as down for pillows, etc.
 Pulu, Uses of, 222, 228
 Pumice (limu) is usually a form of obsidian (which *see*) and contains a large per cent of silica. It is usually the froth-like lava ejected from volcanoes and has a loose spongy or cellular structure which is produced by the escape of gas or steam while the lava, of which it is formed, was becoming consolidated. Light specimens will float and are carried far and wide by the sea; small pieces are occasionally picked up by sea birds, especially the albatross. It was much used by Hawaiians for polishing, and was also used in the last stages of preparing a pig for baking. Pumice is in reality porous volcanic glass, the pores being small.
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 Pupa (385). The third and usually the resting stage of insects which undergo complete metamorphosis.
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Waawaa, 155

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Puunene spider, 410

Pyramid shell, 470, 463

Pyrus (*see* Sand Pear, *also* Pear)

Q

Queensland nut (*Macadamia ternifolia* Muell).

More properly the Australian nut is a medium sized tree producing a round smooth, shiny brown nut, with a very hard shell. The kernal resembles the filbert and may be eaten raw or roasted. Other species of the genus also occur in Hawaii, in most instances having been introduced by Mr. E. W. Jordan.

Quashy-quasher, 252

Quilted triton, 460, 450

R

Rabbit Island, 128, 293

Rabbits, 293

Raceme (248). A flower cluster in which one-stemmed flowers are arranged along the side of the main stem.

Racing in the surf, 80

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Raillardia (*see* Kupaooa)

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distances (*see* Overland Distances)

Rainbow Falls (Hawaii), 160, 176

Rainfall. Precipitation in the islands varies greatly from place to place and year to year. At Honolulu statistics (U. S. Weather Bureau) gives the rainfall varying in ten years from 16.99 (1905) to 30.13 (1909) inches. On Tantalus (three miles distant) in 1905 it was 99.68 inches. On Hawaii in Hamakua, at 1200 feet elevation, it was 260.67 inches (1907). At Waieka, in the rainy Hilo district (1907) it rained 333 days; at Waianae, a dry district on Oahu, it rained on 60 days.

Rain forest, Characteristic growth in, 218

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Short-tailed, 292

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Rats-foot (*Lycopodium* sp.) is a common moss-like plant common about the outskirts of the forests where it often forms thickets after the manner of the staghorn fern. The two species occurring here are widespread over the globe.

Rathburn, Dr. Mary J. (Crustaceologist). 12, 469

Ratoon (261). A shoot or sprout coming up from the root of a plant after it has been cut (*also* ratoon).

Ratoons, Pineapple, 261

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 Reflex action, Example of, 346
 Reforesting. Efforts have been, and are being, made to restore forests in localities where they have been depleted, or have disappeared. Several of these efforts have not only resulted in great benefit to the localities, but are serving as object lessons, showing the need of enclosing and defending the existing forest areas. This work is now carried on under the able direction of the Hawaiian Bureau of Agriculture and Forestry.
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 Roselle (*Hibiscus Sabdariffa* Linn.) Is widely cultivated in the tropics, including Hawaii, where its pleasing acidulous rose-red calyxes are used for tarts, jellies, etc. A cooling drink can also be made from them. The bark yields a fiber elsewhere known as roselle-hemp. In the West Indies the plant is known as Indian or red-sorrel. It is a true *Hibiscus* coming originally from the East Indies.
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S

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 Sacrifice, Human. While sacrifice was an important part of formal worship in old Hawaii, human sacrifices were offered only on special occasions. It was, however, the supreme act of ancient worship in the important heiaus of the highest class. Such occasions as the launching of a war-canoe, the building of a house for a chief, the sickness of a king or queen, the securing of a new idol, or the burial of a chief, called for a human offering to the appropriate gods. The victims were always males and were either taken in war or persons rightly or wrongly accused of violating some of the innumerable tabus. The mode of securing the victim was usually by secret assault, commonly by a blow with a club, though other methods were employed. The Mu was the person whose duty it was to secure the required sacrifice. The dead body of the person so slain was dragged to the heiau and laid on the altar [lele] for sacrifice, together with hogs, dogs and other offerings—there to putrify. It is stated that as many as eighty persons were sometimes immolated at once.
 The last human sacrifice in the islands occurred in 1807. Queen Keopuolani was then dangerously ill. The priest asserted that her illness was caused by the gods who were offended by certain men eating tabu coconuts. Eight men were at once seized by the king's orders and offered in the heiau that then stood at the foot of Diamond Head.
 Sacrifice to Pele. The goddess of volcanoes was much feared on Hawaii. When an eruption took place at Kilauea it was the custom to make offerings to her of hogs, etc., which were thrown into the liquid lava. Devout persons sometimes gave the bodies of their relatives to Pele by throwing them into Kilauea, that they might join the volcanic deities and in this way befriend the family. The ohelo berries were the usual offering to Pele.
 Saddle oysters, 444
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 Sand pear (*Pyrus Sinense* Lindl.) bears an apple-like fruit, 2 inches in diameter, with a sandy, tough, flesh, which has a very fine flavor when baked. This ornamental tree is characterized by dark green, apple-shaped leaves, pointed at the tip, edged with fine teeth; the flowers are large and white. Although not common in the islands, the sand pear is well established.
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 -shaped animals [Loli], 491
 Sausage tree (*Kigelia pinnata*) is a curiosity wherever grown. It is a large tree with whitish bark and spreading branches, coming originally from Africa. The fruit, rough and green in color, is sometimes two feet in length and hangs from a long stalk. It has a corky rind, filled with pulp and numerous rounded seeds. In Nubia this tree is held sacred, and religious festivals are conducted under it by moonlight. A few trees, doubtless introduced by Dr. Hillebrand, may be seen in old gardens; a fine specimen is in the grounds at the Queen's Hospital in Honolulu.
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 Stag-horn fern. A name usually applied to certain introduced species of the genus *Platycerium* commonly grown in baskets; so-called because the fronds are forked like a stag's horn. The name is also applied to native ferns.
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 Tapa beaters (ie kuku) were made with various more or less complicated designs on their four faces to produce water-mark designs on the finished cloth. The designs were designated by names: as many as fifty designs are known.
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Tape worms (*Cestoides*) of many species occur in Hawaii. Almost all species of domestic animals are affected more or less by these parasites which live in the adult stage in the alimentary canal. Dogs, horses, cattle, sheep, swine, and even men have one or more species peculiar to each; in fact, a large majority of vertebrate animals are subject to tape worms. These parasites are peculiar in that they have no mouth nor alimentary canal, absorbing their nourishment from that intended for the host.

