

Sci. Lib.
6-1-1923
950
B 485125

Sci. Lib.
QL
737
11
22
v. 3 no. 4
1917
The Hawaiian Rat.

BY WITMER STONE, A.M., SC.D.

(Curator of Birds and Mammals, Academy of Natural Sciences of Philadelphia.)

WHILE tradition and early accounts of the islands indicate that a native rat occurred plentifully in the Hawaiian Group, the species has, through the immigration of the familiar Norway and Black Rats (*Rattus norvegicus* and *R. rattus*) and the later introduction of the mongoose, disappeared so rapidly that it was generally supposed to have become extinct. Furthermore, no specimens of the animal had been preserved so far as we are aware.

In the spring of 1913 Mr. John F. G. Stokes of the Bernice Pauahi Bishop Museum discovered on the island of Kahoolawe a number of bones and some portions of mummied rodents, a few of which were referable to the House Mouse (*Mus musculus*), but the majority to a species intermediate in size between this and the introduced rats, which he identified (correctly so it proved) as the Hawaiian Rat. His discovery of these remains is best told in his own words:

"In March and April of 1913 I was on the island of Kahoolawe investigating the site of an ancient fishing station or early fish-hook factory. It was situated on the west shore of Kamohio Gulf at about the middle of the southern coast (see U. S. Coast and Geodetic Survey Reg. Map No. 2726, immediately to the east of Black Δ), and protected from the ocean swell by a small promontory. A few feet back from the sea was a rock shelter, worn by wave action apparently, preceding a slight elevation of the land. The cliffs enclosing the gulf were very precipitous, making access from the interior of the island to the sea almost prohibitive in that vicinity. They were barren of vegetation. The entrance and interior of the shelter were partially filled by talus which had fallen from a vertical cliff on the northern side, and on the slopes of the talus, within the shelter, loose stone terraces had been built. One use of the terraces (and perhaps the only one)

was as offertoria to the beach-worn stones which had been set up as fish-gods. The offerings had consisted mainly of fish, but vegetable material was also found, in addition to the remains of petrels. The indications from the ethnological material obtained were that the location had been abandoned early in the nineteenth century.

"The rat remains were found among the lower stones of the terraces and in the underlying talus. The spot was very dry, and the floor of the shelter and the terraces were covered by a layer of dust from six to eight inches deep. The interior of the shelter was never reached by rain, as we had an opportunity of observing during a very heavy storm. There is no reason to suppose that the specimens might not have been preserved for many generations to come.

"I believe that these rats were present during the occupation of the site by the early fishermen, and subsisted on the offerings.

"There is little doubt that we gathered all the fragments that were available when we arrived at the place, as all the dirt and fine dust was sifted. It puzzled me, however, to find mummies or adhering bones, as in Lot 5, and not to find the skull (Pl. IX). Lot 4 gave us a deal of trouble. We found the mummy of the rat head downwards with its skull crushed between two stones, apparently by a movement of the talus as it dived for its home. Beside it was a bird bone which it had possibly been carrying. The stones were carefully removed and the fine dirt below was sifted. As we found no more bones, we removed the lower stones hoping to get the remains of the crushed skull. The jaw (No. 9033) and skull (No. 9032) were found, but I did not realize until Professor W. A. Bryan pointed it out to me in Honolulu that the skull belonged to another species [*Mus musculus*], nor did I stop to make any comparisons, as we had already spent a considerable time on the specimen.

"The last use of Kahoolawe by Hawaiians, except for occasional fishing excursions, was in 1843, when a penal settlement established by the native government was abandoned. In 1863 it was leased for fifty years as a cattle ranch, and neither the island nor the cattle were benefited thereby.

"It might be mentioned that long since the abandonment by the early fishermen of the particular spot I investigated, one or more parties of bird hunters had visited the place with dogs, to

collect petrels, which were nesting in the holes among the stones of the terraces. We found the remains of about a dozen petrels, skulls, feathers and chewed bones, in the upper layer of dust. Two goats had also died in the shelter, possibly being unable to get out."

In May, 1915, Mr. Stokes found a number of mandibles and bones of the same species of rat on the sand-dunes of Heleloa, Mokapu Peninsula, Oahu (Pl. X). Most of these were obtained on the surface of wind-blown hollows on the dunes. In a sand quarry a few hundred feet distant, a broken skull and other fragments were picked up. Upon searching for traces of living rats, several small holes were observed on the tops of the dunes, among the scattered shore plants and scanty grass. As this point of land is almost insular, the possibility suggested itself that the imported rats and mongoose had not yet reached it, and that the native rat might still persist there. Eight traps were therefore set but without result, although one was sprung. An opportunity to repeat the experiment has not occurred.

On the island of Popoia, Kailua Bay, Oahu (Pl. X), a small rusty brown rat had been seen by Mr. Stokes early in 1915, and on the chance that it might be the supposed extinct species a trap was set on May 7, baited with bacon rind and a few drops of oils of aniseed and rhodium. On the 9th the trap contained two dead males and two living females. Mr. Stokes says:

"One of the males (No. 9011) showed the marks of a severe fight, and undoubtedly there had been a fight to a finish. The others were drowned, and the lot (Nos. 9010-9013) placed in alcohol immediately.

"On the 11th, No. 9016 was taken in the morning, and a male, probably her mate, in the afternoon. The trap was visited twice daily, and the location changed every time a day passed without a catch.

"Returning from Honolulu a fortnight later, the trap was set out for about seven days, and only one female caught.

"It seemed well to let them breed up a little, as the island is very small, so no more trapping was done until Sept. 18-19th, when the exposure of the trap for a night and a day secured a pair. The bait was bacon rind only. The female (No. 9017) looked seedy and died a few days afterwards.

"The live rats were kept at my home in Honolulu in the hope that they would breed. No. 9016 and her mate were in one cage, and the second female in another.

"On June 11th, the desired result not being obtained, the second female was added to the pair. She, however, would hold no converse with either of them, taking possession of their sleeping box and showing a disposition to quarrel if either approached. Her presence, though, appeared to excite the male, who finding his approaches were repulsed by the stranger, confined them to his mate.

"About June 21st, finding that No. 9016 was pregnant, she was removed to the other cage, but seemed unable to produce her young and died on the 28th.

"I thought the other female was mating about a month ago (September, 1915), but nothing has happened since. There are now on hand, alive, two males and one female.

"The cages are boxes of comparatively soft wood, with tops and sides removed, and completely covered on the outside with one-half inch mesh wire. It had surprised me that the rats never made any attempt to gnaw through the wood. For the first few days of their captivity they tried to bite through the exposed wire.

"They have taken readily to any food we have given them, and are fond of fish and grain. A crab's leg was wasted, as they seemed unable to crush the shell.

"Popoia islet is a flat piece of raised coral reef, varying in height above the sea from four to seven feet. The area is only three acres. It is just about a furlong from the main shore, the intervening depth reaching eight feet. There is little question that at one period it was joined to Oahu, as there are many places along the shore of Kailua Bay where the formation is exactly similar. The separation may have taken place through depression, but was more probably due to the wave action or dissolution of the reef rock from other causes not yet explained. The islet is rapidly being worn away at present, as may be observed from some of the enclosed prints (Pls. XI, XII).

