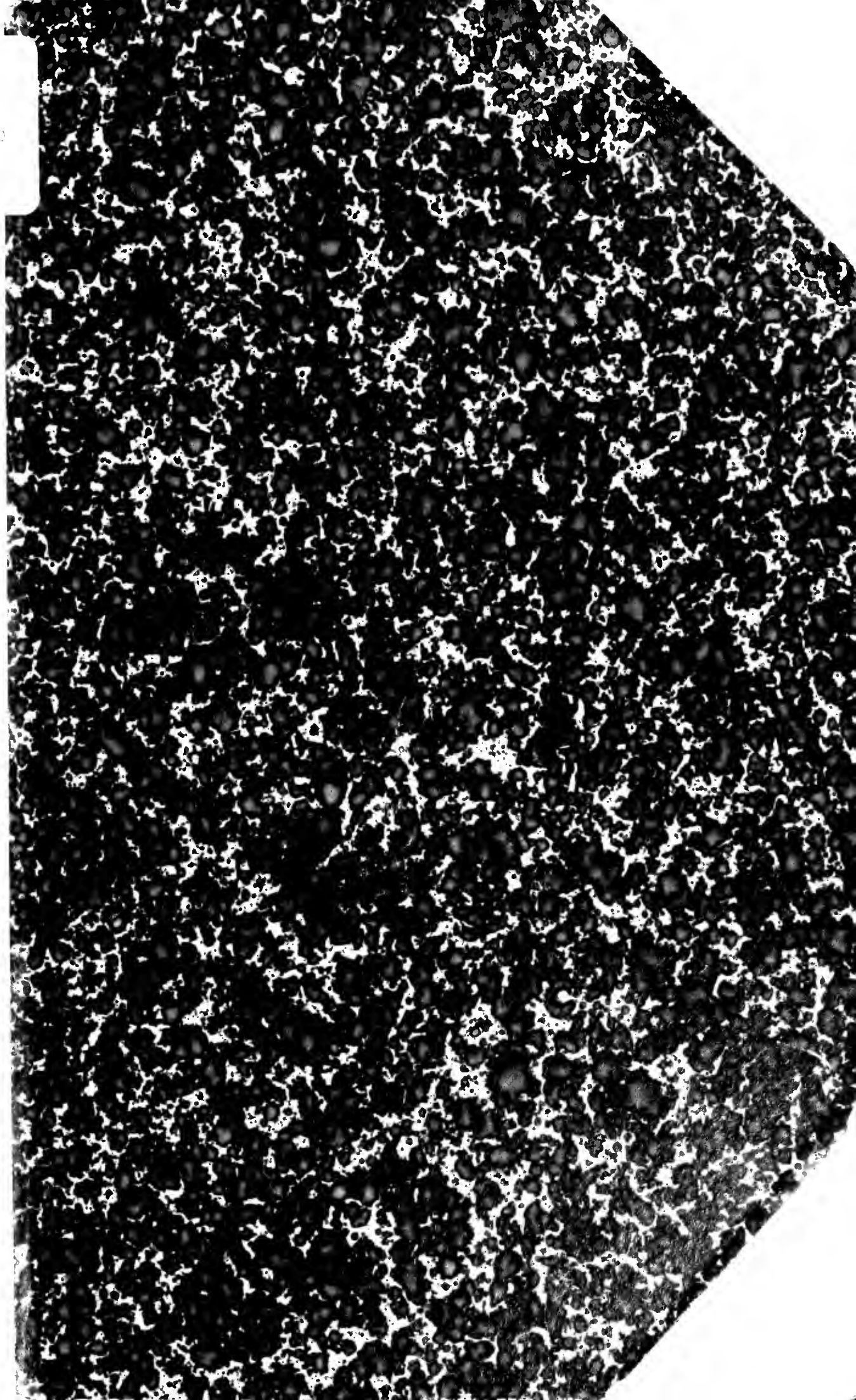

Memoirs of the Museum of Comparative Zoölogy
AT HARVARD COLLEGE.
Vol. XXVI. No. 2.

REPORTS ON THE SCIENTIFIC RESULTS OF THE EXPEDITION TO THE TROPICAL PACIFIC, IN CHARGE OF ALEXANDER AGASSIZ, BY THE U. S. FISH COMMISSION STEAMER "ALBATROSS," FROM AUGUST, 1899, TO MARCH, 1900, COMMANDER JEFFERSON F. MOSER, U. S. N., COMMANDING.

II.

SOME SPECIES OF PARTULA FROM TAHITI.

A STUDY IN VARIATION.

By ALFRED GOLDSBOROUGH MAYER.

WITH ONE PLATE.

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The snails studied in this paper were collected in Tahiti by Dr. H. F. Moore, Ensign C. S. Kempff, U. S. N., and the author during two visits of the United States Fish Commission Steamer "Albatross" to the Island, from Sept. 27–Oct. 4, and from Nov. 6–13, 1899.

A great deal has been written concerning the classification of the species of Partula inhabiting the Islands of the Tropical Pacific. Unfortunately, however, the various species have been distinguished only by inspection of the color, form, etc., of the adult shells; and no attempt has been made to dissect the young out from the full-grown snails and thus determine, by direct evidence, whether or no the so-called "species" intergrade, and if so to what extent. There can be no doubt that if this method were pursued with all the known varieties and so-called "species" of such variable snails as Partula and Achatinella, the number of "species" would be much reduced; and above all our knowledge of the true relationships of the various forms would become established upon a more trustworthy basis than can be derived from decisions concerning merely the external resemblance or dissimilarity of the adult shells. A good example of the confusion which has crept into the synonymy of these species may be instanced in the case of Partula otaheitana (Figs. 3–8), where no less than nineteen specific names have been proposed for the various color varieties.

