THE LAND SNAIL GENUS CARELIA

BY

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CORRECTIONS

Page 4. 17th line. For "A. Bryan" read: W. A. Bryan.
Page 8. 2nd line from bottom. For "low margin" read: lower margin.
Page 11. 14th line from bottom. For "*terebra*" read: *tenebrosa*.
Page 16. Bottom line. For "7" read: 6.
Page 19. 12th line from bottom. For "Waihinahina" read: Waihunahuna.
Page 24. 11th line from bottom. For "second" read: sections.
Page 26. 4th line from top. For "materials" read: material.
Page 27. 4th line from top. For "intial" read: initial.
Page 33. For "Kauai, Kalalau, South Point, fossil in a bank on cliffs overhanging beach (Pease), A. Knudsen, etc." read: Kauai (Pease); Kalalau, south point, fossil in a bank on cliffs overhanging beach, A. Knudsen, etc.
Page 38. Next to last paragraph. For "Habitat? Along trail, Limahuli to Hanakapiai (Jay): P. Deverill, etc." read: Habitat? (Jay); along trail, Limahuli to Hanakapiai, P. Deverill, etc.
Page 38. Next to last line. For "and the very few living" read: and one of the very few living.
Page 39. Last sentence of 3rd paragraph. For "These will be discussed on page ....." read: These are discussed in last paragraph of this page.
Page 47. 17th line. For "groups" read: group.
Page 49. 8th line. Omit one "more."
Page 55. 1st paragraph. For "author's" read: authors.
Page 58. 10th line from bottom. For "60" read: 6.
Page 60. 12th line. For "*cochlea* Gulick" read: *cocklea* Gulick.
Page 60. Next to last paragraph. For "Kauai (author's) Hanalei: Baldwin, Perkins (localized Bishop Museum specimen):" read: Kauai, authors: Hanalei; Baldwin, Perkins. Localized Bishop Museum specimens: base of Hihimanu, etc.
Page 61. Next to last line. For "his band" read: this band.
Page 63. 5th line from bottom. For "was 3½ whorls" read: has 3½ whorls.
Page 69. 14th line. For "largely" read: larger.
Page 72. 18th line from bottom. For "slow elevation" read: low elevation.
Page 74. 4th line from bottom. For "new subspecies" read: new species.
Page 76. 6th line. For "wood brown (buffy-brown)" read: wood brown-buffy brown.
Page 77. 6th line from bottom. For "are larger than" read: are larger with.
Page 78. 6th line. For "ferruginous Hay's-russet" read: ferruginous-Hays's russet.
Page 91. 10th line. For "1830" read: 1930.

The Land Snail Genus Carelia

By C. Montague Cooke, Jr.

INTRODUCTION

SCOPE

The present paper was begun in 1927 to classify the specimens of the genus *Carelia* in the collections of Bernice P. Bishop Museum.[1] As additional material was continually being incorporated into the collection, the paper was revised from time to time as new knowledge was added on the distribution of some of the older species and also in describing new species or subspecies when these were found.

The field is by no means exhausted since, from a glance at the map, it will be observed that most of the area of Kauai is without representatives

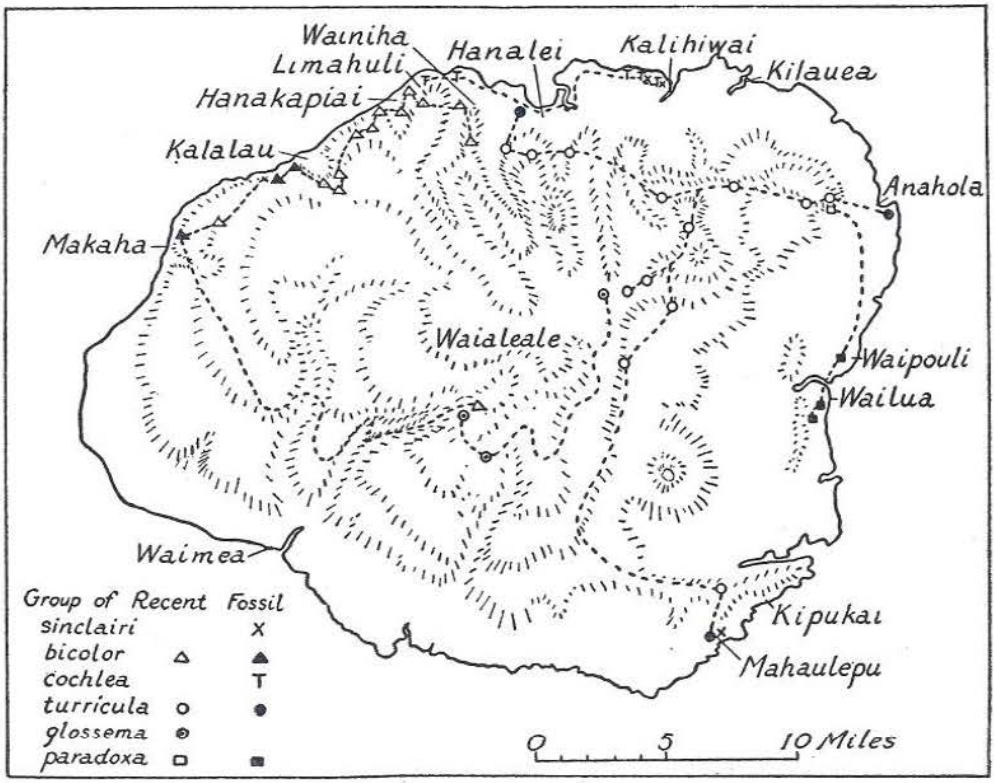


Figure 1.—Map of Kauai, showing the distribution of fossil and recent colonies of Carelia. The dotted lines connect the colonies of each group and tentatively illustrate their distribution.

[1] Specimen numbers throughout, unless otherwise indicated, are B. P. Bishop Museum specimens.

of *Carelia.* That a large part of this area is without living or fossil representatives is almost certain, as the conditions are not at all favorable for the existence of living or the preservation of fossil specimens. With more intensive and systematic collecting, it is not unlikely that the number of species and geographical races may be almost doubled.

Fortunately, what are presumed to be the original localities or, at least, colonies close to these localities have been rediscovered of all but one of the old species (*cumingiana*).

Because the animals of only six species are available, no attempt has been made for a comparative study of the anatomy. With so small a series of representatives no definite conclusions could be determined as to relationships or differences between the species or groups of species.

Valuable gifts, loans, and exchanges have been made by friends of the Bishop Museum and by other museums. The writer wishes to thank the Museum of Comparative Zoology of Cambridge, The American Museum of Natural History, Dr. H. A. Pilsbry, Messrs. D. Thaanum, W. Meinecke, A. Bryan, T. Dranga, I. Spalding, P. Deverill, E. Deverill, W. H. Rice, A. Rice, C. Dole, L. Wishard, E. Lyman, E. Prigge, and O. H. Emerson. Without their generous assistance there would have been much less material for comparison.

STUDY MATERIAL

The collection of the Bishop Museum contains nearly 5,500 specimens belonging to the genus *Carelia.* The majority of these are distributed in large series of a few fossil species *sinclairi, cochlea, dolei, d. isenbergi* and *paradoxa;* fossil species in lesser numbers but with enough material to furnish adequate knowledge of their variation and distribution are *pilsbryi, mirabilis, kalalauensis, lirata, necra* and *necra spaldingi*; fossil species with less than 5 specimens are (*hyattiana* [4], *o. infrequens* [1], *lymani* [1], and *p. Thaanumi* [2]).

Recent species are represented in the collection by abundant material of *kalalauensis, bicolor, cumingiana, c. meineckei, turricula* and *glossema*; with less abundant but representative specimens of *b. angulata, olivacea, o. priggei, tenebrosa*; of excessively rare species, *anceophila* (2), *hyattiana* (5), *o. propinquella* (2), *o. baldwini* (2), *knudseni* (1), *periscelis* (4) and *paradoxa* (2).

Nothing is known of the original localities of the fossil species *lymani* and the following recent species; *cumingiana, hyattiana, o. baldwini, knudseni* and *paradoxa.* A clue to the locality of *hyattiana* is afforded by the fossil material collected by Meinecke. There is some chance that *knudseni* may be found with extensive collecting in the neighborhood of its probable habitat. The original localities of *cumingiana* and *o. baldwini,* both of which species

were undoubtedly lowland inhabitants, are certainly gone; though fossil representatives may be found of the former species in Lumahai Valley and of the latter subspecies back of the beaches to the east of Kalihiwai Stream. The original locality of *paradoxa* was probably in the lowland forests near the extreme eastern point of the Anahola Range. A few broken and worn specimens of this species associated with similar specimens of *olivacea* were taken by Meinecke in native forest in 1928.

Whether these dead specimens of *paradoxa* or the fossil specimens from the Waipouli race track are nearer to Pfeiffer's type can only be determined by an examination of the original specimens in the British Museum. There was no intermediate locality from which Newcomb could have obtained his specimens.

The Museum is fortunate in having the type specimens of the following species and varieties: *sinclairi* Ancey, *dolei* Ancey, *turricula azona* Ancey, *bicolor suturalis* Ancey, *glutinosa* Ancey and *rigida* Hyatt. Besides these, there are specimens of *olivacea* and *adusta angulata* (= *bicolor angulata*) from the Pease collection in the Museum of Comparative Zoology. Ancey's type specimen of *glutinosa* was accompanied by two labels, the first bearing the legend "Achatina (Carelia) glutinosa Anc. I. Sandwich?", and the second "Homorus clava Pfr. I. San Tomé." Both labels are in Ancey's characteristic handwriting.

Of the 29 species and subspecies recognized in this paper, twelve (*sinclairi, pilsbryi mirabilis, dolei, d. isenbergi, cochlea, olivacea infrequens, lymani, lirata, necra, n. spaldingi* and *paradoxa thaanumi*) are known only in the fossil state and it is safe to assume that these are entirely extinct.

Thirteen species or subspecies may be considered as recent or living. These include four species that are known only from recently dead specimens (*anceophila, o. priggei, knudseni* and *periscelis*), and are presumably not extinct at present. Nine species or subspecies may be classed as living. These are *bicolor, b. angulata, cumingiana meineckei, turricula, olivacea, o. propinquella, o. baldwini, tenebrosa* and *glossema. Kalalauensis* and *cumingiana* are known both from living and fossil specimens, while *paradoxa* and *hyattiana* are known from fossil and recently dead specimens.

CHARACTERS OF THE SHELL

SIZE AND SHAPE

The largest species of Hawaiian land snails belong to *Carelia*. The longest specimen recorded is Borcherding's specimen identified as *obeliscus* (turricula) for which he gives the length of 87 mm. The longest specimen in Bishop Museum's collection is an example of *turricula* which is slightly over

85 mm. in length. Other species which are represented by large specimens are: *pilsbryi* (81.7 mm.), *periscelis* (78.5 mm.) and *knudseni* (76 mm.). The smallest adult examples are represented among specimens of *bicolor* (30-31 mm.) and *sinclairi* (29-31 mm.). These small individual examples are shorter and narrower than many specimens of *Amastra magna* from Lanai (40-45 mm.), *A. violacea wailauensis* 33-40 mm.) and *A. hitchcocki* (35-40 mm.) from Molokai.

In adult specimens from single colonies the number of whorls rarely show a range of more than 1¾ whorls. The extreme range for the genus is a little more than four whorls, from slightly less than seven in a specimen of *bicolor* (Pl. IV, fig. 13) to eleven in a specimen of *turricula* (Pl. X, fig. 6).

The shape of the shells in this genus has not become conventionalized to any fixed type. Not only do the species differ from each other, but individual examples from a few restricted colonies show much variation from what might be considered the typical form of the colony. From the narrowly turreted types of *dolei* and *cochlea* with diameters about one-fourth the total length, the shape varies to widely conic examples of *bicolor* in which the diameter equals nearly one-half the length. In some species, such as *cochlea, cumingiana* and *hyattiana,* the whorls are nearly flat; in others for example, *lirata* and *kalalauensis* individual specimens are found with distinctly convex whorls.

TEXTURE

The surface texture of some of the species is quite constant in character while, in other species, specimens show a very large amount of individual variation.

Two species, *sinclairi* and *pilsbryi,* have a rather distinct type of sculpturing not found in any of the other species. The post embryonic whorls are roughly and irregularly sculptured with rather coarse, slightly irregular, low ridges following the lines of growth. This sculpturing is continued on to the base of the shell in front of the aperture. A similar distribution of sculpturing is present in all specimens of *Amastra* which are coarsely wrinkled-striate. On account of the convexity of their embryonic whorls and the type of sculpturing, these two species have evidently retained some of the primitive characters of the genus. There is, however, a third species, *Carelia mirabilis,* which has a somewhat similar amastroid embryo; but the sculpturing is of a more specialized type. In this species the coarse longitudinal sculpture is cut by incised spiral lines giving the striae a beaded appearance. Both the longitudinal and spiral lines are continued not only on to the base in front of the aperture but extend on the parietal wall deep within the aperture.

Only two species of the genus are characterized by strong spiral sculpture confined to the spire and the portion of the last whorl above the periphery. In *C. cochlea* the spiral cords are blunt, rounded and unmodified by longitudinal growth lines, while in *C. lirata* these are sharp and distinct, slightly modified by less prominent longitudinal striae. These two species are not related as they belong to different groups of species.

In *paradoxa* we have the most highly specialized type of surface texture occurring in the genus. The entire surface of the shell is engraved with fine, distinct, closely arranged, longitudinal growth-folds. These are cut nearly to their bases by spiral lines, so that the surface is closely covered with minute granules. The base in front of the aperture is smooth.

Specimens of *cumingiana, c. meineckei, b. angulata,* and about half the examples of *dolei* are characterized by a sharp shoulder angle and also by a less strongly developed baso-peripheral angle. In some specimens of *bicolor* and *kalalauensis* the position of this shoulder angle is slightly indicated, while the baso-peripheral angle is entirely absent in *bicolor* and but very slightly developed in some of the specimens of *kalalauensis*. *C. periscelis* has a raised peripheral keel which is distinct in form from that of all other species. This keel is only indicated in *glossema* and *knudseni*. In none of these three species is there the slightest indication of a shoulder angle.

In the rest of the species the surface is from nearly smooth to coarsely wrinkled. In some individual examples there are coarse spiral cords, while in others these cords are absent or only indicated when examined with reflected light.

The specimens of *turricula* from the colony on the ridge between Waioli and Waipa are of especial interest. These specimens exhibit the greatest amount of variation in their surface texture. A few of these are nearly smooth, marked with delicate growth-lines; others are coarsely and irregularly wrinkled. The spiral cords show an unusual amount of variation in the degree of their development. In some examples these cords are barely indicated, being only visible with reflected light, while in others they are very strong (Pl. XI, fig. 6). In some specimens the longitudinal wrinkles and spiral cords have about an equal amount of development and, when strongly so, the whole surface is coarsely granular (Pl. XI, figs. 7, 8).

Specimens of *kalalauensis* also exhibit an unusual amount of individual variation in the development of their surface textures but in a lesser degree than illustrated among examples of *turricula*.

COLOR

What was probably the primitive color pattern of *Carelia* is illustrated only in specimens of *sinclairi* from Niihau, since some representatives of this

species are found having a light-colored umbilical region. This color pattern is characteristic of many species of *Amastra* belonging to the subgenera *Kauaia,* and *Cyclamastra* and the section *Amastrella.*

The most common color pattern, and what was probably a very early development of the color pattern of the genus, is a uniform sooty-black on the lower whorls gradually shading to a uniform reddish buff color on the early post embryonic whorls. In addition, at least three distinct types of color pattern have been developed which are characteristic of some species and also of some geographical races.

The distribution of the color pattern into the calcareous shell layer is quite distinct from that of most species of *Amastra,* with the exception of a very few species. In *Amastra* the color pattern is present only in the cuticle. A common characteristic of a large number of the species of *Amastra* is a deciduous outer cuticle. In *Carelia* the cuticle is never deciduous, except in dead shells.

Except for many examples of *C. sinclairi* and two specimens of *C. turricula,* the base in the region of the columella is very dark. The color pattern of the lower whorls, but especially that of the base, is retained or at least indicated in most dead and fossil specimens, as a large part of this color is present in the outer calcareous layer of the shell.

The uniform dark color is modified by streaks or dots in only three species, of which examples have been taken from but four colonies. This color pattern is considered of specific importance in only one species, *anceophila.* In this species the streaks are characteristic and well developed in the single adult specimen and are continued on to the base of the last whorl. In a younger specimen they are only well marked on the back of the last whorl as it approaches maturity. This type of mottling is merely indicated in specimens of *kalalauensis* (Pl. III, fig. 11). It is more distinctly, but irregularly, present in specimens of *bicolor* from Hanakapiai (Pl. IV, figs. 1-3) and Hoolulu (Pl. IV, figs. 12, 13), but is entirely lacking in specimens from colonies east of Hanakapiai. This mottling consists of a series of irregular dots arranged in spiral lines which for the most part are distributed above the periphery.

In many species there is a tendency of the dark color to become indistinctly lighter just below the sutures. In some species this becomes a distinct light-colored band of varying widths. In two species, the width of this band is more or less constant and is of specific importance. This line is very narrow (½ mm. to nearly 1 mm. in diameter) in *cochlea,* somewhat broader (1½-2 mm.) in *cumingiana.* Most of the specimens of *olivacea* are furnished with a narrow to rather broad (½-3 mm.) subsutural band. The low margin of this band is never distinct in a *cochlea* and *cumingiana* but merges gradually into the body color. In geographical races of this species

the width of this band, when present, is a more or less constant character. In the fossil species *lymani* the sutural band is somewhat similar in character to that of typical *olivacea*. Most of the specimens from the western colonies of *bicolor* and the colony of *b. angulata* from Limahuli are furnished with a rather broad (2-6 mm.) subsutural band. Its lower edge may be sharply defined or indistinct. In only a very few examples of bicolor from the western colonies (Pl. IV, figs. 8-10) is this light-colored band absent, but in these its position is indicated by a reddish color.

A few specimens from the eastern colonies of *bicolor* (Pl. IV, fig. 6), between Hanakapiai and Limahuli, have the characteristic band of the western colonies. This band, in some specimens, is wider and occupies the whole of the space between the periphery and the sutures (Pl. IV, fig. 4) and was described by Pilsbry as *b. hyperleuca*. The great majority of specimens from the eastern colonies is very dark, unicolorous.

In most fresh specimens of *kalalauensis* and *hyattiana* there is an indistinct, subsutural, reddish band. In fossil specimens this band is white. All the species which have examples furnished with a subsutural band are located in the northern half of Kauai.

A third deviation from the typical solid color pattern is the presence of a wide, light-yellowish, baso-peripheral band. This occurs in about two-thirds of the specimens of *turricula* and in all the fossil specimens of *paradoxa* from Waipouli. It is remarkable that this character should occur independently in two such very distinct species. That which represents an early stage in the development of this band is found in a few specimens of *bicolor* from Hanakapiai. On these it is indicated as an indistinct, discontinuous, narrow line. On some specimens of *kalalauensis* from Kalalau and further south, this band is more plainly indicated but is entirely absent on specimens from the eastern colonies of this species.

Embryos dissected out of newly killed animals are invariably of a uniform dark color (bay), sometimes slightly lighter just below the suture. It is presumed that this dark color is carried in the cuticle since in nearly all examples of recent shells with worn apices and those of well-preserved fossils the embryonic whorls are bicolored. This latter color pattern is probably present in the outer calcareous layer of the shells.

APERTURE

The outline of the aperture is, in some species, a rather constant character; in others it is subject to slight individual variations. In outline it may be narrowly subtriangular (*glossema*), elongately trapezoidal (*knudseni*), rhombic (*cochlea*), ovate (*bicolor*), narrowly ovate, pointed at both ends (*anceophila*). Where individual variations in the outlines of the aperture

occur, the outlines are influenced by the diameter of the shell and also by the presence or absence of a shoulder and basal angle and the degree of development of these angles.

The parietal wall may be very oblique (*glossema*) or much less so (*paradoxa*). The length of the aperture rarely ever exceeds the diameter of the shell. In the great majority of the species it is slightly less than the diameter. In tightly coiled species the aperture is proportionately much shorter than in those that are more loosely coiled.

COLUMELLA

In the more loosely coiled species the columella is rather long, nearly perpendicular and only slightly sigmoid. In juvenile specimens of these, it is invariably straighter than in adults. In more tightly coiled species (*cochlea, dolei and paradoxa*) it is relatively shorter, more twisted and concave above. It is almost invariably furnished with a very oblique, thin, low fold along its inner margin. In some species the fold disappears gradually towards the base, while in others the termination of this fold is distinctly truncate. In the latter species this abrupt ending occurs only in mature specimens.

OUTER LIP

Carelia differs from all other genera of Amastridae (except some species of *Laminella*) in that, on reaching maturity, it never forms a thickening of the inner margin of the outer lip. Its adult stage is indicated by close and irregularly overlapping layers outside of the peristome. This character is emphasized just below the suture and extends downwards at an acute angle with the margin of the lip which it merges into near the periphery. This lamellation forms an almost imperceptible thickening of the outer wall of the aperture just in back of the peristome and undoubtedly is caused by the slowing up of the growth of the shell. With the more rapid growth of juvenile specimens, only characteristic growth striae are formed. Many species of *Amastra,* on reaching maturity, develop this lamellation to a lesser degree than *Carelia* besides forming the characteristic lip rib in common with the other genera of the family. A unique pathologic specimen of *pilsbryi* (Pl. I, fig. 14) has, however, a well developed lip rib deep within its margin.

ANATOMY

The anatomy of the genus and its relationship to the other genera of Amastridae have been discussed by Pilsbry (Man. Conch., vol. 23, pp. 62-65).

ANIMALS

In *Carelia turricula* (no. 86160, alcoholic) the animals are externally of a uniform slate to dark-slate color with the outer portion of the collar similarly colored. The margin of the sole agrees with the flanks in color. The central portion of the sole is commonly lighter than the margins. The inner margin of the mantle is bordered by a deep red-brown line wider and more intensely colored towards the columella. The pallial region is of a uniform slate to dark-slate color, except over the urethra and pulmonary vein which is lighter, sometimes flecked with a few widely spaced irregular white dots. The lips and genital pore are much lighter than the rest of the animal. In *Carelia bicolor* form *adusta* no. 86066, alcoholic) the animals externally resemble those of *C. turricula*. The sole of the foot in most examples is marked with slightly darker edges than the central area. In nearly all the specimens the sole is darker towards the tail and lighter towards the head. The inner margin of the collar is bordered by a dark red-brown band of a uniform width. The pallial region is pigmented a uniform dark slate and with a very dark slate band paralleling the pulmonary vein and urethra. The lips and genital pore are somewhat lighter than the head.

In *Carelia glossema* (no. 86083 alcoholic) the external portion of the animals is of a uniform very dark-slate. In most of the specimens the central portion of the foot is the same shade of slate as the margins. Close to the mouth the sole is lighter colored. The external portion of the collar is dark-slate, the inner margin with a very narrow dark red-brown band of uniform width. None of the specimens have the pallial region pigmented.

In *Carelia terebra* (no. 86151, alcoholic) the external portion of the animals is of a slate color. The flanks just above the sole are very dark-slate, the upper portion of flanks and top of head lighter, of a brownish-slate. Inner margins of collar marked by a very narrow dark line. The pallial region is heavily pigmented with dark-slate and with an indistinct linear arrangement of pigment parallel to the urethra. Sole in five out of six specimens uniform, dark to medium-slate, in one specimen with the margins darker than the central area.

EMBRYOS

Fortunately, embryological material of 20 of the 29 species or sub-species dealt with in this paper is in the Museum collection. Of the 9 remaining species, of which there are no embryological examples, nearly all are represented by specimens in which the more important of the embryonic characters can be easily recognized.

The embryonic characters have served as the basis of subdividing the

genus into groups of species. On account of the very wide differences between the different types of embryos, it might not be inadvisable to consider some of these groups as of subgeneric rank. This larger treatment has not been taken since embryonic differences between some of the groups is only a matter of degree and is liable to personal opinion. Many species (such as *sinclairi, pilsbryi, dolei, paradoxa,* etc.) have characteristic embryos peculiar to each species; while, on the other hand, all the species of a group may have a more or less common type of embryo, and the separation of the different species in these groups is based entirely on adult characters.

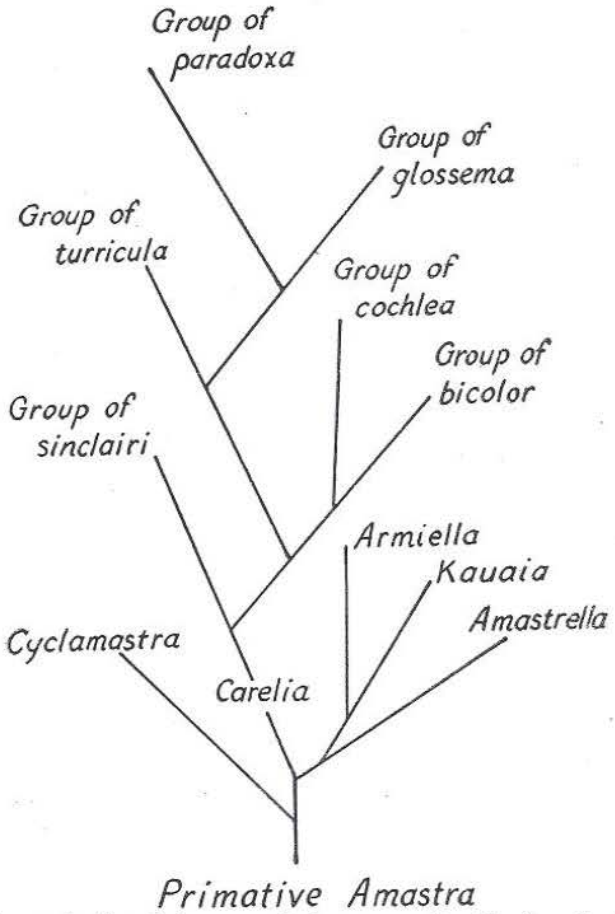


FIGURE 2.—The probable phylogeny of the genus Carelia, based almost entirely on embryological characters.

The age, as determined by the number of whorls, at which the animals of *Carelia* may be expected to contain embryos varies with the different species. In some species, such as *bicolor* and *kalalauensis,* embryos are found in animals of which the shell has not quite or has just reached the completion of the 7th whorl, while in *turricula* no pregnant specimens were found with shells having less than 9 whorls.

Fully developed embryos of *sinclairi, kalalauensis* and *bicolor* do not have more than 4 whorls, while those of the related but more specialized species, *cumingiana meineckei, dolei* and *cochlea* (all of which are ornamented with a distinct shoulder angle or raised spiral ridges) have 4½ whorls. Fully developed embryos of *turricula* and *glossema* have 4½ whorls, while a few of *paradoxa* consist of nearly 5 whorls. It is reasonable to conclude that the embryos of the more evolved and specialized species reach a slightly higher stage of development before being born than in the more simplified species.

Pregnant specimens usually contain 3 embryos, sometimes only 2; 4 embryos are not uncommon, but in only a few individuals were as many as 5 observed. These embryos are always in different stages of development.

In young stages the embryos are always imperforate. When fully developed they are, in most species, minutely perforate. Embryos of *paradoxa* are either imperforate or very minutely perforate. The perforation forms a long, narrow slit extending to the base of the columella under its free exterior margin.

SPECIES CONCEPT

With the abundant material of many of the species and subspecies, the taxonomic treatment followed by Ancey, Borcherding and Pilsbry has been somewhat changed. This is especially noticed by examining the synonymy of *bicolor*. Fortunately we have in the Museum a number of localized "lots" of this species and, in addition to this, the testimony of careful collectors. This has given me a much different concept of this species from that held by other authors. In each of the colonies of this species the size, form and texture of the shells exhibit slight degrees of individual variation without decided color forms. In other colonies, occupying very limited areas, the wide amount of color variation has led authors unacquainted with their distribution to consider them as distinct species or subspecies.

At least five (*o. propinquella, o. baldwini, o. infrequens, n. spaldingi* and *p. thaanumi*) of the nine subspecies recognized in this paper might be treated as species. The conservative view is adopted since there is lack of enough material to illustrate their variability; and besides, the areas inhabited by each of these subspecies is on the periphery of the species to which they are assigned.

On the other hand *knudseni* of only slightly higher rank is considered as a species not only because of its size and coarser texture, but especially because of the differences between its embryos and those of the nearest related species, *glossema*.

NEW SPECIES

The number of new species added to those recognized by Pilsbry, in 1911, is not remarkable, for since the publication of volume 21 of the Manual, more colonies of *Carelia* have been found than during all the years of previous collecting, and the field is by no means exhausted. With the present conditions of the forest area suitable for the living conditions of *Carelia,* it would not be surprising if from six to ten new species of living forms should be found; and, with our knowledge of the restricted areas from which some of the subspecies have been taken, probably double the number of subspecies is as yet undiscovered. For new species some of the valleys and canyons with their branches should be searched at between 750 to 2,500 feet elevations. The whole drainage basin of the Waimea Canyon has not had a single shell reported from it.

It is, however, in the fossil beds that more new material should be discovered. Many such localities are distributed near the coast, but it is only in newly ploughed fields that one is likely to find well-preserved material since, after harrowing anl planting, the larger species are liable to be damaged. With the very large amount of territory of this type that up to the present has not been investigated, it would not be unlikely that with more thorough and systematic collecting at least ten or a dozen new fossil species should be added to the *Carelia* fauna.

Another type of locality which may yield specimens of extinct or recently extinct species is in the areas from near sea level to a 1,000 to 1,500-foot elevation, which fire, cattle or goats have denuded of the native forest. This area was undoubtedly inhabited by *Carelia.* Occasionally "pockets" rich in dead shells are discovered. Only two of these have been found on Kauai: one on the cliffs overhanging the south side of Kalalau, and the second on the ridge of Makaha. Both of these contained specimens of *kalalauensis.* Undoubtedly a great many such "pockets" exist, especially where large rocks or piles of rocks protect the shells from moisture and disintegration. Many "pockets" have been found on Oahu, Molokai, Maui and Hawaii. (Pilsbry, H. A., Man. of Conch., vol. 22, p. xlviii.)

GENERAL RELATIONS

The logical sequence in which the groups of species of *Carelia* are distributed offers some clue to the early geography and topography of the Island of Kauai. At an early period, before Niihau and Kauai were separated and the latter island was not dissected by deep valleys and canyons, *Carelia* developed as a genus from its amastroid stock. This "primitive" type was fairly evenly distributed at a low elevation close to the periphery of this larger land mass.

This is illustrated by the occurrence of *sinclairi* on the Island of Niihau, *pilsbryi* on the northern coast of Kauai and *mirabilis* on the southern coast. The similarity in the form of the embryos of these three species from widely separated localities is opposed to what we know of the distribution of species with similar embryos among the other groups of *Carelia.* In these the different types of embryos are, for the most part, found in adjacent areas or on approximately the same contour lines and not distantly separated.

With the formation of the Waimea drainage basin on the south and the Wainiha drainage basin on the north, the Island of Kauai was divided into two parts in each of which distinct types of embryos were evolved.

There seems to be no evidence of wide migration of any of the species, though some of them occupy much larger areas than others. This is undoubtedly due to natural barriers, such as streams or deep valleys; but, in addition, differences of altitude have played an important part. This may be illustrated by the distribution of two related fossil species, *dolei* and *cochlea.* The localities of these two species are separated by about eight miles. Embryologically they are closely related. Less than half a mile from where *dolei* occurs in the valley of Limahuli there is a colony of *bicolor angulata,* the specimens of which show no embryological relationship to *dolei* but are entirely *bicolor* in character. Other examples of related species inhabiting about the same elevation are furnished by the distribution of *glossema* and *periscelis* and also by *paradoxa* and *necra.*

Among the 29 forms recognized in this paper there is no example, except *kalalauensis,* which has occupied localities in which there is much difference in altitude. Each of the groups of species is more or less restricted to definite contours as there are only five examples (*cumingiana, lymani, hyattiana, olivacea infrequens* and *lirata*) of a species or subspecies living at different altitudes from the rest of the species belonging to its group, and this only occurs where a ridge extends to the coast.

An interesting example of distribution is that exhibited by *kalalauensis, bicolor* and *cumingiana.* All three species are closely related in embryological characters but are easily separated by adult characters. However, specimens from the western colony of *bicolor* and the eastern colony of *kalalauensis,* separated by much less than a mile, resemble each other more closely than examples of these species taken from localities separated by four or five miles.

Except in color pattern, representatives from colonies of *bicolor* separated by approximately two miles agree more closely than those of *bicolor* and *kalalauensis* separated by less than half this distance. On the east, *bicolor* approaches *cumingiana* in a similar manner. The decided break between the two species is caused by the deep Wainiha Valley.

A similar sequence, but one which cannot be completely followed out at

present, is illustrated by the gradation from *olivacea* through *o. priggei* and *o. infrequens* to *lymani*. From this sequence it seems probable that *lymani* from an unknown locality should be found near one of the beaches on the north coast of Kauai between Papaa and Kilauea.

COLONIES

The localities of very few of the species are to be found in literature. During the last 25 years more attention has been paid to this subject and, at present, specimens have been recorded from 42 colonies on the Island of Kauai. With more systematic collecting, the number of these colonies should be at least doubled or tripled. A glance at the map shows large areas from which no species are known at present. A large proportion of this area has been deforested since the advent of the Anglo-Saxons and the *Carelia* which inhabited them are extinct. There are, however, several extensive well-wooded areas which are undoubtedly inhabited by *Carelia* today.

If the island is divided into quarters with a line running north and south from the Kalihikai-Hanalei ridge, and east and west from the mouth of the Wailua River, it will be found that the great majority of the colonies are located in the two northern quarters. Half of the 42 colonies are in the northwest sector, 14 in the northeast sector, 4 in the southeast sector and 3 in the southwest sector. From the northwest sector we know 6 species, 3 subspecies; from the northeast 6 species, 5 subspecies; from the southeast sector 4 species, 1 subspecies; from the southwest sector 3 species.