"The surface of Popoia is broken abruptly by many hollows, approximately twenty by thirty feet in size and one to three feet deep, and is honey-combed in all directions by small vertical and horizontal holes. In every hollow examined soil of volcanic ori-

gin was present, and below the level of this soil I found in two places, where the waves have exposed it, a phosphate rock containing the tests of arboreal and terrestrial mollusca. The presence of these fossils, according to Dr. C. Montague Cooke, indicates a forest area at an earlier period, and a climate very different to that at present.

"The vegetation now consists of twenty-five species, mostly shore plants, seven of which are of foreign introduction. There is but one species of tree, the *milo* (*Thespesia populnea*) present in a small forest covering about one-fifth of the lee side of the island. The open area is partly and the depressions entirely covered with our common salt marsh weed (*Sesuvium Portulacastrum*), and there are three grasses, one of which is native. Of the plants suitable for rat food, there are the grasses, several small berries and the seeds of the *milo*. All the plants have been identified by Mr. C. N. Forbes, our botanist, and I will send you a list if you wish.

"Other life on Popoia is represented, among the birds, by at least two species of petrel (which nest and spend the day time in the surface holes, feeding only at night), the migratory and shore birds (plover, turnstone, snipe, etc.), and two introduced land birds which pass the night there for security. The owl or some other predatory bird must occasionally visit it, as on two occasions I have found on the open surface of the island partly eaten rats—one minus a head, and another without head and shoulders. The Hawaiian hawk has not been reported from this vicinity.

"A skink is very abundant, being found in every corner of the island. I had never seen any geckos until I began to catch the skink, when I saw four specimens and secured three, representing two species. The five skinks caught were of the same species.

"There are the usual shore and rock crabs, and once I secured in the rat trap a pair of *Geograpsus crinipes* (Dana) which I had not seen before.

"Before going farther, I should mention that I do not mean to imply that the presence of the rats on Popoia necessarily dated from the ancient forest conditions above referred to. It may have been so. They may also have been carried there since the island was separated from the shore, in the natives' canoes, a means not so readily available to the imported foreign rats and mongoose on account of their larger size. [257]

"I have been wondering what the principal food of the rats might be on Popoia. Their habits are difficult to study on account of their extreme shyness. The only knowledge I ever had of their presence was the rapid disappearance of a diminutive brown animal on several occasions, and until I saw them in the trap it would have been impossible to give any adequate description of them. A native who frequently visited Popoia told me that there were no rats there. In dry weather—the greater part of the year—I doubt if the vegetable life would support them. I am inclined to think that the rats depend largely on the food brought in by the petrels, whose burrows they seem to share. The only man whom I have met who has previously seen the Hawaiian rat alive is Mr. Augustus Knudsen of Kauai. He told me some time ago that many years previously he had observed the rats and sea birds living together on the ocean cliffs of Kauai, and that the rats did not appear to disturb the eggs, nor the birds the rats. He had not seen them for many years.

"Similar conditions undoubtedly exist on Popoia. The opportunities for observation, however, are not the same, as the tern, which is probably what Mr. Knudsen referred to, nests in open, exposed places, and the petrel the exact opposite."

So much for Mr. Stokes' interesting rediscovery of this supposed extinct mammal. The next question is to determine its identity and relationship to other forms. For this purpose the Bishop Museum has very kindly placed all of its material in my hands for study, consisting of the several lots of bones and seven rats in alcohol, three males and four females.

Two specimens were immediately removed from the alcohol and prepared as skins, the skulls being carefully cleaned.

The first description of a rat from the Pacific islands is by Titian R. Peale, naturalist of the U. S. Exploring Expedition, who in his report of the birds and mammals obtained by the expedition proposed the name *Mus exulans* for specimens of native rats obtained on the Dog and Disappointment Islands (Paumotu Archipelago), Tahiti, Wake Island (20° west of Marianas, 10° north of Marshalls) and Hull's Island (Phoenix Group).

A specimen from Tahiti, which may be regarded as the type, is still preserved in the U. S. National Museum, but lacks the skull.

Peale's description leaves much to be desired, as he merely says, ".....so like the common Brown or Norway Rat, *M. decumanus* of naturalists, that they might be pronounced a diminutive variety....." His plate, while it differs in certain proportions and colors, and in the hair on the tail and forearms, from Mr. Stokes' specimens, is probably not a very reliable representation of the specimen from which it was drawn and should not be given too much consideration.

Peale also described, at greater length, another species *Mus vitiensis* from Fiji.

The types of *M. exulans* and *M. vitiensis* (Nos. 3730 and 3731, Colln. United States National Museum), kindly loaned me through the courtesy of Mr. G. S. Miller Jr., curator of mammals, are old dismounted specimens of an almost uniform yellowish brown color above and below. They were probably immersed in spirits before mounting, and this together with long exposure to light has practically ruined them for purposes of comparison, and they are without skulls.

The hair appears longer and more bristly than in the Hawaiian specimens, especially in the case of *M. exulans*, while the scales on the tail in *vitiensis* are larger and more conspicuous. In each of the types there appears to be more hair on the tail than in the Hawaiian animal.

Mr. Edgar R. Waite (1897)¹ has discussed the Pacific native rat and follows current opinion that specimens from the various Polynesian islands are all referable to one species, for which of course he adopts the name *Mus exulans* Peale. He had, however, no series of specimens before him, so that his interesting paper by no means settles this question. He does, nevertheless, give a good description of a specimen from Funafuti Atoll and figures the skull, which, if the figure is accurate, is broader than that of the Hawaiian animal. Waite does not mention the dark color of the under side of the feet, which is very characteristic of all Mr. Stokes' specimens, while the number of foot-pads in the two do not coincide.

In view of the unsatisfactory nature of the original descriptions of Peale's species and the lack of recent material from these other island groups, no satisfactory results can be reached as to the relationship of the native rats of the several Pacific islands. It

¹ Mammals, Reptiles and Fishes of Funafuti, Mem. Aust. Mus., III, 174, pl. viii, figs. 1a-1f.

does, however, seem extremely unlikely that islands, as far removed as Tahiti and Fiji, should have possessed animals identical with those of Hawaii. Therefore it would seem desirable to name the Hawaiian native rat as a distinct species and a description of it is here appended. It may be known as:

***Rattus* ' *hawaiiensis*.**

(Plate VIII.)

Type. No. 9010, Colln. Bernice Pauahi Bishop Museum. Popoia Island, Oahu, Hawaiian Islands, ♂. May 9, 1915.

Description. Above cinnamon brown or russet shading into cinnamon buff on the sides and light buff or buffy white below, strongly mixed with black hairs on the back and sides. Feet nearly white above, the dusky color of the legs overspreading the tarsus and carpus and narrowing to a point. Whole underside of the hind feet dark.

Measurements. Length, 239 mm.; tail, 118; hind foot, 26; ear, 9.

Skull. Length (occipito-nasal), 32 mm.; zygomatic breadth, 16; interorbital breadth, 5.5; basilar length of Hensel, 27.5; molar tooth row, 5.5; median length of nasals, 12; total length of mandible, 22.