An extensive collection and a careful study of the Partulæ of Tahiti has been made by A. J. Garrett, Journ. Acad. Nat. Sci. Philadelphia, Ser. 2, 1884–95, pp. 43–81. Pls. II. and III. Garrett spent many years upon the Island, and his accounts of the distribution and relationships of the various forms is thus more accurate than are those of other authors who have not visited Tahiti. From him we learn that Partula hyalina (Figs. 1 and 2), although rare, is found everywhere in Tahiti, and it also inhabits the Austral Islands, and Mangaia, one of the Cook group. It nowhere gives rise to any varieties, and is the most widely distributed Partula known. Also, according to Garrett, Partula otaheitana (Figs. 3–8) has its headquarters in Fautaua ("Fautana") valley near Papeete, but is also found "all around the Island." I failed to discover it either in Maruapoo or Vaihiria valleys, and if it exists now in either of them it must be very rare. Partula filosa (Figs. 9, 10) is found only in Piræ (Pirai valley), while Partula sinistrorsa (Figs. 11–13) is found only on the south coast of "Tahiti, where it exists in profusion in the lowland forests for a distance of about ten miles." It is probable, however, that Garrett has confused some of the varieties of P. sinistrorsa with P. otaheitana. Garrett found the dextral P. nodosa restricted to a limited area about two miles up Punaauia valley on the west coast of Tahiti. I discovered a similarly colored *sinistral* snail in Maruapoo valley immediately south of, and adjacent to, Punaauia valley, and have no doubt that it is merely a sinistral, local, variety of P. nodosa (see Figs. 14, 15). Systematic descriptions of the Partulæ of Tahiti have been given by Pfeiffer, Pease, Reeve, Carpenter, and others. A complete citation of their works is given by W. D. Hartman: A catalogue of the genus Partula, West Chester, Pennsylvania, 1881, and also in Proc. Acad. Nat. Sci. Philadelphia, 1885, pp. 203–223.

The general topography and the names of the valleys in the neighborhood of Papeete is given in the British Admiralty Chart of the South Pacific, No. 1158, published July 22, 1895. A good general map of the Tahitian streams and valleys is given in "Karte der Insel Tahiti," J. A. Hecht, 1875.

As is well known the Island of Tahiti is figure 8-shaped, each half of the 8 being formed of a separate volcanic centre. The Island has been subjected to much erosion, and more than 140 deep trough-like valleys extend down-

ward from the high interior to the coast. The general trend of each of these valleys is perpendicular to the coast-line situated at its base, and thus it comes about that adjacent valleys are approximately parallel each to each, and separated from each other by a sharp-edged ridge. Many of the valleys are very broad at their bases near the sea-coast, but they all become narrow gorges in the interior of the Island. The sides of the valleys are steep, often 35°–60°, and in many places precipitous. The copious rain-fall on the upper slopes is sufficient to maintain a stream in almost every valley. The valley-bottoms are thus well watered and support a luxuriant growth of forest trees, such as the Tahitian chestnut (Inocarpus edulis), the "Purau" (Paritium tiliaceum), and others. The wild plantain, or "Fei" (Mussa troglodytarum Linn.), Turmeric (Curcuma), and Dracæna grow in abundance in the moist earth of the valley-bottom, while the Caladium (Colocasia) clusters along the banks of the stream, and the ground under the trees is covered with a carpet of moss and ferns. This vegetation extends for a considerable distance up the sloping sides of the valley, and high up among the mountains the wild plantain and Dracæna often form a continuous forest crossing the ridges from valley to valley. Lower down, however, the ridges between the valleys are covered by a tangled mass of reeds and guava bushes, or are wholly barren of vegetation for long areas; and probably constitute a barrier over which it is impossible for snails to pass from valley to valley. Indeed the physical features of the Island, in so far as the nature of the valleys is concerned, are strikingly similar to the conditions found on the Island of Oahu of the Hawaiian Islands; and in Tahiti, as in Oahu, we find that the snails of each valley are possessed of marked and peculiar characters which distinguish them more or less from the snails of adjacent valleys.

It is evident that we have in Tahiti an opportunity to study the range of variability of the several, more or less isolated colonies of snails living in the different valleys, and to determine the relationships which may exist between the various forms.

Snails were collected in the following six valleys: Piræ, Hamuta, Fautaua, Tipærui, Maruapoo, and Vaihiria. Piræ, Hamuta, Fautaua, and Tipærui valleys are approximately parallel each to each, and are situated on

the north side of the Island in the neighborhood of Papeete. Hamuta valley lies between Piræ and Fautaua, while Tipærui valley is situated to the westward of Fautaua and is separated from it by three ridges. The base of Piræ valley is about two miles east of Papeete, while the foot of Tipærui valley lies at the western end of the town, about three miles west of Piræ valley. Maruapoo valley is situated on the western side of the Island in the district of Punaauia, and is distant about eight miles from Papeete, while Vaihiria valley is upon the south side of the Island, twenty-seven miles from Papeete. Piræ, Fautaua, and Tipærui valleys are broad and well watered, and contain a luxuriant growth of wild plantains and Caladium, upon which the snails are found in large numbers. Hamuta valley is a deep, narrow trough lying between Piræ and Fautaua valleys. Few wild plantains are found within it, and the Caladium is not very abundant. Indeed the majority of the snails obtained in this valley were found upon the leaves and stems of Dracæna. Maruapoo valley is a narrow gorge with precipitous sides. There is but little wild plantain in the valley, and almost all of the snails were found upon the Caladium, which grows in abundance. Vaihiria valley is one of the largest and longest in Tahiti. A stream about ten yards wide and one in depth flows through the valley, and dense thickets of Turmeric extend for miles along its banks. The vegetation of this valley is very varied, all of the characteristic Tahitian trees and plants being represented in great numbers. The Caladium and the wild plantain grow here in abundance, but most of the snails were found upon the wild Turmeric, almost none being discovered upon the Caladium, and but few upon the leaves of the wild plantain.