There are two reasons for the great disparity between the number of colonies and species in the northern and southern sectors; first, that there has been much less deforestation on the northern half; and secondly, that in this region the localities suitable for maintaining *Carelia* are more easily accessible and have been known for a long time. Consequently they have attracted the attention of collectors all of whom, including the author, have more or less neglected the southern sectors where the chances of finding specimens of even the more common endemic genera seem to be unlikely. From the fairly abundant material found in the few fossil colonies located in the two southern sectors, it seems probable that *Carelia* was fairly widely distributed over the whole of the southern half, wherever conditions were suitable for its maintenance.

All of the 28 Kauaian species and subspecies dealt with in this paper are represented in the Bishop Museum collection: 10 by fossil material only, 14 which were alive or only recently dead when collected, and 4 by both fossil and recent specimens. The 14 living species and subspecies were taken from 29 colonies. In addition to these, the Museum collection contains representatives of 7 forms (*bicolor angulata, cumingiana, hyattiana, olivacea baldwini,*

lymani and *knudseni*) of which the original habitats are not definitely known.

Of the 4 species represented by both recent and fossil material two species (*hyattiana* and *cumingiana*), are undoubtedly extinct today, though living specimens were taken about eighty years ago. From the fact that both of these species are known from lowland fossils it is safe to assume that the live specimens were taken at a very low elevation, but today the localities which they probably occupied have been denuded of forest covering. It is doubtful if *paradoxa* is alive today but, since a few dead specimens were collected by Meinecke in 1928, there is the possibility of additional specimens being found near the eastern end of the Anahola range. The fourth of these species, *kalalauensis,* is still fairly abundant in its living state and apparently not nearing extinction. From the wide distribution of fossil specimens of this species, its present habitat is very much contracted. This is the only species which is known to have lived at considerably different altitudes. One of the colonies (Honopu) is nearly at sea level, another (Milolii) is at an elevation of from 1,500 to 2,000 feet. This ability to live at considerably different altitudes is explained by the fact that its distribution was along the high cliffs of northwestern Kauai and that these cliffs were undoubtedly covered at one time with a more or less uniform type of plant association.

As far as known, almost all the colonies were and are inhabited by a single species or subspecies. The few exceptions are; first, the Kalihiwai colony with *pilsbryi* and *cochlea* and the eastern extremity of the Kalihikai colony with the same species; while from the middle of the latter colony to its western end only *cochlea* has been found; the Waipouli colony with *paradoxa* and *n. spaldingi*; the colony located by Thaanum south of the Waialua River with *necra* and *p. thaanumi* and the Mahaulepu colony with *mirabilis* and *lirata*, all these are fossil colonies. The only recent colony with representatives of two species (although all the specimens were dead and had been so for some time) was found by Meinecke near the eastern terminus of the Anahola range. In this colony specimens of both *paradoxa* and *olivacea* were found associated together.

It may be of some significance that the two species, *pilsbryi* and *mirabilis,* which are supposed to be primitive representatives of the genus have not been found in pure colonies.

Of the 42 colonies known at present, 13 (nearly one-third) are fossil. Besides these, specimens from three additional fossil colonies whose localities are unknown are represented in the Museum. All these fossil colonies but two, Makaha and Kalalau, are located near the shore line, for the most part in flats just back of the beach. Loam, with a large proportion of calcareous sand, forms the composition of these flats. The shells are, for the most part, found in somewhat definite layers from a few inches to a foot or two below the surface. Occasionally the specimens are found unevenly distributed

throughout the sandy loam. Wherever hummocks occur, the shell layer is arranged in a line parallel with the surface. In some deposits the shell fauna is very rich. It consists for the most part of representative species of the endemic genera: *Philonesia, Thaumatadon, Amastra, Leptachatina, Lyropupa, Succinea,* etc. In fact, nearly all the widely distributed endemic genera are well represented, both in species and specimens. A few of these species are only known from single fossil colonies, but most of them represent species of rather wide distribution.

Species belonging to the most fragile and delicate genera, in addition to the heavier and more robust genera, are represented by numerous examples. From the perfect condition of the shells and the state of preservation of their surface textures, it is safe to assume that the specimens are found in the exact localities where they originally lived and also that they were covered over while still alive, since only a small percentage of the specimens have the appearance of being "dead shells" (specimens showing the weathering of the surface).

The remarkable similarity of the condition of the specimens found in the beds from Limahuli on the north to the Wailua River on the east indicates that all these beds were formed at about the same period and that this occurred in a very short space of time; for if the extinction of the shells had occupied a rather long period a large proportion, if not most of the specimens, could be identified as "dead shells." The most tenable theory for the formation of these beds is that there was, at one time, a rapid climatic change which suddenly killed the plants holding the beach sand. With the prevalent northeast trades, the loosened beach sand was blown inland, covering the shells. This layer of calcareous sand has also protected the shells from disintegration since any surface water would become impregnated with lime before reaching the shells even at a few inches below the surface. It is evident that fire could not have been the cause for the rapid extermination of this lowland fauna, since the shells have not the least appearance or texture of specimens picked up after a forest fire.

In most species with both fossil and recent material, the fossils are remarkably similar to the recent examples. Whenever there are appreciable differences, these are more readily explained by geographical isolation rather than by evolution subsequent to the formation of the fossil beds.

Pilsbry (Man. Conch., 22, p. xlviii) has discussed the age of the fossil beds located in the Hawaiian Islands. With our present knowledge it is probably safe to assume that these fossil Kauaian beds were formed at the close of the Pleistocene. The fact that the two presumably primitive species have been found in a fossil state only, offers no evidence that these fossil beds are of great age, as both species are not found in pure colonies but are associated with apparently highly specialized species. On the whole, the

fossil species represent the genus at a higher stage of evolution than that exhibited by living species.

HYBRIDS

The specimens from most of the restricted colonies represent a rather homogeneous series, sometimes with different degrees of individual variations in size, texture and color patterns. However, specimens that are clearly hybrids are to be found in four colonies, three of which are definitely located. The colonies are located where the areas occupied by both species overlap. These hybrids are assigned to the species with which they agree in embryonic rather than adult characters. The first two are *necra spaldingi* and *paradoxa thaanumi*. The former has the typical embryo of *necra* but, though lacking the type of whorls of *paradoxa,* it exhibits to a less degree the peculiar granular surface of this species. On the other hand, *paradoxa thaanumi,* though retaining some of the embryonic characters and emphasizing others, has adopted not only the surface texture but also the type of whorling of *necra.*

The third subspecies which offers evidence of hybridization is *olivacea baldwini*. The embryological characters clearly indicate an *olivacea* parentage. However, in its surface texture, type of whorling, and form of columella, it shows some admixture of *cochlea* blood. That *cochlea* blood may have entered into the ancestry of some specimens of *olivacea* is illustrated by (Pl. XIII, figs. 1, 3) specimens which are not only more closely coiled than the typical form but are marked with more pronounced spiral cords. All the other specific characters are, however, those of *olivacea,* so that if *cochlea* blood does exist it must be very much diluted. This type of the species is not common as we have but one localized specimen which was taken near the eastern periphery of *olivacea* above the Waihinahina reservoir.

The fourth subspecies of mixed ancestry is *dolei isenbergi*. Specimens of this form are intermediate between *dolei* and *cumingiana,* not only in adult characters, but also in the form and size of the embryos.

HISTORY

On account of their size and rarity, *Carelia* species have been much prized by collectors; but until the last decade little has been done towards systematic collecting and only 42 definite localities have been discovered.

Carelia literature may be divided into five periods:

In the first period (1837-1850), collecting was more or less sporadic and nothing is known of the sources of the five species (*bicolor* Jay [1837], *turricula* Mighels [1845], *adusta* Gould [1845], *cochlea* Reeve [1849], and *obeliscus* Reeve [1850]).

During the second period (1851-1855), four species (*newcombi* [1851], *fuliginea* [1852], *paradoxa* [1853], and *cumingiana* [1855]), were described by Pfeiffer; three of these were sent him by Newcomb. It is doubtful if Newcomb ever collected on Kauai, but since the material of *Amastra kauaiensis* and *Amastra anthonii* (Newcomb's only *Amastra* from Kauai) were collected by the Rev. E. Johnson, it is not improbable that the latter collected the *Carelia* species sent by Newcomb to Pfeiffer. Mr. Johnson was located at Waioli, Kauai, from 1837 to about 1867 and was an enthusiastic collector of shells; and it is also possible that one or two of the earlier species owe their discovery to Mr. Johnson's activities. The only material in the Bishop Museum collection that is definitely known to have been collected by Mr. Johnson is a series of *cumingiana* which came to the Museum from the late J. S. Emerson.

During the third period (1860-1870), Pease described two species (*olivacea* [1866] and *variabilis* [1870]). Pease does not state whether he personally collected this material or not and it may have been originally found by Mr. Johnson.

During the fourth period (1870-1900), only two species (*sinclairi* Ancey [1892] from Niihau and *dolei* Ancey [1893]) were described. Both are fossil species and the original material was sent to Ancey by D. D. Baldwin.

During the fifth period (1900-1930), the three species described (*pilsbryi* Sykes [1901], *hyattiana* Pilsbry [1911] and *rigida* Hyatt [1911] were received by their authors from entirely different sources and the original material of all three is fossil.

Of the eleven species described from 1837-1870 only one (*cochlea*) is known from fossil specimens, while of all five described from 1890-1916 the original material was fossil.

Of the above sixteen described species, ten are considered as valid. The remaining six are either pure synonyms or are retained as subspecies of earlier described species.

GENUS CARELIA H. AND A. ADAMS

Carelia H. and A. Adams: Genera of Recent Mollusca ii, p. 132, 1858, [February, 1855].—Pfeiffer: Monographia Heliceorum iv, p. 571, 1859; vi, p. 188, 1868; viii, p. 250, 1877.—Albers-Martens: Die Heliceen 1860, p. 208 (type *Achatina bicolor* Jay).—Gulick: Proc. Zool. Soc. Lond. 1873, p. 91 (type *C. adusta* Gld.).—W. G. Binney: Proc. Acad. Nat. Sci. Philadelphia, p. 185, pl. vi, figs. CC, G, O, 1876 (jaw, teeth, genitalia).—Ancey: Mémoires de la Société Zoologique de France, vi, 1893, p. 321 (monograph).—Borcherding: Monographie der auf der Sandwichinsel Kauai lebenden Molluskengattung Carelia, in Abhandlungen Senckenbergischen Naturforschenden Gesellschaft xxxii (February, 1910), p. 227.—Pilsbry: Manual Conchology, vol. 21,

p. 100, 1911; vol. 23, pp. 61-65. Pl. 17, f. 4 (genitalia), Pl. 20, f. 5 (pallial organs), Pl. 21, f. 6 (teeth), 1915.

The shell is imperforate, oblong-turrite, solid; embryonic shell conic, with slightly obtuse apex and flat whorls; first half whorl smooth, the next whorl or two with sculpture of arcuate axial striae or riblets, which are often split; neanic and adult stages irregularly striate or nearly smooth, sometimes with spiral lines or ribs, the whorls slightly convex, or with one or two spiral carinae. Aperture ovate; outer lip simple and acute; columella concave, obliquely or vertically truncate below, and bearing a small callous lamella. Axis slender and nearly straight in the inner whorls, becoming sinuous in the last.

Type *C. bicolor* (Jay). Distribution, Islands of Kauai and Niihau.

Carelia was proposed by Henry and Arthur Adams for the species *bicolor, cochlea, fuliginea, newcombi* and *paradoxa*, and placed in the genus *Achatina* next to *Homorus*. The first of these species was selected as type by von Martens, who retains the genus in practically the same position. Gulick in 1873 removed it to the *Achatinellinae*, a position confirmed by Binney's examination of the teeth, and approved by all subsequent students. A full account of the soft anatomy is still wanting.

The genus contains the largest land snails of the Hawaiian group. We have but little information upon their distribution in Kauai, and no real advance in knowledge of the races can be made until the results of field work in that island are accessible.

According to Pease, "The species of *Carelia* are commonly found on the sides of precipitous rocks of the mountains, under stones and trunks of dead trees. They do not live in large numbers; one finds solitary individuals, or pairs. All of them are rare even in the places where they are most often found. *C. adusta* Gld. is the only exception in this respect. (Pease, J. de C. 1870, 402)" (Pilsbry).

KEY TO GROUPS OF SPECIES

1. Second and third embryonic whorls slightly convex; adult specimens with sculpture continued on base in front of aperture.....Group of **C. sinclairi** nos. 1 and 3.
   Second and third embryonic whorls flattened; adult specimens without distinct sculpture in front of aperture (2).
2. Last two embryonic whorls (3rd and 4th) with distinct longitudinal striae and, when present, weak spiral sculpture (3).
   Last two embryonic whorls (3rd and 4th) with distinct longitudinal striae or ridges, and strong spiral sculpture (6).
3. Embryonic cone narrow (4).
   Embryonic cone broad (5).
4. Adult shells narrowly turreted, majority of adults with 8½ to 10 whorls.....Group of **C. cochlea,** nos. 8 and 9.
   Adult shells oblong ovate: adults with less than 8 whorls..... **C. anceophila,** no. 4.
5. Adult shells narrowly turreted; majority of adults with 8½ to 9 whorls..... **C. dolei isenbergi** (in part) no. 8a.
   Adult shells turreted to oblong ovate, majority of adults with 7 to 8 whorls.....Group of **C. bicolor,** nos. 5 to 7.
6. Embryonic cone widely conic, with nearly straight outlines, fourth embryonic whorl not swollen.....Group of **C. turricula,** nos. 10 to 15.
   Embryonic cone narrowly conic with slightly convex outlines, fourth embryonic whorl swollen (7).
7. Embryonic cone narrow, the first two whorls forming a sharp point.....Group of **C. paradoxa** (in part) nos. 19 and 20 (in part).
   Embryonic cone wider, not sharply pointed (8).
8. Fourth embryonic whorl with spiral sculpture nearly equal in degree to the longitudinal sculpture.....Group of **C. glossema,** nos. 16 to 18.
   Fourth embryonic whorl with longitudinal sculpture much stronger than spiral sculpture..... Group of **C. paradoxa,** no. 20 (in part) no. 20a.

GROUP OF CARELIA SINCLAIRI

The embryonic whorls are slightly convex, the post embryonic whorls are coarsely wrinkled or spirally corded, the sculpture is continued on the base in front of the aperture.

KEY TO SPECIES

1. Shells without spiral sculpture (2)
   Shells with spiral sculpture.....**C. mirabilis, no. 3.**
2. Adult shells less than 40 mm. in length, suture margined.....**C. sinclairi, no. 1.**
   Adult shells more than 60 mm. in length, suture not margined..... **C. pilsbryi, no. 2.**

The species of this group have retained some amastroid characters to a greater degree than any of the other species. This is especially noticeable in the convexity and texture of the embryonic whorls. The species belonging to this group are known only from fossil specimens. Representatives were living at the close of the Pleistocene but became extinct at the same time as most of the species inhabiting the coastal plain during this period. It is probable that the representatives of this group never lived at a higher elevation than a few hundred feet above the present level. It is doubtful if the group is represented by living examples today. The only area in which there is any possibility of finding them is near the bottoms of some of the canyons of the Waimea drainage basin, since this region has never been investigated for shells.

Carelia sinclairi Ancey (Pl. I, figs. 1-8).

Carelia sinclairi Ancey: Mem. Soc. Zool., France, vol. 5, p. 720, 1892; vol. 6, p. 322, 1893.—Borcherding: Abh. Senck. Nat. Ges., vol. 32, p. 246, Pl. 20, figs. 19, 20, 1910.—Pilsbry: Man. Conch., vol. 21, p. 117, pl. 16, fig. 8, pl. 21, figs, 6, 7, 1911.

Shell subfossil, reddish-white or fleshy-whitish, with the aperture and part of the last whorl before it usually violet-red; scarcely shining, solid, the young very narrowly perforate, generally imperforate; oblong-tapering. Spire conoid with subconvex outlines, a little obtuse. Whorls 8, the first four smooth, the rest obliquely and closely, subirregularly plicate, upper whorls flattened, the lower a little convex, last whorl ovate, rounded Suture more or less distinctly margined below, simple above. Aperture suboblique, tapering-oval, narrow above and below, angular above. Columella arcuate, thickened, somewhat twisted, obliquely and lightly truncate above the base. Basal margin forming an angle with the columella, outer lip regularly elliptical. Peristome simple, acute unexpanded. Length 32 to 37, diam. 14 to 16, alt. aperture 12 to 14 mm. ([Ancey] Pilsbry).

Niihau (Ancey, Baldwin, Thaanum, and others) north of Kiekie on the western side of the island (Stokes). According to Pilsbry this species was distributed by Dr. Newcomb under the unpublished name of *Carelia extincta.* Ancey's type material was furnished him by D. D. Baldwin. It consists of three specimens (nos. 18789-91) and the type was not designated. Two of

these (Pl. I, figs. 1, 5) are figured. As Ancey's description was drawn up from more than one specimen, his three specimens should be considered as co-types. In addition to these the Ancey collection contained seven specimens received from D. Thaanum.

This species is very abundant in fossil deposits, at no great elevation above the sea. The specimens are found in calcareous beach sand or in deposits of disintegrated lava mixed with beach sand. From our present knowledge it should be considered a lowland species. There is no doubt that these deposits are relatively close to where the shells lived as the microscopical surface texture of a very large proportion of the specimens is in perfect condition. The remarkable state of preservation of such a large proportion of the specimens would also indicate that these shells had been covered while alive and had at no time been exposed to the elements for any considerable period since the surface textures of most of the specimens are in better condition than those of many of the "dead" specimens of recent species picked up where live specimens occur.

The Bishop Museum collection contains about a thousand specimens of this species from various sources. Only one lot of shells is localized. This was collected by Mr. Stokes in 1912; the rest were simply labeled as coming from Niihau.

There can be scarcely any doubt but that the species is extinct today. Except for a very few small clumps and some isolated trees, none of the original indigenous forest cover of the higher central portion of the island remains. Under the conditions which exist at present and have for many years, the species could not possibly remain alive.

Hyatt and Pilsbry (Man. Conch., vol. XXI, pp. 101-118, 1910) have both noted the relationship of *C. sinclairi* to the genus *Amastra*. There can be no doubt that these species, *C. pilsbryi* and *C. mirabilis*, are the most primitive representatives of *Carelia* of which we have any knowledge. This statement is based almost entirely on their embryological characters. Although these species are somewhat related embryologically their adult characters are quite distinct.

In several characters *C. sinclairi* differs from all the other species of the genus. The whole surface of the post-embryonic whorls is almost uniformly strongly striate. This striation continues on to the base of the last whorl. In all the other species (except *C. pilsbryi*) which are more or less striate, the base in front of the aperture is nearly smooth, or at the most, only microscopically striate. This type of striation occurs in many species of *Amastra*. The raised spiral cords and basal angle which are characteristic of many *Carelia* species are entirely lacking in *C. sinclairi*. Unlike nearly all species of the genus, the suture of *C. sinclairi* is distinctly margined. In *C. cumingiana* the suture of most specimens is sometimes weakly margined and this char-

acter sometimes occurs in individuals of *C. cochlea* and angled specimens of *C. dolei.*

The margined suture is rarely, if ever, present in any of the species of *Amastra* or *Laminella,* but is a common character in many species of *Leptachatina.* It is doubtful if this margined suture is of any importance in the phylogeny of the genus, since the amastroid stock from which *Carelia* is probably descended had differentiated considerably from the *Amastra-Leptachatina* stock by the time *Carelia* had become differentiated.

The majority of specimens of this species are of a uniform white color (Pl. I, figs. 1, 2). In most of these white specimens the delicate surface texture of the embryonic whorls is so perfectly preserved that their exposure for any length of time before being covered, could not have been possible. This and the nearly pure-white color of a few embryonic specimens may be explained by the fact that the original color of a majority of this species was of a lighter shade than is usual in most species of *Carelia* and may have been present for the most part in a thin delicate epidermis as in many species of *Amastra.* A few of these white specimens have brown embryonic whorls. This color becomes weaker and fades out on the fifth whorl. The rest of the shell is white. In quite a number of specimens the three lower whorls are irregularly streaked with a light, yellowish brown (Pl. I, fig. 6), gradually fading out above until the upper embryonic whorls are nearly pure-white. Undoubtedly this color was originally lighter towards the apex. In many of the specimens (Pl. I, figs. 3, 4) the four or five apical whorls are of a uniform, dark, brownish purple gradually becoming lighter downwards. In most of the specimens (Pl. I, figs. 7, 8) which have dark-colored early whorls the base is marked with a very broad brown band. This band occupies nearly the whole of the base except the umbilical region which is of the same color as the upper portion of the last whorl. All the specimens which have the dark base also have a very dark apex. The reverse does not hold true. The pale zone surrounding the umbilical region does not occur in any other species of *Carelia,* but is the characteristic color pattern of many *Amastrae* belonging to the second *Amastrella* and *Cyclamastra* and the species of *Kauaia* and *Armiella.* It is possible that the retention of this color pattern in some specimens of this species may indicate its primitive position in the genus.

Many young and a few adult specimens are minutely perforate, a character not found in other species of the genus, except two examples of *olivacea.* The columella is nearly straight to slightly concave above. The columellar fold is well developed and in full adult specimens terminates abruptly at the base of the columella.

That this species is descended from *Carelia* stock, that had already differentiated from *Amastra,* is illustrated by the complete absence of the thickening of the inner margin of the peristome.

Length	Diameter	Apert. Length	Apert. Diameter	Whorls	Plate	Figure	
35.5	14.7	14.0	7.2 mm.	8	I	5	(cotype)
33.8	12.5	12.1	6.3 mm.	7¾	I	1	(cotype)
36.0	13.7	13.5	7.1 mm.	7¾	I	2	
35.1	12.8	13.1	6.1 mm.	8	I	7	
36.2	14.7	13.4	6.8 mm.	7¾	I	4	
34.6	12.7	12.5	6.2 mm.	8	I	6	
31.7	13.2	12.7	6.7 mm.	7½	I	3	
29.1	12.3	12.0	6.0 mm.	7¼	I	8	

Abundant embryonic material of this species is contained in the Bishop Museum collection. These embryos appear to have retained some of the amastroid characters. They are perforate with the usual embryonic *Carelia* type of slit under the columella, but this slit is wider than in most of the embryos of other species examined. In form, and to a certain degree in sculpture, the embryos apparently have some resemblance to embryonic specimens of some *Amastrella*. The embryos of *sinclairi* are more globular and with the first three whorls shorter and more convex than those of any species of *Carelia* (with the exception of *C. pilsbryi* and *C. mirabilis*) which have been examined, as in all the other species these whorls are flattened and form a cone.

The first whorl (under a strong lens) is very minutely striate. The remaining embryonic whorls are more minutely and closely striate than in any of the typical species of *Carelia*. It is only on the third whorl that these striae are intercepted by the characteristic spiral striae, which usually become obsolete before the fourth whorl is half completed. In well preserved embryos of this species the first two whorls have a narrow indistinct pale zone just below the suture. This zone widens and becomes more distinct with the growth of the shell. On the fourth whorl it occupies about one-third of its width, its indistinct lower margin fading into the color of the rest of the whorl.

Carelia pilsbryi Sykes (Pl. I, figs. 12-14; Pl. II, figs. 1-6; Pl. XVIII, figs. 1-3).

Carelia pilsbryi Sykes: Malac. Soc. of London, Proc., vol. 8, p. 204, 1909. —Pilsbry: Man. Conch., vol. 21, p. 105, pl. 18, fig. 10, 1911. nec. *Carelia pilsbryi*.—Borcherding: Abh. Senck. Nat. Ges., vol. 32, p. 232, pl. 19, figs. 6, 7, (= *Carelia turricula* Mighels), 1910.

Shell elongate, spire much produced, imperforate; sculpture consisting of well-marked, irregular, longitudinal lines, these gradually becoming weaker towards the protoconch, which is smooth; colour of the last whorl red-brown, gradually fading on the upper whorls till the protoconch is only faintly tinged. Whorls 8, the last measuring more than half the entire length, moderately inflated, with a well-marked suture; mouth lunate, outer lip (broken) hardly thickened at all, the white columellar margin reflexed and slightly expanded. Length 65, diam. 23 mm. (Sykes)

Kauai (Sykes, Lyman): Kalihiwai (W. A. Bryan, P. Deverill, C. M. Cooke, T. Dranga); Kalihikai (C. M. Cooke, I. Spalding, Wood-Jones, McLean).

C. pilsbryi is known only from fossil materials. The specimen figured by Borcherding for this species is a rather broad form of *C. turricula* Mighels from the colony on the western ridge of Waioli from which his specimens of the latter species were taken.

Specimens of *C. pilsbryi* have been taken only in low flats, composed of a mixture of loam and beach sand, a few feet above sea level, and on the beach in front of these flats. The deposits from which specimens have been reported extend from the Kalihiwai stream to the streamlet near the eastern beach of Kalihikai, a distance of nearly a mile. Specimens of *C. cochlea* are far more abundant in these deposits than those of *C. pilsbryi,* and are also found in abundance for a distance of nearly a mile west of any *pilsbryi* specimen.

The writer has visited the fossil beds three times and material of this species was found to be very rare. Most of the unbroken specimens and a majority of the fragments were found in a deposit just west of the bluff west of the Kalihiwai stream. A single broken specimen was found near the eastern extremity of the Kalihikai beach and a fragment at an intermediate location. All the specimens, except one, agree very closely. The exception is a part of the spire of a shell, that, if whole, would be proportionately much narrower than any specimens that have been examined.

Mr. Sykes kindly loaned his type specimen (Pl. XVIII, figs. 1-3) to Bishop Museum for study and illustration. From the very close agreement of this specimen with the Bishop Museum material there can be no doubt that his specimen came from one of the deposits from which specimens have been examined. *C. pilsbryi* is a rare species. Besides the type which is in Mr. Sykes' collection in England, there are about 6 specimens in the collection of the Academy of Natural Sciences of Philadelphia, collected by W. A. Bryan. By collecting, gift and loan, about 30 whole or nearly whole adult and juvenile individuals have come under my observation. In the Bryan collection there are 1 entire and 5 nearly entire specimens; in the Spalding collection 7 whole and 4 juvenile specimens; and in the Lyman collection 2 juvenile specimens. The Bishop Museum collection has 9 whole, or nearly whole, adult and 6 juvenile specimens, and a few fragments. Of these, 2 adults and 3 juveniles were obtained by collecting, 1 adult and 1 juvenile from Bryan, 2 adults (1 pathologic) and 1 juvenile from Spalding, 2 adults from Wood Jones, and 1 adult each from Mrs. McLean and Mrs. Deverill.

All the specimens agree closely in their embryonic characters. From what remains of the color it is evident that the post-embryonic whorls of this species were of a uniform very dark color. The embryonic whorls in one

specimen are bicolored, the rest of the specimens are so faded that this character could not be made out. The first three whorls increase very rapidly and are more uniformly convex at all stages of growth than in other species of the genus. The intial whorl is minute, smooth, the second and third embryonic whorls are microscopically finely and evenly striate with closely packed slightly arcuate striae. These increase in strength with the growth of the shell and are continued with increasing development on the post-embryonic whorls. The spire is slightly convex in outline and tapers gradually upwards, but more abruptly above the fourth whorl. The position of the basal angle is indicated but not well defined. The aperture is oblong-ovate. The columella is nearly straight, only slightly sigmoid and furnished with a very weak fold which terminates very gradually at the base of the columella. The basal sulcus of the aperture is broad, shallow, and evenly rounded.

C. pilsbryi differs from the other species of *Carelia* from Kauai not only in its distinctive embryological characters, but also in the absence of any indication of spiral lines at all stages of growth. In the uniform convexity of its embryonic whorls, which are closely and evenly striate, and the coarse striation of the post-embryonic whorls, it is apparently closely related to *C. sinclairi* from Niihau. It differs embryologically from this species in the entire absence of the fine spiral lines.

Specimens of what may be considered the commonest form of this species are cylindrically turreted, tapering very slowly to the broadly conic apex. There is a great deal of individual variation in the proportion of the diameter to the length. In fact, with the small series at hand, each shell presents rather individual characters so that it is extremely difficult to select a specimen which might serve as a representative example. However, 4 of the 8 adult specimens in the Bishop Museum collection are well represented (Pl. II, figs. 1, 6), and these might be selected as fairly representative of a majority of the species.

A slight variation is shown by one of the specimens collected by Spalding (Pl. II, fig. 2) in which the outlines are more conic. This specimen, except for its characteristic embryo, illustrates in its type of whorling some of the specimens of *C. olivacea* found to the east of *C. pilsbryi* while the Wood Jones specimen (Pl. II, fig. 3), except for its typical embryo, might pass as a specimen of *C. turricula,* a species which is found only a few miles to the west. These resemblances probably have no significance in the relationship of this species, but illustrate the variability of the individuals inhabiting this colony. Another type of shell, of which two or three examples exist, most of which are badly broken, is illustrated by Bryan's specimen (Pl. II, fig. 5). This example is proportionately much narrower and the whorls are more convex and more loosely coiled than in the representative form. Sykes' type

is intermediate between this form and the more representative specimen (Pl. II, fig. 1).

The type, according to my system, measures: 65.5 mm. in length, 21.4 mm. in diameter; whorls 8 (Plate XVIII, figs. 2, 3). Other specimens have the following measurements:

Length	Diameter	Apert. Length	Apert. Diameter	Whorls	Plate	Figure
71.0 mm.	24.8	26.2	12.5	8¾	II	1
81.7 mm.	24.9	24.6	13.0	9⅞	II	4
64.0 mm.	25.2	23.5	12.2	8½	II	6
70.0 mm.	22.4	21.8	12.0	9½	II	3
72.0 mm.	21.3	(aperture broken)	(broken)	9	II	5
66.0 mm.	24.1	23.7	13.1	9+	II	2
79.0 mm.	26.4	26.3	15.5	9¼	(Bryan Collection)	
76.0 mm.			26.5	9½	(Spalding Collection)	
71.5 mm.			25.8	9¼	"	"
66.5 mm.			23.0	9¼	"	"

My measurements of the type differ slightly from those of Sykes. The type is slightly smaller than the adult specimen (Pl. II, fig. 1) which has been selected as fairly representative of the species. In the type the whorls are slightly more convex; the last whorl is more strongly and irregularly striate, and due to a slight injury on the penultimate whorl, there is a very shallow broad sulcus on the last whorl.

Two juvenile specimens, with about 7½ whorls, in Mr. E. Lyman's collection agree closely with the specimens in Bishop Museum. Their color, however, is in a better state of preservation. The post-embryonic whorls are uniformly colored (in life undoubtedly black or dark, reddish black) which, on the last whorl below the periphery, shades gradually to a slightly darker hue near the columella. A whole specimen in W. A. Bryan's collection is roughly striate, especially below the sutures of the last five whorls; the upper four are smooth and even.

The dwarf pathologic specimen (Pl. I, fig. 14) collected by Spalding has 8+ whorls and measures: length 47.1, diameter 18.3 mm. Its surface is not well preserved, but the last three whorls show the characteristic coarse striation. In its present condition, the embryonic whorls seem fairly typical. The post-embryonic whorls are almost flat, giving the shell a nearly straight outline, tapering gradually above. There is an indistinct basal angle. The shell is very thick and heavy, much thickened inside the lip and below the columella, with a broad callus. The margin of the lip is thin. This is the only specimen of *Carelia* of all those examined in which there is a well developed callus. An immature specimen of nearly the same length (45 mm.) has 7½ whorls.

There are two embryos of *pilsbryi* in the Museum collection, one of which is whole. Both are probably not quite fully developed, but very nearly so,

as they consist of four whorls. The slightly broken specimen is imperforate. The whole specimen has a very narrow cleft-like umbilicus, as the edge of the columella is folded over but not joined to the outer wall of the shell. The specimen is almost globose.

Carelia mirabilis, new species (Pl. I, figs. 9-11).

The shell is narrowly turreted, conic, tapering gradually and evenly to a rather acute embryonic cone; the post-embryonic whorls are marked with coarse, close, longitudinal riblets, cut at right angles by less deeply engraved spiral lines, giving the surface a closely tuberculate texture which begins abruptly at the completion of the embryonic whorls. Below the periphery and continuing to near the columella the base is strongly marked with vertical riblets and spiral striae forming a tuberculate texture slightly weaker than that above the periphery; below the periphery the tubercules are arranged in spiral while above they are arranged in vertical rows. Whorls 8-9, uniformly convex, increasing very slowly and evenly; the first and second nearly smooth, the third and fourth marked with very fine vertical striae; beginning about the middle of the fourth whorl there are faint spiral striae. Near the completion of the fourth whorl the longitudinal striae become slightly coarser. The suture is distinctly margined. The last whorl is rather short, rounded at the periphery which is furnished with a low distinct cord-like ridge. The aperture is small, wide in proportion to its length. The columella is strongly sigmoid, convex above and furnished with a strong fold ending abruptly at its base. The sinus at the base of the columella is relatively narrow.

The material from which the above description is drawn does not contain a whole adult specimen. Exact measurements of the length cannot be given, but from the material at hand, an adult would measure about 45-48 mm. in length. The largest specimen has a length of 40.5 mm., diameter 14.3 mm., 8¼ whorls, Pl. I, fig. 10. A young specimen, (Pl. I, fig. 11) measures: length 28.2, diameter 12.0 mm., 7½ whorls. The last whorl of two adult specimens measures: (a) diameter 15.7, aperture length 13.6, diameter 8.0 mm., (Pl. I, fig. 9); (b) diameter 15.5, aperture length 12.6, diameter 8.2 mm.

Kauai, limestone bluff about 0.5 of a mile east of Aweoweonui Bay, in Mahaulepu, from 50-150 feet above sea level, 1930, C. M. Cooke. Type no. 100391.

The material on which this species is based consists of portions of 17 individuals, only one of which, a juvenile, is apparently nearly complete. Unfortunately, the species was not recognized as different from *C. lirata* in the field, as these smaller specimens were thought to represent an extreme individual variation. While in process of cleaning, the lime-incrusted surface was exposed and this form was recognized as constituting a very distinct species.