A female (No. 9012, Colln. Bernice Pauahi Bishop Museum), now in the collection of the Academy of Natural Sciences of Philadelphia, is exactly similar in coloration but slightly smaller in size.

Measurements. Length, 225 mm.; tail, 111; hind foot, 25; ear, 9.

Skull. Length (occipito-nasal), 31 mm.; zygomatic breadth, 16; interorbital breadth, 5.3; basilar length of Hensel, 25; molar tooth row, 5.5; median length of nasals, 11; total length of mandible, 21.

In concluding the account of this interesting rodent, I wish to acknowledge the kindness of Mr. J. F. G. Stokes in placing all of his material and notes in my hands for description. The paper is really more his than mine, and to his indefatigable efforts we are indebted for bringing to light this animal long since regarded as extinct.

¹The Hawaiian Rat is placed in the genus *Rattus* as opposed to *Mus* (type *M. musculus*), following Trouessart. It may be that the old genus *Mus* is susceptible of further generic subdivision and that this species is not congeneric with the Norway and Black Rats.

Notes on the Hawaiian Rat.

BY JOHN F. G. STOKES.

IN the preceding paper Dr. Stone has undertaken to give the writer more credit for his observations than is his due, such observations being mostly the result of accidental findings in the prosecution of his regular work; and has further done him the honor of inviting him to add his name as co-author, which it seemed to him more fitting to decline, since his work is outside the field of systematic zoology.

We much appreciate Dr. Stone's kindness in looking into the subject of the native rat and describing the specimens, especially as there is no mammalogist on the Museum's staff.

The following notes may be added to those already communicated and may be of service in throwing more light on the habits of the native rat. They include observations made since the despatch of the original rat material to Dr. Stone, and references to the rat in the life of the Hawaiian people.

On the island of Kauai, in 1916, the Weliweli and Mahaulepu sand-dunes, in the neighborhood of some petroglyphs the writer was measuring, were visited. Some little time was spent on the Weliweli dunes gathering fossil land shells, and incidentally a fairly thorough but unsuccessful search for rat bones was made. On the Mahaulepu dunes, three miles to the north, the visit was briefer and the search confined to ethnological material and fossil shells, since the Weliweli dunes had yielded no rat remains. A few samples of sand containing the fossil shells from Mahaulepu were brought back to Honolulu, and when Dr. C. M. Cooke sifted the same, he found a small mammal bone comparable in size to the rat bones from Heleloa and Kahoolawe. Being a mammal bone, its size would indicate that it probably belonged to the native rat species.

The same year remains of rats were found at three places in the Wailuku sand-dunes, Maui. These dunes, used as pastures, extend about five miles to the northeast and southwest of the Iao stream's stony bed. The stream, a mountain torrent subject to heavy floods, has swung back and forth, during its existence, over

a breadth of a quarter of a mile. The resultant stretch of volcanic rocks and soil divides the two series of dunes. The present trend of Iao is westward, and it is now undermining the dunes on that side, leaving a high bank of dry, rolling sand. The eastern series of dunes is now well covered with fodder trees (*Prosopis juliflora*), but on the dry, western series the vegetation is merely a thin growth of dune grasses and weeds; its upper strata are changing into æolian sandstone.

Crowning two of the high dunes of the latter series, and about three hundred feet apart are the foundations of the old temples Pihana and Halekii. The foundations are loose, dry-laid, water-worn stones, piled up over a century ago by the Hawaiians. Such stones are seldom seen on the dunes, and when found there, their presence is traceable to human agency. Generally near them are stunted lantana shrubs. The Pihana and Halekii dunes are more or less isolated from the surrounding volcanic soil and rocks by other sand-hills or bare sandy slopes; Halekii more so than Pihana.

The rat specimens first noted here were a few scattered leg bones among the remains of the offerings—human, pig, dog and fish bones, shells, etc., on the surface at Pihana. Offerings at temples ceased a century ago, and the large mammal bones were almost completely destroyed by weathering. The rat bones were in a good state of preservation, and unless they had been recently uncovered by the sand shifting, they post-dated the other bones. They were from mature animals, and probably the native rat. Half of Pihana's foundations had slid down the steep bank which the stream had undermined, and the offerings were found on the remaining portion of the stone floor and on the sliding sand.

Halekii temple had not been disturbed by the stream and was five hundred feet distant from it. A recently dead rat was found there exposed to the weather on one of the foundation stones. It had been dead probably less than ten days, as the eyes were present in position. Decomposition of the soft body parts was complete, and the flesh of the legs and tail had dried. There was still a marked odor. The fur was present, except on the right side, on which the animal was lying. The writer has little hesitation in identifying the specimen as a native rat, from the color of the fur and the size of the animal.

This specimen and the rat bones above mentioned were forwarded to Dr. Stone, but crossed his MS. in the mails.

In the eastern dune series, on the site of the old battle field of Kakanilua, two miles from Halekii, half a mandible and two leg bones of what may reasonably be referred to the native rat, were later picked from the surface of the sand.

The presence of the living rats on Popoia (reported to Dr. Stone) suggested a search on other islets. There is a small mushroom-shaped islet called Kekepa on the coral reef at the eastern entrance to Kaneohe Bay (see map, Plate X). Its area is about an acre, and the highest point of its surface is fifteen to eighteen feet above mean tide. On account of its situation a landing can only be made on the narrow wave-washed shelf encircling its base, at low tide and in calm weather. The writer visited Kekepa in 1915. It was of raised coral reef formation; its surface was honey-combed, and the same species of petrels were nesting as at Popoia. Vegetation was confined to shore plants; there were no shrubs or trees. Though the writer, when starting, prepared himself with traps, he could not use them since the boatman, on reaching Kekepa, limited the stay to fifteen minutes on account of the rising sea. Enough was seen of conditions at Kekepa, however, to suggest the probability of the rat being present.

Another reason for the visit was curiosity aroused by the account of a young native boy that his parents had seen on the islet a small brown bird of the size of the imported mina (*Acridotheres tristis*) which jumped instead of flying. The parents were absent, and the information above was furnished in reply to a casual enquiry of what was to be seen on Kekepa, which was in sight in the distance. Of course, the description of the bird would fit one of the extinct Hawaiian rails (*Pennula* sp.) better than any other known Hawaiian birds, and considering the honey-combed condition of the surface of Kekepa, the writer would not care to state that the rail was not on the islet.

On the volcanic island of Mokulua North a fairly thorough search was made among the rocks near the sea, and in likely places a little further back, without finding indications of rats. A less thorough search at Mokulua South gave no better results. These islands are high and were probably formed independently from Oahu.

Summarizing the results concerning native species from all the localities visited and mentioned in this and Dr. Stone's article preceding, we get, if the writer's identification of the material be correct, on the islands of—

Kauai :

Sand-dunes, Weliweli. No traces of rats.
Sand-dunes, Mahaulepu. Skeletal material.

Oahu :

Reef islet of Popoia. Living rats.
Reef islet of Kekepa. Natural conditions for rats similar to Popoia.
Volcanic coastal islets of Mokulua. No traces of rats.
Sand-dunes, Heleloa. Skeletal material and possibly living rats.

Maui :

Sand-dunes, Wailuku. Skeletal and fresh material.