In all of the valleys except Vaihiria the snails were found high up, very few of them being captured below 200 feet above sea-level, while above this point they grew more and more abundant as one ascended the valley-bottom. In Vaihiria valley, on the contrary, no snails were met with over 300 feet above sea-level, while they were found in considerable numbers from an altitude of 100 feet to near sea-level. It is remarkable that in Vaihiria valley, despite its luxuriant vegetation, and abundant supply of water, snails were much less common than in any of the other valleys which we explored.

The snails are probably nocturnal, for they were almost never found crawling during the day. With five exceptions they were all found upon the *under* sides of the leaves and stems of the plants they affect. They show a very decided preference for certain plants, and almost all of them were discovered upon the wild plantain and Caladium. In Hamuta valley, however, they were quite abundant upon Draeæna; and in Vaihiria the great majority of them were found upon the Turmeric. About half a dozen snails were found upon the stems of Guava (Psidium guaiava), "Purau" (Paritium tiliaceum), and upon various species of ferns.

It was my habit to spend the greater part of a day in each of the valleys and to take every snail which was seen.

As is well known, these snails are hermaphroditic and viviparous, and bring forth their young in an advanced state of development; and in order to facilitate the study of the relationships between the various forms, the young were dissected out from every adult containing them. The following table will show the number of snails captured in each valley, the number of adults which contained young snails, and the number of young which were dissected out from them. It will also show what might be termed the "ratio of fecundity," or the number of young for adult containing them.

Name of valley.	Date.	Total number of snails collected.	Number of snails containing young	Number of young taken from the adults.	Number of young per adult.
	1899.				
Piræ . . .	Nov. 13	164	61	91	1.5
Hamuta . .	Oct. 2	127	64	127	2.0
Fautaua . .	Sept. 29[1]	47	27	43	1.6
" . .	Nov. 7	111	52	102	2.0
Tipærui . .	Sept. 28	124	72	130	1.8
Maruapoo .	Nov. 15	101	55	94	1.7
Vaihiria . .	Nov. 9	61	19	23	1.2
Total		735	350	610	Av. 1.7

We see from the above table that the snails differ both in abundance, and in their fecundity in the various valleys.

Certain general statements may, however, be made concerning the Partulæ of all six valleys. For example, the young of dextral or sinistral snails

[1] These snails were collected in about two hours instead of in six hours, as in other cases.

are usually dextral or sinistral respectively, but this is not invariably the case. It is interesting to observe, however, that *all* of the young developed within any given adult are either dextral or sinistral, never some of them dextral and others sinistral. The young are born one at a time; three eggs and two or three young snails in various stages of development being often found in a single adult animal. At the time of birth the shell of the young one comprises two and a half whorls. No young are developed until after the lip of the adult shell has been completely formed.

Partula hyalina Broderip.

Figs. 1, 2; 1'-1'.

This snail is found in all six valleys, but is never abundant; constituting but $2\frac{1}{2}$ per cent of the total number of snails in Piræ, 3 per cent in Hamuta, 12 per cent in Fautaua, 7 per cent in Tipæruı, 1 per cent in Maruapoo, and 2 per cent in Vaihiria valley. It is readily distinguished from all the other snails by its milky-white, translucent shell, and the absence of a tooth upon the columella. Every individual found is dextral, as are also the young taken from the adults. In all forty-four specimens were obtained, and nineteen of these yielded fifty-five young snails. The young are all white in color, and show no tendency to intergrade with the young of any other species, hence we conclude that this is a true species separate and distinct from any other snail of the six valleys.

Partula otaheitana Bruguière.

Figs. 3-8.

Piræ, Hamuta, Fautaua, and Tipæruı Valleys. The relationships of the color-types represented in Figs. 3, 4, 5, and 8.

These forms, which are represented in Figs. 3, 4, 5, and 8, are mere color varieties of one and the same species. They are found in Piræ, Hamuta, Fautaua, and Tipæruı valleys, but appear not to exist in Maruapoo or Vaihiria. Fig. 3 represents the lightest colored type, where the entire shell is of a horny-yellow hue, while Fig. 4 represents the darkest type, the shell being of a uniform rich brown. In Fig. 5 we see a horny-

brown shell streaked longitudinally with darker brown, while Fig. 8 shows a light horny-brown shell having the apex tinged with pink. Many individuals which are intermediate in color between these various forms are found. An idea of the relative abundance of these color varieties in the different valleys may be obtained through an inspection of Table I. at the end of this paper.

Shells of the color-type represented in Fig. 3 are abundant in all of the four valleys, but are especially characteristic of Piræ, where they constitute 58 per cent of the entire number of snails found in the valley.

Fig. 4 is drawn from the darkest snail obtained in Tipærui valley. It contained two young which were much lighter in color than their parent, and resembled the young commonly found in snails of the type represented by Fig. 5.

Snails of the type of Fig. 5 are abundant in Hamuta, Fautaua, and Tipærui valleys, where they constitute 47, 62, and 53.5 per cent, respectively, of the shells found in each valley. In Piræ valley, however, they are not so abundant, constituting but 19 per cent of the snails found.