C. mirabilis has the distinction of being the only species with a strongly spirally sculptured base. In all the other spirally sculptured species the base below the periphery is smooth or only faintly engraved.

The embryonic whorls are slightly convex and not flattened as in the other

species (*cochlea* and *dolei*) which have a narrow embryonic cone. These slightly convex embryonic whorls are somewhat similar to those of *C. sinclairi,* and represent a slight advance in the development toward the flattened typical embryos.

It is unfortunate that this species is not represented by a whole adult specimen. It is, however, so distinct from any other species, both in embryological and adult characters, that I have no hesitancy in describing it.

GROUP OF CARELIA BICOLOR

The embryonic whorls are flattened, sculptured with distinct longitudinal striae, the striae often split near their bases. In some specimens weak spiral striae are present. Adult shells are oblong ovate to turreted, with from 6¾-8½ whorls and are 29-52 mm. in length. The post embryonic whorls are regularly convex or marked with a well developed shoulder and basal angles.

The species of this group are associated together for the most part by their embryonic characters. They form a group that is intermediate between the *turricula* and *sinclairi* groups, but are apparently more closely related to the former on account of the flatness of the embryonic whorls. None of the species except *kalalauensis* are represented by specimens with strong spiral surface cording, though this character is sometimes indicated with very low ridges, often so faint that they can be seen only with reflected light. Most of the specimens of *kalalauensis* are marked with engraved spiral lines which are often strong enough to form distinct spiral cords. This is remarkable as the embryos of this species are less often and not so distinctly spirally engraved as the embryos of *bicolor.*

This group is distributed from the east side of the Waimea drainage basin to the ridge east of the Wainiha stream. It undoubtedly occupied the whole of the western and northwestern portion of Kauai. Up to the present time no species referable to other groups have been found in this region except *dolei,* a lowland species whose habitat is surrounded inland by species belonging to the *bicolor* group (see map). The species and subspecies characterized by the presence of a distinct and well developed angle occur only in the northern portion occupied by the group. In the southern, western and northwestern colonies this character is entirely lacking or only indicated. A very few exceptions to this occur among specimens of *kalalauensis* (Pl. III, fig. 7), but the rule generally holds good. The eastern peripheral forms of this group (*cumingiana, C. meineckei* and *b. angulata*) form a connecting link with the *cochlea* group through specimens of *dolei isenbergi,* but the embryos of the former associate them more closely with the *bicolor* group.

The southernmost and geographically the most isolated species (*anceophila*) differs from the other species of this group by its much narrower embryonic cone. This type of embryo has undoubtedly evolved through a

long period of isolation. Its apparent similarity to embryos of the *cochlea* group is probably accidental.

The demarcation between the embryos of the *bicolor* and *turricula* groups with our present knowledge, is abrupt. Specimens of the former have been taken on the western ridge of Lumahai, of the latter from the eastern ridge of the same valley. There is no intergrading either in embryonic or adult characters although the two colonies are separated by not much more than a mile.

KEY TO SPECIES OF BICOLOR GROUP

1. Shell with distinct shoulder angle (4).
   Shell without distinct shoulder angle (2).
2. Shell with finely engraved spiral lines..... **C. kalalauensis,** no. 5.
   Shell without distinct engraved lines (3).
3. Embryonic cone narrow, aperture narrow, slightly pointed below, columellar fold very low, thread-like..... **C. anceophila,** no. 4.
   Embryonic cone broader, aperture rounded below, columellar fold distinct, truncated..... **C. bicolor,** no. 6.
4. Surface between shoulder angle and suture roughly wrinkled... **C. kalalauensis,** no. 5.
   Surface between shoulder angle and suture not roughly wrinkled (5).
5. Suture bordered below by a white band (6).
   Suture not bordered below by a white band (7).
6. Shell with strong shoulder and basal angle..... **C. cumingiana,** no. 7.
   Shell with strong shoulder angle, basal angle rounded or absent. **C. bicolor angulata** (in part), no. 6a.
7. Adult shells with less than 8 whorls, rarely over 45 mm. in length. **C. bicolor angulata,** (in part), no. 6a.
   Adult shells with 8-8½ whorls, 47-52 mm. in length, stout. **C. cumingiana meineckei,** no. 7a.

Carelia anceophila, new species (Pl. III, figs. 9, 10).

The shell is narrowly and acutely oblong-ovate, solid but not thick, nearly smooth. The spire has slightly convex outline and tapers gradually and regularly, not terminating above in an abrupt cone. Whorls 7¾, the lower slightly and evenly convex and becoming slightly flatter towards the apex. The apical whorls are somewhat worn but enough remains of the surface texture to determine their characters. The first whorl is smooth. Beginning on the second whorl are narrowly-spaced, rather broad, and slightly arcuate vertical ridges. These ridges are somewhat similar on the rest of the embryonic whorls. Beginning near the completion of the third whorl there are faint indications of minute spiral sulci but these are not strong enough to give the vertical striae a granular appearance. On the fifth and sixth whorl there are about seven inconspicuous low rounded ridges visible only with the aid of a strong lens. On these two whorls the vertical ridges are very low and inconspicuous, except just below the suture where they are moderately developed. The last whorl is oblong and there is scarcely, if any, indication of a peripheral keel.

The embryonic whorls (about 4) are indistinctly bicolored, the upper half of each whorl is cinnamon-rufous, the lower half bay. The two lower whorls are Hay's russet broken by irregular vertical stripes of light yellowish brown.

The aperture is narrowly ovate, brown with a bluish sheen, its outer margin regularly curved. The columella is brown, narrow, nearly straight, very slightly arcuate above. The columellar fold is scarcely developed, but there is an indistinct thickening of the columella on its inner margin. The sinus below the columella is shallow and rounded.

Length 38.7, diameter 13.4, aperture length 14.3, aperture diameter 7.5 mm., whorls 7¾. Type (Pl. III, fig. 9). Length 32.6, diameter 12.7, aperture length 13.1, aperture diameter 7.6 mm., whorls 7. Paratype (Pl. III, fig. 10). Kauai, Olokele, C. M. Cooke. Type, nos. 14790A; paratype no. 14790B.

This species is based on two specimens. The type is adult and the second specimen is nearly so. Both specimens were found along the Olokele trail and had been dead only a short time when collected as the type specimen contained putrid portions of the animal when found. Both specimens were taken only a short distance from where dead specimens of *C. glossema* were found. These specimens agree very closely and undoubtedly represent a very restricted colony. The younger specimen has slightly darker and more uniform colored embryonic whorls and the surface texture is better preserved. In this specimen the weak nearly obsolete spiral sulci are slightly more conspicuous than on the type. The color pattern on the second shell is typical, but begins at a later stage than in the type. Unfortunately, there are no embryonic shells, but in both specimens the demarcation between the embryonic and post-embryonic whorls is distinctly defined. This occurs just after the completion of the fourth whorl. In *C. anceophila* the embryonic shells are of the narrow type similar to those of *C. dolei* but somewhat longer.

C. anceophila is undoubtedly descended from the *bicolor-kalalauensis* stock and differs from all the other species of this stock by its slender and gradually tapering spire and its very distinct color pattern which is not present in any other species of the genus, except in occasional specimens of *C. kalalauensis,* but more often in those of *C. bicolor* from Hanakapiai to Hoolulu.

C. anceophila is at present a rare shell. No specimens were found by Thaanum, Meinecke, or Dranga, all of whom have collected along the Olokele trail. It is probable that the specimens were outlying individuals near the periphery of its habitat and that the species exists in larger numbers at no great distance, on the slopes of the canyon below the trail.

Carelia kalalauensis, new species (Pl. III, figs. 1-8, 11-17).

The shell is turreted with slightly convex outlines, solid, irregularly sculptured with rather coarse longitudinal growth folds, cut at irregular intervals by deep spiral grooves. The spire tapers gradually, terminating above in a cone. Whorls 7½; the first nearly smooth, the second flat, sculptured with distinct, equally and closely spaced, slightly arcuate riblets. The third whorl and the first half of the fourth are similarly sculptured. On the second half of the fourth whorl, faint spiral sculpture begins abruptly and at this point the whorl increases slightly in width and is more convex than above. The post-embryonic whorls are convex, more strongly vertically sculptured just below the sutures than on the lower portion of the whorls. There are about ten incised unequally spaced spiral grooves, the upper two of which are more pronounced than those below. The intersection of these lines with the coarse growth striae gives the surface of the shell a slightly irregular tuberculate appearance, more or less spirally arranged. The last whorl is somewhat flattened, and indistinctly angulate.

The embryonic whorls are of a uniform, very dark color—nearly black; the rest of the whorls, liver-brown; base nearly black, bordered above by a narrow pale band. The

aperture is irregularly ovate, the upper half bluish white, the lower bluish black. The columella is nearly straight, furnished with a moderately developed columellar fold which terminates gradually near its base. The sinus below the columella is shallow and indistinctly angular.

Length	diam.	apert. length	apert. diam.	whorls	age	Plate	figure	locality	
38.7 mm.	15.5	14.5	8.4	7½	adult	3	11	Kalalau	Type
37.9 mm.	16.6	15.0	9.5	7¼	"	3	6	"	(topotype, dead)
36.2 mm.	15.6	14.6	9.1	6¾	"	3	7	"	(topotype, dead)
40.7 mm.	12.6	12.9	6.8	8	"	3	8	"	(topotype, dead)
45.0 mm.	16.1	14.0	8.6	8	"	3	2	"	(dead)
37.6 mm.	15.1	13.2	7.7	7⅔	"	3	4	Milolii	(dead)
37.3 mm.	14.7	13.2	7.8	7¾	"	3	12	Hanakoa	
40.8 mm.	15.5	14.2	8.8	7½	"	3	13	"	
40.2 mm.	15.4	14.4	8.8	7¾	"	3	14	"	
43.7 mm.	15.4	15.0	8.5	8	"	3	15	"	
38.1 mm.	14.9	14.0	7.9	7½	"	3	16	"	
39.7 mm.	15.5	14.0	7.7	7¾	"	3	17	Waiahuakua	
41.5 mm.	14.1	12.3	7.7	8½	"	3	1	Kalalau	(fossil)
42.9 mm.	14.2	13.0	7.5	8½	"	3	3	Honopu	(fossil)
37.2 mm.	15.7	14.4	7.9	7¾	"	3	5	Makaha	(fossil)

Kauai, Kalalau, South Point, fossil in a bank on cliffs overhanging beach (Pease), A. Knudsen and C. M. Cooke; head of valley, dead specimens. A Knudsen and H. Hitchcock; south side of valley on spur ridge near head, C. S. Dole and C. Forbes; north side of valley east of double waterfall, (type locality [W. Meinecke]); Honopu, fossil in bed of valley, A. Knudsen; Milolii, above cliffs near large orange tree, A. F. Judd, B. Cartwright, C. M. Cooke; Hanakoa, three colonies, W. Meinecke; Waiahuakua, W. Meinecke; Makaha ridge (fossil), C. S. Judd. Type no. 79947A.

The above localities are arranged chronologically as they were collected. Since the series collected by Meinecke contained the most material and illustrated a wider range of variability, the type was selected from it. Material of this species was distributed by Pease under the name of *Carelia paradoxa.* Material collected by Pease is in the collections of the Museum of Comparative Zoology, the American Museum, E. R. Sykes, and Bishop Museum. Other than that this material came from Kauai, no data are found on the labels of Pease. The material in Bishop Museum and Meinecke's collection indicates that the species is extremely variable. (See Plate III, figs. 1-8, 11-17.) Since the majority of the specimens of these two series has the last whorl distinctly flattened, one of the specimens with this character was selected as the type.

The material collected by Meinecke was procured on two trips. The first trip in 1925 resulted in finding about 15 live and 40 dead specimens. During the summer of 1927, Meinecke again visited the same colony and found nearly 50 live and about 200 dead specimens. This locality is a very restricted one, consisting of a few square yards of talus slope, overgrown with shrubs and small trees, high up on the side of the valley.

A few specimens have the last whorl regularly rounded (Pl. III, figs. 6, 14). There is a great amount of variability in the development of the vertical and spiral sculpture. In some specimens the spiral lines—except the two or three nearest and below the suture—are almost obsolete, while in other specimens all the spiral striae have a nearly equal development. In nearly all the adult specimens the microscopical texture of the early whorls is more or less worn. The type specimen is in this condition. The embryonic characters will be treated below. One specimen collected by Meinecke is distinctly biangular (Pl. III, fig. 7) and might pass for a specimen of *C. b. angulata.*

Specimens distributed by Pease, probably collected between 1860 and 1870, Pease's most active period, and those collected by Forbes and Dole eighteen years ago, are much lighter in color than the specimens collected by Meinecke in 1927 and 1928. Most of the specimens, except for the base and apical whorls, are of a uniform color, becoming lighter above. A number of the specimens (13 out of 30 live specimens collected by Meinecke, 1927) are marked with a narrow, light subsutural band, characteristic of many specimens of *turricula.* The base is, in all but one specimen, dark as in the latter species. Two or three have a color pattern resembling typical specimens of *bicolor* and one specimen (86039) collected by Meinecke has the dark base and lighter spire described by Pilsbry as *C. b. hyperleuca.* A few examples—except for a narrow, reddish, subsutural line—could pass as the *adusta* color pattern of *C. bicolor.* In a few specimens the apical whorls are distinctly bicolored, a color pattern which is not represented in any of the embryos. This color pattern is due to the partial wearing away of the epidermis.

Except in being slightly more turreted and with the surface more distinctly tuberculated, adult specimens found in the fossil beds of Kalalau and Honopu do not differ materially from living examples taken today. There is apparently not enough difference from the modern stock to separate them as varieties. From the appearance of the shells and the conditions under which they occur, they were undoubtedly laid down at the same period as other fossil species, namely: *dolei, cochlea, pilsbryi, paradoxa,* etc. Three dead specimens collected by Judd in 1892, and two fragments collected by Cartwright and Cooke from Milolii, are in the Bishop Museum collection. The Cartwright and Cooke specimens were found in the bed of the valley, some distance above the cliffs. Although this locality is about three miles from Honopu and more than four miles from the nearest colony in Kalalau, there is little difference between these and Kalalau specimens of the same state of preservation. In A. F. Judd's material (Pl. III, fig. 4), the specimens have a dark base, the spire being light-colored, with the pattern almost as distinct as in the color form *C. bicolor hyperleuca.*

From the presence of the peripheral band in many specimens and the occurrence of a more or less tuberculate surface, *C. kalalauensis* at first glance

appears to be a diminutive *C. turricula.* From its size and the color of many of the specimens there is some resemblance to specimens of *C. bicolor.* However, its geographical distribution and the absence of very distinct spiral engraving on embryonic specimens distinguish *C. kalalauensis* from any other species of the genus. The less specialized type of embryo is interesting as it may be a retention of an early stage in the phylogeny of the group of *C. bicolor.*

A few examples collected by Meinecke from Waiahuakua (Pl. III, fig. 15) and the type locality have nearly the appearance of being typical examples of *C. bicolor adusta.* The whorls are similarly rounded. However, under a strong lens the characteristic spiral lines of *C. kalalauensis* are easily visible and the surface just below the sutures is more coarsely engraved.

Two very interesting series of shells collected by Meinecke belong to this species. These were taken from Hanakoa and Waiahuakua, northeast of Kalalau. Mr. Meinecke located three colonies in Hanakoa Valley and a fourth colony on the western side of Waiahuakua Valley. In Hanakoa nearly 400 examples were taken, a fourth of which were alive. The specimens from this valley were found just above the lowest range of cliffs above the trail, a locality not accessible to the cattle pastured in the valley. The specimens average slightly larger than the average adult specimens from Kalalau and show, from their more convex whorls, an approach to *C. bicolor.* This resemblance is more accentuated by their color pattern, as nearly all the examples have a subsutural, lighter colored band, characteristic of the western colonies of *C. bicolor.* This zone is less conspicuous and considerably narrower than in the specimens of the latter species. Of the 29 live specimens, 3 examples have the peripheral band merely indicated. The surface of all the specimens is decidedly more sculptured, both with vertical and spiral striae, than those of *bicolor.* The angle and sculpture of the apical cone is nearer that of *C. kalalauensis.*

Slightly further east on the western side of the valley of Waiahuakua, Meinecke located another colony, the specimens of which closely agree with those found in Hanakoa. Two dead specimens have a rather wide, light-colored, subsutural band. None of the 9 live specimens have the peripheral band indicated. The shells from both of these valleys have slight affinities with *C. bicolor* and are intermediate between this species and *C. kalalauensis* and represent a geographical race of the latter species.

A fossil colony located by C. S. Judd in 1929 on Makaha ridge south of Milolii (Pl. III, fig. 5) has specimens slightly cylindrical in form and with the strongly sculptured surfaces found in the fossil deposits of Kalalau and Honopu. The Makaha specimens are slightly shorter than those from the other fossil beds and have a well developed basal angle which is more pronounced than in any except a very few of the Kalalau (both recent and fossil)

examples. The three fossil colonies, though distributed over an area of about six miles, are very similar in their adult character and show less variation than living specimens occupying less than half of this area.

Most of the animals of shells with 7½ or more whorls, are pregnant with 2 to 3 embryos. Only one example with just 7 whorls contained an embryo. None of the embryos have over 3¾ whorls and none are bicolored, but are of a uniform liver-brown color. The initial half of the first whorl is smooth, the last half is very minutely, microscopically, vertically striate, the rest of the whorls are uniformly striate with regular closely and evenly-spaced arcuate striae which on the last whorl are continued with slightly less strength on to the base. On the second whorl there is a slightly developed shoulder angle which disappears at about the beginning of the third whorl. The spiral sculpture is slightly less developed in this species than on embryonic specimens of *C. bicolor*. Under a strong lens it is merely indicated. The minute basal spiral sculpture has about the same development in both species. The embryos are perforate with the characteristic slit-like perforation.

An infant from the type locality (86480) has not quite 3¾ whorls, length 7.5 mm. Evidently the young are born at a slightly earlier stage than those of *C. bicolor*. Three embryos (86474A) from a single specimen, taken in the type locality, have the following measurements: length 7.5 mm., 3 2/3 whorls; 5.4 mm., 3 whorls; 3.2 mm., 2 whorls.

A specimen from Hanakoa (88321) contained 3 embryos. The largest, 8.5 mm. long, is longer than the Kalalau specimens, although it has 3 2/3 whorls. This specimen lacks the shoulder angle on the second whorl. The second specimen is 6.9 mm. long, 3 1/3 whorls; the third, 3.9 mm., 2 2/3 whorls with the shoulder angle present on the second whorl. Three mature embryos (88322) with 3¾ whorls, from different animals, had the shoulder angle present on the second whorl. These three embryos measure: 9, 8.9, and 8.4 mm. in length and are larger with fewer whorls than any typical *bicolor* embryos.

Among the Waiahuakua specimens (88385) there was one with 2 embryos, the larger 8.8 mm. long, 3¾ whorls; the smaller, 5.8 mm., 3 whorls.

Only four immature embryos were obtained from fossil material from the south side of Kalalau. The largest and best preserved has just 3 whorls. These embryos, when compared with specimens of the same age from the type locality are more globose, with a shorter, flatter, and less conical spire. The second whorl is slightly flattened above and separated from the first whorl by a very broad suture, with more convex outlines and much weaker striae. These embryos apparently represent an earlier stage in the development of the species.

From the fossil Honopu specimens 11 embryos were taken. The two largest embryos have from 3¾ to 4 whorls, conical outline, and are propor-

tionately narrower than typical embryos with the whorls slightly more flattened. In surface texture they agree closely with the typical form. Two of them measure: length 6.6, whorls 4; 6.4 mm. 3¾ whorls.

Two embryos were taken from one of the Makaha fossil specimens. Both of these are slightly broken and the surfaces somewhat decayed. In outline and texture they apparently are closer to the fossil Kalalau material than to the fossil embryos from the intermediate valley of Honopu.

The embryos of *C. kalalauensis* present an interesting problem.The most primitive types come from the fossil beds of Kalalau and Makaha ridges. Those from living examples of Kalalau, Hanakoa and Waiahuakua are slightly more specialized and apparently intermediate between this primitive type and those of *C. bicolor.* The embryos of Honopu, an isolated valley between Kalalau and Makaha, though retaining their primitive characters, differ from all the other embryos in being proportionately narrower.

There are no adult characters that are correlated with these three types of embryos. However, nearly all of the fossil specimens agree in being more uniformly turreted, with flatter whorls and a stronger developed and more consistent basal angle.

Carelia bicolor (Jay) (Pl. IV, figs. 1-17).

Achatina bicolor Jay: Catalogue of Recent Shells, 3d ed., p. 119, pl. 6, fig. 3, 1839.

Achatina (*Carelia*) *bicolor* H. and A. Adams: The Genera of Recent Moll., vol. 2, p. 132, [1858]; von Martens, in: Albers, Die Heliceen, p. 208, 1860 (type of subgenus).

Achatinella bicolor Pfeiffer: Mon. Hel. Viv., II, p. 233, 1848.

Carelia bicolor Pease: London, Proc. Soc., p. 472, 1871.—Binney: Philadelphia, Proc. Ac. of Nat. Sci., p. 185, pl. 6, figs. CC, G and O, 1876 (radula, jaw and genitalia).—Ancey: France, Mem. Soc. Zool., vol. 6, p. 323, 1893.—Borcherding: Mon. Gen. Carelia, p. 241, pl. 20, figs. 9 and 10, 1910.—Pilsbry: Man. Conch., vol 21, p. 113, Pl. 20, figs. 1, 2, 3, 4, and 7, Pl. 16, figs. 7 and 9 (juvenile and apex).

Achatina adusta Gould: Boston, Proc. Soc. Nat. History, vol. 2, p. 26, 1845.

Carelia adusta Pease: Jour. de Conchyl, p. 403, 1870.—Gulick: Proc., Zool. Soc., London, p. 91, 1873 (type of genus).—Borcherding: Mon. Carelia, p. 242, Pl. 19, figs. 12, 13, 14 and 15, 1910. *Achatinella adusta* = *bicolor* Pfeiffer: Mon. Hel. Viv., vol. 2, p. 233, 1848. *Achatina adusta* (var. *bicolor* Jay) Gould: Otia Conch., p. 194, 1862. *Carelia bicolor* var. *adusta* Pease: London, Proc. Zool. Soc., p. 472, 1871.—Paetel: Cat. Conch-Samml., vol. II, p. 241, 1889.—Pilsbry: Man. Conch., vol. 21, p. 114, pl. 20, figs. 8, 9, 10, 1911.

Carelia adusta var. *minor* Borcherding: Mon. Carelia, p. 244, pl. 20, figs. 17 and 18, 1910.

Carelia adusta var. *zonata* Borcherding: Mon. Carelia, p. 244, pl. 20, figs. 13 and 14, 1910.

Carelia adusta var. *minor,* forma zonata Borcherding: Mon. Carelia, pl. 20, figs. 15 and 16, 1910.

Achatina fuliginea Pfeiffer: London, Proc. Zool. Soc., p. 66, 1852: Mon. Hel. Viv., vol. 3, p. 490, 1853: Conchyl Cab., I, 13, Achatina, p. 367, pl. 43, figs. 21 and 22.

Carelia fuliginea Pease: London, Proc., Zool. Soc., p. 473, 1871.—Ancey: France, Mon. Soc. Zool., vol. 6, p. 322, 1893.—Borcherding: Mon. Carelia, p. 239, pl. 20, figs. 11 and 12, 1910.

Carelia bicolor var. *fuliginea* Pilsbry: Man. Conch., vol. 21, p. 115, pl. 21, figs. 9 and 10, 1910.

Carelia fuliginea var. *suturalis* Ancey: London, Proc. Mal. Soc., vol. 6, p. 122, 1904.

Carelia bicolor hyperleuca Pilsbry: Man. Conch., vol. 21, p. 114, pl. 20, figs. 5 and 6, 1910.

Shell oblong-ovate, solid though not thick, spire red-brown, darkening on the apical and penult. whorls, the last whorl or two black or black-brown, with a cream-white zone below the suture; this zone ascends the spire 2½ or 3 whorls, and reappears on the earliest whorls. The first 3½ whorls are but slightly convex and form a conic terminal cone; following whorls become decidedly convex, and taper more slowly. The indistinct spirals of the early neanic whorls often become low subobsolete cords or angles on the last whorl. The angle bounding the base, distinct in the neanic stage, is sometimes traceable in adult shells. Aperture very dark with a bluish iridescence inside. The columella is moderately concave, narrowly truncate at the base, and bears a very obliquely-descending white lamella.

Length 36.5, diam. 15, length aperture 13 mm. Whorls 7½.

Length 34, diam. 13.5, length aperture 13 mm. Whorls 7½.

"The width of the subsutural white band varies a good deal—from 1½ to 5 mm. wide in shells about 35 mm. long. In some shells the junction of the white band with the dark color is a sharp line; in others the dark color fades gradually through red-brown; again, bright blue appears at the upper edge of the darker color."—(Pilsbry.)

Habitat? Along trail, Limahuli to Hanakapiai (Jay): P. Deverill, C. S. Dole, D. Thaanum, W. Meinecke, T. Dranga, F. Wood Jones, Cooke; Hanakapiai, P. Deverill, Cooke); along trail from Hanakapiai to Hoolulu, C. S. Dole, W. Meinecke, H. St. John, and E. Hume. Besides this localized material the Museum has, from various sources, an abundance of material labeled "Haena" or simply "Kauai." Most of this material undoubtedly came from along the trail between Limahuli and Hanakapiai, as this is the most easily accessible locality where this species occurs.

This is the oldest species of the genus, having been figured by Jay in 1839. It is also the commonest species in collections and the very few living species that can be collected in representative numbers at present.

The typical color pattern occurs only in pure colonies in and west of the valley of Hanakapiai. The width of the light-colored subsutural line varies from 1 to 3 mm. in diameter. From an examination of more than 50 localized individuals (this includes the large series in the Meinecke collection) this band is never absent (*adusta* pattern), nor is it as wide as in the color form figured as *hyperleuca* by Pilsbry. In a very few specimens it is represented by a narrow indefinite line (Pl. IV, fig. 16), while in some it occupies nearly half of the portion of the penultimate and last whorls above the periphery.

Specimens collected in July 1925 by Meinecke are between dull greenish-black and black, the color of the subsutural zone is olive-buff. Specimens collected by the writer, about 1895, have faded considerably since they were collected as the color of the last whorl is from bay to chestnut.

Specimens collected by Deverill (Pl. IV, figs. 1-3), in the Bishop Museum collection from Hanakapiai Valley, have the dark color of the last and penulitmate whorls irregularly marked with blotches of a lighter color, while in a very few examples, there is a narrow, broken, indistinct, peripheral band. Occasional specimens with the typical color pattern also occur in the colonies east of Hanakapiai. These will be discussed on page .....

Ancey's type specimens (two) of *suturalis,* one of which is shown in Plate IV, figure 6), are not only typical of *bicolor,* but undoubtedly came from a colony west of Hanakapiai Valley. Borcherding's forms *C. adusta minor zonata* and *C. adusta zonata* are merely immature specimens of what are probably typical *C. bicolor* and should not be considered of even varietal rank. Likewise, his *C. adusta minor* should be considered merely a juvenile specimen of the *adusta* form. All three forms can be matched with localized juvenile specimens of the species in the Bishop Museum collection.

In each of the colonies there is some variation in the proportion of the diameter of the shell to its length. There is also some slight variation in the convexity of the last and penultimate whorls. In a very few individual specimens the position of the shoulder angle is merely indicated. Most of the localized material which I have examined is either from the valley of Hanakapiai or from a colony found by Meinecke just above the trail west of Hanakapiai and just east of Hoolulu. In this species the outer margin of the aperture is always curved in adult specimens. The columella is rather short, concave above. The columellar fold is well developed, even in immature specimens, and terminates abruptly just above the base of the columella.

Embryonic specimens (78933) up to 3½ whorls are very minutely perforate, the columella nearly straight, furnished with a low gradually-terminating columellar fold.

Adults from the colonies found east of Hanakapiai show much more variation, both in color and surface texture, than those from farther west. Specimens from the individual colonies in the steep gullies above the trail

between Haena and Hanakapiai have all the different color forms associated in very limited areas. In most of these the color form described by Gould as *C. adusta* (Pl. IV, fig. 8) greatly predominates. The color form described as *hyperleuca* (Pl. IV, fig. 4) is represented in varying proportions among the examples from three of these colonies. There is an intermediate color form (Pl. IV, fig. 7) with a dark base, lighter-colored above. This last is intermediate between typical *adusta* color pattern and typical *hyperleuca*. Examples of the typical *bicolor* pattern with the narrower white zone are not common in any of the localized material in the Bishop Museum collection.

Gould's measurement (length, 38.1 mm.) is close to the maximum size reached by this species which only rarely is over 39. mm. in length. The fact that he had specimens that had a "band of yellow," would clearly indicate that *adusta* should be considered a pure synonym of *bicolor* and should only be retained to designate a color pattern occurring in some of the colonies of the species. A specimen agreeing closely with Gould's description is figured (Pl. IV, fig. 8), the only marked difference being that it has 8 whorls instead of 7. This specimen came from one of the colonies between Haena and Hanakapiai.

Gould's material undoubtedly came from east of Hanakapiai. From his description of the color, this seems to be the probable locality; but he mentions that his shells are subcarinate which, if the carination is at the shoulder, would indicate a more eastern habitat, probably the variety recognized in this paper as *b. angulata* Pease. As Gould later considered his species and Jay's *bicolor* as varieties of the same species, and as specimens easily referable to both forms are found in the same colony, it seems advisable to treat *adusta* as a synonym of *bicolor*.

I see no reason for considering Pfeiffer's *C. fuliginea* distinct even as a variety. His description and figure show a proportionately broad specimen of the *adusta* pattern. Borcherding figures an unusually dark specimen, with specific rank. Four specimens in the Bishop Museum collection agree almost exactly with Pfeiffer's description and figure. These represent only an individual variation. A specimen which might have served as Pfeiffer's type, both for his description and figure, is given on Plate IV, figure 9.

The glossy surface—a character on which Borcherding lays much stress—is of common occurrence in specimens which have not reached maturity (as in Pfeiffer's type which has but 6½ whorls). In fully adult specimens the surface is nearly always dull, due to abrasion. Sykes (Fauna Haw., p. 373), who undoubtedly examined Pfeiffer's type, considers *fuliginea* as a pure synonym of *bicolor*.

In all characters, except color pattern, specimens from the colonies east of Hanakapiai agree closely with those found in the valley and also to the west. The color of freshly collected material is much darker than that of specimens

collected by the writer a little more than 30 years ago. In fresh material (Dranga's, Pl. IV, fig. 10) collected in December 1926, the last whorl is sooty-black to black, shading above on the fifth whorl to Diamino-brown and to Hay's-russet. This material came from a very restricted colony (the fourth small gully west of Limahuli), and all the specimens are of one color pattern (*adusta*).

Measurements of specimens from different colonies are as follows:

Length	Diam-eter	Apert. length	Apert. diameter	Whorls	Age	Locality	Plate	Figure
42.5 mm.	13.9	13.3	7.6	8½	adult	Hanakapiai	IV	3
36.5 mm.	16.4	14.9	8.9	7½	"	"	"	1
35.8 mm.	14.8	13.0	7.9	7¾	"	"	"	2
31.4 mm.	13.1	11.7	6.8	7½	"	W. of "	"	15
30.9 mm.	11.8	10.9	6.0	7¼	nearly adult	" "	"	14
38.6 mm.	15.2	13.4	8.6	8	dead, adult	" "	"	12
31.0 mm.	15.5	13.5	7.7	7¼	dead, nearly adult	" "	"	17
36.7 mm.	13.7	13.0	7.4	7½	"	" "	"	11
29.9 mm.	13.8	13.1	7.2	6¾	alive	" "	"	13
39.5 mm.	15.2	14.3	7.6	8	adult	East of "	"	8
33.2 mm.	11.8	10.7	6.2	7¾	"	" "	"	7
34.9 mm.	15.8	14.7	8.5	7⅓	"	" "	"	9
31.3 mm.	13.6	12.2	7.4	7⅓	"	" "	"	10
37.3 mm.	14.1	13.6	7.4	8	"	" "	"	5
40.0 mm.	14.0	13.3	7.2	8¼	"	" "	"	4
36.0 mm.	15.7	13.0	8.2	7½	"	" "	"	6
36.9 mm.	13.2	13.0	7.2	7¾	"	" "	"	16

Pregnant specimens collected along the trail west of Hanakapiai had more than 6½ whorls and were all adult or nearly adult as indicated by the lamellation in back of the lip. Small pregnant specimens measured in length from 29.5 to 30 mm. One of these small examples is figured on Plate IV, fig. 13. Pregnant shells from the colonies east of Hanakapiai had at least 6½ whorls. The most mature embyro from this colony (86066) has 4 whorls and a length of 8.1 mm. It was probably not quite ready for birth. A second embryo from the same uterus had 2 1/3 whorls, just over 3 mm. in length. In the largest specimen the whorls are nearly flat, slightly convex, with the aperture about half the length of the shell. The shell is perforate, the perforation very narrow; the columella is narrowly traingular, slightly swollen above and furnished with a rather strong fold, terminating gradually to its base. The initial half whorl is smooth, the rest of the first whorl gradually becoming axially striate, the striae stronger below. The second whorl is covered with regularly spaced, slightly curved striae which are broadened and forked below. There is a slight shoulder angle present on the second whorl which disappears at about the beginning of the third whorl. The rest of

the embryonic whorls are furnished with rather evenly spaced striae. Similar, though much weaker, striae are on the base. Beginning at about the middle of the fourth whorl are faint microscopical spiral lines, visible only with reflected light. The base is covered with very minute, incised, closely spaced spiral lines. The spiral striation is not anywhere so strong as in *turricula* in which the upper surface of the last embryonic whorl is almost tuberculate. Embryos from the Hoolulu colony are similar in texture but are proportionately slightly narrower. One specimen (88410) contained three embryos. The largest has 4¼ whorls, length 8.3 mm.; the second 3½ whorls, 6.8 mm.; the last has 2 1/3 whorls, 3.1 mm.