Kahoolawe :

On barren coast. Skeletal material, with introduced species.

Except for Kahoolawe, these observations cover a period of less than two years. Only at Popoia and Kahoolawe was there any amount of time spent. When we consider that the results obtained were mostly due to accidental discoveries through brief visits made only as time permitted, the conclusion seems obvious that the Hawaiian rat may yet be found alive in many other localities which it may have reached, where conditions are favorable for its preservation.

In seeking for these favorable conditions, we would ordinarily select localities from which the native rodent's introduced competitors or natural enemies (large rats and mongoose) are debarred by natural conditions; which do not furnish sufficient food or cover to attract them; or to which they have not so far extended. This much has apparently been found in the shore-lying islets and coastal sand-dunes, which are common in this group. Among the former, for instance, on Oahu (see map) may be Kekepa (raised reef) and Mokolii (volcanic). Other islands, Kapapa (raised reef) and Mokumanu, Mokulua, and Manana (all volcanic) may be too distant. Moku o Loe (volcanic), in Kaneohe Bay, should be a good locality, and it is reported as being overrun with rats of a species not known at present. This island was recently inhabited, and is so frequently and easily visited that the rat may well prove to be of an introduced species.

The sand-dunes, used for cattle grazing, are generally covered with a sparse herbal growth, sufficient perhaps to support the

smaller native rat, yet not enough to attract the larger introduced animals from the richer pastures around the human dwellings or in the sugar-cane fields inland. On the dunes the mongoose is a rare visitor. Its nature is to stay close to cover, and a place bare of stones and without thick grass probably would not appeal as good hunting ground.

The writer would suggest that a study of conditions similar to those of the Hawaiian group, in the islands of the South and West Pacific, might demonstrate that the other species of Oceanian rats, now believed to be rare or extinct, are yet to be found alive.¹ It is a matter for zoologists to follow up if the suggestion be deemed worthy of consideration.

Some of the Popoian rats were kept alive in Honolulu, as reported to Dr. Stone. The intention was to breed them and distribute the progeny among some of the more distant small islets where they could work no harm and might be preserved from their introduced enemies. The record is herewith:—

FIRST CAGE.

May 11, 1915. No. 0 ♂ and No. 9016 ♀ trapped, placed together.
 June 11, 1915. No. 9040 ♀ added to pair. No. 0 ♂ and No. 9016 ♀ mated.
 June 28, 1915. No. 9016 ♀ died in parturition.
 June 28, 1916. No. 9040 ♀ died.
 At date. No. 0 ♂ on hand, alive.

SECOND CAGE.

Sept. 19, 1915. No. 9024 ♂ and No. 9017 ♀ trapped, placed together.
 Sept. 22, 1915. No. 9017 ♀ died.
 Nov. 29, 1915. No. 9024 ♂ died.

Observations on the habits of the rats have been conducted with difficulty on account of the extreme shyness of the animals. The cages were fastened just outside window sills so that the ani-

¹ Skeletal material might be found in old Polynesian temples. In the notes sent to Dr. Stone it was mentioned that the fishermen's religious offerings of food (fish, meat, fruit and vegetables) had served to sustain the Kahoolawe rats. The specimens found on the Wailuku ruins were, probably, all comparatively recent, but their presence calls to mind the indirect reference made by many writers, native and others, to rats in Hawaiian temples. There the rodents would find ample shelter among the loose stones, and live on the fat of the land. The food offerings were abundant and varied. "Poor as a church mouse" could not be said of the Hawaiian temple rat. In Tahiti particularly, where worship and offerings were very similar to the Hawaiian, a search might bring results which would aid materially in identifying Peale's *Mus exulans*.

imals could be watched from the room through the uncovered wire at the top. Their reaction to sound and scent was so sharp that they could detect the quiet approach of an observer before they could see him and would then remain motionless, except for their twitching snouts and ears, as long as a person cared to watch from a little distance. A nearer approach to the window would cause a scurry for the sleeping box. Subsequent observations would then be limited to the pair of twitching noses poking out of the box opening.

The appearance of a person above the cage always terrified them. Later, the cage was changed to a window where the rats were just above the level of one's head when standing on the ground. In this situation, one of the rats became tame enough to eat from (and of) the fingers. However, movement above the cage continued to frighten them as much as ever, and the upper part of the cage was subsequently covered over.

Noise of any kind disturbed them, particularly the sharp snapping of the cage wire when opening the little door, when they would freeze as though expecting to meet their doom. It is evident that any future observations should be conducted in a cage which can be handled noiselessly.

They are on the move during the whole day, and feed freely at this time. Judging from the noise, however, their greatest activity is in the early part of the night. Their long sleep must take place between 9 P.M and 8 A.M.

Their food has been bread, cooked meat, bones, fresh, salt and smoked fish, lettuce, sow-thistle, cabbage, wheat, oats, walnuts, apples or anything else in the house. The bones are not closely gnawed. Papaya (*Carica papaya*), a fruit of which the imported rats are very fond, destroying many on the trees, was refused by those under observation.¹ A leg of the common rock crab (*Grapsus* sp.) was also refused, though probably on account of the difficulty of breaking through the shell. They have been observed chasing the common wood-roach, which occasionally crawls into the cage, but the chase stopped as soon as the observer approached the cage from above and the roach escaped. Living sow-bugs and

¹ In January, 1917, papaya was fed to and eaten by the male which had been in captivity for twenty months. At this time also the milo seeds were first fed, to the same rat; they were not eaten very readily.

parts of centipedes were eaten readily, the harder portions being chewed for some time and then ejected. An immature mouse was once found in the cage with the head eaten.

Early in 1916, during the damp weather, the introduced snail (*Eulota similis*) was very plentiful. A few were fed by the writer's wife to the rats in the illustration (Pls. XIII, XIV); they ate them very readily, biting through and completely crushing the fragile shells with ease. The rodents sat on their haunches and held the snails with their fore paws. In less than an hour twenty-one snails were eaten, and the indications were that more would have been consumed had they been available. From this time on snails, when found, became a part of the rats' diet. One of the large introduced slugs (*Veronicella* sp.) was placed in the cage and the male rat made many attempts to bite it before it crawled out again.

The native arboreal and terrestrial mollusca in some of the local forests are suffering from the depredations of rats, according to present day collectors, undoubtedly the introduced species. Dr. Cooke states that, at times, scores of mutilated shells are found about the entrances to the burrows, the owners of which had apparently carried them there to eat at their leisure. On learning of the Hawaiian rats' appetite for the *Eulota*, two nearly mature living specimens of *Partulina redfieldii*, a native arboreal pulmonate, were placed in the rats' cage. The rodents attacked them only at the aperture, breaking off the outer lip and failing to reach the soft parts.

In Pl. XV, No. 2 is one of the shells so treated, placed for comparison beside a whole specimen (No. 1) of *Partulina redfieldii* of about the same size and in the same relative position. They are illustrated at the suggestion of Dr. Cooke, who has kindly mounted with them eight other specimens (Nos. 3-10) recently collected, from which the softer parts had been extracted by an introduced rat. No. 8 is harder than No. 2, and Nos. 5-7 nearly as hard.