Fig. 8 represents a snail which resembles Fig. 3, excepting that the apex of the shell is tipped with pink.[1] It is remarkable that in Hamuta valley 63 per cent of the snails of the types shown in Figs. 3 and 5 are pink-tipped. In Piræ and Fautaua 9.5 per cent and 30 per cent respectively of these snails are pink-tipped, while in Tipærui valley none of them display this peculiarity. This as well as all the other evidence which we have collected concerning the biology of the Tahitian snails leads one to believe that the constitutions and inherited tendencies of the snails of any given valley are quite different from those of the snails of any other valley; for it would be difficult on any other grounds to account for the fact that the horny epidermis is readily disintegrated in Hamuta, while it resists weathering almost perfectly in Tipærui valley.

In Tipærui valley *all* of the snails represented in Figs. 3, 4, 5, and 8 are dextral, while in Piræ valley they are *all* sinistral. In the two intermediate valleys, Fautaua and Hamuta, however, the snails are some of them dextral, others sinistral. For example, in Fautaua valley 54 per cent

[1] This pink coloration is due to the partial disappearance of the outer epidermis of the shell.

are sinistral and 46 per cent dextral; while in Hamuta valley 69 per cent are sinistral and 31 per cent dextral. We see, then, that the snails gradually change from dextral to sinistral as we pass from Tipærui to Piræ valley.

Two hundred and eight snails of the type represented in Figs. 3 and 8 were collected in the four valleys, and 96 of them contained 150 young. 71 per cent of these young snails were of a light horny-yellow color very similar to that of the parent snail; 10 per cent, however, were slightly lighter than the parent, and 19 per cent were considerably darker in color than the shell from which they were dissected, and resembled the normal young obtained from snails represented by Fig. 5. Turning to the color-type represented in Fig. 5, we find that out of 255 individuals collected in Tipærui, Fautaua, Hamuta, and Piræ valleys, 119 contained 198 young. Of these young snails 55 per cent were very similar in color to the adults from which they were dissected, 40 per cent were lighter in color and resembled the normal young of the color type shown in Figs. 3 and 8, while 5 per cent were slightly darker than the parent shell. It is evident, therefore, that Figs. 3, 5, and 8 represent mere color sports of one and the same species of snail, for the young intergrade freely.

In Tipærui valley *all* of these young snails are dextral, while in Piræ they are all sinistral, exactly as are the adults in the respective valleys. In Fautaua valley, however, 54 per cent of the adults and 55.5 per cent of the young are sinistral; while in Hamuta, which lies between Fautaua and Piræ valleys, 69 per cent of the adults and 73 per cent of the young are sinistral. The small discrepancies between the percentages of sinistral adults and their sinistral young are probably due to aberrations of chance caused by the smallness of the number of snails observed, and would perhaps tend to disappear were a larger number to be studied.

It is interesting to observe that in Fautaua valley the dextral adults give 60 per cent dextral and 40 per cent sinistral young; while the sinistral adults of the same valley give 68 per cent sinistral and 32 per cent of dextral young. Also in Hamuta valley the dextral adults give 66.6 per cent dextral and 33.3 per cent sinistral young; while the sinistral adults give 95.5 per cent sinistral and 4.5 per cent dextral young. We see

that in both cases the sinistral snails breed truer to their type than do the dextral.

Partula otaheitana var. lignaria Garrett.

Figs. 6, 7.

The snail represented in Fig. 6 is found in Tipærui valley. The ground-color of the shell is quite similar to that of snails of color-type 5, but they are distinguished from the latter by the presence of a more or less distinct whorl-stripe, which extends from the suture of the spire through the middle of the body-whorl. In a few individuals there are two separate whorl-stripes, one through the middle of the body-whorl and the other adjacent to the suture. These snails constitute 26.5 per cent of the fauna of Tipærui valley. All of the specimens obtained were dextral, as were also the young dissected from them. Nineteen adults yielded thirty-three young, of which number twenty-eight were similar in ground-color to the type of snail shown in Fig. 5, while two were as light as the snails represented in Figs. 3 and 8, and three were slightly darker in color than the parent shells.

Of these young ones 41 per cent exhibit a distinct whorl-stripe, while 59 per cent are unstriped, and resemble in all respects the normal young of snails of type 5. Indeed among the sixty-one young taken from adults of type 5 in Tipærui valley, five exhibit the whorl-stripe characteristic of the young of type 6. There can be but little doubt, therefore, that in type 6 we have a race of snails which is derived from type 5, and which under conditions of more perfect isolation might in time develop into a distinct form. It is possible that this tendency may be prevented in Tipærui valley by constant intercrossing between the adults of types 5 and 6.

Fig. 7.

The sinistral snail with two whorl-stripes, which is represented in Fig. 7, is found in Hamuta and Piræ valleys, where they constitute 3 per cent and 4 per cent respectively of the snail-fauna. In Hamuta valley four adults yielded seven young, five of which were as light in ground-color

as the young of type 3 from the same valley, while two were slightly darker and resembled the ground-color of the young of type 5. Of these seven young, only one exhibited the whorl-stripe, the others being of a uniform ground-color. All of the adults were sinistral, while of the young three are dextral and four sinistral. There can be no doubt that type 7 of Hamuta valley is derived directly from snails of types 3, 5, and 8, of the same valley, and that together they form a race between the members of which no specific distinctions can be drawn. Snails of type 7 are also found in Piræ valley; unfortunately, however, only one young one was obtained from the five adults collected. This young snail possessed the ground-color of snails of type 5 with the addition of a very faint whorl-stripe.

Partula filosa Pfeiffer.

Figs. 9, 10.