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Tattooing was practiced in ancient times to a certain extent. The acrid poisonous juice of *Heo* (*Plumbago Zeylandica*), a small shrub occurring on the lowlands, was used to produce black tattoo-marks. The acrid juice of *Sicyriochium acce*, from the high mountains of Hawaii and Maui, produced a blue tattoo-mark. Contact with sailors, soon after the discovery of the group, tended to stimulate the art of tattooing. During the early whaling days tattooing the body became very common with the result that almost every old Hawaiian sailor of that period was marked with the conventional designs used by sea-faring men. The practice was not regarded at any time as a religious ceremony (as in certain Polynesian islands), but simply as a matter of personal fancy or sometimes as a token of affection or as an indication of bereavement.

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Temperature. The highest shade temperature (U. S. Weather Bureau in Honolulu) in ten years has been 86° Fahr. The lowest 56°. Occasionally on the lowlands a temperature as high as 90° and as low as 52° occurs, but these extremes are rare indeed. Temperature decreases about 1° for each 320 feet of ascent in the mountains.

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Theft. Thieving was a widespread habit among the Hawaiian people at the time of their first contact with Europeans. Within a few years after the arrival of the missionaries conditions had so changed, however, that valuables might be left unprotected without loss.

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Thorax (409). In insects that part of the body situated between the head and the abdomen. Thorns (203). (*See* spines.)

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 Tomato. The tomato (*Lycopersicon esculentum* Mill.) is a race that has been developed during 200 years of cultivation. It is closely related to the potato and the two can be grafted on each other with ease, although they will not cross. They thrive in Hawaii and are perennial. Species and varieties have been introduced that have run wild, among them the current tomato (*L. pimpinellifolium* Dunal.), a weak plant with small leaves and small currant-like red berries. The cherrie (*L. e. var. cerasiforme* Hort.) or grape tomato with its small red and yellow fruits is common and the fruits are sometimes used for preserves and pickles.
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 Total land, fresh water and marine fauna of Hawaii has never been estimated. Excluding *Protozoa*, but including native and introduced species from *Porites* to man, there would probably be at least 12,000 species.
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 Tuber (197.) Any thickened portion of the root provided with buds (eyes), as a potato.
 Tuff. Fine volcanic products, as volcanic ash, that has become coherent, as by cementation is called tuff, sometimes tufa, though the latter term is more properly applied to cal-

- carious materials of a similar nature. In Hawaiian geologic literature both terms have been used in describing tuff cones.
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- Ulae [Lizard-fish], 380, 349, 359
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- Uli. The chief god of sorcerers was Uli, although this class worshiped numerous other deities. The class of lesser demons were chiefly females, as the reptile goddess [Kiha-wahine], the goddess Hiaka, etc. Certain shark gods were also worshiped by sorcerers.
- Ulili, A bamboo flute (*see* plate 5, fig. 1)
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- Uluha (a pillow). They were made of lauhala or of very light wood as wiliwili, etc.
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- Umbilical cord. The cutting of the umbilical cord was attended by important religious ceremony.
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- Umeke. A calabash usually used to contain poi and then called uimekepoi
- Umeke (*see also* calabash), 57, 59
- Umeke (bowls), 57, 70
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- Umoki. The stopple for a water gourd. The shell of one of the marine *Terebra* spp. was commonly used as a stopple.
- Unaia. The barnacles found clinging to the hulls of vessels.
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- Unisexual [Bot.] (217). Flowers having either stamens or pistils only.
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 Varnishes, gums, paste, etc. The natives made varnish of kukui bark, banana buds and ki leaves; paste of ama’uma’u; gums of the breadfruit juice.
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 Volcanic Bombs. Masses of lava that have solidified into more or less rounded masses in the crater and are hurled out as bombs. Specimens occur at various places in the group, as Palolo crater, Haleakala, etc.
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 Vows were usually made and kept by Hawaiians—through fear of their gods. A vow once made was regarded as a very sacred engagement.
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Waa. A canoe. The ancient Hawaiian canoes were dug out of a single koa log. Among the specific names were waa kaukuhi—a single canoe; waa kaulua—a double canoe; waa pelelua—a blunt canoe.

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 Wai. A general name for that which is liquid;
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 (kai). A word with many compounds.
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