It will be noticed that the attack by the introduced rat was generally directed at the last whorl, in which the larger part of the molluscan body lay. Of the nine specimens in the Museum's possession,¹ one, not illustrated, was also attacked at the aperture

¹ From the shell collection of Mr. Irwin Spalding.

lip. In one (No. 3) it will be observed the apex is gone. Popoian rats had always completely crushed the shells of the *Eulota*, so observations were made on the method of initial attack on this species by the remaining living native rat, ♂ No. o. After feeding one snail at a time and then interrupting the meal, it was found on examining the shells that all were attacked at the last whorl, one of which was also broken at the aperture. In the latter instance, the body of the snail was expanded just before it was seized by the rat. From the above observations and illustrations, it might appear that the rats attack the portion of the shell where the molluscan body is found.

Many of the Hawaiian terrestrial mollusca are smaller and are provided with more fragile shells than those illustrated above, and may well have contributed to the diet of the native rat before it was displaced by the introduced species.

In the communications to Dr. Stone, reference was made to the inability or lack of desire on the part of the Popoian rats to escape by gnawing through the soft wooden lining of the cage. Evidence of the ability of the common house rats, or even mice, to gnaw through thick wood has been presented to most people who live in wooden houses. The Popoian rats, on the other hand, have made no attempt to gnaw their way out through the wood, though for the first two days of captivity they tried to bite through the exposed wire front. Bones and tough cartilage they do not seem to make an impression on, and they were unable to bite through the leg of our common rock crab, as already mentioned.

It would thus seem that there was a comparative weakness in the Hawaiian rat's gnawing system, due probably to undevelopment in the species. Such a probability could be explained if we were to take into consideration, for example, the conditions under which the house varieties of the different species operated. Foreign rats and mice have had, for very many of their generations, closely fitting wooden walls and floors to contend with, and innumerable enemies to compel them to keep close within the shelter of such wooden constructions. The Hawaiian rat shared the open life of its human neighbor, with few natural enemies except the same neighbor, and found the grass house walls, and loose stone foundations and floors, places for easy hiding.

When repacking the first rats caught on Popoia to mail to Philadelphia, a number of lice and mites were found in the original alcohol. Mr. O. H. Swezey examined them, and as our literature on the subject is very scanty, he has only tentatively determined the louse as *Polyplax* [*Haematopinus*] *spinulosa*: adults, young and eggs. Mr. J. C. Bridwell has recognized the mite as belonging to the *Gamasidae*, and closely resembling but not identical with the poultry tick, *Dermanyssus gallinæ*.

Mr. T. G. Thrum, a lifetime student of Hawaiian legendary lore, has found in his readings many references to the native rat. In particular, an interesting account of the pastime of rat hunting is given in the legend of Pikoikaalala,¹ the infant prodigy with the bow and arrow. The legend, full of the marvelous, is appropriately referred to at this time on account of the mention of three kinds of places where the rat-killing contests occurred. One was a wilderness or deserted cultivation field on Kauai. The second, on the coastal plains of Oahu, covered with a lowland herbaceous form of the *aweoweo* (*Chenopodium sandwicheum*), among the stems and leaves of which the rats took shelter. The third was the king's grass dwelling house near the shore, where the rats were shot on the floor and the interior of the roof.

From the legend is also ascertained the mode of procedure in the contests. The first competitor shot continuously at such rats as were pointed out by his opponent to the number agreed upon. Then the latter took his turn and shot as ordered by the first. The total score, of course, determined the winner. From the same legend, it would appear that the chiefs had in their retinue, men or women employed as rat killers, and indulged in betting on the contestants' skill.

There is another account, that a place was cleared of brush and weeds, and the rats then driven into the clearing as marks for

¹S. M. Kau, He Kaa no Pikoikaalala. Nupepa Kuokoa, Honolulu, Dek. 16, 1865-Mar. 18, 1866. This is not the best version, as Kau missed the point of the legend, i. e., the opportunity of bringing in a play on words, where the youngster displayed his smartness. It was selected for this reference, however, because the places where the shooting was said to have occurred must have appeared so natural to a Hawaiian recounting the legend fifty years ago as to mislead him in his understanding of the intent of the tale. A better version, from among the Abraham Fornander MSS., will be published in the Museum Memoirs in the near future.

the archers. In the pastime the small extinct rail previously mentioned was sometimes substituted for the rat.

We have no record in the Hawaiian Group of any contrivance in the shape of a rat-trap such as occurs on some of the other Pacific islands. The bow and arrow was probably depended on to keep down the rats as vermin. As late as 1888, Mr. J. S. Emerson secured from a native, about ninety years of age, on the island of Hawaii, a small bow and arrow which was kept in the house for shooting "mice".¹ Mr. Emerson set up a mark about sixteen feet off, to test the old man's skill, and found him very proficient. The bow was not used in warfare.

The Hawaiians formerly had an outdoor rack for protecting food from dogs, hogs and rats. Sometimes it was a branched tree set up outside the house, from the branches of which the food bowls would be suspended in netted bags. In this museum are two carved wooden racks for the same purpose. They are canoe-shaped, notched on the upper edges, and were set across the ends of upright posts.²

One of the native superstitions concerning the rodent was that if the baby's umbilical cord (some authorities state, the boy's prepuce also) were eaten by a rat the child would grow up a liar and a thief.

¹ Introduced, without doubt. One or two references to the probable existence of a native mouse, as well as a rat, have been met with, but on what grounds it was not stated. Cook and King (Cook's Third Voyage, London, 1785, Vol. II, p. 228, and Vol. III, p. 117 respectively) both state that there were only three mammals in the Hawaiian Islands, the dog, hog and rat, resembling those seen at every other island touched at. King spent several weeks ashore and had full opportunity for observing the mouse were it present. The Hawaiian term for the rat was *iole*, and the same term in its varying dialectic forms was found among other Polynesians with the identical application. The early Hawaiian biological nomenclature was very profuse and apparently exact as to variety. To quote two examples only, there were over sixty terms for varieties of taro; and three or four terms for the fish *ulua* in its different stages of growth, although all stages were recognized as belonging to the same fish. There is little question that had there been two native rodents the ancient Hawaiians would have used two different terms. As the old systems became obsolete through foreign influence, the Hawaiians seemed to lose their aptitude in "giving a thing a name." The introduced mouse was known as *iole liliti*, "little rat", and the wharf rat *iole nui*, "big rat", which term was also applied to the rabbit.

² B. P. B. Museum Memoirs, vol. ii, fig. 67, p. 205.

LATER NOTES.

Dr. Stone has identified the Wailuku temple rats as the same as the others.

On February 4, 1917, I met a native at Kailua who said that his grandfather claimed to have accidentally introduced the rats to Popoia, where, according to the statement, there were none before. The account is that the rats were transported from Kailua beach in the folds of a fish-net, and escaped when the net was spread out on Popoia. The claim that such an introduction took place is reasonable, and I am glad to be able to mention it in these notes. It would suggest the advisability of examining the sand-dunes before the shore islets when looking for the native rat. The introduction occurred "more than twenty years ago," which might mean, on account of the Hawaiians' difficulty in recalling dates, any time previous to such limit. At the present time introduced rats and mice are plentiful about the houses at Kailua beach.