This snail is found in Piræ valley. It may at once be distinguished from all other forms in this valley by its small size and the short blunt spire, also the outer surface is furrowed by deep longitudinal striæ, and the shells are all dextral. Thirty adults were collected, of which fourteen are dark brown in color and well represented by Fig. 9, while thirteen are light in color and resemble Fig. 10; and two others are intermediate in hue between Figs. 9 and 10. Ten adults of type 9 yielded twelve young, of which five were as light as type 10, while seven were similar to their parents in color. Eight adults of type 10 give eleven young, of which eight were about the same color as their parents, while three were darker and resembled type 9 in color. There can be no doubt, therefore, that Figs. 9 and 10 represent one and the same species of snail.

Summarizing the preceding observations, we find that there are but three species of Partulæ in Piræ, Hamuta, Fautaua, and Tipærui valleys. Two of these species, represented in Figs. 1, 2, and Figs. 3–8, respectively, are common to all four valleys; while the third, represented in Figs. 9 and 10, is found only in Piræ valley. The snail represented in Figs. 1 and 2 (P. hyalina Broderip) is found in scanty numbers in every valley in Tahiti which the author explored. It is a distinct species, and shows no tendency

to intergrade with any other forms, the young being always dextral in whorl, and of a white milky color very similar to the adult shell. Figs. 3–8 represent mere color varieties of one and the same species (P. otaheitana). Snails of the types of Figs. 3 and 5 are very common in all four valleys. Fig. 4 represents an extremely dark-brown individual found in Tipærui valley. No other individual was found which displayed this degree of melanic coloration, although many were found of a hue intermediate between Figs. 4 and 5. The pink-tipped snails illustrated in Fig. 8 are common in Hamuta valley, but are not very abundant in Fautaua or Piræ valleys, and were not discovered in Tipærui valley. Figs. 6 and 7 represent a peculiar color variety (P. otaheitana var. lignaria) which is evidently derived from the snails shown in Figs. 3, 4, 5, and 8; for some of the young taken from snails of the type of Figs. 6 and 7 resemble the normal young[1] of types 3, 4, 5, and 8, while some of the young of the latter exhibit the whorl-stripes characteristic of the normal young of Figs. 6 and 7. The snails of the type of Figs. 6 and 7 occur in the same valleys as their close relatives of the types of Figs. 3, 4, 5, and 8, and it is not improbable that their tendency to generate a whorl-striped variety is swamped by frequent inter-crossing with the unstriped snails of the same valleys. Were they isolated, it seems probable that they would soon initiate a new race, and in time perhaps a distinct species.

Partula hyalina, *Figs. 1, 2.* *Partula nodosa* var. *sinistralis*, *Figs. 14, 15.*
Maruapoo Valley.

Maruapoo valley is situated on the western side of Tahiti, about seven miles south of Tipærui valley, from which it is separated by at least seven ridges. Of the two species of snails found in Maruapoo, only one is common to both Tipærui and Maruapoo. This one is the translucent milky-white species, P. hyalina, represented in Figs. 1 and 2. The predominant species of Maruapoo, P. nodosa Pfeiffer, var. sinistralis, is represented in Figs. 14 and 15, and constitutes 99 per cent of the snail-fauna of the valley. The shell is blunt in shape, and the spire is short. The lip is quite thick, and is usually

[1] The term "normal young" is applied to any young snail which is similar in color to the adult which bore it.

provided with a well-developed tooth upon the columellar side, and there is also a tooth upon the wall of the aperture. The surface of the shell is smooth and slightly polished, and there are no deep longitudinal furrows. About 57 per cent of these snails are well represented by Fig. 14. The ground-color is a light horny-yellow streaked longitudinally with darker brown, in addition to which there are two dark-brown whorl-stripes and a white whorl-stripe adjacent to the suture of the spire. In about 43 per cent the dark-brown whorl-stripes are either absent or very faint, and the ground-color of the shell varies from light horny-yellow to rich brown. A snail of this type is fairly well represented in Fig. 15, a dark-brown individual being drawn. Ninety-seven per cent of the adult snails of type 14 and 91 per cent of type 15 are sinistral; while of the young, 100 per cent from type 14 and 90 per cent from type 15 are sinistral. In the case of the snails of type 15, twenty-six sinistral adults gave forty-six sinistral and one dextral young; while two dextral adults gave four dextral and no sinistral young. Among the snails of type 14, only one of the dextral adults contained young, and this one gave a single sinistral offspring. Twenty-six whorl-striped adults of the type of Fig. 14 gave forty-two young, of which 76 per cent display whorl-stripes, while 24 per cent are plain colored. On the other hand, twenty-eight adults of type 15, which are either unstriped or with very faint whorl-stripes, gave fifty-one young, of which 61.5 per cent are marked with whorl-stripes and 38.5 per cent are plain colored. It is very evident that the striped and unstriped forms intergrade.

Of the one hundred adults found in the valley, 94 per cent are sinistral, while of the eighty-eight young taken from them, 94.5 per cent are sinistral. This condition appears, therefore, to be stable from one generation to another.

It will be observed that P. nodosa is somewhat like P. filosa (Figs. 9 and 10) from Piræ valley; it differs from the latter, however, in that there is a well-developed tooth upon the columellar lip, and the surface of the shell is polished and never furrowed, with dull-colored longitudinal grooves.

Partula hyalina, Figs. 1, 2. Partula sinistrorsa Pease, Figs. 11–13.
Vaihiria Valley.