Carelia bicolor angulata Pease (Pl. V, figs. 1-7).

C. adusta var. *angulata* Pease: Jour. de Conchyl., p. 403, 1870. Borcherding: Mon. Carelia, p. 243, 1910.

C. Bicolor angulata Pease: London, Proc. Zool. Soc., p. 472, 1871.—Ancey: France, Mem. Soc. Zool., p. 323, 1893.—Pilsbry: Man. Conch., vol. 21, p. 116, pl. 20, fig. 16, 1911.

Shell generally more slender, whorls above broadly angular. The wide and acute angulation which occupies the greater part of the width of the whorls gives this variety a particular aspect, which I think should be distinguished by a special name (Pease).

The specimen figured measures, length 25⅓, diam. 12 mm., having 6⅓ whorls. The first whorl is smooth, the next two rather strongly costulate, about as in pl. 16, fig. 9. Then the surface becomes striate. At the first third of the fourth whorl an angle at the shoulder begins, becoming stronger to the last whorl, where it is rather acute, the surface slightly concave above and below it. A less acute angle divides the flat peripheral from the slightly convex basal surface. The embryonic whorls are bicolored, the upper third pale fleshy-brown, lower two-thirds dark red-brown; the following whorl light fleshy-brown, becoming darker on the penult., dark brown on the last whorl, but pale below the suture.

The spire widens more rapidly than in *C. dolei,* and the lower angle is decidedly stronger. In *C. cumingiana* the surface is smoother, the coloration much more brilliant, and there is more sculpture on the first neanic whorl (Pilsbry).

Kauai, Wainiha, C. M. Cooke; Limahuli, E. S. Deverill.

Named examples of this subspecies could not be found in the Pease collection in the Museum of Comparative Zoology and it is possible that none are in any other collection. Pease's description is very incomplete and it would be next to impossible, with our present knowledge of *bicolor,* to accurately determine which race of this species Pease had before him in drawing up his description.

Fortunately, Pilsbry has redescribed and figured a specimen which adequately represents this subspecies. This specimen has been loaned to me for study and comparison with localized material in the Museum collection. Pilsbry's example agrees so closely with juvenile specimens (Pl. V, fig. 6)

collected above the power house on the western side of Wainiha that its habitat must have been in the immediate vicinity.

C. b. angulata differs from typical bicolor in always being furnished with a distinct shoulder angle and a more or less distinct basal angle. It occupies a position intermediate between *bicolor* and *cumingiana meineckei.* However, in size, color, and embryonic characters it is more closely related to *bicolor* and represents an extreme eastern development of the species. All the specimens from Wainiha have a uniform color pattern, the last two whorls seal-brown to sooty-black, the upper post-embryonic mahogany-red to Kaiser-brown. The embryonic whorls are dark and indistinctly bicolored.

Some of the dead specimens from Wainiha are somewhat larger than any specimens of *bicolor* in the Museum collection.

Three specimens have the following measurements:

Length	Diameter	Apert. Length	Apert. Diameter	Whorls	Age	Plate	Figure
35.7 mm.	14.5	13.4	7.0	7¼	adult	V	4
37.0 mm.	13.2	13.4	broken	7½	"	V	5
47.7 mm.	15.9	15.4	8.2	7¾	" dead	V	8

Two series of specimens were collected by E. S. Deverill and given to the Museum. These specimens came from the small valley of Limahuli which is inland from the *dolei* colony. They are interesting as they are clearly of *bicolor* origin and occupy a position between *bicolor* and *bicolor angulata,* and show no influence of *dolei* blood either in embryological or adult characters although the former locality of the latter species is much nearer than that of any known *bicolor* colony. Of the 30 adult or nearly adult examples, all but 6 are furnished with a more or less distinct shoulder angle. In only a few specimens are the shoulder and basal angles as distinctly developed as is common with the specimens from Wainiha. Of these specimens, 25 have a distinct whitish band accompanying the sutures. In most examples this band is narrow, but in four specimens it is from 1/4 to 1/3 the width of the whorl between the sutures. The width of this band is slightly narrower than in specimens from the westernmost colony of *bicolor.* On account of the nearly uniform presence of the shoulder angle, the specimens are included in the subspecies *angulata,* although the color pattern is not typical of this subspecies.

Three specimens measure:

Length	Diameter	Apert. Length	Apert. Diameter	Whorls	Age	Plate	Figure
38.8 mm.	15.5	14.2	7.2	7¾	adult	V	2
35.3 mm.	13.0	12.2	6.6	7¾	"	V	1
32.1 mm.	12.2	11.8	5.8	7¼	"	V	3

Carelia cumingiana Pfeiffer (Pl. VI, figs. 1-4).

Spiraxis cumingiana Pfeiffer: London, Proc. Zool. Soc., p. 106, pl. 32, f. 1, 1855; Mon. Hel Viv., vol. 4, p. 572, 1859.

Carelia cumingiana Pfeiffer: Mon. Hel. Viv. vol. 8, p. 251, 1877.—Ancey, France, Mem. Soc. Zool., vol. VI, p. 328, 1893.—Borcherding, Abh. Senck. Nat. Ges., vol. 32, p. 238, pl. 19, f. 10 and 11, pl. 20, f. 7 and 8.—Pilsbry, Man. Conch. vol. 21, p. 112, Pl. 21, figs. 3, 4, and 5, Pl. 18, figs. 7 and 9, 1911.

The shell is turreted, rather solid, smoothish. The spire tapers slowly, but terminates above in a more rapidly tapering cone. The first half or three-fourths whorl is smooth; then rather coarse, curved, vertical ribs set in. On the third whorl these become finer and more or less split into sharp striae. About the middle of the third whorl some shallow spiral sulci appear and part of the striae are cut into oblong granules; at the end of the 3½ whorls, weak cords appear at the shoulder and close above the suture below; these gradually enlarge into conspicuous angles or keels, the lower one usually covered at the suture except on the last whorl. The vertical sculpture gradually diminishes, leaving the last two whorls smooth. The embryonic whorls are bicolored, purple-black and tawny, but the dark lower zone gradually fades as growth proceeds, and is usually narrow or inconspicuous after the 4th whorl. The intermediate whorls of the spire are some shade of tawny brown. A pale zone below the suture begins on the fifth whorl, becoming opaque white on the last two or three whorls. The last whorl is biangular, smooth and very dark brown or black below the white zone.

Aperture trapezoidal, bluish white within, with a broad black margin within the thin, acute lip. Columella concave, bluish white with a brown edge, narrowly truncate at base; spiral lamella above the truncation moderate or inconspicuous.

Length 43.5, diam. 16 mm.; whorls 8 (A. N. S. P.)
Length 46, diam. 14.5 mm.; whorls 8 (A. N. S. P)
Length 37, diam 15.5 mm.; whorls 7 (A. N. S. P.)
Length 48, diam. 16 mm.; whorls 8 (Pfeiffer: type). (Pilsbry).

Kauai (Newcomb, in Cuming collection); Koolau (Rev. E. Johnson [J. S. Emerson collection]).

The valley of Lumahai seems to be the most logical locality from which this species could have come, since the valleys to the east and west are, and were, inhabited by different forms of *Carelia,* and also from the fact that *C. c. meineckei* is at present living on its western rim. Besides, the original forest which was probably occupied by this species was destroyed by fire or cattle many years ago. Since most of the species of *Carelia* occupy rather restricted colonies, I feel certain that the typical form of this species must be considered extinct. From the close similarity of the specimens, I feel sure that all came from a restricted colony and that at the time they were collected they were fairly abundant. Newcomb, who supplied Cuming with the type specimens named by Pfeiffer, probably received his specimens from the Rev. E. Johnson.

In the form and texture of the embryonic whorls this species is descended from the same stock as *C. bicolor* and is the easternmost representative of this

group. In its post-embryonic character it is related to *C. cochlea* from Kalihikai and to *C. dolei* var. *isenbergi* from Haena; both lowland species. From the latter it differs by its more pronounced basal angle and broader and shorter apical cone. A very few specimens of *C. d. isenbergi* show some resemblance to *C. cumingiana,* but when of about the same length, they invariably have half a whorl more. One of these is figured (Pl. VI, fig. 6).

From *C. cochlea, C. cumingiana* is easily separated by its stouter form and the almost entire absence of spiral ridges on the last two whorls.

C. cumingiana, as known today, probably represents a stock which had migrated from a higher elevation and whose blood has been diluted by a species of the *cochlea* group already inhabiting the area. This is confirmed by the surface texture and sculpture of the post-embryonic whorls which are intermediate in character between those of *C. cochlea* and *C. d. isenbergi.* This species has retained, however, embryonic whorls which are characteristic of the group of *C. bicolor.*

A fossil beach-worn specimen in the Museum collection confirms the supposition that the species was originally collected at a low elevation. This fossil specimen is typical of the species (Pl. VI, fig. 1). The color is ivory-white, slightly darker on the last whorl and of a darker shade around the columella. The embryonic whorls are bicolored, the dark coloring becoming proportionately narrower with the growth of the shell and disappearing on the fifth whorl. The white sutural band is indicated. The characteristic shoulder and basal angles have the same position and development as typical examples of this species, though slightly less so on the upper whorls, probably due to abrasion. The apical whorl is flatter than in any of the "live" specimens, but this may be due to wave action, as it is much worn. The apical cone has about the same angle as specimens from the original locality.

In color pattern, surface texture and form this species shows much less variability than most of the species of the genus. In numbers of specimens *C. cumingiana* is not an abundant species in collections, though it is commonly represented by two or three specimens in many of the older collections, which I have been able to examine.

The Bishop Museum collection contains 51 examples (24 of which are from the J. S. Emerson collection) of this species which were obtained from eleven different sources. All of these specimens were acquired from older collections which have come into the Museum from time to time. From the condition of the inner surface of the aperture, at least 40 of these specimens were collected alive. Except for variation in the sharpness and strength of development of the shoulder and basal angles, and with slight differences in the angle of the apical cone, these specimens are remarkably similar and show very little individual variation. The color has faded much since they were

first collected, as a comparison with Pfeiffer's description ("nigra") and figure show. This is confirmed by the material found by Meinecke, living examples of which are of an almost uniform sooty-black color, except for the fourth and fifth whorls which are somewhat lighter with a reddish tinge.

In *C. cumingiana* the surface texture, except for the shoulder and basal angles of the last two whorls, is smoother and glossier than in any other species of the genus. Two of the specimens show a departure from this normal smooth surface. In the first (73901) the penultimate whorl is marked with distinct, low vertical ridges. The second (55820) differs in that the space between the shoulder and basal angle is marked with 4 to 5 spiral cords. These cords are sharp and distinct on all but the last whorl, where they are low and visible only with reflected light.

In nearly all the examples the columellar fold is weak, and terminates very gradually near the base of the columella. In two specimens, however, this fold is stronger, terminating abruptly and giving the columella a truncate appearance.

Four adult shells have the following measurements:

Length	Diameter	Aperture Length	Aperture Diameter	Whorls	Plate	Figure
45.0 mm.	16.8	14.8	9.0	8	VI	2
45.0 mm.	15.1	14.0	8.5	8¼	VI	3
46.9 mm.	15.8	15.0	8.8	8¼	VI	4
41.5 mm.	15.5	(broken)	(broken)	7½	VI	1 (fossil)

Two typical specimens of *C. cumingiana* in the Bishop Museum collection are labeled "Achatina incisa? Kauai, Sand. Isles. 1855". The handwriting is that of Dr. Newcomb.

Carelia cumingiana meineckei, new subspecies (Pl. V, figs. 9-13).

The shell is somewhat longer than typical specimens, with from one quarter to half a whorl more. The light subsutural band is entirely absent, all the whorls being uniformly colored. The shoulder angle occupies a slightly lower position and the basal angle is, in adult specimens, not as distinctly developed. The surface is slightly striate and is not as smooth and glossy. The aperture is ovate, its outer margin regularly curved and not angulate as in the typical form. In color, the last two whorls are sooty black; in some specimens the whole shell is more or less of a uniform color; in others, the fourth and fifth whorls are of a uniform mahogany red to bay. This dark, sooty-black color agrees somewhat with the color of Pfeiffer's figure for the type specimen (P. Z. S., London, 1855, pl. 32, f. 1).

Length	Diameter	Apert. length	Apert. diameter	Whorls	Plate	Figure	
47.3 mm.	16.4	15.5	9.0	8¼	V	10	(Type)
48.7 mm.	17.3	15.8	9.4	8¼	V	11	
50.9 mm.	16.2	15.8	9.5	8¼	V	12	
48.4 mm.	17.4	17.3	8.8	8	V	13	
51.2 mm.	18.2	18.2	10.2	8	V	9	

Kauai, ridge between Lumahai and Wainiha, 1927, W. Meinecke. Type No. 86373.

Meinecke's specimens were collected on both sides of the ridge, from three rather restricted colonies. The lowest colony was in the first "pocket" above the post marking the lower limit of the forest reserve at about 1100 feet elevation. The uppermost colony was nearly a mile farther up on the ridge at about 1600 feet elevation. About a dozen live specimens were taken and three times as many dead ones.

C. c. meineckei is easily recognized from the angulate forms of *C. bicolor,* which are found on the western side of Wainiha valley at a somewhat lower elevation. The former is larger, thicker and with a much more pronounced shoulder angle, and the angle of the apical cone is much closer to the typical *C. cumingiana* than that of any of the known forms of *C. bicolor.*

The embryos of *C. c. meineckei* are intermediate in size and sculpture between those of the *turricula* and *bicolor* groups. They differ from the *cochlea* group in their much wider angle. They are somewhat larger than any of the *bicolor* groups to which they are most closely related, and some of them show a slightly stronger spiral sculpture on the fourth whorl than the embryos of this series. The embryos are remarkably large in proportion to their parents, as they are nearly equal to some of the embryos of *C. turricula.* However, in their initial angle and other characters they approximate closely to the apical whorls of *C. cumingiana.* An embryo with 4 whorls (86361) measures: length 9.9, diameter 6.5 mm. The striae on the penultimate embryonic whorl are arranged in pairs. In this specimen the spiral striae are very indistinctly developed, and only on the fourth whorl. A second specimen (86374) with 4¼ whorls measures: length 10.2, diameter 6.6 mm. The spiral sculpture is more strongly developed, not only on the last, but also on the penultimate whorl.

Carelia cumingiana meineckei? (Pl. VI, fig. 5).

While searching the Pease collection in the Museum of Comparative Zoology for named specimens of *C. bicolor angulata,* an unnamed lot of shells was found. As these specimens were furnished with a distinct shoulder angle, they were tentatively placed under Pease's variety of *bicolor.* A more critical examination of a specimen of this lot which the Bishop Museum received in exchange, shows that my determination was wrong and that they should be assigned to *cumingiana.*

The shell (No. 59035) is a juvenile with 7¼ whorls. When compared with juvenile specimens of *cumingiana* a number of differences appear which demonstrate that this specimen did not come from the original *cumingiana* colony. These differences are in its surface texture, position of the shoulder angle which is duplicate, and somewhat larger aperture. In these

differences it approaches juvenile specimens of *C. c. meineckei* described above, but it is distinct from this subspecies by the presence of a light-colored indistinct subsutural line. It measures: length 23.5, diameter 14.5 mm. This specimen probably came from a colony at a somewhat higher elevation than the original *cumingiana* locality, intermediate between this and the locality of the subspecies *meineckei,* but nearer to the latter.

GROUP OF CARELIA COCHLEA

The embryonic whorls are flat, forming a narrow pointed cone, (except in some examples of *dolei isenbergi*), marked with fine longitudinal striae and indistinctly engraved spiral lines. The shell is narrowly turreted, the diameter about one-fourth the length; whorls 8-10½, closely coiled. Most examples are furnished with a strong shoulder angle or with 4-9 raised spiral cords. The aperture is relatively small in proportion to the length of the shell; the columella is comparatively short and is distinctly concave above.

From the embryological characters the species of this group are closely related to those belonging to the *bicolor* group. Through *dolei isenbergi, cumingiana* and *bicolor adusta* there is a nearly complete series of intergrading stages both in embryonic and adult characters. Both *cochlea* and *dolei* are easily recognized from all the species of the *bicolor* group by the narrower embryonic cone and the more closely coiled whorls. Representatives of this group are only known from fossil specimens which occupied the low flats between Limahuli and Kalihiwai on the northern coastal plan of Kauai. Undoubtedly there were intergrading forms between these two distinct species which are known from near the peripheral boundaries of the area formerly occupied by this group. It is improbable that more than one or two connecting forms will ever be found, as a large part of the intervening area is not suited for the formation of fossil beds.

On the east there is some evidence that *cochlea* has hybridized with specimens of *olivacea* (see *o. baldwini,* no. 12a). This group represents a somewhat higher stage in the evolution of the genus than is found in any of the species of the *bicolor* group.

KEY TO SPECIES OF COCHLEA GROUP.

1. Shells with strong spiral cords.....**C. cochlea,** no. 9.
   Shells without strong spiral cords (2).
2. Shells narrow, 11.5-14.5 mm. in diameter; the majority with distinct shoulder angle; embryonic cone narrow.....**C. dolei,** no. 8.
   Shells broader, 14-15.5 in diameter; the majority without shoulder angle; embryonic cone sometimes broad.....**C. dolei isenbergi,** no. 8a.

Carelia dolei Ancey (Pl. VII, figs. 1-13); Pl. VIII, figs. 1-6).

Carelia dolei Ancey: Mem. Soc. Zool. France, vol. 6, p. 328, 1893

[1894].—Borcherding: Mon. Carelia, p. 237, pl. 20, fig. 5 and 6 [= smooth form of *C. Cochlea,* Reeve], 1910.—Pilsbry: Man. Conch., vol. 21, p. 109, pl. 18, figs. 1 to 4, pl. 16, fig. 10, 1911.

Carelia cumingiana var. *Kobelti:* Borcherding, Mon. Carelia, p. 239, pl. 20, figs. 1 and 2.

Shell elongate-turreted, solid, (dead), without gloss; intense wine-brown colored, darker at the acute apex and the aperture. Striate, the striae less distinct at the aperture. Spire very much lengthened, slowly tapering, a little more more rapidly so above. Whorls 9 to 9½, slowly increasing, the first scarcely convex, suture linear, following 5 whorls at first sloping, then angular above the middle, flattened below the angle; suture impressed; the last whorl has an upper angle, with another obtuse one below the middle, sides flat, tapering downward. Aperture oblong, acute above, tapering, brown inside. Columella thick, strongly and obliquely truncate, white, arcuate above; parietal callus strong. Length 45 to 51, diam. 14 to 16, alt. of aperture 12 to 13 mm. (Ancey).

This species was based on dead examples, presumably fossil. There is a superb set of 91 shells from sand dunes along the shore, Haena, northern Kauai, in the collection of Mr. C. M. Cooke. It is a highly variable form, closely related to *C. cumingiana,* from which it differs by the more slender spire, the generally weaker basal angle, and the weaker development of minor spirals on the neanic whorls.

The upper angle or keel begins on the fourth whorl; it varies widely in degree of prominence, and sometimes becomes subobsolete on the last two or three whorls. In a few cases it is doubled. The basal angle is usually rounded off, and seems never to be so strong as in *C. cumingiana.* The more minute surface-sculpture is like that of *cumingiana,* except in the weaker spirals. As in *cumingiana* the flat, sloping shoulder is often weakly plicate; otherwise the later whorls appear smooth under the lens.

The specimens are in large part bleached, but many show color. The first four whorls are usually purplish with a narrow subsutural white border. This color fades to white on the following whorls. The last two or three whorls are chestnut, the base darker, with a wide white zone below the suture. This zone includes the shoulder-keel, thus differing from *C. cumingiana* in which the white zone lies above the keel. In a few examples the early whorls are white. Several shells in which the upper carina is weak on the later whorls, want the subsutural white zone. They are chestnut-colored, paler just below the suture and in the upper part of the spire; apical whorls either pale or dark. This seems to be the typical color form, described by Ancey.

This species is slightly more advanced in evolution than *C. cumingiana,* shown by the frequent loss or weakness of the keel on the last whorl, a feature of senility. (Pilsbry).

Kauai, Hanalei, D. D. Baldwin; Haena, D. D. Baldwin, J. F. G. Stokes, and C. M. Cooke; Limahuli, J. S. Emerson, A. F. Judd, T. Dranga, C. M. Cooke; in front of and slightly to the east of Wet Cave, W. Meinecke. Ancey's "Hanalei" is a generic locality name as his type specimen is undoubtedly from Limahuli. Baldwin's and Stokes' "Haena," in the Bishop Museum collection, are likewise Limahuli representatives, as is also "Haena" as quoted by Pilsbry for the Cooke collection. "Haena" although more restricted than "Hanalei" is too wide a locality name to be used in the present paper. The fossils from Haena proper (the coastal plain between the Manoa stream and Wainiha bay) belong to a distinct geographical race, examples of which are not represented among the Baldwin, Stokes, or Cooke specimens.

Borcherding's *C. cumingiana* var. *kobelti,* as pointed out by Pilsbry is a synonym of *C. dolei.* His figure of *C. dolei* is drawn from a beach-worn specimen of *C. cochlea* from the same source as his specimen of this species.

Ancey's two type specimens are in the Bishop Museum collection, one of which is figured (Pl. VIII, fig. 4). His co-types (no. 18788), specimens from the Baldwin collection (55817, 55822), and those from the Thwing collection (25318) in the Bishop Museum collection—all of which passed through Baldwin's hands—are apparently from a different fossil deposit than the specimens described below from Limahuli, coming from the sand dunes near Wet Cave. This is shown by the large percentage of uniform dark-colored specimens (7 out of 9) and also from a slightly different state of preservation. These specimens are probably from a fossil deposit somewhat to the east of the deposit from which the rest of the Museum's specimens were obtained, as they are somewhat intermediate in character between the specimens found near Wet Cave and those from Haena treated under *C. d. isenbergi.* The type and Baldwin's specimens are, however, more closely related to the western rather than to the eastern specimens and probably belong to a slightly isolated colony, the exact location of which is not known, and, except for these specimens, not represented in the Bishop Museum collection. Since the exact locality of Baldwin's material is unknown, it seems unwise to separate the smaller narrower form from the western colonies as a geographical race. With more thorough collecting and a more intimate knowledge of this species, it may be proper at some future time to recognize at least one, or possibly two or more, rather distinct geographical races.

In the rather slender specimens of *C. dolei* there is a tendency in many individuals for the fifth whorl to be slightly more contracted than the fourth. This character is more noticeable in specimens in which the shoulder angle is not strongly developed. The shoulder angle in about half of the specimens is more pronounced and sharper than in any other species. In post-embryonic characters this species is apparently related to its nearest neighbors, *C. bicolor* on the west and *C. cumingiana* on the east. The embryos, however, are similar in form and sculpture to those of *C. cochlea,* which inhabited a more distant locality, about eight and a half miles to the east. It may be that *cochlea* and typical *dolei* are representatives of what was at one time a widespread lowland group of species.

It is surprising that *C. dolei* does not show a closer relationship to *C. bicolor,* since the latter's habitat (including its different geographical races) surrounds that of *C. dolei.* The size, narrower spire, flatter and more numerous whorls, and proportionately smaller aperture of *C. dolei* easily distinguish the two species. *C. dolei* from Limahuli has the same

range of color patterns as is shown in the colonies of *C. bicolor* found between Limahuli and Hanakapiai. The color pattern described by Pilsbry as *hyperleuca* for *bicolor* is by far the commonest among the specimens of *C. dolei* before me. The next commonest pattern is that represented by typical *bicolor,* while the uniform colored pattern of *C. b. adusta* is the most infrequent. The occurence of these color patterns is apparently the only resemblance between *C. dolei* and *C. bicolor.* The shoulder angle, when present, is stronger, sharper, and situated lower on the whorl than that of *C. cumingiana.* From this species *C. dolei* also differs in its narrower spire, color pattern, and weaker basal angle.

The weak spiral lines, characteristic of the genus, which in most species are fairly well indicated on the fourth and fifth whorl, are not often present in this species. In most of the specimens they are entirely lacking on the upper whorls. A few specimens show one to three rather blunt, raised spiral lines between the shoulder and basal angle (Pl. VII, figs. 6, 9). That their absence is not due to wear or abrasion is clearly explained by the well preserved surface texture of the embryonic and neanic whorls.

The different degree of development of the shoulder angle is remarkable in this species. The loss of this angle is considered by Pilsbry as evidence that this species has advanced further in evolution than *C. cumingiana.* In about half of the Museum specimens the shoulder angle is well developed. In some examples this angle is keel-like (Pl. VII, fig. 6). The shoulder above the angle is commonly more distinctly plicate than the portion of the whorl below the angle. In a few examples there is a low spiral cord between the shoulder angle and the suture (Pl. VII, fig. 7). In a few specimens the shoulder angle is duplicate (Pl. VII, figs. 3, 8). Very few specimens show an entire absence of this shoulder angle when viewed with a lens. In many examples it is much weaker on the last two whorls than above (Pl. VII, fig. 10): while in fewer specimens the reverse is true, the angle developing only on the penultimate and last whorls (Pl. VII, fig. 3). In most specimens in which the basal angle is present it is not so strongly developed as in specimens of *C. cumingiana,* but on a few shells it is considerably more accentuated than in any example of *C. cumingiana* which has been examined.

In *C. dolei* the aperture is proportionately smaller than is usual in the genus. The aperture is usually narrowly ovate to ovate, its outer margin is regularly curved except in specimens in which the shoulder and basal angles are strongly developed. In these the aperture has a somewhat rhombic outline. The columella in adult specimens is bent forward below, arcuate above, and in some examples is separated from the base of the aperture by a shallow, narrow sinus. In immature specimens the columella is straighter. The

columellar lamella is uniformly weak, tapering gradually at the base, rarely truncate.

The type measures: length 49.5, diameter 15.5, aperture length 13.9, aperture diameter 7.7 mm., whorls 9 + (Pl. VIII, fig. 4). Others measure:

Length	Diameter	Apert. length	Apert. Diameter	Whorls	Age	Plate	Figure
51.2 mm.	13.1	12.9	broken	9½	?	VII	9
50.1 mm.	13.5	broken	broken	9¼	?	VII	10
46.8 mm.	12.5	11.7	6.6	9½	adult	VII	3
44.5 mm.	13.2	broken	7.3	9¼	adult	VII	5
45.1 mm.	14.4	13.0	7.3	8⅔	nearly adult	VIII	3
45.0 mm.	12.0	11.4	6.3	9⅓	adult	VII	2
43.9 mm.	13.0	11.9	broken	9¼	adult	VII	6
42.3 mm.	11.7	broken	6.5	8½	adult	VII	13
41.4 mm.	11.9	11.1	6.7	9½	adult	VII	11
41.0 mm.	12.6	12.0	6.8	8⅔	juv.?	VII	12
41.7 mm.	13.0	broken	7.2	8⅔	juv.?	VII	4
41.0 mm.	13.0	broken	broken	9	juv.?	VII	7
40.5 mm.	15.2	13.5	8.0	8½	adult	VIII	1
35.2 mm.	11.5	broken	6.0	8½	juv.	VII	8
40.4 mm.	13.4	12.3	6.8	8⅔	juv.	VII	1
39.5 mm.	13.8	13.2	6.8	8	juv.	VIII	2
38.6 mm.	14.0	12.0	6.6	8⅓	juv.	VIII	5
44.8 mm.	13.9	broken	7.2	8⅔	adult	VIII	6

The embryos of *C. dolei* are, at the same stage of development, somewhat smaller and much narrower than those of *C. bicolor*. In the latter species specimens with 6¾ whorls are usually pregnant, the age at which they begin to reproduce is between 6½ and 6¾ whorls. To determine the age at which *C. dolei* begins to reproduce, 64 examples were "uncoiled." Of these 8 had from 7½ to 8 whorls; none of these were pregnant. Of specimens with 8 and 8¼ whorls, 14 were opened, 4 of which contained embryos. Of 42 specimens with 8½ or more whorls, 17 contained embryos. Evidently *C. dolei* has to reach a growth of at least 8 whorls before it begins to reproduce. This is apparently a much more advanced age than that of *C. bicolor.*

Embryos of *C. dolei* are well represented in the Bishop Museum collection. The largest specimens have slightly more than four whorls, are minutely perforate, with a straight, very narrow slit under the columellar edge. The first whorl is smooth, slightly incised; the second, just below the suture, is smooth, and the lower two-thirds striate with wide intervals between the striae. The third and fourth whorls are closely packed with fine arcuate striae, which sometimes become weaker just before the completion of the fourth whorl. In most examples minute spiral incisions are lacking, while in a few they are very faintly developed. In examples in which the shell is furnished with a shoulder angle, at the beginning of the fourth whorl the striae are slightly accentuated in the region which is later occupied by the shoulder angle. The embryonic shells are narrowly biconic, the aperture

being nearly as long as the spire; the whorls are nearly flat, the base smooth; the peripheral angle is well marked and distinct, the outer margin of the aperture is slightly angled; the columella is nearly straight and furnished with a minute, thread-like fold which terminates abruptly at the base of the columella. The embryos are bicolored on the third and fourth whorls, there being a rather wide (about ¼ the width of the whorl) white zone below the sutures of these two whorls, its lower margin not distinct, but fading into the darker color of the shell. Compared with the embryos of *C. bicolor,* those of *C. dolei* are proportionately narrower, with flatter whorls and a smaller perforation. On the third and fourth whorls the striae are finer and more closely packed. There is in most examples a complete absence of the weak spiral lines which usually are found near the end of the fourth whorl of the former species.

Three embryos were taken from a single specimen (no. 86167a). The largest has just 4 whorls and measures: length 8.4, diameter 5 mm.; the next 3 1/2 whorls, and the smallest 2 2/3 whorls.

Carelia dolei isenbergi, new subspecies (Pl. VI, figs. 6-12).

The shell is more robust than the type specimen with a more cylindrical and broader spire tapering gradually to a more pronounced apical cone, and with more convex whorls. Solid colored specimens occur in much larger proportion than among the specimens from Limahuli and the subsutural band, when present, is proportionately much narrower (in only a few specimens exceeding more than a fourth of the width of the whorl). The embryonic shells are usually slightly broader in proportion to their length.

Kauai, Haena plain, a few hundred yards east of the Manoa stream, 1914, 1922, C. M. Cooke. Type no. 37542A; paratypes, no. 37540-37542.

The material on which this subspecies is based was collected at two different times. In the first lot all the material from the western end of the Haena plain was "bunched." On a later visit three colonies, from 100 to 200 yards apart, were kept separate. The specimens from these colonies show no distinctive characters.

C. d. isenbergi occupies a position between the typical *C. dolei* on the west and *C. cumingiana* on the east. In most of its characters it is more closely related to the former species. Its slightly broader apical whorls and spire, and narrower subsutural line (when present) may be only an accidental resemblance to *cumingiana,* but I hardly think so. Undoubtedly, if additional material can be found at or near the eastern extremity of the Haena plain this should show a still further divergence from the *dolei* form.

In surface texture and in the presence or absence of the shoulder angle, *isenbergi* agrees with specimens of *C. dolei,* but there are no examples in the Museum collection with the basal angle as well developed as in a few of the specimens of *dolei.*

The type measures: length 49.7, diameter 15.3, aperture length 14.3, diameter 8.1 mm., whorls 9 1/3 (Pl. VI, fig. 11). Other specimens have the following measurements:

Length	Diameter	Apert. length	Apert. diameter	Whorls	Age	Plate	Figure
56.8 mm.	15.2	14.3	7.2	9¾	adult	VI	9
48.3 mm.	15.8	14.6	7.7	8¾	juv.	VI	12
48.6 mm.	14.1	13.2	7.5	9	adult	VI	10
44.5 mm.	15.2	broken	8.1	8⅔	adult	VI	7
43.0 mm.	15.5	13.6	7.6	8½	adult	VI	6
41.8 mm.	15.4	broken	8.0	8¼	adult	VI	8

Embryos of *isenbergi* are slightly broader in proportion to their length than those of *dolei* from Limahuli. They agree fairly closely in their texture, though there is some variation, not only in their relative diameter, but also in the convexity of their whorls. Three examples from different individuals have the following measurements: length 9, diameter 5.1 mm., whorls 4, flat; length 8.9, diameter 5.6 mm., whorls 4¼, slightly convex; length 8.2, diameter 5.4 mm., whorls 4¼, slightly convex. The variation in form in the embryos may indicate that this race is of mixed ancestry rather than that it is a pure derivative of *dolei* stock.

C. d. isenbergi may equal Borcherding's *C. cochlea kobelti,* but from his meager description and conventionalized figure it is impossible to recognize his variety other than that he had a shell belonging to some form of *C. dolei.*

Carelia cochlea (Reeve) (Pl. VIII, figs. 7-12; Pl. IX, figs. 1-5).

Achatina cochlea Reeve: Conch. Icon., Achatina, Pl. 1, species 5, 1849.—Pfeiffer: Mon. Hel. Viv., vol. 3, p. 498, 1853; Conchyl. Cab., p. 347, pl. 38, f. 7, 1845-1855.

Carelia cochlea Pfeiffer: Mon. Hel. Viv., vol. 8, p. 251, 1877. Ancey: Soc. Zool. France, Mem., vol. 6, p. 327, 1893.—Borcherding: Abh. Senck. Nat. Ges., vol. 32, p. 236, pl. 20, figs. 3 and 4, 1910.—Pilsbry: Man. Conch. vol. 21, p. 108, pl. 18, figs 5, 6, and 8, p. 356, note, 1911.

Carelia dolei Borcherding: Abh. Senck. Nat. Ges., vol. 32, pl. 20, figs. 5 and 6.

Carelia rigida Hyatt: Man. Conch., vol. 21, p. 111, pl. 21, figs. 8, and 13, 1911.