Two Hawaiian rats were seen on Popoia on February 4, one in the open, and one among the milo trees; and on February 11 a young male was trapped at the latter place. It was active and seemed healthy, but died on March 1.

On February 25 and March 4, Dr. C. Montague Cooke found many native rat bones on undulating sand-plains and low dunes near the northern point of Oahu. They were in beds of fossil shells, which had been disturbed by road grading. The shell deposits are probably much older than the Heleloa dunes.

PRESENTED JANUARY 17, 1917.

PUBLISHED MARCH 8, 1917.

PLATES

EXPLANATION OF PLATES.

PLATE VIII.

Rattus hawaiiensis, type.

PLATE IX.

Material from Kahoolawe; No. 9032, *Mus musculus*. Other rat material, *Rattus hawaiiensis*. Nos. 9027 and 9029 from young specimens.

PLATE X.

Part of Oahu, showing location of Heleloa and Popoia.

PLATE XI.

Popoia Islet.

South shore, showing erosion.

PLATE XII.

Popoia Islet.

Upper figure. Shore pool showing erosion: looking outward.

Lower figure. Surface of northern part.

PLATES XIII, XIV.

Rattus hawaiiensis, ♂ No. 9030, ♀ No. 9040. Height of drinking cup is 68 mm.

PLATE XV.

Hawaiian pulmonates attacked by rats. Explanation on plate.



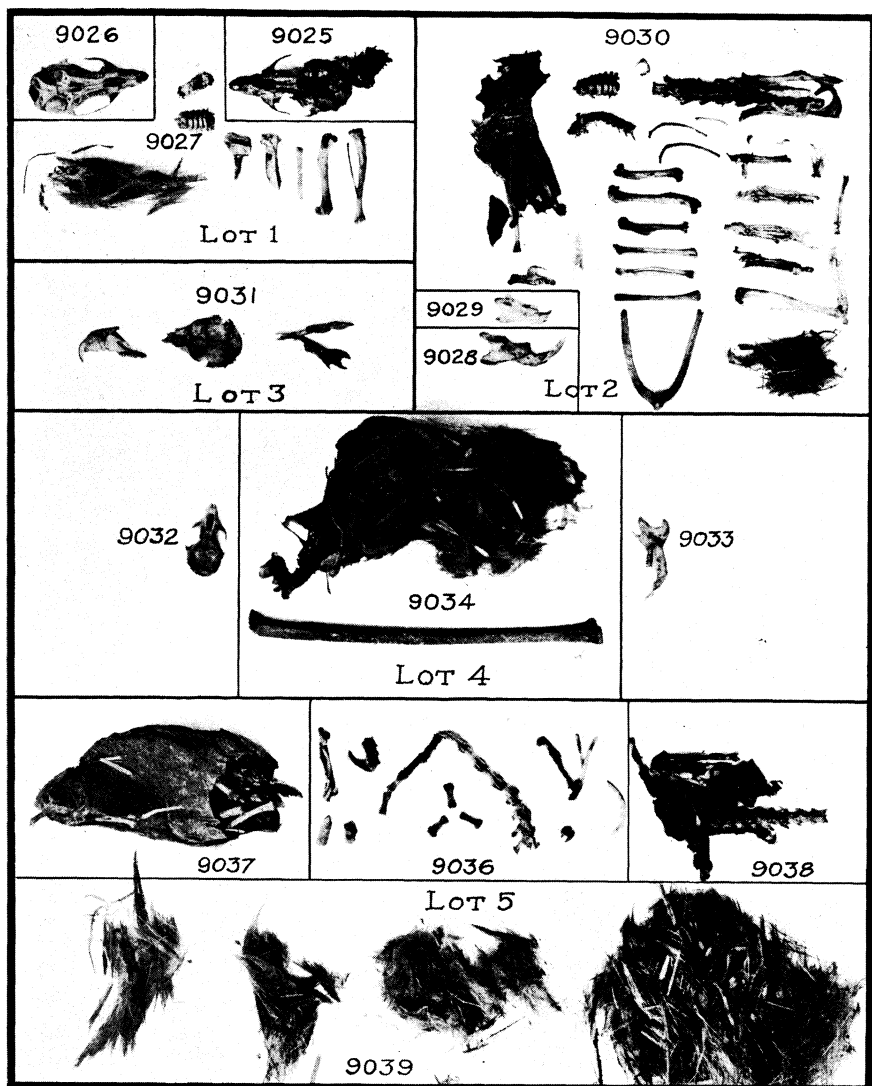
× 2.5



RATTUS HAWAIIENSIS, TYPE.