Vaihiria valley is situated on the south side of the Island, about nineteen miles from Marnapoo, from which it is separated by about thirty ridges. There appear to be but two species of Partula in this valley, one of which is P. hyalina, represented in Figs. 1 and 2. The other species, P. sinistrorsa, represented in Figs. 11–13, constitutes 98 per cent of the snail fauna of the valley. These snails are very variable in color, and were it not for the fact that they all[1] give light yellow-white colored young they might readily be mistaken for several distinct species. Sixty-one per cent of the snails of this species belong to the type illustrated in Figs. 11 and 12, where the surface of the shell is smooth and polished and the ground color is of a light horny-yellow. Two broad whorl-bands of darker color traverse the body-whorl, and usually extend about the distance of another whorl up the spire of the shell. In about 95 per cent of these shells the whorl-stripes are of a rich dark-brown, as in Fig. 11, while in about 5 per cent they are faint in color, as in Fig. 12, or absent.

In about 8 per cent of the snails belonging to the predominant species of Vaihiria valley the ground-color is of a light horny-yellow, very similar to the color of Fig. 3, while in about 16 per cent the ground-color is of a light horny-brown, streaked longitudinally with darker brown, giving very much the appearance of Fig. 5. Again, in about 10 per cent the shell is of a uniform rich dark-brown, similar in color to Fig. 4. Finally, in about 3 per cent of the snails the shell is parti-colored, the body-whorl being light horny-yellow, while the spire is rich brown, as in Fig. 13.

The snails of Vaihiria valley may be distinguished from those of similar color in Tipæmi, Fautaua, Hamuta, and Piræ valleys by the following characters: In Vaihiria valley the snails lack a tooth upon the wall of the aperture, and the lip is relatively thin and fragile. The shell is also more constricted at the suture than is the case in the snails of the valleys near

[1] A single light-brown adult gave one light-brown young; all of the others gave light yellow-white colored young ones.

Papeete. Moreover, no matter what the color of the adult shell may be in Vaihiria, the young is light yellow, almost white.

All of the snails of the types represented by Figs. 11–13 are sinistral, as are also their young. Six snails of a uniform dark-brown color were found, and of these five were sinistral and one dextral. Among these, only one adult, a sinistral one, gave a single sinistral young.

Five light horny-yellow snails of uniform plain color were found, and all of these were dextral. Among them two adults gave rise to four dextral young. It is possible that these light-colored dextral snails may be considered specifically distinct from their darker associates, but as they give rise to young of the same color and general appearance as do the other snails of the valley, it seems probable that no specific distinction can be drawn.

Ten snails of a light horny-brown ground-color, streaked longitudinally with darker brown, were found. All were sinistral, and four of them gave six sinistral young.

Altogether, 90 per cent of the snails of Vaihiria valley are sinistral, as are also 90 per cent of the young dissected from them.

General Conclusions.

In Tahiti five species of Partula were found in the six valleys of Piræ, Hamuta, Fautaua, Tipærui, Maruapoo, and Vaihiria.

One species (P. hyalina Broderip), represented in Figs. 1 and 2, is rare everywhere, and yet it is found in all of the valleys. This is the only snail that is universally distributed. Another (P. otaheitana), shown in Figs. 3–8, is predominant in Piræ, Hamuta, Fautaua, and Tipærui, but is not found in the other valleys. The three other species are restricted each to a single valley. For example, the species shown in Figs. 9, 10 (P. filosa) is found only in Piræ valley, while the forms illustrated in Figs. 11–13 (P. sinistrorsa), and 14, 15 (P. nodosa var. sinistralis) are found, the former in Vaihiria and the latter in Maruapoo valley.

Partula hyalina, represented in Figs. 1 and 2, is very stable in all of the valleys, and gives rise to no varieties. All of the other species, however, are remarkably variable, and give rise to numerous color-sports.

These color-sports tend to breed true to themselves, and therefore to originate new color-forms and finally new species. This tendency is, however, held in check by frequent inter-crossing with the parent stock, and becomes effective only when the new color-variety is isolated, or when it displays a remarkably strong tendency to breed true. A good example of a color-variety that tends to breed true, but which is nevertheless held in check by frequent inter-crossing with the parent stock, is afforded by the type of snail represented in Fig. 6, which is derived from the type shown in Fig. 5, both coming from Tipærui valley. Here we find that 59 per cent of the young of Fig. 6 resemble the normal young of Fig. 5, while 8 per cent of the young of Fig. 5 exhibit the whorl-stripe characteristic of the young of Fig. 6.

It is probable that geographical isolation plays a most important part in the formation of new species. If two valleys be adjacent, their snails are closely related each to each, whereas the wider the separation between any two valleys, the more distant the relationship between their snails. The ridges between the valleys, being either barren or covered with vegetation unsuitable to the snails, afford barriers over which the animals must find it more or less difficult to pass. Thus the Partulæ in the Tahitian valleys are isolated very much as are the Achatinellidæ of Oahu in the Hawaiian Islands.

In Tahiti the snails are most abundant in the valley-bottoms, where they usually occur on the under sides of the leaves of Caladium and Plantain, although in some valleys they are frequently found on Dracæna and Turmeric. Although more abundant in the bottom, they extend for some distance up the sides of the valley and appear to be present in most places where the plants which they affect are found. As far as the very limited observation of the writer goes, there appears to be no difference in the character of the snails in different parts of the same valley. The difference between any two adjacent valleys is, however, very marked.

All of the snails of Tipærui valley are dextral, while all of the same species in Piræ valley are sinistral. In the two intermediate valleys of Hamuta and Fautaua some individuals are dextral and some sinistral.

TABLE I.