Shell elongately turreted, whorls eight in number, spirally ribbed, depressed round the upper part, convexly flattened beneath, slightly angled at the base, columella deeply arched and twisted; burnt chestnut colour, with a narrow white zone beneath the sutures. Hab. Peru (Reeve).

Shell turreted, slowly tapering, more rapidly so near the summit; reddish brown, darker towards the apex, with a white band revolving below the suture throughout. The first three whorls are nearly flat, the rest moderately convex, the last whorl obtusely angular peripherally. The early whorls have curved riblets, as usual in the genus; on the fourth whorl spiral sculpture begins, often abruptly becoming stronger at or near

the end of the fourth whorl. Subsequent whorls have 5 or 6 strong unequal spiral cords and light growth-lines; base smooth. The aperture is rhombic; columella descends in a long spiral curve, the basal truncation being very weak.

Length 38, diam. 13.7 mm.; whorls fully 8.

Length 39, diam. 14.5 mm.; whorls 7½ (Reeve's type according to Pfeiffer) (Pilsbry).

Kauai (author's) Kalihiwai: W. A. Bryan, C. M. Cooke, Kalihikai, W. A. Bryan, F. Wood Jones, I. Spalding, T. Dranga and C. M. Cooke.

This species is easily recognized from the other species of *Carelia* by its slender turreted form, relatively small aperture, and especially by the presence, in most specimens, of distinct continuous spiral ridges. From its form, proportions and embryological characters it is apparently more closely related to *C. dolei* than to any other species. Hyatt's *Carelia rigida* is a pure synonym. The figured type (no. 73841) of this species is in the collection of the Bishop Museum. The surface of this specimen is much smoother than that of most specimens, but from its color and surface texture it is evidently a specimen which had been washed out of its original fossil bed and had been found in "ripple marks" of the beach. For comparison with other specimens of *C. cochlea* this specimen is figured on Plate VIII, fig. 9. A second specimen received from Hyatt and labeled "C. rigida type lot" in the Bishop Museum collection is much younger (7½ whorls). This is typical of specimens of *C. cochlea* of the same age. Borcherding's figure of *C. dolei* is from a typical worn specimen of *C. cochlea* in the same condition as Hyatt's type specimen. This and his figured specimen of *C. cochlea* were procured from Sowerby.

The probable original locality was rediscovered by Bryan in 1915 and independently by myself in 1922. Specimens are rather common in the low flats, between the sea and the cliffs, which extend from the western side of Kalihiwai valley to the margin of Anini stream, a distance of about two miles. The shells are scattered in a mixture of beach sand and loam. *C. cochlea* was undoubtedly a lowland species and probably did not occur inland any great distance. Originally the species may have lived on the cliffs bordering the flats and in the small valleys, cutting into the cliffs. From the topographical features of this portion of Kauai and with what we know of the restricted "localization" of most of the colonies of *Carelia, C. cochlea* must have occupied a very narrow strip of land and possibly did not live above an elevation of 250-300 feet.

The remarkable preservation of the microscopic texture of the surface of many of the specimens indicates that shells of their size and weight could not have been washed, even for a short distance, without showing signs of abrasion. The perfect preservation of the surfaces of a very large proportion of the shells can only be explained by the supposition that they were

covered while still alive. Fragments and broken specimens were very abundant in the sandy loam of which this flat is composed and also in the high tide "ripple marks." Whole specimens were dug out from exposed banks back of the beach and along the streamlets cutting through the flat.

The material on which the study of this species is based consists of a number of small lots without locality received by the Museum from various sources, three localized lots collected by I. Spalding, F. Wood Jones and W. A. Bryan at "Kalihiwai," and large series collected by C. M. Cooke in 1922, 1925 and 1930. There are at present about 450 specimens, most of which are whole, in the Museum collection.

The specimen described and figured by Reeve is not fully mature and is not typical of most of the specimens as represented by the series in Bishop Museum. In Reeve's figure the whorls are distinctly convex and the shell tapers evenly from the last whorl to the summit of the apex. A specimen of this type is figured on Plate VIII, figure 7.

In most of the specimens the apical whorls are narrowly conic, and the outlines of the spire taper more gradually upwards than those of Reeve's figure. The post-embryonic whorls are nearly flat, with the shell having nearly straight outlines. There is a very slight shouldering below the suture about one-fourth to one-third the width of the whorl. This is accentuated in specimens in which the second and third spiral line is more strongly developed than the rest of the spiral lines. The baso-peripheral angle is rounded and not as well defined as in specimens of *C. cumingiana*. The base is nearly straight in outline. The aperture is relatively small compared with most other species of the genus. In specimens with flattened whorls it is slightly angular at the periphery and nearly rhombic in outline; in specimens with convex whorls it is broadly ovate.

The post-embryonic whorls are spirally lirate with 4 to 9 (usually 7 or 8) distinct lirae, which are sharply triangular in cross-section. These lirae are only indicated on the last embryonic whorl (fourth), but become fully developed during the growth of the fifth. The lira occupying the position of the shoulder angle in some species is usually much stronger than the other lirae. There are, in most specimens, one or two much weaker lirae between this and the suture. Sometimes the lirae occur only on the upper half of the whorl between the suture and basal angle (Pl. VIII, fig. 8). Where there are only a few lirae (Pl. IX, fig. 3) they are proportionately much stronger than when there are many. The base is obsoletely microscopically spirally striate in most specimens. Beginning at the shoulder-lira the lirae diminish in size towards the base. In many examples the spiral lirae are almost entirely absent or only faintly indicated. The growth striae, when present, are sometimes coarse and blunt.

In its living state *C. cochlea* must have had the nearly black color of most of the living species. In most of the specimens the embryonic whorls are much darker than the upper (fifth and sixth) whorls, and there is no indication of a light colored peripheral line. The suture is always accompanied below by a white line. This line is usually narrow and well defined below. Usually the base is darker (from claret-brown to burnt-sienna) than the rest of the post-embryonic whorls, the color gradually becoming lighter above. The columella is usually only slightly twisted in adult specimens, sometimes strongly so (Pl. IX, fig. 2); often it is nearly straight. The columellar fold is in most specimens very weak, terminating gradually near the base of the columella. In a few examples it ends abruptly giving the columella a truncate appearance. In juvenile (6 to 7 whorls) specimens the columella is straighter than in adults and the columellar fold is nearly obsolete.

The largest specimen examined came from the easternmost deposit (Kalihiwai) from which specimens have been taken. It measures: length 66, diameter 17.8, aperture length 14.8, aperture diameter 9.2 mm., 10½ whorls (adult, Pl. IX, fig. 2). The others measure:

Length	Diameter	Apert. length	Apert diameter	Whorls	Age	Plate	Figure
58.7 mm.	15.8	15.2	9.5	10⅓	adult	VIII	10
46.0 mm.	13.7			8	juv.?	IX	4
42.3 mm.	14.8			8½	"	IX	5
37.3 mm.	11.3			8¼	"	VIII	11
54.7 mm.	15.8			9¾	adult?	IX	3
50.4 mm.	15.0			9¼	adult	VIII	12
48.8 mm.	14.5			9+	adult?	IX	1
48.5 mm.	16.3			9¼	adult	VIII	7
42.4 mm.	12.1			8¾	juv.	VIII	8

Three shells not figured measure:

Length	Diameter	Apert. length	Apert. diameter	Whorls
42.8 mm.	15.9	13.7	8.8	8¾
53.0 mm.	15.3	13.7	9.6	9½
45.1 mm.	15.6	14.5	9.3	8½

Portions of broken specimens indicate that somewhat larger specimens than any of those whose measurements are given above may be found with additional collecting.

On cleaning the fossil material a number of well preserved embryos were obtained, some of which show the delicate surface texture as well as embryos removed from fresh specimens of other species. One of the largest (77925) of these embryos has 4¼ whorls and is 9.3 mm. long, and 5.4 mm. in diameter. It is minutely cleft-perforate, the spire is conic, with almost flat whorls. It is distinctly angulate at the periphery, with an almost straight

tapering base. The columella is slightly twisted with a strong abruptly-terminating columellar fold which gives the columella a decidely truncate base. The aperture is elongate-rhombic. The texture of the surface of the four initial whorls is similar to that of the embryos of *C. turricula,* but with more weakly developed striae, especially the spiral lines. Specimens not so far advanced in their development (2½ to 3 whorls) have the columella straight with a weak gradually terminating columellar fold. Below the first whorl the embryos are bicolored, the white sutural line being in some specimens very narrow, in others nearly half the width of the whorl. The suture is minutely, but distinctly margined.

GROUP OF CARELIA TURRICULA

The embryonic whorls are flat, forming a cone, with nearly straight outlines, the second whorl furnished with distinct, longitudinal striae, the next two beginning faintly but increasing with the development of the embryo, are spirally sculptured; the last embryonic whorl (4th) is rather strongly engraved, both longitudinally and spirally, so that the surface is minutely but distinctly granulate. The post-embryonic whorls are from nearly flat to slightly convex, the last two are in the very great majority of specimens marked with very faint spiral cords to distinct sharp spiral lirae.

Specimens of this group have been taken from a larger area than that occupied by any other group. Beginning on the north on the eastern ridge of Lumahai (valley east of Wainiha) along the mountain slopes to the eastern extremity of the Anahola range. Going south, the group is represented by a few localities to the eastern foot of Waialeale, then, with quite a jump to Haupu in the Kipukai range, with a fossil colony near the foot of the southernmost spur of this range.

Living specimens of the species referred to in this group have been taken from about 500 to nearly 2,000 ft., though most of the specimens are between 800-1,200 ft.

This group contains 10 of the 29 forms recognized in this paper and has nearly twice the number of forms as the next largest group *(bicolor* with 60.) This is undoubtedly due to the large area occupied by the group, and consequently there are more topographical barriers to afford opportunities of isolation. Of the 10 forms recognized in this paper 4 are fossil. The largest species of the genus belongs to this group (*C. turricula*). This group also has representatives of some of the smallest forms.

This group undoubtedly represents a somewhat higher stage in the development of the genus than is shown in the *bicolor* group. The more distinctly granulate surface texture of the embryo is a further stage in the departure from the type of embryo found in what are considered representatives of the "primitive" stock.

KEY TO THE TURRICULA GROUP

1. Shell furnished above the periphery with sharp spiral lines.....**C. lirata,** no. 15.
   Shell not furnished above the periphery with sharp spiral lines, the spiral sculpture, when present, consists of low corded ridges (2).
2. Shell with a pale, whitish or cream line or band below the suture (3).
   Shell without a pale, whitish or cream line or band below the suture (10).
3. Adult shells not over 40 mm. in length.....**C. olivacea priggei,** no. 12c.
   Adult shells over 42 mm. in length, most species 45-70 mm. in length (4).
4. Shell subcylindrical, apical cone abrupt (5).
   Shell tapering gradually to the apical cone which is not abrupt (6).
5. Columella short, concave above.....**C. olivacea baldwini,** no. 12a.
   Columella long, nearly straight.....**C. olivacea,** no. 12.
6. Shell with distinct sharp basal angle (7).
   Shell without distinct sharp basal angle (8).
7. Adult shell with 9½-9¾ whorls, length 54-62 mm.....**C. hyattiana,** no. 11.
   Adult shell with 8-8½ whorls, length less than 45 mm.....
   C. olivacea infrequens, no. 12d.
8. Median whorls flat or nearly flat.....**C. hyattiana,** no. 11.
   Median whorls slightly convex (9).
9. Shell ovate, conic, whorls tightly coiled, sutures nearly transverse....**C. lymani,** no. 13.
   Shell narrowly ovate conic to turreted, whorls more loosely coiled, sutures oblique.....**C. olivacea,** no. 12.
10. Adult shells less than 40 mm. in length, not more than 14.75 mm. in diameter, tapering evenly to the apical cone, with nearly straight outlines, surface not coarsely wrinkled or distinctly spirally corded.....**C. olivacea propinquella,** no. 12b.
    Adult shells 40 or more mm. in length, wider than 15.5, apical cone distinct, surface coarsely wrinkled or distinctly spirally corded (11).
11. Adult shells not over 48 mm. in length nor with more than 8 whorls, color uniform.....**C. tenebrosa,** no. 14.
    Adult shells rarely less than 55 mm. in length and with 9-10½ whorls, a few specimens uniformly colored, but the majority with a broad yellowish subperipheral band.....**C. turricula,** no. 10.

Carelia turricula (Mighels) (Pls. X, XI, XII).

Achatina turricula Mighels: Boston, Proc., Soc. Nat. Hist., vol. 2, p. 20, 1845.—Pfeiffer: Mon. Hel. Viv., vol. 2, p. 261, 1848, *Spiraxis* (?) *turricula* Pfeiffer: Mon. Hel. Viv., vol. 3, p. 470, 1853.

Carelia turricula Pease: London, Proc. Zool. Soc., p. 473, 1871.—Kobelt: Jahr. Deutsch. Malak. Ges., vol. 2, p. 225, pl. 7, fig. 1, 1875.—Ancey: France, Mem. Soc. Zool., vol. 6, p. 326, 1893.—Baldwin: Cat. Land and Freshwater Shells of Hawaiian Islands, p. 12 (Hanalei, Kauai) 1893.—Borcherding: Mon. Carelia, p. 229, pl. 19, figs. 2 and 3, 1910.—Pilsbry: Man. Conch., vol. 21, p. 103, pl. 19, fig. 1, 1911.—Pilsbry: Man. Conch., vol. 23, p. 65, pl. 17, fig. 4 (Genitalia) 1915-1916.

Achatina obeliscus Reeve: Conch Icon., vol. 5 (*Achatina*), sp. 129, pl. 23, fig. 129, 1850.

Carelia obeliscus = *C. turricula* Mighels, Baldwin: Catalogue Land and

Freshwater Shells of the Hawaiian Islands, p. 24, 1893. Sykes: Faun. Haw., vol. 2, pt. 4, p. 374, 1900 (Hanalei).

Carelia turricula var. *obeliscus* Reeve, Pilsbry: Man. Conch., vol. 21, p. 104, pl. 19, figs. 7 and 8, 1911.

Carelia newcombi Pfeiffer: London, Proc. Zool. Soc., p. 262, 1851. *Spiraxis newcombi* Pfeiffer = *Spiraxis turricula* Mighels: Pfeiffer: Mon. Hel. Viv., vol. 4, p. 571, 1859.—Borcherding: Mon. Carelia, p. 230, pl. 19, figs. 2 and 3, 1910. *Carelia turricula* var. *newcombi* Pfeiffer, Pilsbry: Man. Conch., vol. 21, p. 104, pl. 19, figs. 4, 5, and 6, 1911.

Carelia turricula var. *azona* Ancey: London, Proc. Malac. Soc., vol. 6, p. 121, 1904.

Carelia cochlea Gulick: Evolution, Racial and Habitudianal, p. 38, Pl. 1, fig. 1, 1905.

Carelia paradoxa Pfeiffer: Borcherding: Mon. Carelia, Pl. 19, figs. 4 and 5, 1910.

Carelia pilsbryi Sykes, Borcherding: Mon. Carelia, Pl. 19, figs. 6 and 7, 1910.

Carelia olivacea Pease, Borcherding: Mon. Carelia, Pl. 19, figs. 8 and 9, 1910.

Shell cylindrical, turreted, sometimes dark, sometimes light brown, imperforate; whorls 10, convex, more or less distinctly striate transversely; incremental striae coarse; aperture oblong; lip simple, acute. Length 2.75 inches, diam. 0.8 inch (69.7 mm., length, 20.3 mm., diam.) (Mighels).

The summit is rather pointed, the first 3 whorls being straight-sided, subsequent whorls are slightly convex, and last whorl is somewhat cylindric, being flattened in the middle, convex or subangular above, and angular at the periphery, below which it tapers straightly to the base. Apical sculpture as in the other species; the spiral sculpture begins on the fourth whorl as spiral series of long granules. On the last 3 or 4 whorls there are several low, cord-like spirals, more or less knotted by coarse, irregular, longitudinal growth-folds. This sculpture varies from strong to subobsolete in different specimens, and is wanting on the base. There is also a very dense, fine, wavy microscopic spiral striation, visible in the most perfect shells, but readily worn off.

The color varies from rather bright yellow to dark chestnut, the base being darker, of a chocolate shade. In the color-form *newcombi* there is a pale belt below the periphery (Pilsbry).

Kauai (author's) Hanalei: Baldwin, Perkins (localized Bishop Museum specimen); base of Hihimanu on the east side of Waioli, 1908, C. S. Dole; Waioli-Waipa Ridge, 900 to 1200 feet elevation, P. H. and E. S. Deverill; W. H., C. A. and A. H. Rice; and C. M. Cooke, prior to 1900; J. S. and O. H. Emerson, 1913; T. Dranga, 1926; W. Meinecke, 1927; D. Thaanum; Waipa-Lumahai ridge, W. Meinecke, 1927.

The Bishop Museum series of this species is made up of about 500 specimens. Fortunately, nearly all of them are exactly localized. I have been informed by two of the older residents of Kauai that this species was

known to them, 75 years ago, only from the Waioli-Waipa Ridge, where as boys they had collected specimens. Probably most of the early material came from this locality. About 30 to 35 years ago Messrs. P. H. and E. S. Deverill, W. H., C. A., and A. H. Rice were active collectors of this species, especially the first two, who lived in Hanalei. The author, as a boy, collected with the Deverills. The Baldwin and Thwing specimens which are in Bishop Museum, and the material used by Borcherding (from Mrs. H. Isenberg) was collected by the Rices and Deverills. All of this material came from the western ridge of the Waioli valley, back of the village of Hanalei. This colony is near the locality Kapalikea on the U. S. Survey map. Ancey's, and most of the material studied by Pilsbry, is also from the same locality.

Specimens in the Museum collection acquired from earlier sources than those mentioned above bear no other locality than the Island of Kauai.

During 1926, Dranga collected a fine series of this species from the same colony. His specimens were found "under rotten logs, under dead leaves and recumbent stems of *ieie* (*Freycinetia arnotii*)." In 1927, Meinecke visited the same locality, finding shells on both sides of the ridge.

Specimens from this colony vary to a very great extent in form, color, and in the texture of the surface. This variability led to the early description of two additional species, *obeliscus* and *newcombi*. On account of the unusual amount of variability among his specimens, Borcherding recognized five species from the material he had from this colony. From its color pattern and texture he considered *obeliscus* (Mon. Carelia, Pl. 19, fig. 1) as distinct from *turricula* (= *newcombi*, Mon. Carelia, Pl. 19, figs. 2 and 3). For comparison three specimens are figured (Pl. X, fig. 5 = *obeliscus* and Pl. XII, figs. 2, 3 = turricula, color pattern *newcombi*). His specimen (Mon. Carelia, Pl. 19, figs. 4 and 5), identified as *paradoxa*, is a small tuberculate example of *turricula*. Somewhat similar specimens are figured (Pl. XI, fig. 7, and Pl. XI, fig. 8), though the tubercules are not as pronounced as in his examples. For *pilsbryi* (Mon. Carelia, Pl. 19, figs. 6 and 7) he figured a rather broad, unicolored, roughly-striated specimen, with a comparatively long aperture. A nearly similar example (Pl. XII, fig. 1) though dead and worn, is in the Museum collection and has the exact measurements of Mr. Sykes' specimen (65 by 23 mm.) though with an additional whorl. A specimen which might have served as a model for Borcherding's figure (Mon. Carelia, Pl. 19, figs. 8, 9) of *olivacea* is figured (Pl. XI, fig. 5). This color pattern is not very unusual among the Museum's specimens, but it lacks the characteristic light, narrow, subsutural band of Pease's species. Specimens furnished with his band (Pl. XI, fig. 4) are excessively rare among the examples from this colony.

Specimens from 75 to 80 mm. in length are not uncommon among the many series of dead specimens in the Museum collection.

Length	Diameter	Apert. length	Apert. diameter	Whorls	Age	Condition	Plate	Figure	Collector
85.3 mm.	23.6	25.3	13.1	10½	adult	dead	X	1	W. Meinecke
82.0 mm.	21.8	22.2	11.2	11	adult	dead	X	6	"
71.8 mm.	18.0	18.5	8.9	10½	adult	dead	X	3	"
67.6 mm.	23.6	21.5	11.6	9¾	adult	dead	XI	6	"
80.0 mm.	21.7	22.6	11.7	10½	adult	alive	X	4	T. Dranga
78.8 mm.	24.7	23.7	13.2	10½	obelis.	dead	X	5	
76.5 mm.	22.3	22.3	13.0	10⅓	newcombi	alive	XI	2	
73.4 mm.	20.7	21.0	11.2	10⅔	newcombi	alive	XII	3	
65.2 mm.	19.2	20.3	11.0	10¼	obelis.	alive	X	2	
56.6 mm.	22.5	19.6	12.2	9½	obelis.	alive	XI	1	
57.4 mm.	17.9	18.3	9.7	9½			XII	4	

There is considerable variation in the color and color pattern of the specimens in the Bishop Museum collection from the Waioli-Waipa colony. Fresh specimens, collected by T. Dranga in 1926, and W. Meinecke in 1927, are, as a whole, much darker than those collected by Deverill, Rice and C. M. Cooke, 30 or more years ago. This may be due to the shells fading since they were collected.

A fresh specimen (Pl. X, fig. 4) with 10½ whorls has the first 2½ whorls bicolored, but by the completion of the fourth whorl the color is uniform. The upper 6½ post-embryonic whorls are much worn, drab-gray, gradually shading to carob-brown on the penultimate whorl. The last whorl is sooty-black.

A second specimen from the same lot (86160xx, not figured) has the peripheral band Sanford's-brown, below the band sooty-black, above the band light seal-brown. Younger specimens with 6 to 7 whorls, and showing no wear on the surface, are of a nearly uniform, sooty-black below the periphery, Hessian-brown above, gradually becoming darker towards the apex, which is blackish brown—2. Nearly all the immature specimens in this lot (86160) have a narrow, light, Sanford's-brown band at the periphery.

The typical (25331) *obeliscus* color pattern has the base sooty-black up to the periphery which is sometimes very indistinctly marked (Pl. X, fig. 2) with a narrow Sanford's-brown line, and the upper whorls uniform Vandyke-brown to tawny. With the broadening and lighter colored peripheral band, there is a very gradual change from the *obeliscus* pattern to the *newcombi* color pattern. This latter is by far the most abundant color pattern represented among the Bishop Museum specimens. In all examples of this color pattern the base is sooty-black. This sooty-black area is usually bordered above with a distinct chamois to honey-yellow band which extends to but not above the union of the outer lip with the last whorl. This band is from less than 1 (Pl. XI, fig. 2) to 3 1/3 mm. (Pl. XII, fig. 2) in width. Above this zone the shell is from clay-color to russet.

The dark color on the base is an almost constant character. There are, however, two specimens in the Museum collection which have the base as light, or lighter than, the upper portion of the last whorl. One of these, not quite adult (Pl. XI, fig. 3), collected by Meinecke, has the upper portion of the last whorl chestnut, the base, cinnamon-rufous.

There is considerable variability in the form of this species, some specimens being proportionately much broader (Pl. XI, fig. 1) than others. The apex is usually conic, the first four whorls being nearly flat, the succeeding whorls usually becoming slightly more convex until the penultimate, which is almost invariably more convex than the preceding whorls. The last whorl in adult specimens is flattened, with a slight shoulder (almost imperceptible in a few specimens) above, below bluntly-angled at the periphery, with a slightly convex base.

The aperture of this species is in most examples somewhat longer than broad. This is especially noticeable in specimens just before reaching maturity, the aperture broadening during the growth of the last whorl. In most examples the outline is indefinitely rhombic, with the outer margin of the peristome slightly flattened. The position of the basal angle is usually more or less indicated at the margin of the peristome. There are specimens, however, in which the outer margin is regularly curved without flattening or any indication of the basal angle.

The margin of the peristome is always thin and delicate. In nearly every adult individual the margin is more or less broken. In very few specimens is the portion at the base of the aperture whole. The number of deformed specimens shows that the individual frequently meets with accidents. This gives the measurements of the length of the aperture little significance as far as measurements go.

Specimens with 9½ or more whorls are usually pregnant; from 9 to 9½ rarely so. Consequently, the breeding age begins after the ninth whorl is completed, when the shell is about 55 mm. in length. In a single example 5 embryos with shells in different stages of growth were found. Usually, in well developed specimens, there are 3 or 4 embryos. In a specimen with 4 embryos the largest has 4½ whorls, is 11.6 mm. in length, and is perforate. The outer edge of the columella is straight, slightly swollen over the perforation, with a thin columellar plate superimposed upon it which does not terminate abruptly. The second embryo has 4 whorls, is 10.2 mm. in length, with a similar cleft-like but smaller perforation. The columella is similar, but the columellar fold is weaker. The third was 3½ whorls, and is 7.7 mm. in length. The perforation is very minute. The columella is less swollen within, almost perfectly straight, with a very minute thread-like, scarcely sigmoid, columellar lamella. The fourth has about 2½ whorls, is about 4.3 mm. in length, and, under a lens, is very minutely perforate. The columella

is straight, narrowly triangular in outline with an almost straight, very minute, thin fold which does not extend to the base of the columella.

In embryonic specimens of 4½ whorls, the first whorl is nearly smooth. Beginning about the middle of the second whorl there are well defined arcuate ridges. Before the third whorl is reached, faint spiral lines are gradually apparent which at about the beginning of the fourth whorl gradually become raised ridges, well defined at the completion of this whorl.

At all stages of embryonic growth, the periphery is distinctly angled. Early embryonic stages show a nearly smooth shining base, this gradually becomes closely packed with distinct revolving striae which become stronger up to the time of birth. This basal striation is present (especially on strongly spirally striate shells) up to the completion of the seventh whorl. Later stages show only microscopical striation.

Undoubtedly *turricula* existed and may exist at present, for a mile or so to the east, but not beyond the west side of Kalihiwai stream. East of this stream all the specimens of *Carelia* that have been reported are referable to Pease's *olivacea.* The nearest species found on the west is *C. cumingiana* var. *meineckei,* and it is doubtful if intergrades will be found connecting these two very distinct forms.

Only two additional colonies of this species have been reported up to the present. The first is something over a mile to the east where C. S. Dole in 1908 found two dead specimens "on the slopes of Hihimanu," on the east side of Waioli valley. Both of these specimens are immature, dead, and worn, with the surface bleached to a dull-white color. They undoubtedly belong to this species and show no differences from specimens of the same age from the Waioli-Waipa locality. The larger specimen measures: length 51.8, diameter 18.2 mm., whorls about 8½.

The second and westernmost colony from which *C. turricula* is known is on the Waipa-Lumahai ridge, discovered by Meinecke in 1927 (Pl. XII, figs. 5-8). The shells are much smaller than those found across Waipa valley and none had more than 9½ whorls. In color pattern, texture, and form they have almost as much individual variation as specimens from the Waioli-Waipa locality, from which they differ only in their smaller size. Eight of the specimens were pregnant. These pregnant specimens had 8½ to 9 whorls. One pregnant specimen which contained 2 embryos (Pl. XII, fig. 8) has the adult characters of the lip and measures 47.2 by 17.3 mm., with 8½ whorls. The largest pregnant live specimen (Pl. XII, fig. 5) with 9 whorls, measures 56.4 mm. by 18.2 mm. The largest dead specimen (Pl. XII, fig. 7) is 72.6 mm. in length; 20.0 mm. in diameter with about 10 whorls. A second dead adult specimen, much shorter and proportionately broader (Pl. XII, fig. 6) measures 54.8 by 20.1 mm, 9 whorls.

Specimens from this ridge have no intergrading characters with *C. cumingiana* var. *meineckei* found on the ridge across Lumahai valley, though the latter locality is no further away from it than from the typical *turricula* colony.

The embryos of this variety are only slightly smaller than those from the Waioli-Waipa ridge. The largest (86410A) embryo, with nearly 4½ whorls, measures: length 10.6, diameter 6.7 mm. In form and surface texture it agrees closely with specimens from the type locality. Compared with specimens from the Waioli-Waipa locality, the size of the embryos is out of all proportion to that of their parents.

Carelia hyattiana Pilsbry (Pl. IX, figs. 6-8).

Carelia hyattiana Pilsbry: Manual of Conchology, vol. 21, p. 108, pl. 21, figs. 1, and 2.

The shell resembles *C. turricula* in shape. The embryonic whorls and up to the end of the fourth taper more rapidly than those following. The first 3½ are bicolored and nearly flat, with a sculpture of narrow, curved, axial grooves, separated by much wider intervals. They are somewhat worn in the type. The rest of the whorls are rather weakly and about equally convex, with sculpture of faint growth-wrinkles and indistinct traces of fine, dense, wavy spiral striolation. The color of the post-embryonic whorls is fallow or tawny yellow; this deepens to a rich chestnut and then dark reddish chestnut on the last whorl which is darkest basally. A rather narrow (about 1.5 mm.) snow white zone borders the suture below, on the last 5 whorls. The aperture is ovate. Columella vertical, brown, with a very weak basal truncation and no noticeable spiral lamella.

Length 54, diam. 17.2, length of aperture 17 mm.; whorls 9. Type no. 10132, Academy of Natural Sciences of Philadelphia (Pilsbry).

Hawaiian Islands (Pilsbry, also Steward Collection in the American Museum [B. P. Bishop Mus. No. 58954]): Kauai, J. S. Emerson; Waipa (fossil), W. Meinecke (nos. 86296, 88437).

This species is based upon a fossil shell which was associated with *C. dolei* in the collection, and which evidently came from the same formation. It differs from *C. dolei* in wanting an angle or carina at the shoulder at all stages of growth. On the last whorl there is an obtuse but quite appreciable basal angle, which, with its shorter aperture, serves to differentiate this species from *C. pilsbryi* Sykes.

C. olivacea Pease may be identical with this shell, but the proportions, from Pease's measurements, must be much more slender. The var. *variabilis* of Pease, of the same length as *hyattiana,* is wider and has two whorls less (Pilsbry).

C. hyattiana is a rare shell in collections. In addition to the type, I have identified as belonging to this species two specimens in the collection of the American Museum and nine (5 adult and 4 juveniles) in the Bishop Museum collection.

Unfortunately, the type specimen is not before me, but a specimen (Pl. IX, fig. 8) received from the American Museum was compared with the

type by both Dr. Pilsbry and myself and we were convinced that the two specimens belonged to the same species as both agree in all essential characters. A second nearly whole fossil specimen (Pl. IX, fig. 6), embryos, 3 juveniles, and a few fragments, were collected by Meinecke during 1927 in a deposit at the mouth of Waipa Valley, just west of the Waioli stream. Three adults and one immature specimen (Pl. IX, fig. 7) from the collection of the late J. S. Emerson are referable to this species. The American Museum specimen and those from Mr. Emerson are not fossils, but from the appearance of the aperture were undoubtedly dead when collected.

From a comparison of the material available at present, I consider that *hyattiana* is a derivative of *turricula* stock. Its association with specimens of *C. dolei* in the collection of the Academy of Natural Sciences of Philadelphia was purely accidental, as no *Carelia* species of *turricula* stock has been reported from west of the Wainiha stream.

Typical specimens of *C. hyattiana* and *C. turricula* are easily recognized from one another. In the former the surface is smoother and glossier, the whorls are consistently less convex and the spire tapers more gradually towards the apex, not forming the distinctive cone which is characteristic in most of the specimens of the latter species. With the scanty material of *C. hyattiana* before me and the absence of intergrading specimens, I consider it appropriate to consider this species as distinct from *C. turricula*.

One specimen (Pl. IX,, fig. 8) is proportionately slightly narrower than the type, though in other characters it agrees very closely. It was evidently recently dead when collected, as the surface of the lower whorls is glossy, but the interior of the aperture is of a dull-whitish color. The color of the last three whorls is Sanford's-brown with a light narrow zone below the sutures. Its base is mahogany red, darker nearer the columella. The upper and embryonic whorls are much worn. It measures: length 55.6, diameter 16.1, length of aperture 17.5, diameter 8.8 mm.; whorls 9¼.

A second specimen (Pl. IX, fig. 6) found in the fossil deposit at Waipa, is somewhat larger than the type and the specimen described above. The embryonic whorls are bicolored, flat, as in the type, and are rather strongly axially sculptured. The fifth and sixth whorls are faded and marked with rather distinct widely spaced growth wrinkles. The last three whorls are nearly hazel in color with a narrow, light band below the sutures. The base is dark reddish black. The surface of the last three whorls is smoother in texture and not so distinctly marked with growth-wrinkles as the two preceding whorls. Length 61.4, diameter 18.0, aperture length 18.3, diameter 8.7 mm., whorls 9¾.

Fortunately, a well formed embryo with slightly more than 4 whorls was found when cleaning this specimen. The outline of this embryo, though slightly narrower, is similar to those of *C. turricula* of about the same age.

It is, however, somewhat smaller. In this embryo the axial riblets are more pronounced than in any of the embryos of *C. turricula* which have been examined and there is an entire absence of the characteristic spiral lines on the last (fourth) embryonic whorl. The lack of these spiral lines, if a constant character of the embryos of this species, would be of much importance as it would indicate that *turricula* and *hyattiana* have been differentiated for a comparatively long time.

A third specimen (Pl. IX, fig. 7) I have tentatively referred to this species. It is a juvenile specimen with slightly more than seven whorls, given to Bishop Museum by the late J. S. Emerson. This specimen differs slightly from the two described above, in that the apical whorls form a very slightly more decided cone and on the last whorl (seventh) there are indistinct low spiral ridges. The sharper basal angle is characteristic of many juvenile specimens of other species of this age. There is no other species, so far as I know, to which this specimen could be more suitably referred.

Of the three additional specimens from the J. S. Emerson collection, one is very similar in characters and condition to the American Museum specimens. While the remaining two are not typical *hyattiana,* they are, however, nearer to this species than to any of the other species, and have been included under this name. Although slightly darker in their present condition, they somewhat resemble the two specimens mentioned above. Both are slightly more roughly striate and on one there is a faint indication of raised spiral cords. Both of these specimens were undoubtedly taken alive, as the interior of their apertures is more or less coated with dried animal matter. It is possible that these two specimens are representatives of a local race of *C. olivacea* whose locality has not been rediscovered. From a comparison of all the available material, referring them to *C. hyattiana* seems the most reasonable solution. There was no indication of their source, for they were only labeled "C. rigida, Kauai."