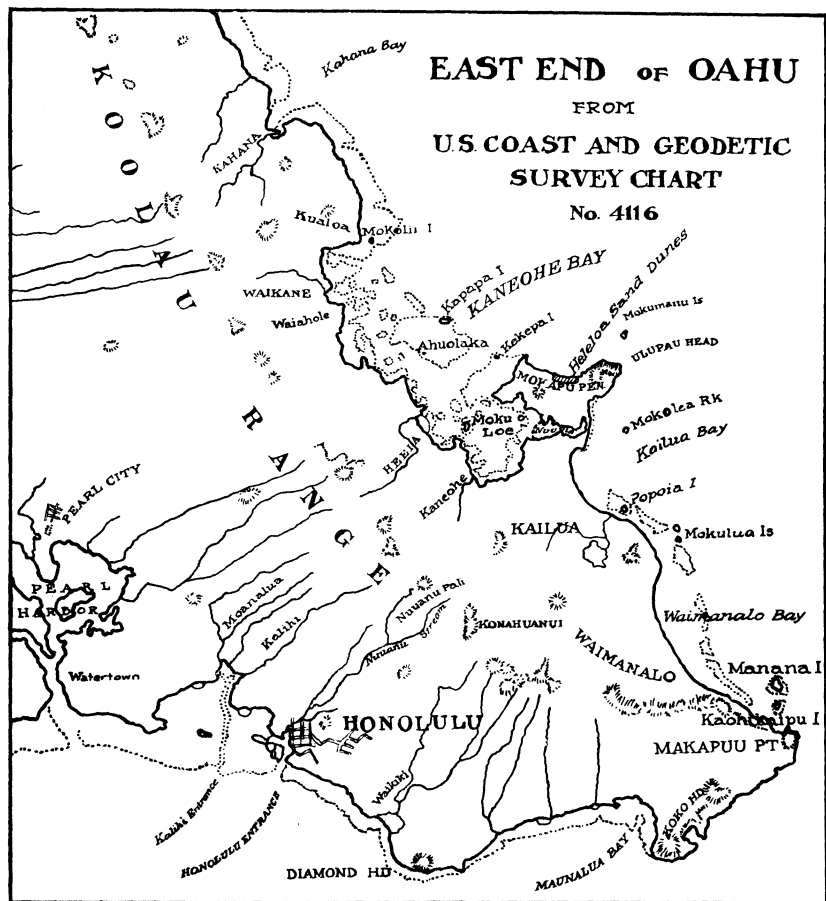
× .6





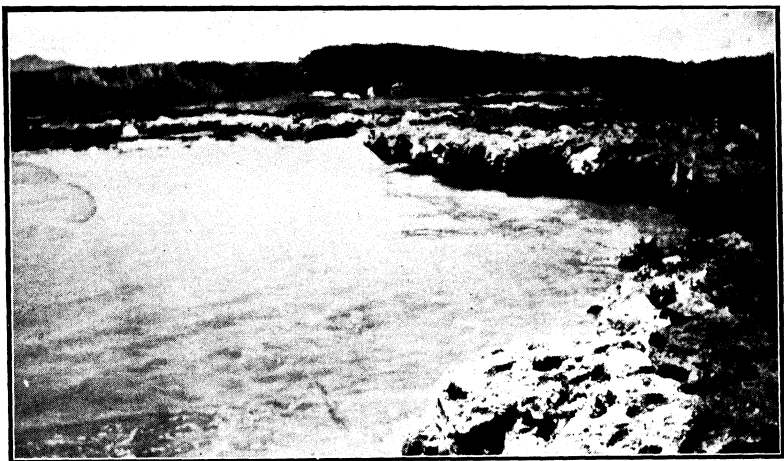
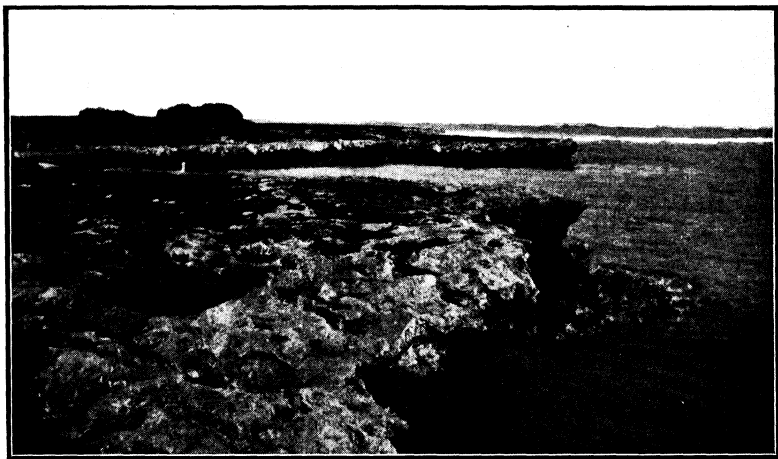
RAT AND OTHER MATERIAL, FROM KAHoolaWE.





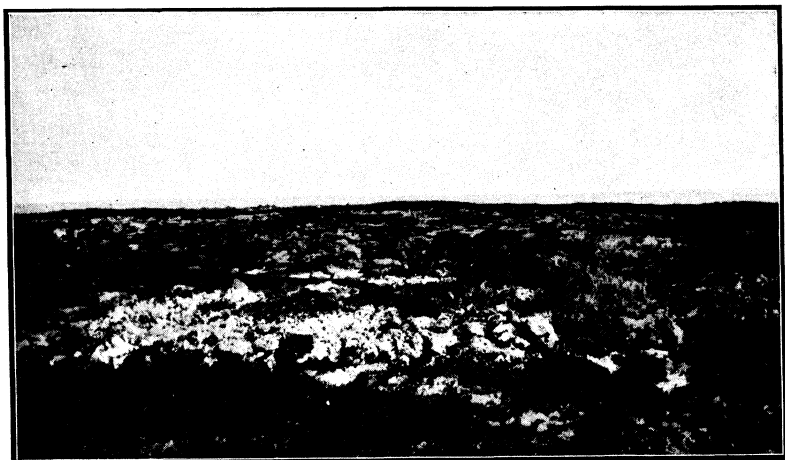
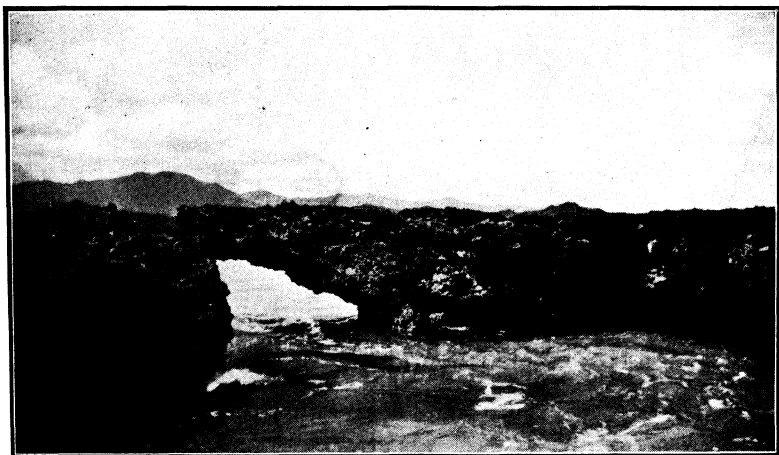
EAST END OF OAHU.





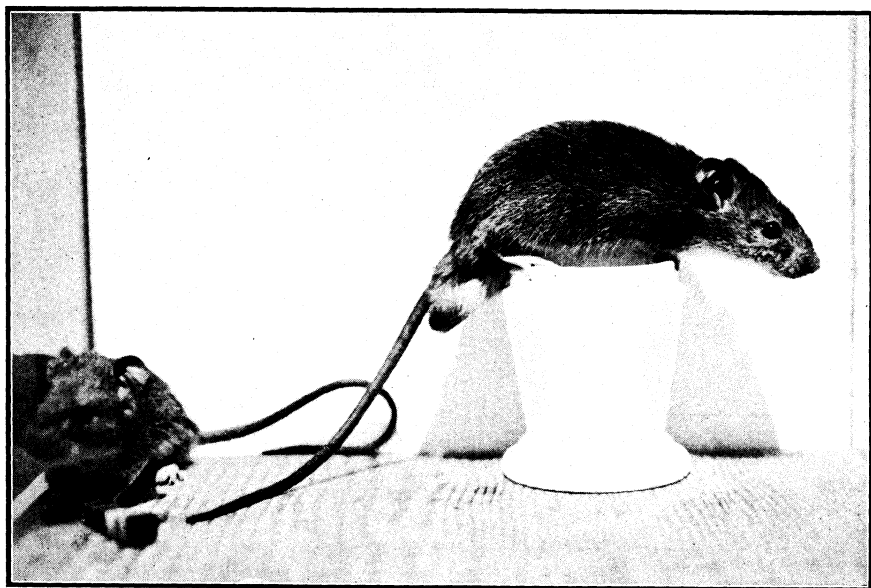
POPOIA ISLET.





POPOIA ISLET.