SHOWING THE ACTUAL NUMBER OF SNAILS COLLECTED, AND THE PERCENTAGE OF EACH COLOR-TYPE IN THE SNAIL-FAUNA OF EACH VALLEY. THE GREATER NUMBER OF THESE COLOR-TYPES ARE FIGURED ON THE PLATE.

Name or description of snail.	Number and percentage of each color-type of snail in each valley.											
	Piræ Valley.		Hamuta Valley.		Fautaua Valley.		Tipa-rui Valley		Maruapoo Valley.		Vaihiria Valley.	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Partula hyalina Figs. 1, 2 . .	4	2.5	4	3	20	12	9	7	1	1	1	2
Partula otaheitana { Figs. 3, 8	95	58	58	46	40	26	15	12	. .	. .	. .	. .
Partula otaheitana { Fig. 4	. .	. .	. .	. .	. .	. .	1	1	. .	. .	. .	. .
Partula otaheitana { " 5	31	19	60	47	98	62	66	53.5	. .	. .	. .	. .
Partula otaheitana var. lignaria { " 6	. .	. .	. .	. .	. .	. .	33	26.5	. .	. .	. .	. .
Partula otaheitana var. lignaria { " 7	5	3	5	4	. .	. .	. .	. .	. .	. .	. .	. .
Partula filosa { " 9	14	8.5	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Partula filosa { " 10	15	9	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Partula sinistrorsa { " 11	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	35	58
Partula sinistrorsa { " 12	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	2	3
Partula sinistrorsa { " 13	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	2	3
Partula nodosa var. sinistralis { " 14	. .	. .	. .	. .	. .	. .	. .	. .	57	56.5	. .	. .
Partula nodosa var. sinistralis { " 15	. .	. .	. .	. .	. .	. .	. .	. .	43	42.5	. .	. .
Plain colored light horny-yellow	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	5	8
Plain colored dark brown . .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	6	10
Light horny-yellow with longitudinal brown streaks . . .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	10	16
	164	100	127	100	158	100	124	100	101	100	61	100

TABLE II.

SHOWING THE NUMBER, COLOR, AND CHARACTER OF WHORL OF YOUNG SNAILS DISSECTED OUT FROM ADULTS OF P. OTAHEITANA OF THE TYPE SHOWN IN FIGS. 3, 8.

Valley.	Number and character of adults from which young were obtained.	Number of young which are slightly lighter than the parent shell.	Number of young which are similar in color to the parent shell.	Number of young which are darker than the parent shell, and resemble the normal young of snails shown in Fig. 5.	Number of dextral young.	Number of sinistral young.
Tipærui . .	9 D	1	8	3	12	0
Fautaua . .	9 D	2	10	3	10	5
"	16 S	5	17	7	20	9
Hamuta . .	22 S	2	17	14	2	31
"	10 D	3	10	1	8	6
Piræ . . .	30 S	2	44	1	0	47
	96	15	106	29	52	98
		10%	71%	19%		
			150			

D indicates that the shell is dextral in whorl ; S, sinistral.

TABLE III.

SHOWING THE NUMBER, COLOR, AND CHARACTER OF WHORL OF YOUNG SNAILS DISSECTED OUT FROM ADULTS OF P. OTAHEITANA OF THE COLOR-TYPE SHOWN IN FIG. 5.

Name of valley.	Number and character of adults from which young were obtained.	Number of young which are lighter in color than the parent shell and resemble the normal young of snails shown in Fig. 3.	Number of young which are similar in color to the parent shell.	Number of young which are darker than the parent shell.	Number of dextral young.	Number of sinistral young.
Tipærui . .	37 D	21	36	4	61	0
Fautaua . .	21 D	12	23	0	20	15
" . .	22 S	14	19	3	1	35
Hamuta . .	8 D	3	10	0	10	3
" . .	21 S	21	14	3	1	37
Piræ . . .	10 S	9	6	0	0	15
	119	80	108	10	93	105
		40%	55%	5%		
			198			

D indicates that the whorl of the shell is dextral; S, sinistral.

EXPLANATION OF THE PLATE.

Five species of snails are represented on the Plate; as follows: Figs. 1, 2. *Partula hyalina* Broderip; Figs. 3–8. *Partula otaheitana* Brugnière; Figs. 9, 10. *Partula filosa* Pfeiffer; Figs. 11–13. *Partula sinistrorsa* Pease; Figs. 14, 15. *Partula nodosa* var. *sinistralis* Pfeiffer = *P. trilineata* Pease.

Figs. 1–15 represent adult or nearly full-grown snails, while Figs. 1^a–3^a, etc., show young snails taken from adults of corresponding number. Thus: 3^a is a young one taken from the type of snail represented in Fig. 3, etc. These Figures of young snails are four times the natural size, while the Figures of adults are one and a half times the natural size.

Figs. 1, 2. *Partula hyalina.* — From a snail obtained in Tipærui valley near Papeete. This species is found in all of the valleys of Tahiti, but is never abundant anywhere.

Figs. 3–8. *Partula otaheitana.* — These Figures show various common color-varieties of one and the same species of snail. Figs. 3–6 are taken from snails of Tipærui valley; Fig. 7, from Piræ; and Fig. 8, from Hamuta valley.

Fig. 6 represents a color-variety derived from the form shown in Fig. 5; while Fig. 8 is similarly derived from Fig. 3. All of these snails are dextral in Tipærui, and sinistral in Piræ valley; while in the two intermediate valleys of Fautaua and Hamuta some individuals are dextral and others are sinistral. In Hamuta valley the apex of the shell is often tinged with red-brown, or pink, as in Fig. 8. This is due to the wearing away of the outer epidermis of the shell.