Carelia olivacea Pease (Pl. XIII, figs. 1-6).

Carelia olivacea Pease: American Jour. of Conch., vol. 2, p. 293, 1866. Jour. de Conchyl., vol. 18, p. 402, 1870.—Pfeiffer: Mon. Hel. Viv., vol. 8, p. 251, 1877.—Ancey: Mem. Soc. Zool., France, vol. 6, p. 324, 1893.—Borcherding: Mon. Carelia, pp. 234-236, Pl. 19, figs. 8 and 9 (figures = *C. turricula* Mighels), 1910.—Pilsbry: Man. Conch., vol. 21, p. 106, 1911 with *variabilis;* vol. 23, p. 16, pl. 9, figs. 11, 15, 1915-16.

Carelia variabilis Pease; Jour. de Conchyl., vol. 18, p. 402, 1870, with variety *viridis.*—Proc. Zool. Soc., London, 1871, p. 473, with varieties *olivacea* and *viridans.*—Pfeiffer: Mon. Hel. Viv., vol. 8, p. 251, 1877.—Ancey: Mem. Soc. Zool., France, vol. 6, p. 325, 1893.

Shell elongately turreted: whorls 8-9, flatly convex, smooth or obscurely ribbed transversely, the last roundly angulate at its base; aperture small, ovate, about one-fifth the length of the shell; columella strongly arched and obliquely truncate at base; covered with a greenish-olive epidermis, which often, after the death of the animal, darkens; the suture is sometimes margined with a white or light colored band, which is free of epidermis; aperture bluish, edge black, base of columella dark chestnut. Length 69, diam. 19 mm. (Pease.)

"Sandwich Islands" (Pease). Kauai (Pease for *variabilis*): Kilauea, back of Wahunahuna (P. Deverill); head of East Fork of Kilauea River, about one-half mile west of Puukeakea, L. H. McDaniels, W. Meinecke; ridge south of Keahua Stream, Wailua Drainage Basin near Pole 403, O. Sweezy; Kalihiwai, near crest of ridge between Mt. Keoike and Puu Eu, E. Prigge; south slope of Puu Ehu, E. Prigge, W. Meinecke.

Pease's locality "in a space of over 15 miles on the eastern part of Kauai" undoubtedly refers to the spur back of Kilauea from the eastern side of the Hanalei River and extending westward to Anahola Bay. On the map this spur has a length of about 10 miles, measured by the government road the length of Pease's locality would be about correct. Probably between 1866-1870 this locality received some personal attention from Pease as he collected other species in different parts of the island, and also from the fact that he mentions the area of distribution. Fire and cattle have played havoc with most of the native forests along the northern side of this range and probably the original localities from which Pease obtained his material have been destroyed.

That Pease was confused over the validity of *olivacea* and *variabilis* as species is shown by his treatment of them. Borcherding has discussed this fully (Mon. Carelia, p. 235). It is possible that Pease's material (which he says "is found in a space of over 15 miles on the eastern part of Kauai, therefore occupying a larger area than any other of the genus") may contain representatives of different geographical races. Localized material of this species in the Bishop Museum collection, coming from quite distant localities (as much as 5 miles apart) show rather constant characters, though there is some variability in form and surface texture between individuals from at least one colony.

Since Pease was somewhat uncertain of the specific value of his two species, I agree with Borcherding in considering *variabilis* a synonym of *olivacea.*

The Bishop Museum collection has four specimens from Pease's original material. One (Pl. XIII, fig. 2) is from material distributed by Pease under the name *C. olivacea,* and was received in exchange from the American Museum of Natural History. The remaining three are from the Pease collection now in the Museum of Comparative Zoology and were received in

exchange. The latter three were unlabeled and were undoubtedly part of Pease's duplicate collection.

Besides these specimens the Museum has a small series from five quite widely separated localities. Two of these localities are represented by single specimens; two by 2 specimens; and the fifth by 10 whole dead adults and a number of broken and juvenile specimens.

Of the four Pease specimens now in the collection of the Museum, three types of shells occur, differing from each other in form and surface texture. What was probably the original form of Pease's *olivacea* is well illustrated by Pilsbry (Man. Conch., vol. 23, pl. 9, fig. 15). Two of this type are represented in Pease's material in the Bishop Museum. It appears not only to be the most abundant form, but also the most widely distributed, occuring in all localized colonies.

In this form the shells are largely, proportionately broader, with a larger aperture and with more rapidly increasing and more convex whorls than in the other two forms. The light subsutural band is broad and fairly well defined below. The spiral lines are low, and blunt, but easily visible to the naked eye. The sides of the last whorl are slightly flattened, and the whole tapers very gradually to the base of the columella with a slightly convex outline.

The aperture is elongate ovate, with its outer margin slightly flattened. The columella is nearly straight, slightly concave above, and furnished with a very low inconspicuous lamella, terminating gradually above the end of the columella. Pease's specimen is minutely perforate.

Length	Diameter	Apert. Leng.	Apert. Diameter	Whorls	Plate	Figure	Locality
54.7 mm.	19.3	19.4	10.0 mm.	8½	XIII	4	?
61.2 mm.	19.7	broken	10.2 mm.	9½	XIII	6	Kilauea
58.7 mm.	19.5	20.5	10.2 mm.	9	XIII	5	Kalihikai

This is undoubtedly the form described by Pease under the name *variabilis* and agrees with Pease's description in all essential characters except that he describes his specimen with 7 whorls and a length of 55 mm.

A specimen in much better condition was collected by Deverill back of the Waihunahuna Reservoir, Kilauea. The two initial whorls are worn smooth, bicolored, with the upper half almost white. The first to third whorls are slightly darker than the fourth which is the lightest of all. The post-embryonic whorls become darker as the shell increases in size. The body whorl is Sanford's brown, its base being between liver-brown and black. The subsutural line is nearly 1.5 mm. wide, light-yellowish near the suture and fading into the color of the body whorl below.

A much worn specimen collected by Sweezy on the south side of the range has embryonic whorls which are similarly colored. The subsutural

band is only indicated, and there is no differentiation in color between the base and upper portion of the last whorl, which are of a uniform very dark color, intermediate between liver-brown and black.

A second form of this species is represented by two specimens in the Museum. The first (Pl. XIII, fig. 3) is from the Pease collection; the second (Pl. XIII, fig. 1) was collected by P. Deverill from the same locality as one of the typical form. The first of these two is minutely perforate, somewhat cylindrical in outline, the four lower whorls tapering very gradually upwards, the four upper whorls more abruptly, forming a cone. Beginning just below the completion of the fourth whorl, there is a slight shoulder angle just above the middle of the whorl. This angle increases in strength with the growth of the shell and reaches its maximum development on the seventh whorl where it is well defined, but becomes weaker towards the completion of the last whorl. The spiral sculpture is faintly indicated only on the last whorl. The transverse sculpture is strongly developed on the last two whorls above the shoulder angle. The subsutural band is rather narrow. The basal angle is slightly more sharply defined than in typical forms of the species. The aperture, which is badly broken, is apparently proportionately smaller than the typical form. The columella is rather straight with its lamella much weaker than in most specimens. Length 50.0, diam. 17.0 mm., 8 + whorls.

The second specimen (Pl. XIII, fig. 1) of this form is a nearly adult individual with 8 + whorls. The outline is subcylindrical, the four upper whorls forming a cone. The shoulder angle is lacking. The first whorl is smooth, and bicolored. Near its beginning the lower half of the second whorl is marked with well-defined coarse striae which are somewhat worn above. Towards the completion of the second whorl and continued onto the third these striae are arcuate and bent forward. Beginning on the latter half of the third whorl there are faint indications of spiral incised lines which cut the striae into minute microscopical tubercules. On the fourth whorl these tubercules are well defined and increase in size until the middle of the sixth whorl where they gradually fuse and form low almost obsolete blunt ridges which are continued on to the upper half of the last whorl. The last two whorls are slightly flattened. The basal angle is very weakly defined. The color of the two lower whorls, except for a narrow, light subsutural line, is between maroon and black. This color becomes gradually lighter towards the upper part of the spire (mahogany red on the fifth whorl). The two initial whorls are slightly darker than the two following. The aperture is long, narrow, with its outer margin slightly flattened. The columella is nearly straight, hardly concave above with an extremely weak fold which terminates just above the lower end of the columella. Length 44.8, diameter 15.5, aperture diameter 8 mm. whorls 8 +.

A third form (Pl. XIII, fig. 2), of which there is but a single example in the collection of the Museum, came from the American Museum of Natural History (ex Haines Collection), and was labeled "Carelia olivacea," presumably by Pease. In this specimen the spire has slightly convex outlines, tapering gradually to the apex. The post-embryonic whorls which increase very slowly, are slightly convex. The last whorl is very faintly marked with nearly obsolete indistinct spiral lines and is furnished with a rounded basal angle. The subsutural light zone is very narrow and not distinctly differentiated from the color of the whorls. The aperture is small, its outer margin regularly curved. The columella is nearly straight and furnished with a low, inconspicuous fold which terminates gradually above the lower end of the columella. Length 52.1, diameter 16.8, aperture length 17.0, aperture diameter 9.5 mm., whorls 9½.

Unfortunately, there are no well-developed embryonic specimens of this species represented in the Bishop Museum collection.

Carelia olivacea, new subspecies (Pl. XIII, fig. 7).

A single specimen in the Museum collection has 8 whorls and is not quite adult, though nearing maturity. In form and sculpture of the upper part of the spire and embryonic whorls and in the outlines of the aperture it is evidently related to *olivacea.* It differs from the typical forms of this species by the absence of the substural light-colored line or band and in being sculptured on its last two whorls with a number (six) of rather sharp spiral ridges. Its coarser texture, thicker shell, and, if adult, larger size distinguish this specimen from *C. o. propinquella.* From young specimens of *C. turricula* this example is easily separated by its straighter outlines as well as its less sculptured embryonic whorls. The peripheral angle is sharper and more distinct than that of any specimen of either *olivacea* or *turricula* of about the same age with which it has been compared.

Length 39.9, diameter 15.3, aperture length 15.5, diameter 7.4 mm. (No. 86082).

Kauai, Hanalei, side of the division ridge between Hanalei and the north fork of the Wailua River, 2000 feet elevation (T. Dranga).

On account of the absence of adult material, it seems best not to designate this specimen with a subspecific name. The example evidently represents a geographical race intermediate between typical *olivacea* and the subspecies *propinquella.*

Carelia olivacca baldwini, new subspecies (Pl. XIII, fig. 8).

The shell is nearly subcylindrical in outline with a rather conical apex. Whorls 9¼, nearly flat, of which the upper five are badly worn and do not show any of the juvenile sculpture. The first three whorls are flat, bicolored, the darker color occupying about ⅔ of the lower portion of each whorl. Beginning with the fourth whorl, the whorls are slightly convex and increase very slowly and regularly. At the beginning of the sixth whorl there are indications of faint almost obsolete spiral cords.

These increase slightly with the growth of the shell. The last whorl is distinctly, though bluntly, angled at its periphery. Except for the first three whorls, the rest are uniformly colored, except for a very narrow subsutural line, which is white on the

upper whorls, with yellowish tinge on the last. The last whorl has the base slightly darker than the rest of the whorl. The color of the last whorl is bay-black, shading to tawny on the fifth whorl. The aperture is small, rhombic in outline with its outer margin bluntly angled. The columella is short, twisted, slightly concave above and furnished with a distinct low lamella which terminates rather abruptly near the base.

Length	Diameter	Apert. length	Apert. diameter	Whorls	
49.3 mm.	15.4	14.5	7.7		(type)
46.8 mm.	15.5	14.5	8.4	9	(paratype)

Kauai, D. D. Baldwin. Type no. 55881 A; paratype no. 55881.

The original series of this species consists of two very closely agreeing specimens. One of these was undoubtedly alive when collected, while the other had been dead but a short time. Both specimens came to the Museum in the D. D. Baldwin collection and were labeled "*C.*——? Kauai" in Baldwin's characteristic handwriting.

At first glance this subspecies appears to be more closely allied to *C. cochlea* than to *C. olivacea.* Its size, outlines, short columella, and proportionately small aperture certainly show a strong resemblance to the former species. In the form and surface texture of its embryonic whorls and in the texture of the surface of its last two whorls, it proves to be more closely allied to *C. olivacea.* It may represent a hybrid form between these two very distinct species or, less probably a very aberrant type of *olivacea.*

From the fact that in its most essential characters this subspecies approaches closely to *olivacea,* it is probable that the colony was located near the western boundary of *olivacea* on the east side of the Kalihiwai stream at a rather slow elevation near the periphery of the area formerly inhabited by *cochlea.*

Carelia olivacea propinquella, new subspecies (Pl. XIII, figs. 9,10).

The type specimen is dead and has lost nearly all of its very thin delicate epedermis. It has almost the outlines of a diminutive *olivacea.* The spire has slightly convex outlines and tapers gradually to the apex. There are 8 whorls, the first three flat, forming a narrow cone, the rest only slightly convex, increasing regularly. The surface is slightly worn and the surface sculpturing is lost. The aperture is narrow, long, broadly-lenticular, and bluntly pointed at both ends, with its outer margin regularly curved. The columella is slightly twisted, hardly convex above, with a low distinct lamella, terminating not very abruptly just above its base.

Length 39.9, diameter 14.6, aperture length 14.0, diameter 7.6 mm.

Kauai, at about 1000 feet elevation, Wailua, just within the native forest in the valley on the south branch of the north fork of Wailua River, C. M. Cooke and T. Dranga. Co-types (no. 81185).

In a living young specimen with 7 whorls the color is uniform maroon on the last whorl, lighter above, as the surface is slightly worn. All the worn surfaces have a slightly greenish tinge overlying the darker color. The first

two whorls are bicolored, the second striated with forwardly bending, curved, coarse striae which on the third whorl are indistinctly cut by fine spiral lines. These spiral lines increase in development on the fourth and fifth whorls and the surface has a microscopical granular appearance. This granular texture gradually becomes weaker on the development of the sixth whorl and is absent on the last. There are three inconspicuous spiral ridges on the penultimate whorl, situated in the upper third of the whorl. The whole surface of the last whorl is covered with minute, wavy, microscopical, spiral lines. The basal angle is well-defined, due to the imaturity of the shell. The aperture is long, rhombic in outline. Columella straight and furnished with a very inconspicuous fold. Besides the two specimens described above, the fragments of four rat-eaten specimens and two embryos are in the collection.

Compared with embryos of *turricula,* these embryos are smaller, proportionately narrower, and the sculpture, both spiral and transverse, is not as strongly developed. One of them with 4¼ whorls is distinctly perforate and has a length of 8.6 mm. These are the only embryos of *olivacea* stock in the Museum collection.

Carelia olivacea var. **priggei,** new subspecies (Pl. XIV, figs. 1-3).

The shell is subcylindrical, with evenly convex outlines, tapering at both ends and ending above in a slightly narrowed cone. Whorl 7¾, the embryonic flattened, the last three evenly convex. The embryonic whorls have the characteristic surface texture of *olivacea,* the post-embryonic are marked with fine growth striae and with very indistinct low rounded spiral ridges which are visible only under a lens. There is an indistinct shoulder angle on the last two whorls about one-third the distance below the suture. The characteristic subsutural white line of *olivacea* is well marked. The last whorl is descending just before its completion and is cylindrical, tapering gradually to the rather elongate base. The aperture is relatively long and narrow, angled at both ends. The columella is nearly straight, only slightly sigmoid and furnished with a weak, gradually terminating columella fold. The embryonic whorls of the dead type specimen are bicolored, the fifth and sixth sayal-brown, the last whorl is almost black with a greenish tinge.

Length	Diameter	Length Apert.	Apert. diameter	Whorls	Plate	Figure (Type)
39.1 mm.	14.1	15.2	7.2	7¾	XIV	1
38.7 mm.	14.1	14.0	7.2	7⅔		(not figured)
37.6 mm.	14.9	14.2	7.3	7½	XIV	2

Kauai, southern side of the Anahola ridge at Kiokala, E. Prigge.

This original lot consists of four adults and three juveniles, and, in addition, one young specimen which appears to belong to the typical form of *olivacea.* This dwarf form differs in several characters from the typical

olivacea and constitutes a geographical race, probably inhabiting a very restricted area. Six of the specimens are remarkably uniform in specific characters, the seventh (Pl. XIV, fig. 2) presents a number of individual differences.

In a fresh young specimen with nearly 6½ whorls, the embryonic whorls are indistinctly bicolored, the last whorl bay-colored.

The only individual variant in the original series is the example figured on Plate XIV, figure 2. The shell is stouter, heavier, and there are two raised ridges forming a fairly well developed shoulder angle. Its columella is more sigmoid and furnished with a slightly stronger columellar fold.

Carelia olivacea var. **infrequens,** new subspecies (Pl. XIV, fig. 4).

The shell is shorter than any of the adult typical specimens, more closely coiled, with a slightly narrowed apical cone, and the surface more roughly sculptured, being marked with rather coarse closely placed longitudinal striae on the last three whorls. The shell is narrowly conic, with very slightly convex outlines, gradually and evenly narrowing towards the apex. The post-embryonic whorls are very slightly convex and closely coiled, increasing slowly and at an even rate downwards. The last whorl is indistinctly biangulate, with the basal slightly stronger than the shoulder angle, somewhat flattened between the angles and with faint indications of spiral cords. It tapers rather abruptly to the base. The aperature is small, subrhombic, its outer margin modified by the angle and flattened above. The columella is sigmoid, decidedly concave above and furnished with a very weak lamella. Color (in its fossil state), cinnamon on the intermediate whorls, walnut-brown on the last whorl, much darker on the base. The embryonic whorls are much darker than the intermediate whorls and indistinctly bicolored. On the last three whorls the characteristic *olivacea* subsutural band is clearly visible.

Length 42.1, mm. diameter 15.5, aperture length 13.9, aperture diameter 8.7, whorls 8½, length 44.5, diameter 15.0, whorls 8, Spalding collection.

Kauai: Anahola, in plowed field just south and near the mouth of the stream. 1928. I. Spalding. Type (no. 88478).

Besides the type, Spalding found a single whole and a second broken specimen. All three agree in their essential characters. At first glance this subspecies appears to be an ancient form of *O. priggei,* but on a closer comparison, they appear sufficiently distinct from each other to be designated by subseparate specific names. *Infrequens* is easily recognized by its more closely coiled whorls, less convex outlines, proportionately smaller aperture, and shorter and more sigmoid columella.

In its close coiling and slightly sharper apical whorl this subspecies appears to be distantly related to *C. lymani,* a species whose habitat is unknown at present.

Carelia lymani, new subspecies (Pl. XIV, fig. 5).

The shell is fossil, not quite mature, narrowly conic, tapering gradually and evenly from the periphery of the last whorl to its apex, with slightly convex outline. Whorls, 8¾, the embryonic flattened forming a cone, the succeeding whorls slightly convex, in-

creasing very slowly, and closely coiled. In its present condition the surface of the last four whorls is slightly striate, with low, more or less regularly spaced, growth lines. Under a lens there are no indications of any spiral lines. The last whorl is indistinctly angulate at the periphery. The embryonic whorls are bicolored, marked with a broad white zone, from ⅓ to ½ the width of each whorl, below the sutures. The earlier whorls are more intensely colored than the succeeding, with the color fading out completely near the completion of the fourth whorl. The fifth and sixth whorls are lighter than ivory-yellow; the seventh and last whorls are cinnamon-buff shading to a broad patch of Kaiser-brown around the umbilicus, with a narrow pale band accompanying and below the sutures. The aperture is short-ovate, pointed above, rounded below. Columella slightly sigmoid, nearly vertical, its inner margin accompanied with a low indistinct fold. The sulcus below the columella is very broad and shallow. Length 46.7, diameter 19.0, aperture length 17.0, diameter 10.0 mm.

Kauai, E. Lyman. Type no. 87448.

The exact locality for this species is not known. It was in Lyman's collection in the same tray with two specimens of *C. pilsbryi,* but I do not consider that this is any indication of its original habitat. This material was not collected by Mr. Lyman, but was given to him many years ago.

Unfortunately, the above and only specimen is not quite adult, but additional adult material would be easily recognized by the peculiar, narrow, closely coiled, and slightly convex whorls. This character has not been observed in any other species.

From the outline of the embryonic whorls, this species is probably descended from the same stock as *C. olivacea* and *C. turricula,* though the presence of the light subsutural band would indicate a closer relationship to the former species, and besides its closely coiled whorls show some resemblance to those of *C. olivacea infrequens.* It is probable that *C. lymani* is descended from the same ancestral stock as *olivacea* but through long isolation both have diverged to a very marked degree. If this slight similarity counts for anything, the locality of *C. lymani* should be found on one of the beach flats on the north shore of Kauai between Kalihiwai and Anahola bays. To me the vicinity of Kilauea Bay seems to be the most likely spot for finding additional material of this interesting and distinct species.

Carelia tenebrosa, new species (Pl. XIV, figs. 6-8).

The shell is subturreted, with slightly convex outlines, the last three whorls tapering very slowly, the earlier much more rapidly, solid, the post-embryonic whorls marked with distinct spiral cords. Whorls, 7½, more or less worn, especially the embryonic. The first whorl is smooth, bicolored; the second is faintly vertically striate, with arcuate riblets and is indistinctly bicolored. The third whorl is similarly colored and sculptured, except that faint spiral lines make their appearance. The fourth whorl is similar in color, but the sculpturing both spiral and vertical is more pronounced. The fifth whorl is slightly swollen and the spiral lines become fully developed having the appearance of a closely strung string of beads. The last two whorls are similar to the fifth except that they are slightly less convex, and there is an indistinct margining of the suture. The last whorl is rounded below the basal angle, which is only faintly indicated. Aperture narrowly ovate, very dark colored. Columella nearly straight,

brownish, furnished with a weak columellar fold which terminates somewhat abruptly just above the base. The sinus at the base of the columella is slightly angular, rather wide and shallow.

The type specimen is slightly worn but is the best preserved of any of the adult live specimens. The first three whorls are bicolored with a slightly brownish tinge, the subsequent whorls wood brown (buffy-brown). The last whorl especially near its termination is glossy, almost black in color.

Length	Diameter	Apert. Length	Apert. Diameter	Whorls	Plate	Figure (type)
40.0 mm.	15.6	16.7	8.6	7½	XIV	7
45.2 mm.	17.7	16.5	10.1	8 (dead)	XIV	8
43.5 mm.	16.3	15.8	10.0	7¾	XIV	6

Kauai, on the upper slopes and top of Haupu, the highest peak of the Kipu range, 1500-2200 feet elevation, L. Wishard, C. S. Dole, T. Dranga, and C. M. Cooke. Type No. 86151.

A rather rare species, as the Museum material, the result of eight trips, contains but 18 specimens of all ages taken alive, and 38 dead specimens. All but one of the specimens, taken alive, were collected by Dranga and are the result of three trips. He notes, "Carelia. Conditions damp. Very scarce and difficult to find alive. Well concealed under mass of dead leaves and rubbish."

All the specimens before me agree fairly well in form. There is some variation in the proportions of length to breadth, also in the relative size of the aperture and its proportions. A few specimens have the base slightly more flattened which is shown in Pl. XIV, fig. 8, of a dead specimen. The basal angle is apparently never distinctly developed in adult specimens. In young specimens of about 5 whorls the angle is more prominent, but not sharp. The surface texture is badly worn in most specimens and in a few specimens the spiral sculpture is almost, if not quite, obsolete. In nearly all the specimens the upper four or five spirals are stronger than the lower one or two. In young specimens with 5-6 whorls, there is but a slight break between the embryonic and following whorls. The surface texture is carried over with scarcely, if any, change. With the beginning of the post-embryonic whorls the shell thickens abruptly and is lighter in color, the spiral ridges are slightly more sharply defined. The surface of the fifth and sixth whorls is tubercular with the tubercules arranged in closely packed spiral rows. In young specimens of *C. tenebrosa* the spiral arrangement is more pronounced than in specimens of similar age of *C. glossema*.

Nearly all the specimens are worn so that most of the color is of a more or less neutral tint. The indistinct bicolored pattern of the embryos is not carried over onto the post-embryonic whorls. In fairly well preserved specimens the fifth and sixth whorls have a slightly reddish tinge and are lighter colored than the embryonic or last whorl which is of a uniform nearly

black color. This color is more or less fugitive as a live specimen collected by Wishard in 1908 has the last whorl of mahogany-red to chestnut. The Wishard collection has a remarkable color variant of this species. In this specimen the last whorl is pinkish-cinnamon gradually becoming darker towards the summit with the apical whorls of the same color as those of typical dark shells. Of 5 individuals from which embryos were taken, none had less than 7½ whorls. One to four embryos were taken from each of these. Probably the normal number for fully adult specimens is four. Four embryos from one specimen had respectively: 4, 3½, 2¼, and 2 whorls. From an examination of the apices of juvenile specimens the embryonic growth is completed between 4 and 4¼ whorls. All the oldest embryos are cleft-perforate, broadly biconic, with a distinct peripheral angle. They are indistinctly bicolored, there being a very narrow somewhat lighter indefinite zone just below the suture. The dominant color is between maroon and black. The initial half whorl is smooth, then the surface becomes gradually marked with faint vertical striae. These increase in intensity until on the second whorl they are well defined, blunt and arcuate. On the third and first half of the fourth whorls the surface is covered with rather closely placed sharp arcuate striae. Beginning on the second whorl very indistinct spiral lines or scratches can be made out, with a strong lens. These gradually increase in development, but do not modify the vertical striae until the fourth whorl is about half completed, when they gradually cut the vertical striae into spiral rows of oblong granules which become tubercular in form by the completion of this whorl. One of these embryos measures: length 10.2, diameter 6.6 mm.

Though separated by nearly 15 miles, *C. tenebrosa* is undoubtedly more closely related to *C. olivacea* than to any other living species.

Adult specimens of *C. tenebrosa* are smaller than typical specimens of *C. olivacea* and usually more compactly coiled, with more distinctly tuberculate juvenile whorls. Moreover, *C. olivacea* has the post-embryonic whorls marked with a quite distinct subsutural band, a color pattern which is entirely lacking in any specimen of *C. tenebrosa.*

In embryonic characters there is a rather close relationship between *C. tenebrosa* and *C. turricula.* In the latter species fully developed embryos are larger than about 4½ whorls, and the surface has a somewhat coarser sculptured texture.

Both species are descended from the same root-stock with *C. olivacea.* From the combination of the specific characters it is probable that *C. tenebrosa* and *C. olivacea* were descended from a common stock after it had been separated from a stock which included *C. turricula.*

Carelia lirata, new species (Pl. XIV, figs. 9-12).

The shell is narrowly ovately turreted with convex outlines, tapering almost evenly to the apex, the four upper whorls forming a cone, the last three whorls convex and with strong sharp spiral ridges. In specimens in which the color pattern is still present, the embryonic whorls are bicolored, light just below the sutures, shading gradually to a reddish-brown below. The post-embryonic whorls are ferruginous Hay's—russet, without a light subsutural band. (Undoubtedly in life the post-embryonic whorls were a uniform almost black, shading to a reddish tinge above.) Whorls 8, the first smooth, the second sculptured with evenly spaced relatively strong, slightly arcuate riblets; the third and fourth whorls very finely and closely vertically striate. In some specimens the indications of spiral lines occur on the fourth whorl, but in most examples these begin abruptly with the beginning of the post-embryonic whorls. On the fifth and sixth whorls the spiral ridges are somewhat modified by rather strong vertical striae, but on the last two whorls this is less pronounced and the spiral lines are present as strong, rather sharp, ridges. On the last whorl there are from 5-10 of these ridges, all located above the periphery. The peripheral ridge is, in most examples, stronger than the others, sometimes causing the periphery to become angulate. Below the periphery the last whorl is nearly smooth, without spiral lines, and tapers slowly to the base. The aperture is relatively long and narrow. In some examples the outer margin of the aperture is regularly curved; in others the upper portion is slightly flattened and subangulate at the periphery. The columella is slightly sigmoid, in the type, rather straight in most specimens, but in a few it is shorter and concave above. In most specimens the columellar fold is rather weak and terminates gradually near the base of the columella. The sinus at the base of the columella is narrow and shallow.

Length	Diameter	Apert. length	Apert. diameter	Whorls	Plate	Figure
48.7 mm.	18.7	18.0	10.0	8	XIV	12 Type
48.6 mm.	17.0	17.3	8.0	8½	XIV	9

A badly broken specimen has a length of 54.8 mm.

Kauai, limestone bluff about one-half mile east of Aweoweonui Bay in Mahaulepu, from 50 to 150 feet above sea level, 1930. C. M. Cooke. Type No. 100370 A.

The fossil bed from which this species was taken was found accidentally while looking for a fossil bed described by one of the older Kauaians as having been seen about forty years ago. The present fossil bed is on the steep southerly slope of the spur extending westward from the ridge separating Mahaulepu and Kipukai. There are two distinct fossil beds, one superimposed on the other. The lower bed in which the *Carelia* were found is made up of wind-drifted coral sand among which the shells are somewhat scattered, in some places in very great numbers. About forty species of shells belonging to most of the endemic genera now living on Kauai were taken. Most of these represent new species, though one or two are still found alive in the neighboring Kipu range. Practically all the species belong to groups of species which inhabit only the wet land forests. That these shells were covered up when alive is apparent from the sharpness of their surface texture and the presence of fragile species of *Godwinia, Microcystis,* etc. This bed was covered up when the shore line, which is now cliffs, extended several hun-

dred yards out to sea and was margined by a coral sand beach. The upper layer is made up of red earth thickly imbedded with shells. All the species found in this layer belong to a typically dry land fauna.

C. lirata's nearest relative is *C. tenebrosa* a few of which at present are to be found living on the slope of Mt. Haupu not quite two miles distant. The fossil species is easily separated by its consistently sharper spiral lirae, more convex whorls, and more tapering base. The embryos of both species are similar in form and texture and show a very close relationship. In their adult characters they are quite dissimilar.

There is considerably more individual variation in form and texture of the fossil than of the living species.

The number and position of the spiral lirae are subject to great individual variation. When a large number are present they are rather thin and evenly spaced; when fewer (from 7 to 8), stronger and more widely spaced, sometimes arranged in groups of two or three separated by rather wide intervals (Pl. XIV, fig. 11). There is also a great deal of variation in the development of the peripheral lira. In some individuals (Pl. XIV, fig. 10) it is very strong, the shell then being angulate at the periphery, while in others it is not appreciably stronger than any of the other lirae, the periphery being more or less rounded. The material of *C. lirata* in the Bishop Museum consists of 40 whole, or nearly whole, examples, and 170 broken specimens and fragments.

GROUP OF CARELIA GLOSSEMA

The first 2½-3 of the embryonic whorls are flat, the fourth distinctly convex forming an apical cone with the slightly convex outline. The surface of the last embryonic whorl (4th) is very distinctly granulate or tuberculate. The post-embryonic whorls are very nearly flat, forming a spire with almost straight outlines tapering slowly and evenly from the angulate or keeled base to the apical cone. The aperture is long-rhombic.

This group, with that of *Paradoxa,* constitutes a series of species that have departed widely from typical species of the genus and undoubtedly represent a higher and more specialized stage in the evolution of the genus.

In both groups the spire is apparently contracted just before the embryo is fully developed. This is due to a flattening of the upper portion of the last embryonic whorl.

Although embryos of all three species of this group are in the Bishop Museum collection, only *glossema* is represented by fully developed examples. These are between 1/5 and 1/4 the length of their maternal parent. The species associated in the group of *C. glossema* have all been taken at comparatively high altitudes, between 1,500 and 2,500 ft. Undoubtedly there are additional undiscovered species belonging to this group, but the region in

which they probably occur is one of the most difficult to investigate as the sharp ridges and deep, precipitous valleys are covered by a dense rain jungle.

Key to Species of Glossema Group

1. Shell furnished with a strong high peripheral keel..... **C. periscelis,** no. 18.
   Shell bluntly angled at the periphery (2).....
2. Shell with slightly less than 9 whorls more than 75 mm. in length.. **C. knudseni,** no. 17.
   Shell with 8¾ whorls less than 65 mm. in length..... **C. glossema,** no. 16.

Carelia glossema[2], new species (Pl. XV, fig. 1-3).

The shell is narrowly subulate, solid, the upper whorls tuberculate, the lower with coarse vertical striae. The outlines of the spire are nearly straight, tapering gradually and evenly towards the summit. Whorls 8, the post-embryonic (fifth to eighth) nearly flat, the fourth convex, slightly swollen. The first whorl is nearly smooth. At about the beginning of the second whorl, low, broad, vertical costae appear. These become more pronounced with the growth of the shell, and many of them are split just above the suture. Near the beginning of the third whorl faint revolving lines can be made out, but these apparently do not modify the appearance of the vertical striae to any extent. These spiral lines increase in development with the growth of the third whorl so that near its completion the whole surface of the whorl is tuberculate, with the tubercules arranged in both spiral and vertical rows. This tuberculate surface texture increases in development during the growth of the fourth whorl and is carried over to the post-embryonic whorls on the fifth whorl, so that there is scarcely any demarcation in texture between the embryonic and post-embryonic whorls. The tuberculate surface texture is well developed on the whole of the fifth whorl, but becomes weaker on the sixth. The seventh and eighth whorls are strongly vertically striate and there are faint, nearly obsolete, spiral lines. The last whorl is oblong with a fairly strong and well developed basal angle. The base is vertically striate in a lesser degree than above the basal angle.

The embryonic whorls are uniform, nearly black, with a slight tinge of red; the fifth whorl is lighter, nearly claret-brown; the rest of the whorls are lighter colored near and below the suture (claret-brown) shading to a dark reddish black below. The base and the termination of the last whorl are nearly black. The margin of the suture is indistinctly marked with a very narrow line of a pale indefinite color.