♀

♂

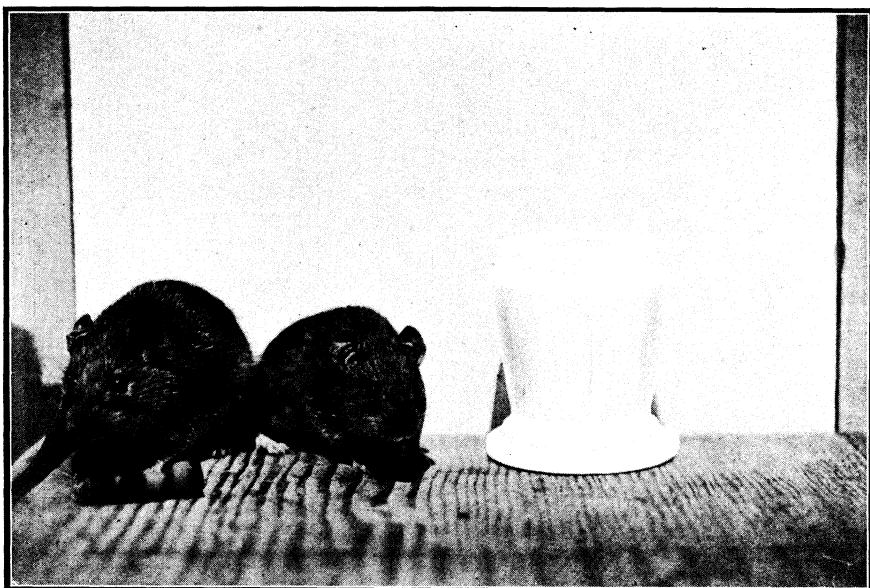


♂

HAWAIIAN RATS.

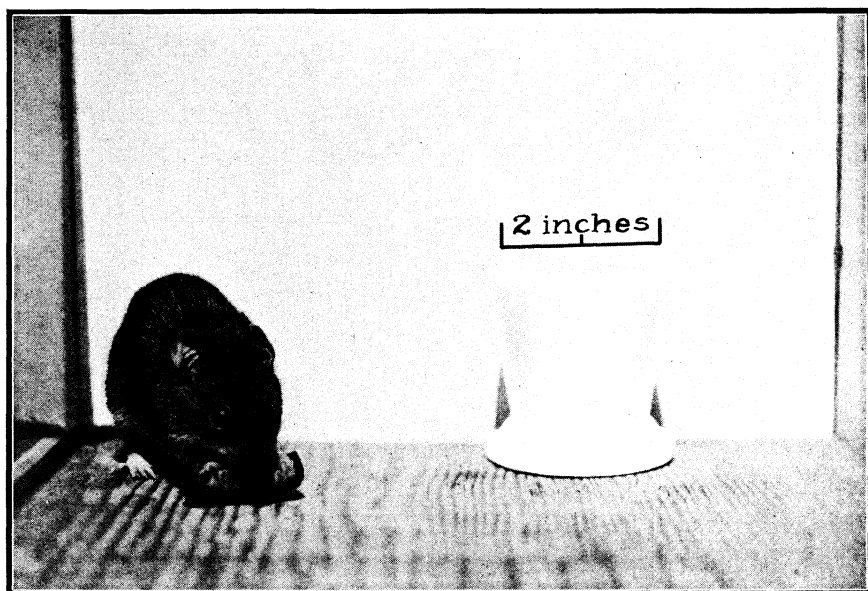
♀





♂

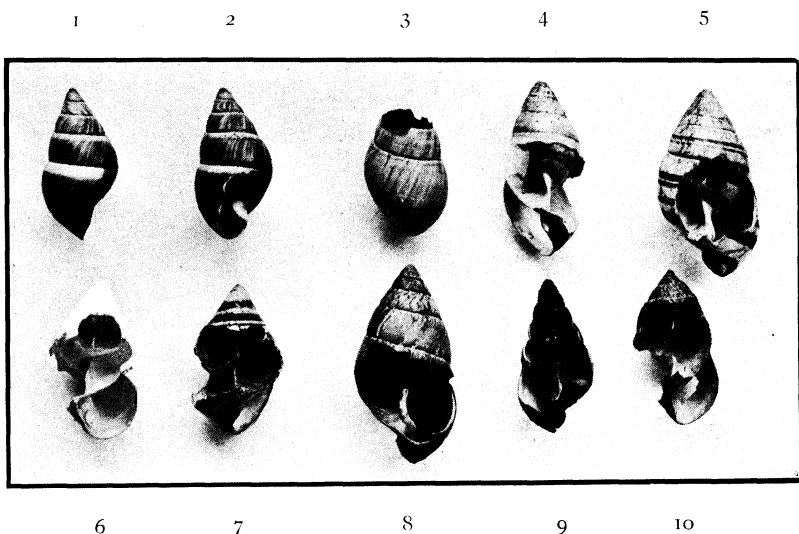
♀



♂

HAWAIIAN RATS.





HAWAIIAN PULMONATES ATTACKED BY RATS. NO. 2 BY NATIVE RAT
IN CAPTIVITY; NOS. 3-10 BY INTRODUCED RATS.

- No. 1. *Partulina redfieldii*; whole immature specimen for comparison.
 No. 2. *Partulina redfieldii*; aperture attacked.
 No. 3. *Achatinella fulgens*; apex attacked.
 No. 4. " *fulgens*; ultimate and penultimate whorls attacked.
 No. 5. " *phaeozona*; ultimate and penultimate whorls attacked.
 No. 6. " *apicata*, var. *aloha*; ultimate and penultimate whorls
 attacked.
 No. 7. *Achatinella apicata*, var. *beata*; ultimate and penultimate whorls
 attacked.
 No. 8. *Laminella gravis*, var. *aurantium*; ultimate whorl attacked.
 No. 9. *Amastra spirozona*; all but apical whorls attacked.
 No. 10. *Amastra tristis*; all but apical whorls attacked.
 All arboreal except No. 10, which is terrestrial.





3 9015 01637 3519

PUBLICATIONS
OF THE
Bernice Pauahi Bishop Museum
Honolulu, Hawaii, U. S. A.

MEMOIRS.

(Quarto.)

Vol. I.—Nos. 1-5. 1899-1903.

Vol. II.—Nos. 1-4. 1906-1909.

Vol. III.—Ka Hana Kapa: The Making of Bark-cloth in Hawaii. By Wm. T. Brigham. 1911. Complete volume.

Vol. IV.—Fornander Collection of Hawaiian Antiquities and Folk-lore. Gathered by Abraham Fornander. With Translations Revised and Illustrated with Notes by Thomas G. Thrum. Part I. 1916. [Part II in press.]

OCCASIONAL PAPERS.

(Octavo.)

Vol. I.—Nos. 1-5. 1898-1902. [No. 1 out of print.]

Vol. II.—Nos. 1-5. 1903-1907.

Vol. III.—Nos. 1, 2, 3, 4. 1907-. [Volume incomplete.]

Vol. IV.—Nos. 1-5. 1906-1911.

Vol. V.—Nos. 1-5. 1912-1913.

Vol. VI.—No. 1. Director's Report for 1913. — New Hawaiian Plants, IV. By Charles N. Forbes. 1914.

No. 2. Director's Report for 1914. 1915.

No. 3. Director's Report for 1915. New Hawaiian Plants, V. By Charles N. Forbes. 1916.

A Handbook for the Bishop Museum. 1903. [Out of print.]

Bishop Museum Handbook.—Part I: The Hawaiian Collections. 1915. Octavo.—Part II: Hawaiian Fishes. (In preparation.)

Index to Abraham Fornander's "An Account of the Polynesian Race." By John F. G. Stokes. 1909. Octavo.

A detailed list, with prices, will be mailed to any address on application to the Librarian.