Figs. 9, 10. *Partula filosa.* — A species obtained in Piræ valley.

Figs. 11–13. *Partula sinistrorsa.* — Color-varieties of a species of snail obtained in Vaihiria valley.

Figs. 14, 15. *Partula nodosa* var. *sinistralis.* — Color-varieties of a form obtained only in Maruapoo valley.

Figs. 1ª, 1ᵇ, 1ᶜ. *Partula hyalina.* Young of the snail shown in Figs. 1 and 2.

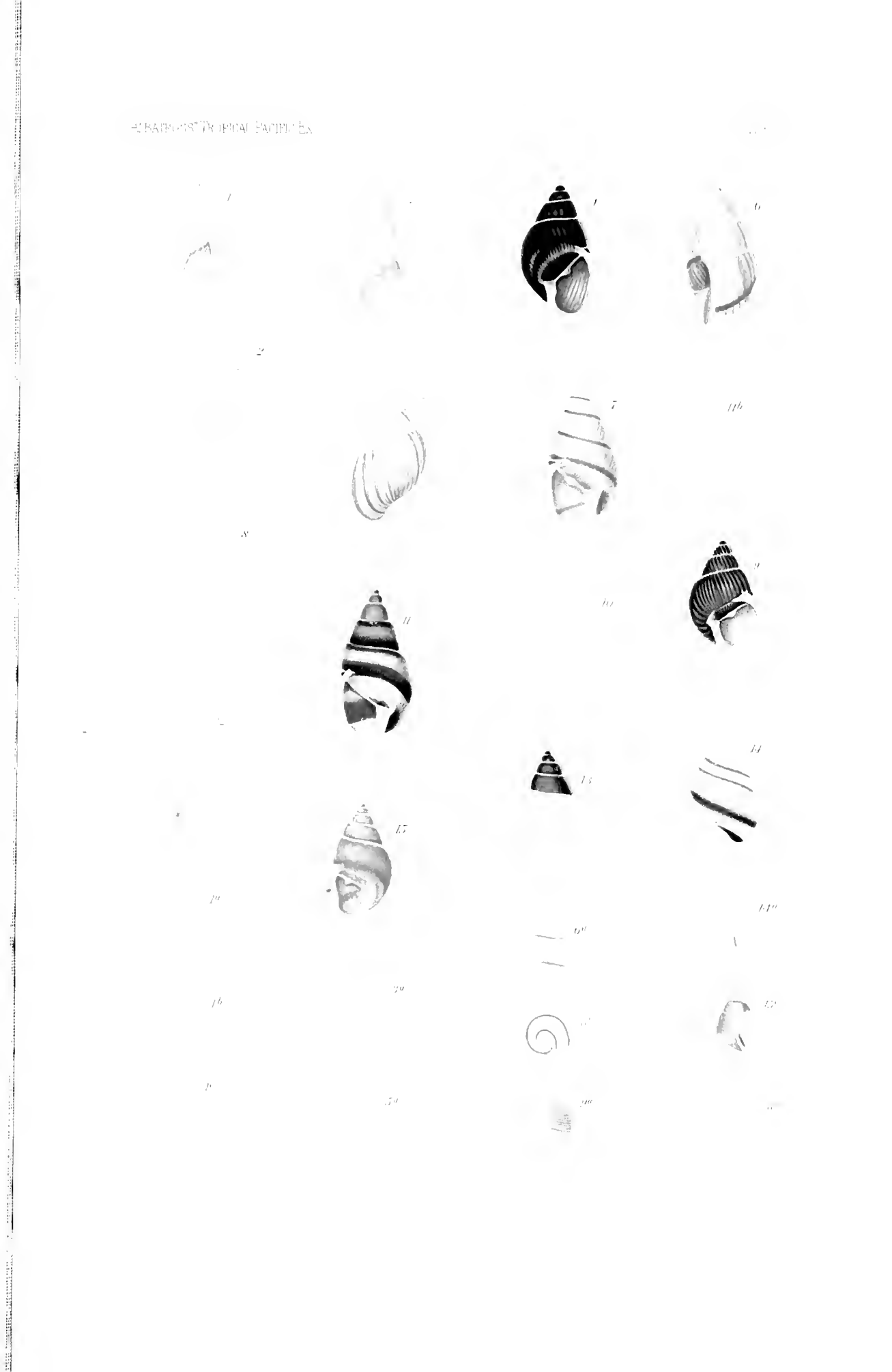
Figs. 3ª, 5ª. *Partula otaheitana.* Young of the snails represented in Figs. 3 and 5. Many of the young of Fig. 3 resemble 5ª, while very often the young of Fig. 5 resemble 3ª. Snails of the color type shown in Figs. 4, 6, 7, and 8 often give young of the types represented in Figs. 3ª and 5ª.

Figs. 6ª, 6ᵇ. *Partula otaheitana* var. *lignaria.* Young of the snail shown in Fig. 8. Similarly colored young are often given by the snail shown in Fig. 7. Very often the young of Figs. 6 and 7 resemble Figs. 3ª and 5ª.

Fig. 9ª. *Partula filosa.* Young of the snails shown in Figs. 9, 10. This is a young one of a medium hue, some being darker and others lighter in color.

Figs. 11ª, 11ᵇ. *Partula sinistrorsa.* Young of the snails represented in Figs. 11–13.

Figs. 14ª, 15ª. *Partula nodosa* var. *sinistralis.* Young of the snails shown in Figs. 14 and 15. Some of the young of Fig. 14 resemble 15ª, while some of the young of Fig. 15 resemble 14ª. Some of the young are plain colored, while others exhibit distinct whorl-stripes as in 14ª.



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