The aperture is irregularly, narrowly triangular, bluish black within, its thin outer and lower edges margined with a broad black band. The columella is nearly vertical, slightly bent forward below, twisted, having a moderately well developed fold which terminates rather abruptly close to its base. The sinus below the columella is rather deep and narrow.

Length	Diameter	Apert. length	Apert. diameter	Whorls	Plate	Figure	Type
48.2 mm.	16.5	16.9	9.0	8	XV	1	
52.6 mm.	18.0	18.0	9.5	8¾	XV	2	
62.2 mm.	18.0	20.2	9.8	8½	XV	3	(dead)

Kauai, Olokele, C. M. Cooke; Olokele, above Rainbow Falls, W. Meinecke and T. Dranga; Makaweli, A. F. Judd. Meinecke's and Dranga's material came from the same colony. "Just around bend above Rainbow Falls," W. Meinecke. Type no 86083.

[2] γλωσσημα, point of a dart.

Southeast side of Olokele Canyon, about ⅜ mile above the point where Rainbow stream is crossed by the trail. Collected on steep talus slope at the base of vertical pali, on the side of canyon, from a few to 100 or more feet above the trail. The slope is covered by a thick growth of ferns, lantana, and bushy olona plants. I took the live *Carelia* mostly under masses of small loose rotten rock, mostly near the top of the talus, but took 3 specimens amongst the fern roots. . . . . Specimens were decidedly scarce (11 adult or nearly adult, 11 juvenile, and about 100 dead specimens) and these are the result of two days collecting. I tried other localities further up the canyon without success and also tried below Rainbow Stream, but found only a dead fragment. Elevation 1400 feet (Dranga).

Mr. Judd's specimen from Makaweli consists of fragments of a badly broken dead shell. If complete, it would undoubtedly be much larger than any of the Olokele specimens, as the last whorl is 20.1 mm. in diameter and the aperture is 23.0 mm. in length. The surface is badly worn and shows none of the characteristic surface texture, except that of the last whorl. The aperture and basal angle are characteristic of this species, as is also the convexity of the fourth whorl.

The series of this species in the Bishop Museum collection (including live and dead specimens) consists of about 125 specimens representing all stages of growth. All the specimens agree very closely in specific characters and there is practically no variation except very slight differences in the proportion of the diameter to the length. Such close agreement of specimens occurs in only one other species of the genus—*C. cumingiana.*

From the fact that Judd took a typical specimen at Makaweli, about four miles from the type locality, this species must have been widely distributed in the region between the Olokele and Hanapepe rivers.

In immature specimens with 5½ to 6½ whorls, the basal angle is more sharply defined than in adults and the vertical striation is less diminished in strength on the base. The columella is nearly straight and the columellar fold is indicated as a slight thickening of the inner margin of the columella.

The animals of nine specimens collected by Dranga were examined and 6 were found to be pregnant with 1 to 3 embryos. The larger number of embryos were in the more mature animals. From a comparison of the shells with the animals it is evident that the shells reach a breeding age when 7½ whorls are completed. The embryos are large when compared with the size of the aperture. The largest embryo has 4¼ whorls, is minutely perforate, narrowly bulimoid and measures: length 12 mm., diameter 7 mm. The uterus containing this specimen had two others in different stages of development. The middle specimen has 3½, and the youngest just 2 whorls. A second specimen with three embryos was opened, the embryos having respectively 4¼ (11.6 by 6.6 mm.), 3½, and 2 whorls.

In embryonic specimens the first whorl and the beginning of the second whorl are nearly smooth. Beginning at the second whorl are rather irregular

striae, at first not distinctly formed, but when the second whorl is completed they have developed into rather coarse striae. Coincident with the beginning of the formation of the vertical striae, microscopical spiral lines appear and by the completion of the second whorl are fairly well developed. By the time the 3½ whorl is reached the whole surface is distinctly closely tuberculate, the tubercules arranged in vertical and spiral rows. These tubercules increase in size so that by the time the fourth whorl is half completed they are easily visible to the naked eye. In embryos of four whorls the base below the peripheral angle is microscopically striate, the striae cut by minute spiral incised lines. The third whorl is more convex than the second and the fourth more convex than the third.

The strongly developed tubercular texture of embryonic specimens does not occur in any other species of the genus, except in the closely related *C. knudseni.* It is somewhat similar to the adult texture of *C. paradoxa.*

The relatively large size of the embryos of this species indicates that it is descended from an ancestor (undoubtedly closely related to *C. knudseni*) that was much larger than the normal adult size of the specimens found today.

Carelia knudseni, new species (Pl. XV, fig. 4).

The shell is dead and much worn, subulate, with almost straight outlines, thick and solid. In its worn condition enough of the color pattern of the last and penultimate whorls remains to indicate that above the periphery the shell was of a uniform dark color slightly paler just below the sutures, and of a uniform very dark color below the periphery. The spire tapers evenly from the basal angle to the embryonic whorls. Whorls nearly 9; the first three embryonic whorls forming a cone; the lowest (fourth) swollen; the post-embryonic nearly flat, increasing slowly and regularly. The last whorl is oblong, distinctly angulate at the periphery, marked with rather widely spaced coarse growth lines, the interstices of which are irregularly striatulate. The aperture is elongate-trapezoidal. The columella is nearly straight, only slightly twisted and bordered with a low inconspicuous fold which terminates imperceptibly at the base. The basal sulcus is very shallow. Length 76.2, diameter 24.3, aperture length 24.4, diameter 13.2 mm. Type.

Kauai, Mrs. Valdemar Knudsen. Type no. 87450.

The type and only known specimen of this species was found by Mrs. Knudsen many years ago and was given to the Bishop Museum by her son, Eric Knudsen. The exact habitat of this species is unknown, though it was tentatively reported as having been found at Halemanu. This is unlikely, as the region has been collected over for a number of years and no additional *Carelia* material has been reported.

From its resemblance to *C. glossema* it was undoubtedly taken from some locality between the Waimea and Hanapepe drainage basins, a region which has, except for Makaweli and Olokele, received little or no attention from collectors.

This species is closely related to *C. glossema* from Olokele and Maka-

weli. It is, however, much larger, with coarser growth striae. Fortunately the specimen contained an embryo with 4 1/3 whorls and there is quite a marked difference between this and any of those of *C. glossema.* From a comparison of these embryos the two species are certainly distinct. This embryo of *C. knudseni* is proportionately much broader and more conical with straighter outlines, length 13.2 mm, diameter 8.1 mm. The first whorl is smooth; with the beginning of the second whorl, coarse curved-forward axial costae make their appearance which become stronger with the development of the whorl. At about 3½ whorls minute spiral lines make their appearance which increase rapidly in strength so that by the completion of this whorl the striae are cut into series of vertical granules. These granules become more distinct with the further development of the embryo. In *C. knudseni* the spiral lines make their appearance fully a whorl later than in those of *C. glossema.* Although *C. knudseni* is at first glance somewhat similar to *C. periscelis,* the straighter columella, the absence of a raised basal keel, and especially the distinct surface sculpture of embryonic specimens easily distinguish the two species.

Carelia periscelis, new species (Pl. XV, figs. 5, 6).

The shell is narrow and elongately conic with nearly straight outlines, solid, thick, sculptured with coarse, irregular growth-folds. Whorls, 8 to 8½, the last embryonic whorl (fourth) convex, swollen; the post-embryonic nearly flat. The last whorl oblong with flattened outlines, furnished with a strong and prominent peripheral keel, which is continued above the sutures of the last and part of the penultimate whorls. The keel, on the last whorl, is bordered above and below by shallow furrows. The base is long, tapering with a nearly straight outline. The aperture is narrowly triangular, its outer margin nearly straight, modified by the peripheral angle. The columella is arcuate above, abruptly bent forward below and furnished with a thin but prominent fold which terminates abruptly just above the base of the columella. The sulcus below the columella is broad and shallow. Length 78.5, diameter 23.7, aperture length 23.9, diameter 13.4 mm. Type. Length (broken), diameter 26.0, aperture 26.3, diameter 15.5 mm., paratype 86174.

Kauai, Hanalei Valley, Kaapoko branch, at 2000 feet elevation (associated with bones of a human skeleton under a pile of boulders), W. W. Henderson. Type no 86174 A.

The material on which this species is based consists of two nearly whole, and three badly broken specimens. The specimens had been dead for a long time when found and are in a very fragile condition. The outer surface is worn and somewhat chalky in texture. The inner surface of the aperture in two of the specimens is glossy; in one of them of a blackish plumbeous color. Enough of the color remains on one specimen to indicate that live specimens are probably of a nearly uniform black with a reddish tinge which was possibly of a slightly lighter shade below the sutures. The most distinctive character of this species is the very distinct prominent basal keel, a character not found in any other species of the genus.

The only species to which *C. periscelis* shows any relationship is *C. glossema* from Olokele and Makaweli. From this species *C. periscelis* differs in its larger size, greater development of the basal ridge, coarser and more irregularly spaced growth folds, a proportionately wider and shallower basal sulcus and a more arcuate and bent forward columella. There is no doubt that both of these species are descended from a common ancestor as the general appearance of the two species is apparently more than a coincidence.

Fortunately, in washing, two specimens were found to contain embryos. None of the embryos were fully developed as the most mature specimen had slightly more than 3 whorls. These embryos are only slightly, if any, larger than specimens of a similar age of *C. glossema* and are proportionately slightly broader. The color of one of these embryos is retained to a remarkable degree, indicating that they were of a uniform very dark color, and showing no traces of bicoloration. There is some difference between the embryos of both specimens. Two of them agree in that the first whorl is smooth, the second is sculptured with prominent sharp slightly arcuate costae which increase in prominence with the growth of the whorl, the interstices between these costae are irregularly faintly striate. In two specimens (from one shell?) the third whorl is distinctly sculptured with spiral lines. In the earlier stages of this whorl only the interstitial striae are cut into oblong granules while the strong costae are not modified by the spiral lines; near the completion of the third whorl the whole surface is covered with narrow oblong granules arranged spirally, and of uneven height. A third embryo (from another shell) is proportionately narrower, the initial stage of the second whorl has three raised spiral lines closely placed and just below the suture; below these spiral lines are short vertical striae, in less than half a whorl the spiral lines disappear and only vertical costae are present. In this specimen the granular texture does not occur until the third whorl is near completion. This third embryo is undoubtedly not typical of the species, but is so distinct from any other embryo examined that I consider it to be an individual mutant.

The evidence furnished by the embryonic material confirms the conclusion that *C. glossema* and *periscelis* should be considered as distinct species. In no species of *Carelia* (except *paradoxa*) are the embryos so strongly costate on the earlier embryonic whorls as the examples of this species.

GROUP OF CARELIA PARADOXA

The embryonic shells are narrow, with convex outlines; the first two whorls form a sharp narrow cone, the fourth distinctly convex. The longitudinal sculpture of the embryos consists of distinct sharp costae to heavy blunt ridges, with the spiral sculpture, when present, not as strongly developed as the longitudinal. The upper post-embryonic whorls (5th and 6th) are, in nearly all examples, engraved with fine spiral and longitudinal striae forming a fine granular surface. With *paradoxa* the adult shells are

covered with this granular surface; in the three other forms it is only present on the early post embryonic whorls. The spire tapers gradually from the periphery to the summit with more or less straight outlines. The whorls are nearly flat to slightly convex. The last whorl is bluntly angular or rounded. Shells rather slender, from 45-60 mm. in length with 8¼-9¼ whorls.

The species of this group are associated together partly on their geographical distribution and partly on the form of the embryos of most of the specimens. The two species with the two subspecies do not apparently have as close affinities as the members of the other groups. All are associated by having as a common character the fine granular surface texture of the early post-embryonic whorls.

From its adult characters, flattened whorls, presence of a peripheral angle, and form of aperture, *C. necra,* might be associated with the *glossema* group except that the outline of its embryo agrees with that of specimens of *paradoxa* from Waipouli. However, the spiral sculpture of the embryonic whorls begins at a later stage of development than is characteristic of the species of the *glossema* group. The embryonic whorls of *necra* differ from those of *paradoxa* by the absence of the strong, blunt, longitudinal ridges on the lower embryonic whorls.

Paradoxa is undoubtedly the most specialized species of which we have any knowledge, both in embryological and adult characters. Its strongly ridged embryonic whorls and also the fine regular granular surface are not found in any other species.

KEY TO SPECIES OF PARADOXA GROUP

1. Embryonic whorls not strongly longitudinally ribbed (2).
   Embryonic whorls strongly longitudinally ribbed (3).
2. Adult whorls (7th and 8th) without granular surface..... **C. necra** no. 19.
   Adult whorls (7th and 8th) with granular surface..... **C. necra spaldingi,** no. 19a.
3. Interstices between longitudinal ribs granular, adult whorls only longitudinally sculptured..... **C. paradoxa thaanumi,** no. 20a.
   Interstices between longitudinal ribs longitudinally striated, adult whorls regularly finely granular..... **C. paradoxa,** no. 20.

Carelia necra, new species (Pl. XVI, fig. 1-3).

The shell is narrowly cuneate with slightly convex outline, tapering slowly and evenly to the embryonic whorls which form a narrow cone; solid, irregularly, but not strongly, vertically spirally striate. Whorls 8½; the three upper nearly flat, the fourth somewhat swollen, convex, the last four slightly convex. The embryonic whorls of the type are slightly worn, but enough of the surface texture remains to indicate its important characters. The surface of the first whorl is smooth, or nearly so, indistinctly bicolored; the surface of the second whorl is microscopically regularly and arcuately vertically striate, and is less distinctly bicolored than the first. The third whorl is nearly flat, sculptured to about the same degree and character as the second, but apparently

unicolored; the fourth whorl is swollen, wider than the fifth, near the beginning of the fourth whorl there are faint indications of spiral incised lines, increasing in strength with the growth of the whorl, and at its completion the whole surface is weakly granular with closely packed spiral rows of minute tubercules. This surface texture is carried over onto the fifth whorl where it increases in strength but becomes obsolete before the completion of the sixth whorl. The last whorl is oblong with a distinct, but obtuse basal angle. The aperture is much longer than wide, in the type the outer margin is badly broken. The columella is nearly straight and is furnished on its inner margin with a minute, hardly distinguishable, thread-like fold which terminates above the base of the columella.

Length	Diameter	Aper. length	Aper. diameter	Whorls	Plate	Figure	(Type)
54.2 mm.	17.4			8½	XVI	3	
57.5 mm.	16.5			9¼	(not figured)		
	17.6	17.3	10.0		XVI	2	(fragment)
45.6 mm.	16.8			8⅓	XVI	1	

Kauai, Hanamalu Flats, about one mile south of the Wailua stream, C. S. Dole. D. Thannum, I. Wishard, I. Spalding, C. M. Cooke. Type no. 19477 A.

The type has the outer margin of the aperture badly broken. It is, however, the most complete specimen in the Bishop Museum collection. Broken specimens and fragments of this species are fairly abundant in road cuttings and the sand quarry just below the road. This species was originally collected by Mr. Charles S. Dole. Two subsequent trips by the writer did not yield a single whole specimen. From the more or less complete specimens and well preserved parts, I feel sure that this species cannot be referred to any of the already described species. At first glance this species seems to be almost identical with the specimens which are referred to *C. hyattiana* in this paper, not only in general form and size, but also in the degree of the development of the basal angle. However, the embryos of *C. necra* indicate, both in form and texture, derivation from the *paradoxa* group. Although lacking the strong ribs of *paradoxa,* the fourth whorl has the characteristic swelling of the other members of this group.

It is unfortunate that there is not a complete adult specimen in the Bishop Museum collection. An examination of a number of broken specimens shows that adult shells commonly reach a larger size than any of the measurements given above. Well matured specimens probably have from 9½ to 10 whorls and should measure up to about 65 mm. in length. The body whorl of such a specimen is figured (Pl. XVI, fig. 2). In this specimen there are faint indications of almost obsolete spiral lines. The aperture is narrowly triangular, its outer margin considerably modified by the basal angle. Above the basal angle the whorl is slightly flattened. The columella is only slightly sigmoid and is not furnished with a distinct fold. The sinus below the columella is very shallow, due to the columella extending nearly to the base of the shell.

Specimens of this species show considerable individual variation, both in form and texture. In a number of examples (Pl. XVI, fig. 1) the first three whorls form a broader cone than those of the type specimen. In individuals having this character the fourth whorl is not so swollen and the post-embryonic whorls are flatter, more closely coiled, and decrease more slowly toward the apex. The outlines of the spire are less convex, the shell is more turreted and has a more compact appearance.

The texture of the embryonic whorls also shows considerable individual variation. In some specimens the spiral lines, which are well developed on the fourth whorl of typical examples are nearly obsolete. This character is to some extent correlated with the above-mentioned shells which have a broader apex. A few examples have the early post-embryonic whorls furnished with strong, well developed riblets. This is not due to better preservation, but is apparently an individual variation. As there are numerous well preserved specimens showing intermediate development of all these characters, it seems inadvisable to consider these extreme forms of varietal rank.

It is possible that these variations may be represented in the material by examples of different ages in the development of the species, or by specimens from slightly isolated colonies. The fossil bed from which this material was collected covered a relatively large area, when compared with other fossil beds, with no topographic features of isolation, and has every appearance of having been laid down at one time. The remarkable preservation of the minute microscopical texture indicates that most, if not nearly all, of the specimens were not exposed to the elements for even a short period after their death, but were covered over while still alive, and that they were laid down where they lived, not washed from the low range of hills in back of the beds. This is further borne out by the fact that the nearest 50-foot contour is about a third of a mile inland from where some of the specimens were found.

The color pattern of a number of individuals is well indicated, though undoubtedly much faded. In such specimens the embryonic whorls are bicolored, and the width of the subsutural white band is subject to considerable individual variation. Its demarcation from the darker color below is always gradual, never abrupt. In most examples the post-embryonic whorls were apparently uniformly colored, but some specimens show a narrow, though not clearly defined, subsutural band.

There are but 5 embryonic specimens of this species in the Bishop Museum collection, 3 of which have less than 3 whorls and the remaining 2 have about 4 whorls, neither of which is perfect. Specimens with the well preserved apices show that the embryo has 4 to 4¼ whorls at birth.

Carelia necra spaldingi, new subspecies (Pl. XVI, figs. 4-7).

The shell is somewhat smaller, more closely coiled and with more convex whorls than typical specimens. The surface texture is more pustulate, the close spiral lines being more deeply engraved while the vertical striae are finer and closer.

Length	Diameter	Apert. length	Apert. diameter	Whorls	Plate	Figure	(Type)
49.4 mm.	16.1	15.3	8.8	9	XVI	6	
43.2 mm.	15.0	14.3	7.8	8½	XVI	5	
40.4 mm.	14.9	14.7	7.1	8½	XVI	4	
48.4 mm.	16.8	16.5	9.0	8⅔	XVI	7	

Kauai, northern half of Waipouli race track, 1930, C. M. Cooke (type locality), ploughed field 0.25 of a mile south of Waipouli race track, 1928, I. Spalding. Type no. 100182A.

The type was selected from the later collected material as it is represented by 9 whole or nearly whole, and 26 broken specimens, and illustrates the range of variation of the species better than the Spalding material which consists of a single specimen.

The type lot was found mixed with the very abundant *paradoxa* material. There can be no doubt that this race is not related to *paradoxa,* but to *necra.* From the former it differs by its very distinct embryonic whorls, which are entirely unlike those of *paradoxa;* by the presence of a subperipheral angle; by its somewhat flatter whorls and the entire absence of the subperipheral, light-colored band which is an almost constant character of the fossil material of *paradoxa.*

The differences between this race and typical *necra* are noted above.

This subspecies is apparently not a derivative of *paradoxa.* It is possible that this subspecies represents the ancestral form of both *paradoxa* and *necra,* but I think that this is unlikely as the embryos have no intermediate characters. The more probable view is that *necra* and *paradoxa* had become differentiated as species, both occupying about the same area, before the Wailua River came through the range made up of the Nounou and Kalepa mountains. With the cutting through of the river, representatives of both stocks became isolated, the subspecies *C. p. thaanumi* developing from *paradoxa* stock on the south side of the river, while *C. n. spaldingi,* cut off on the north side of the river, differentiated some degree from its parent, *C. necra.* It is possible that the subspecies *C. n. spaldingi* is not of pure parentage, as the weakly pustulate lower whorls seem to indicate that there may have been some admixture of *paradoxa* blood, though this has been diluted to a very great extent. Unfortunately, no colonies of fossil *Carelia* have been found in the region (about a mile to a mile and a half) between these two colonies of *necra* and *n. spaldingi.*

It is interesting that the single specimen found by Spalding (Pl. XVI, fig. 7), nearly 0.5 mile south of the type locality represents a race more typical of *necra* than those found with *paradoxa,* as it has somewhat flatter whorls and less pustulate surface. It is possible that a purer form existed in this region, where it had not been able to mix with *paradoxa* specimens.

Carelia paradoxa (Pfeiffer) (Pl. XVII, figs. 1-9; Pl. XVIII, figs. 4-6).

Spiraxis paradoxa Pfeiffer: Zool. Soc. Proc., London, p. 128, 1853; Mon. Hel. Viv., Vol. 4, p. 572, 1859.

Achatina (*Carelia*) *paradoxa* H. and A. Adams: Gen. Rec. Moll., vol. 2, p. 132, 1858.

Carelia paradoxa Pfeiffer: Mon., Hel. Viv., vol. 8, p. 251, 1877.—Pease: Zool. Soc. London, Proc., p. 473, 1871.—Ancey: Mem. Soc. Zool., France, vol. 6, p. 329, 1893.—Borcherding: Mon. Carelia, p. 231, pl. 19, figs. 4, 5 (=*C. turricula*).—Pilsbry: Man. of Conch., vol. 21, p. 105, pl. 19, fig. 3 (= *C. turricula*).

Shell turrite, solid, distinctly and closely granulate, black-brown; spire long, forming an acute cone above. Whorls 8, convex; the upper ones remotely costate, the last whorl two-sevenths of the total length, angular below the middle, smooth; aperture a little oblique, subrhombic, bluish within, columella calloused, white, twisted, subtruncate at the base; peristome unexpanded, acute. Length 46, diam. 16, apert. 15 mm. long, 8 wide (Pfeiffer). (Translation by Pilsbry.)

Pfeiffer also described a var. b; larger, white becoming orange-red towards the apex, the last whorl deep purple-chestnut around the columella; length 60, diameter 18 mm. (Pilsbry.)

Kauai, "very rare" (Newcomb in Cuming collection; fossil; in sand and loam deposits near the north end of the Waipouli Race Track in North Olohena District, C. S. Dole, D. Thaanum, I. Spalding, C. M. Cooke.

This fossil material was found in road cuttings, embedded in the sand and humus 6 to 12 inches below the surface; ploughed portion of the northwest end of the race track (Cooke); on the southern side of the Anahola range between Puu Ehu and Kawaiumakua (Meinecke).

A specimen (Pl. XVIII, figs. 4-6) [no. 45166 in the Museum of Comparative Zoology, Cambridge] may represent a typical example of this species. The shell of this specimen is turreted, solid, with 8½ whorls. The spire tapers slowly, the upper three whorls more rapidly, forming a cone. The first whorl is smooth. The second whorl is smooth above, transversely striate below, the striae becoming stronger towards their bases, this whorl is crenulate just above the suture of the third whorl; the striae gradually become coarser during the growth of the second whorl, and during the growth of the third whorl, form blunt nearly straight transverse ridges. In this specimen there are 18 ridges on the third whorl arranged in groups of 2 to 4. On the fourth whorl there are 16 more or less evenly spaced ridges which are not

arranged in groups as on the preceding whorl. The interstices between the ridges of the third and fourth whorls are microscopically granulate. These ridges terminate abruptly at the end of the fourth whorl. Near the beginning of the fifth whorl the surface is coarsely and irregularly striate, and numerous incised spiral lines make their appearance, forming a pustulate surface which increases in strength with the growth of the whorl and which becomes stronger on the succeeding whorls. On the sixth, seventh, eighth, and upper part of the last, the whole surface of the whorl is densely packed with these pustules arranged in spiral and transverse lines. The two upper whorls are slightly convex. Beginning with the third whorl, the convexity increases to the fifth whorl, which is more convex than the succeeding whorls. The sixth whorl is imperceptibly contracted and slightly less convex than the fifth. The seventh and eighth whorls are slightly more convex than the sixth. The last whorl is obsoletely angled at its base, slightly concave below the position usually occupied by the angle in some other species. The base is not pustulate, but is somewhat distinctly striate with lines of growth. The apical whorls are bay colored, slowly shading to clay color with the growth of the shell.

The aperture is rather small, indistinctly trapezoidal in outline (somewhat accentuated by the broken base of the aperture). The outer margin is only slightly flattened, bluish white within. The columella is slightly concave, somewhat truncate below, with an abruptly-terminating, low, thin, columellar lamella. The parietal wall and columella are incrusted with a thin white callus. Length 49,3, diameter 17.4, aperture (slightly broken below) length 14.3, diameter 11.0 mm.

No data exists in regard to the source and locality of this specimen; but since living examples of the species have not been found by any later collector, it is not improbable that the specimen belonged to the original Newcomb material, probably collected by the Rev. E. Johnson.

The specimen, if not full grown, is very nearly adult. From all appearances, it was dead when collected, but had not been so for a long time as the surface texture of the last whorl shows very little weathering. One interesting character is that the large majority of the pustules on the sixth and seventh whorls have the appearance of being punctured, while those of the eighth (last) are, for the most part, intact.

This species is represented in the Museum collection by more than 300 specimens from four separate colonies, three of which are definitely located. Nearly a hundred of these specimens are whole or nearly whole. The specimens from each of the colonies represent slightly different geographical races, easily recognized from each other. Only one of these is distinct enough to be considered as a separate subspecies.

The most important of these examples, since they offer a clue as to the

original locality of this species, is a small series consisting of three broken dead specimens taken by Meinecke in a small ravine on the southern side of the Anahola range. In the outlines and angle of the apical whorls these specimens (Pl. XVII, figs. 7-8) are remarkably similar to the specimen in the collection of the Museum of Comparative Zoology, described above, and are quite unlike the apical whorls of examples from the other three colonies. The convexity of the lower whorls and the form of the aperture of one of these specimens is also similar in character.

Shells of this species, most of which were badly broken, were very abundant in the recently ploughed (October, 1830) northern portion of the Waipouli race track, and about a hundred whole, or nearly whole, specimens were taken. Previous to this, whole specimens were excessively rare, but several fragments and broken specimens had been found in the road cuttings near the race track.

These examples constitute a somewhat distinct and easily recognized geographical race. Compared with the M. C. Z. specimen, the shells are more closely coiled, with half a whorl more for the same length, more pointed with the embryonic whorls forming a narrower angled cone, the spire tapers more evenly to its summit and the whorls are more convex. The peristome is also more convex. The sculpturing of the embryonic and the surface texture of the post-embryonic whorls agree closely with that of the typical form of the species. All the specimens were ornamented with a rather broad, distinct, nearly white, subperipheral band. The base below this band is very much darker than the rest of the shell.

All the examples of *paradoxa* from this locality represent a very homogeneous series, showing very little individual variation. However, in some specimens the spire is slightly slenderer than in others, and the fourth and fifth whorls show some variation in their convexity.

Length	Diameter	Apert. length	Apert. diameter	Whorls	Plate	Figure
55.4 mm.	19.1	15.7	9.6	9+	XVII	2
49.8 mm.	16.2	13.0	8.8	9¾	XVII	1
47.3 mm.	16.6	14.1	8.5	9	XVII	3
46.5 mm.	15.2	13.1	7.8	9	XVII	5
46.4 mm.	16.2	14.4	8.5	9	XVII	6
41.3 mm.	15.0	13.8	8.0	8½	XVII	4

The surface texture of a very large number of the specimens is remarkably well preserved with the minute microscopical striae sharp and distinct, for which the only explanation is that the shells were found exactly where they formerly lived and that many were buried while still alive. Since the nearest 100-foot contour line is a mile or more inland, these specimens could

not have been washed from the Nounou Mountains or their slopes without having considerable damage done to these delicate surface textures.

Embryos of different stages of development were obtained, during cleaning, from nearly 30 specimens. These embryos are narrowly conic, with slightly convex outlines, imperforate or minutely perforate. The perforation, when present, forms a long, narrow slit under the columellar lip and terminates under the end of the columellar fold. This slit is deeper than broad. Embryos with 4½ to nearly 5 whorls have a length of 10.5 (100175 S) to 10.8 (100173 C)mm., and are proportionately larger for the size of their parents.

A third geographical race of this species is represented in the Museum collection by a beach-worn example. This specimen was picked out of unlabeled "lot" of marine shells.

The shell represents (Pl. XVII, fig. 9) a colony that probably existed somewhat to the north of the Waipouli specimens. It differs from these, however, by its narrower and flatter embryonic cone. Although the surface is much worn, the characteristic ribbing of the embryonic and the pustulate surface texture of the lower whorls is clearly indicated. The first whorl is rounded, but this roundness may be due to abrasion.

C. paradoxa is undoubtedly the most specialized species of the genus and differs from all the other species by its distinct embryonic sculpturing and the fine granular texture of the post-embryonic whorls.

Some confusion has been occasioned in the identification of this species. Pease distributed specimens of *C. kalalauensis* with the designation "C. paradoxa," while, on the other hand, Borcherding has figured a coarsely granulated specimen of *C. turricula.*

Carelia paradoxa thaanumi, new subspecies (Pl. XVI, fig. 8).

Two specimens in the Bishop Museum collected by Thaanum differ in many characters from the typical examples. They belong to a distinct geographical race that has long been separated from the typical northern form by the Wailua River. These specimens were taken on the "south side of the river in a cane field south of gate" near the base of the Kalepa range. Unfortunately both specimens are immature. These two specimens with one or two others in the Thaanum collection agree very closely in all characters. Their most distinctive characters are the remarkable convexity of the last half of the third and the fourth whorls and the absence of any spiral striation on the last 2 almost flat whorls. The embryonic whorls are swollen, and their sculpture, both longitudinal and spiral, is coarser, more widely and evenly spaced, and begins at an earlier age. The third whorl has 12 widely and evenly spaced prominent ridges cut by 5 to 6 fine incised spiral lines forming both transverse and spiral series of long granules, covering the ridges and the interstices between them. On the fourth whorl there are also 12 prominent transverse ridges and the spiral lines are more deeply engraved so that the ridges and interstices are covered with minute pustules. The coarse transverse ribs terminate abruptly at the end of the fourth whorl. The fifth whorl is uniformly covered by the characteristic pustules of the typical form arranged in transverse and spiral series. These pustules gradually become weaker near the completion of the fifth

and have disappeared before the beginning of the seventh whorl. Below the fourth whorl the spire is contracted, with the fifth whorl much less convex than the fourth. The sixth and seventh whorls are almost flat. The basal angle is well defined, but not sharp. The aperture is rhombic in outline, its outer margin nearly straight, its lower margin is badly broken. The columella is nearly straight, very slightly concave above, furnished with a weak, low, thread-like lamella. There is an indistinct, narrow, dark band below the sutures of the three lower whorls. The last whorl is cinnamon, the basal region vinaceous-russet.

Length 39.2, diameter 15.5, aperture diameter 8.0 mm., 7½ whorls. Type no. 49265; paratypes, Thaanum's collection.

EXPLANATION OF PLATES

PLATE I

Carelia sinclairi Ancey (figs. 1-8) p. 22: 1, no. 18790, co-type, Ancey Coll., nearly adult; 2, no. 25333A, Thwing Coll., nearly adult; 3, no. 16065C, collector?, adult; 4, no. 16065A, collector?; 5, no. 18791, co-type, Ancey Coll. adult; 6, no. 16065D, collector?, adult; 7, no. 25333B, Thwing Coll., adult; 8, no. 16065B, collector?, adult.

Carelia mirabilis new species (figs. 9-11) p. 29: 9, no. 100490, Mahaulepu, collected by C. M. Cooke; 10, no. 100391 (Type), Mahaulepu, collected by C. M. Cooke; 11, no. 100490, Mahaulepu, collected by C. M. Cooke, juvenile.

Carelia pilsbryi Sykes (figs. 12-14) p. 25: 12, no. 77889, Kalihiwai, collected by Cooke, juvenile; 13, no. 77889, Kalihiwai, collected by C. M. Cooke, juvenile; 14, no. 88469, Kalihikai, collected by I. Spalding, pathologic.

PLATE II

Carelia pilsbryi Sykes (figs. 1-6) p. 25: 1, no. 77889, Kalihiwai, collected by C. M. Cooke; 2, no. 88467, Kalihikai, collected by I. Spalding; 3, no. 88481B, Kalihikai, collected by F. Wood-Jones; 4, no. 87447, Kalihiwai, collected by Mrs. W. E. H. Deverill; 5, no. 92620, Kalihiwai, collected by W. A. Bryan; 6, no. 88481A, Kalihikai, collected by F. Wood Jones.

PLATE III

Carelia anceophila new species (figs. 9, 10) p. 31: 9, no. 14790A (Type), collected by C. M. Cooke; 10, no. 14790B (paratype), collected by C. M. Cooke.

Carelia kalalauensis new species (figs. 1-8, 11-17) p. 32: 1, no. 15661, Kalalau, collected by A. Knudsen and C. M. Cooke (fossil); 2, no. 19692, Kalalau, collected by C. Forbes and C. Dole (dead); 3, no. 49233, Honopu, collected by A. Knudsen (fossil); 4, no. 17974, Milolii, collected by A. F. Judd (dead); 5, no. 96228, Makaha, collected by C. S. Judd (fossil); 6, no. 79947B, Kalalau, collected by W. Meinecke (topotype, dead); 7, no. 79947C, Kalalau, collected by W. Meinecke (topotype, dead); 8, no. 79947D, Kalalau, collected by W. Meinecke (topotype, dead); 11, no. 79947A, Kalalau (Type), collected by W. Meinecke; 12, no. 88321, Hanakoa, collected by W. Meinecke, spirally engraved, light-colored; 13, no. 88321B, Hanakoa, collected by W. Meinecke, light-colored; 14, no. 88321C, Hanakoa, collected by W. Meinecke, dark-colored, subtuberculate; 15, no. 88321D, Hanakoa, collected by W. Meinecke, very dark-colored, smoother; 16, no. 88321, Hanakoa, collected by W. Meinecke, dark-colored, strongly spirally engraved; 17, no. 88385, Waiahuakua, collected by W. Meinecke, dark-colored, with narrow, light-colored, median band, spiral engraving weak.

PLATE IV

Carelia bicolor (Jay) (figs. 1-17) p. 37: 1, no. 16639, Hanakapiai, collected by P. Deverill; 2, no. 16639, Hanakapiai, collected by P. Deverill; 3, 16639, Hanakapiai, collected by P. Deverill; 4, no. 55813, east of Hanakapiai, *b. hyperleuca* ex. Baldwin Coll.; 5, no. 55814, east of Hanakapiai, *b. hyperleuca,* ex Baldwin Coll.; 6, no. 18784, west of Hanakapiai *f. suturalis* (Type), ex Ancey Coll.; 7, no. 73849, east of Hanakapiai (=*adusta*), collected by C. M. Cooke; 8, no. 73888, east of Hanakapiai (=*adusta*), collected by C. M. Cooke; 9, no. 55819, east of Hanakapiai (=*fuliginea*), ex Baldwin Coll.; 10, no. 86066, east of Hanakapiai (=*fuliginea*), collected by T. Dranga; 11, no. 88415 (=*hyperleuca*), Hoolulu, collected by W. Meinecke; 12, no. 79934, Hoolulu, collected by W. Meinecke; 13, no. 88410, Hoolulu (pregnant), collected by W. Meinecke; 14, no. 79933, Hoolulu, collected by W. Meinecke; 15, no. 79933, Hoolulu, collected by W. Meinecke; 16, no. 88415, Hoolulu (=*adusta*), collected by W. Meinecke; 17, no. 79934, Hoolulu, collected by W. Meinecke.

PLATE V

Carelia bicolor angulata Pease (figs. 1-8) p. 42: 1, no. 19970, Limahuli, collected by E. Deverill; 2, no. 21460A, Limahuli, collected by E. Deverill; 3, no. 21460B, Limahuli, collected by E. Deverill; 4, no. 15537A, Wainiha, collected by C. M. Cooke; 5, no. 15537B, Wainiha, collected by C. M. Cooke; 6, no. 15537D, Wainiha (juvenile), collected by C. M. Cooke; 7, no. 25325, locality Thwing Coll.; 8, no. 15537C, Wainiha (dead), collected by C. M. Cooke.

Carelia cumingiana meineckei new subspecies (figs. 9-13) p. 46: 9, no. 86378D (topotype, dead), collected by W. Meinecke; 10, no. 86373 (Type), collected by W. Meinecke; 11, no. 86378A (topotype, dead), collected by W. Meinecke; 12, no. 86378B, topotype, dead), collected by W. Meinecke; 13, no. 86378C (topotype, dead), collected by W. Meinecke.

PLATE VI

Carelia cumingiana (Pfeiffer) (figs. 1-4) p. 44: 1, no. 104110, locality? (fossil), collector? 2, no. 25316, locality? ex Thwing Coll.; 3, no. 102609A, locality? ex Emerson Coll., collected by Rev. E. Johnson; 4, no. 102609B, locality? ex Emerson Coll., collected by Rev. E. Johnson.

Carelia cumingiana meineckei? (fig. 5) p. 47: no. 59035, locality? Mus. Comp. Zool. Cambridge, collected by W. H. Pease?

Carelia dolei isenbergi new subspecies (figs. 6-12) p. 53: 6, no. 37540C, Haena, collected by C. M. Cooke, in form and sculpture similar to *C. cumingiana;* 7, no. 78014, Haena, collected by C. M. Cooke; 8, no. 37542B, Haena, collected by C. M. Cooke; 9, no. 37540A, Haena, collected by C. M. Cooke; 10, no. 37540B, Haena, collected by C. M. Cooke; 11, no. 37542A, Haena (Type), collected by C. M. Cooke; 12, no. 77990, Haena, collected by C. M. Cooke.

PLATE VII

Carelia dolei Ancey (figs. 1-13) p. 48: 1, no. 16063F, Limahuli, collected by C. M. Cooke, strongly biangulate; 2, no. 86175, Limahuli, collected by W. Meinecke, shoulder angle sharp; 3, no. 16064A, Limahuli, collected by C. M. Cooke, shoulder angle duplicate; 4, no. 16063D, Limahuli, collected by C. M. Cooke, shoulder angle duplicate; 5, no. 16063B, Limahuli, collected by C. M. Cooke, strongly biangulate; 6, no. 16063C, Limahuli, collected by C. M. Cooke, additional spiral lines between angles; 7, no. 16063E, Limahuli, collected by C. M. Cooke, very sharp shoulder angle; 8, no. 16064E, Limahuli, collected by C. M. Cooke, shoulder angle duplicate; 9, no. 86165A, Limahuli, collected by T. Dranga, longest specimen, additional spiral lines between angles; 10, no. 16063A, Limahuli, collected by C. M. Cooke; shoulder angle sharp; 11, no. 16064C, collected by C. M. Cooke, without distinct shoulder angle; 12, no. 16064D, Limahuli, collected by C. M. Cooke, without distinct shoulder angle; 13, no. 16064B, collected by C. M. Cooke, unicolorous color pattern.

PLATE VIII

Carelia dolei Ancey (figs. 1-6) p. 48: 1, no. 16064F, Limahuli, collected by C. M. Cooke, very broad specimen; 2, no. 16063G, Limahuli, collected by C. M. Cooke; 3, no. 86173, Limahuli, collected by A. F. Judd, specimen approaching *d. isenbergi;* 4, no. 18788, exact locality? (Type), ex Ancey Coll.; 5, no. 55822, exact locality? (paratype?) ex Baldwin Coll.; 6, no. 55817, exact locality? (paratype?) ex Baldwin Coll.

Carelia cochlea (Pfeiffer) (figs. 7-12) p. 54: 7, no. 77898A, Kalihikai, collected by C. M. Cooke, very broad adult specimen with 7 spiral ridges; 8, no. 77898B, Kalihikai, collected by C. M. Cooke, very narrow juvenile specimen with 7 spiral ridges; 9, no. 73841, locality? type of *C. rigida* Hyatt, ex Cooke Coll., smooth beach-worn specimen; 10, no. 55821, locality? ex Baldwin Coll., adult, smooth beach-worn specimen; 11, no. 77925E, Kalihikai, collected by C. M. Cooke, juvenile, partly beach-worn; 12, no. 77938B, Kalihikai, collected by C. M. Cooke, adult specimen with 9 spiral ridges.

PLATE IX

Carelia cochlea (Pfeiffer) (figs. 1-5) p. 54: 1, no. 77938C, Kalihikai, collected by C. M. Cooke, adult specimen with convex whorls, with 8 spiral ridges; 2, no. 100244, Kalihikai, collected by C. M. Cooke, largest specimen, with 8 spiral ridges; 3, no. 77938A, Kalihikai, collected by C. M. Cooke adult (?) specimen with 4 spiral ridges; 4, no. 77925C, Kalihikai, collected by C. M. Cooke, adult (?) specimen with 7 spiral ridges; 5, no. 77925D, Kalihikai, collected by C. M. Cooke, adult (?), specimen proportionately broad, smooth, beach-worn.

Carelia hyattiana Pilsbry (figs. 6-8) p. 65: 6, no. 86296, Waipa, collected by W. Meinecke (fossil); 7, no. 33222, locality? ex Emerson Coll. (juvenile); 8, no. 58954, locality? ex Steward Coll. in American Museum.

PLATE X

Carelia turricula (Mighels), Waioli-Waipa colony, (figs. 1-6) p. 59: 1, no. 86391, collected by W. Meinecke, largest specimen in Mus. Coll. *"obeliscus"* pattern (dead); 2, no. 25331, ex Thwing Coll., *"obeliscus"* pattern with widely spaced spiral cords; 3, no. 86268B, collected by W. Meinecke, proportionately the narrowest specimen in Mus. Coll., *"newcombi"* pattern; 4, no. 86160A, collected by T. Dranga, *"obeliscus"* pattern with low spiral cords; 5, no. 22151, collected by A. H. Rice, *"obeliscus"* pattern; 6, no. 86268A, collected by W. Meinecke, narrow specimen, *"newcombi"* pattern.

PLATE XI

Carelia turricula (Mighels), Waioli-Waipa colony (figs. 1-8) p. 59: 1, no. 25330, ex Thwing Coll., *"obeliscus"* pattern, proportionately the broadest specimen in the collection; 2, no. 16352, collected by C. S. Dole, *newcombi* pattern, peripheral band very narrow; 3, no. 86399, collected by W. Meinecke, juvenile specimen with light-colored base; 4, no. 86400B, collected by W. Meinecke, juvenile specimen with light subsutural band; 5, no. 86400A, collected by W. Meinecke, juvenile specimen=Borcherding's *"C. olivacea"*; 6, no. 86268C, collected by W. Meinecke, *"newcombi"* pattern, indistinctly biangulate, with coarse spiral cords; 7, no. 16640, collected by P. Deverill, *"newcombi"* pattern, with coarse, spiral, and transverse sculpture; 8, no. 86268, collected by W. Meinecke, *"newcombi"* pattern, irregularly tuberculate=Borcherding's *"C. paradoxa."*

PLATE XII

Carelia turricula (Mighels), Waioli-Waipi colony (figs. 1-4) p. 59: 1, no. 86406, collected by W. Meinecke (dead) in size, proportion and manner of whorling = Borcherding's *"C. pilsbryi"*; 2, no. 55807, ex Baldwin Coll., collected by P. Deverill, *"newcombi"* pattern, very wide subperipheral band; 3, no. 25332, ex Thwing Coll., *"newcombi"* pattern average width of subperipheral band; 4, no. 77817, collector? *"newcombi"* pattern, exceptionally small adult specimen.

Waipa-Lumahai colony (figs. 5-8) p. 64; 5, no. 86410A, collected by W. Meinecke, *"obeliscus"* pattern, largest pregnant live specimen; 6, no. 86349, collected by W. Meinecke, *"newcombi"* pattern, specimen somewhat coarsely sculptured; 7, no. 86327, collected by W. Meinecke, longest dead specimen from this colony; 8, no. 86410B, collected by W. Meinecke, *"newcombi,"* pattern, smallest pregnant specimen.

PLATE XIII

Carelia olivacea Pease (figs. 1-6) p. 67: 1, no. 14789, Kilauea, collected by P. Deverill, cylindrical specimen with spiral cords; 2, no. 58419, locality? ex American Mus. collected by W. H. Pease?; 3, no. 59033, locality?, ex Mus. Comp. Zool. Cambridge, Pease Coll., cylindrical specimen; 4, no. 59032, locality?, ex Mus. Comp. Zool. Cambridge, Pease Coll., typical form; 5, no. 87446, Kalihiwai, collected by E. Prigge, typical form; 6, no. 86417A, Kilauea, collected by W. Meinecke, typical form (dead).

Carelia olivacea new subspecies? (fig. 7) p. 71: no. 86082, upper Hanalei Valley, collected by T. Dranga.

Carelia olivacea baldwini new subspecies (fig. 8) p. 71: B. P. Bishop Mus. no. 55881 (Type) locality?, ex Baldwin Coll.

Carelia olivacea propinquella new subspecies (figs. 9-10) p. 72: 9, 10, no. 81185, Wailua, collected by T. Dranga and C. M. Cooke (co-types).

PLATE XIV

Carelia olivacea priggei new subspecies, south side of Anahola ridge, collected by E. Prigge (figs. 1-3) p. 73: 1, no. 88504A (Type); 2, no. 88504B (paratype); 3, no. 88504C (paratype, juvenile).

Carelia olivacea infrequens new subspecies (fig. 4) p. 74: no. 88478, Anahola (Type), collected by I. Spalding.

Carelia lymani new species (fig. 5) p. 74: no. 87448, locality? (Type) ex Lyman Coll.

Carelia tenebrosa new species (figs. 6-8) p. 75: 6, no. 17088, Haupu, collected by L. Wishard; 7, no. 86151A (Type), collected by T. Dranga; 8, no. 81408, collected by T. Dranga (topotype, dead).

Carelia lirata new species (figs. 9-12) p. 78: 9, no. 100370B, Mahaulepu, collected by C. M. Cooke (topotype); 10, no. 100489, collected by C. M. Cooke, broken specimen with angled periphery and straight outlined base; 11, no. 100370D, collected by C. M. Cooke, broken specimen with 8 lirae arranged in 3 groups; 12, no. 100370A (Type), collected by C. M. Cooke.

PLATE XV

Carelia glossema new species (figs. 1-3) p. 80: 1, no. 86083, Olokele (Type), collected by T. Dranga; 2, no. 79852, Olokele, collected by W. Meinecke (topotype, dead); 3, no. 86084A, Olokele, collected by T. Dranga (topotype, dead).

Carelia knudseni new species (fig. 4) p. 82: no. 87450, locality? (Type), collected by Mrs. V. Knudsen.

Carelia periscelis new species (figs. 5, 6) p. 83: 5, no. 86174A, Kaapoko, collected by W. Henderson (Type); 6, no. 86174B, Kaapoko, collected by W. Henderson (paratype).

PLATE XVI

Carelia necra new species (figs. 1-3) p. 85: 1, no. 20911, Hanamaulu flats, collected by C. M. Cooke; 2, no. 19524, Hanamaulu flats, collected by C. S. Dole, base of fully adult specimen; 3, no. 19477A, Hanamaulu flats, collected by C. S. Dole (Type).

Carelia necra spaldingi new subspecies (figs. 4-7) p. 88: 4, no. 100182C, North Olohena, collected by C. M. Cooke (paratype); 5, no. 100182B, North Olohena, collected by C. M. Cooke (paratype); 6, no. 100182A, North Olohena collected by C. M. Cooke (Type of subspecies); 7, no. 88479, South Olohena, collected by I. Spalding.

Carelia paradoxa thaanumi new subspecies (fig. 8) p. 92: no. 49265, Hanamaulu flats, collected by D. Thaanum (Type of subspecies).

PLATE XVII

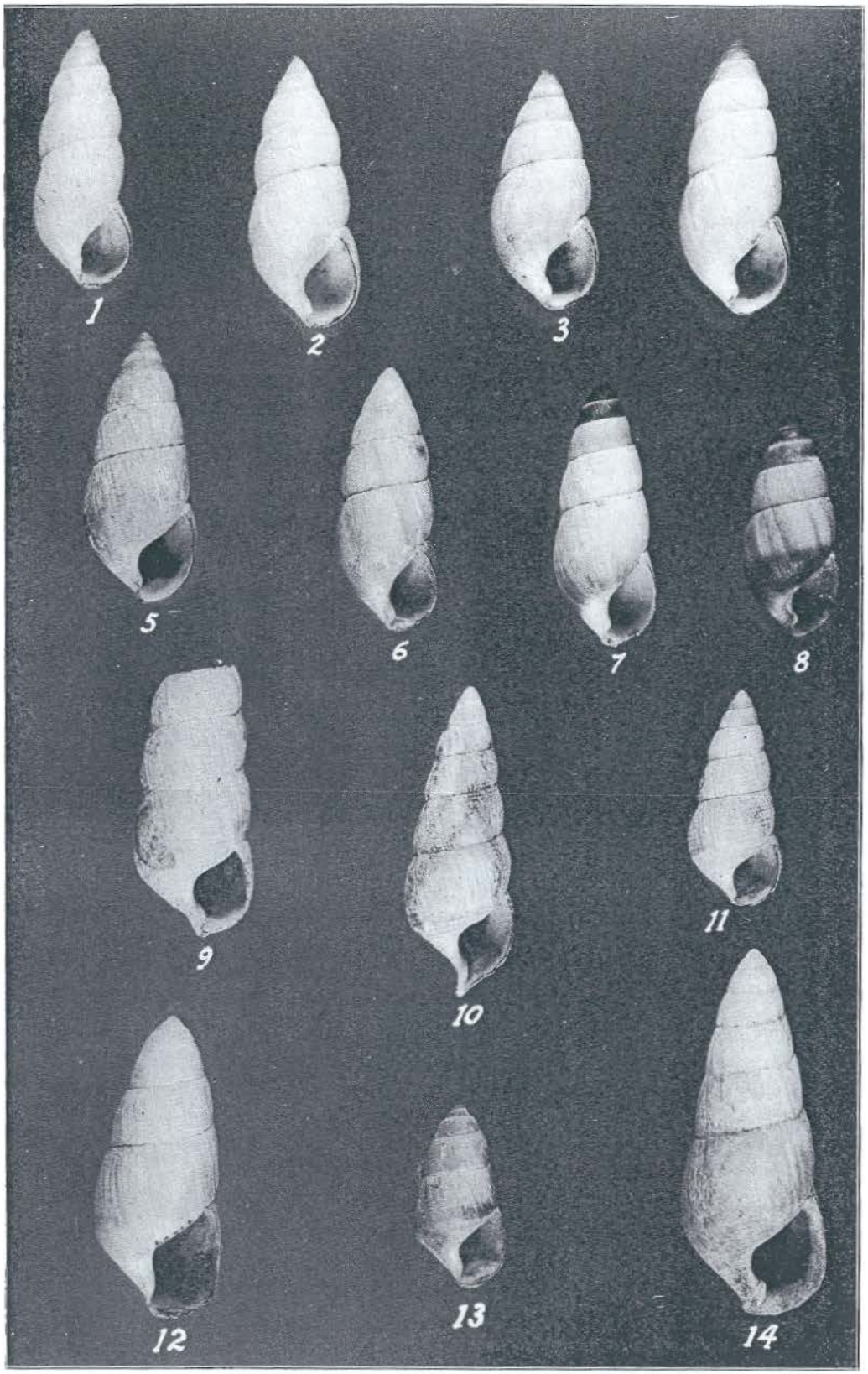
Carelia paradoxa (Pfeiffer) (figs. 1-8) p. 89: 1, no. 100173B, North Olohena, collected by C. M. Cooke; 2, no. 100173A, North Olohena, collected by C. M. Cooke, largest whole specimen in Mus. Coll.; 3, no. 100179, North Olohena, collected by C. M. Cooke; 4, no. 100173D, North Olohena, collected by C. M. Cooke; 5, no. 19442, North Olohena, collected by C. Dole; 6, no. 100173C, North Olohena, collected by C. M. Cooke; 7, 8, no. 88457, Anahola Range, collected by W. Meinecke, typical geographical race?

Carelia paradoxa new subspecies (fig. 9) p. 92: no. 104112, locality?, collector.

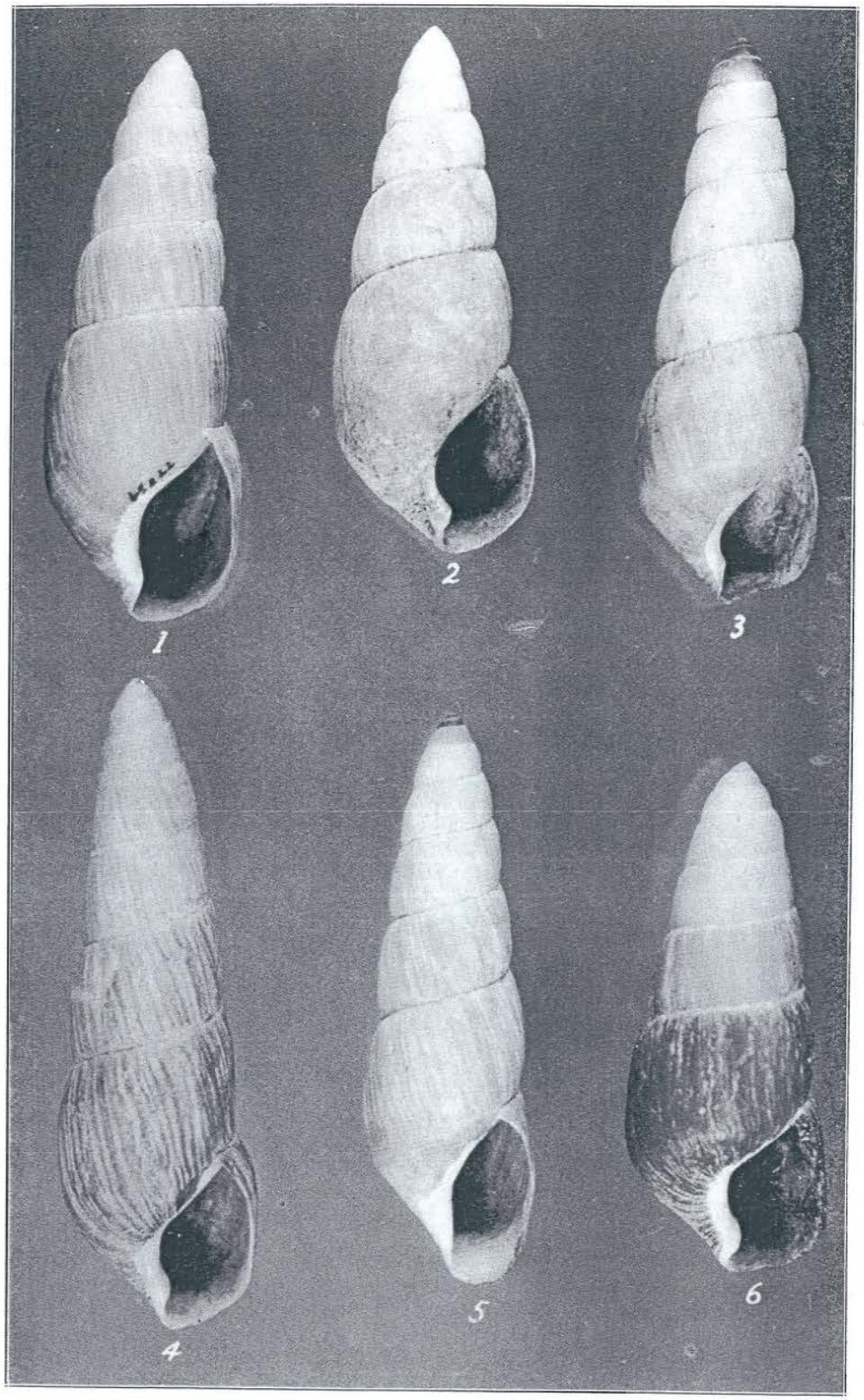
PLATE XVIII

Carelia pilsbryi Sykes (figs. 1-3) p. 25: 1, Sykes' Coll. (Type), enlarged; 2, 3, same specimen, natural size.

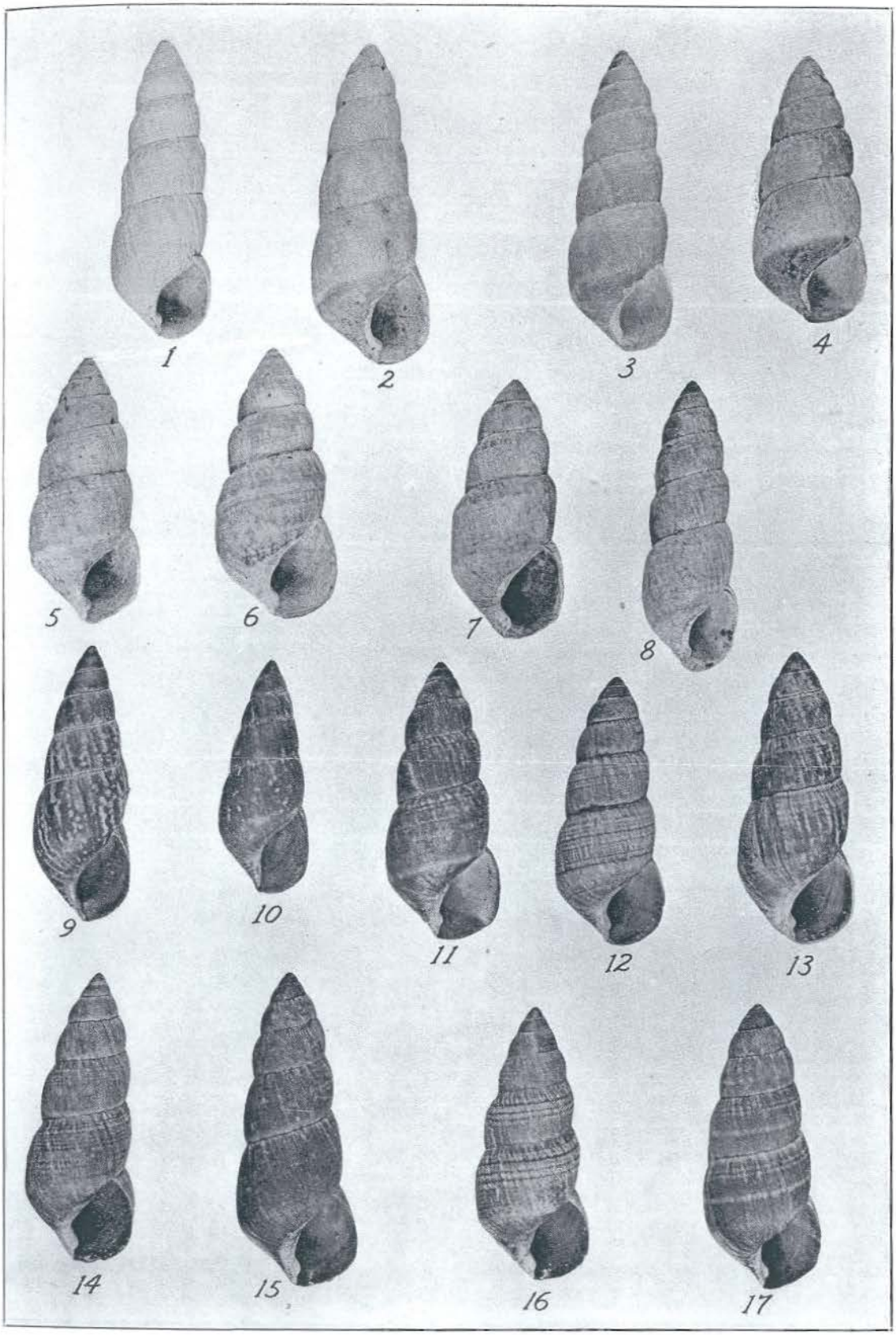
Carelia paradoxa (Pfeiffer) (figs. 4-6) p. 89: 4, 5, Mus. Comp. Zool. Cambridge, no. 45166, typical example?, natural size; 6, same specimen, enlarged.



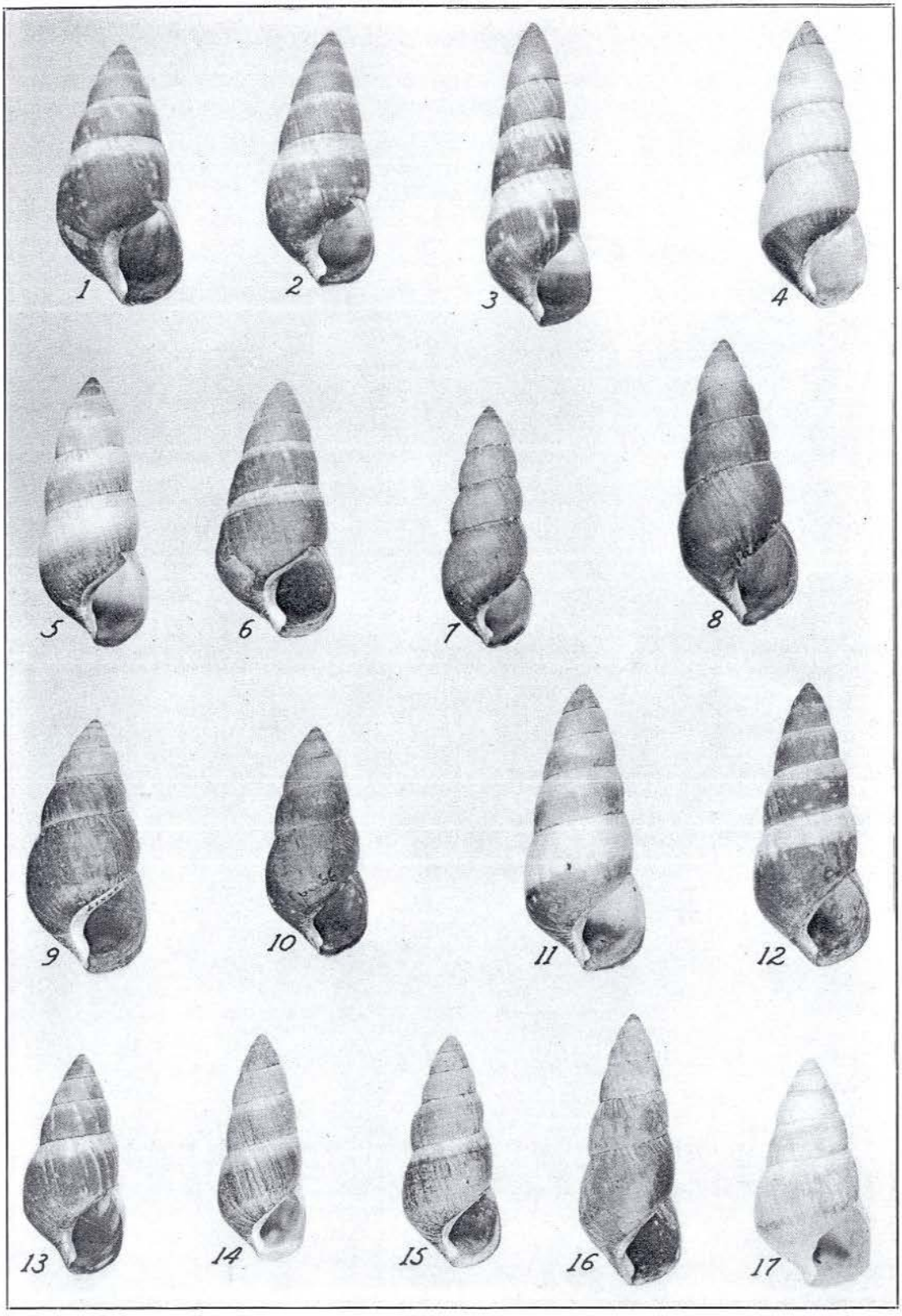
C. SINCLAIRII, C. MIRABILIS, AND C. PILSBRYI.



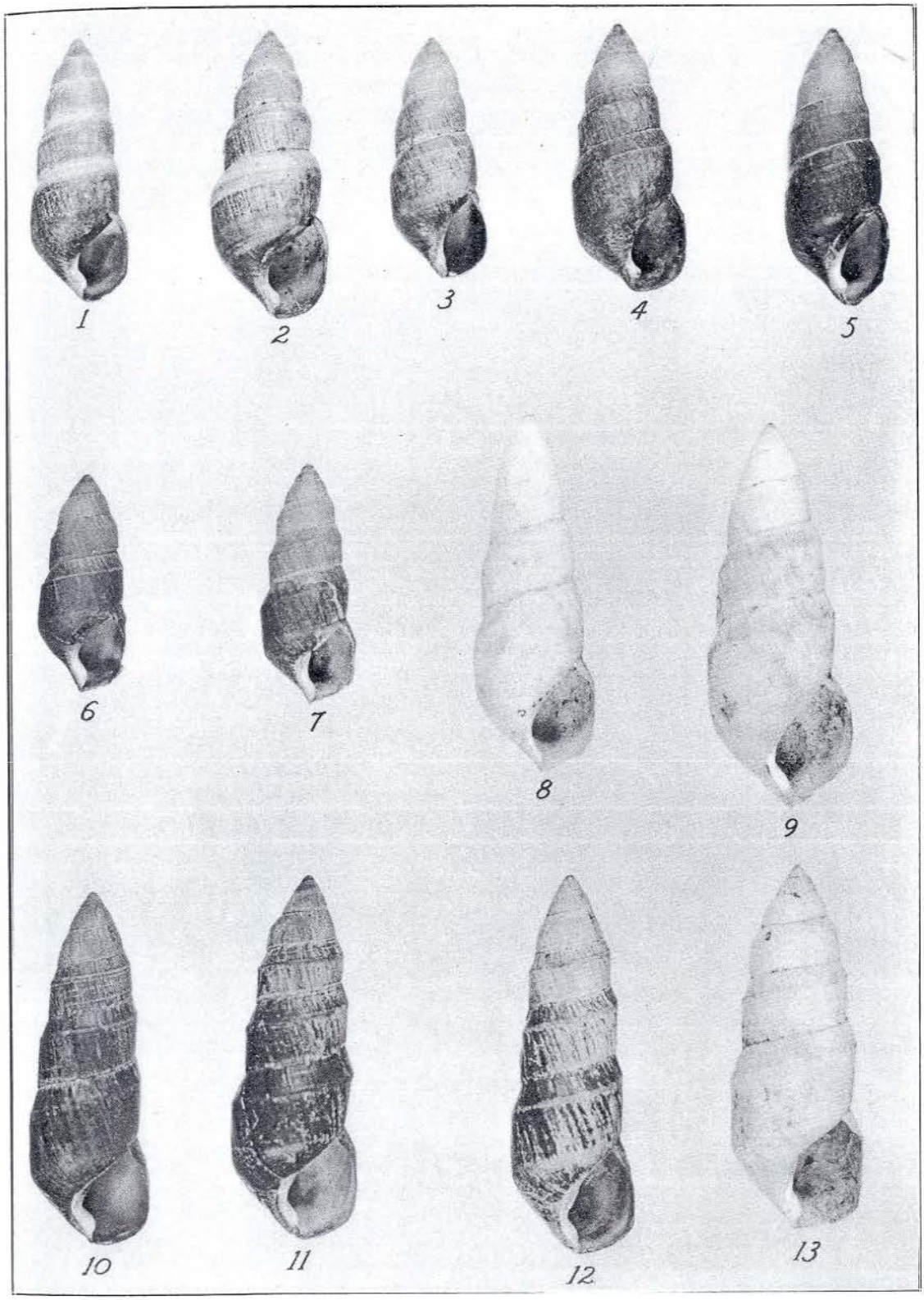
C. PILSBRYI.



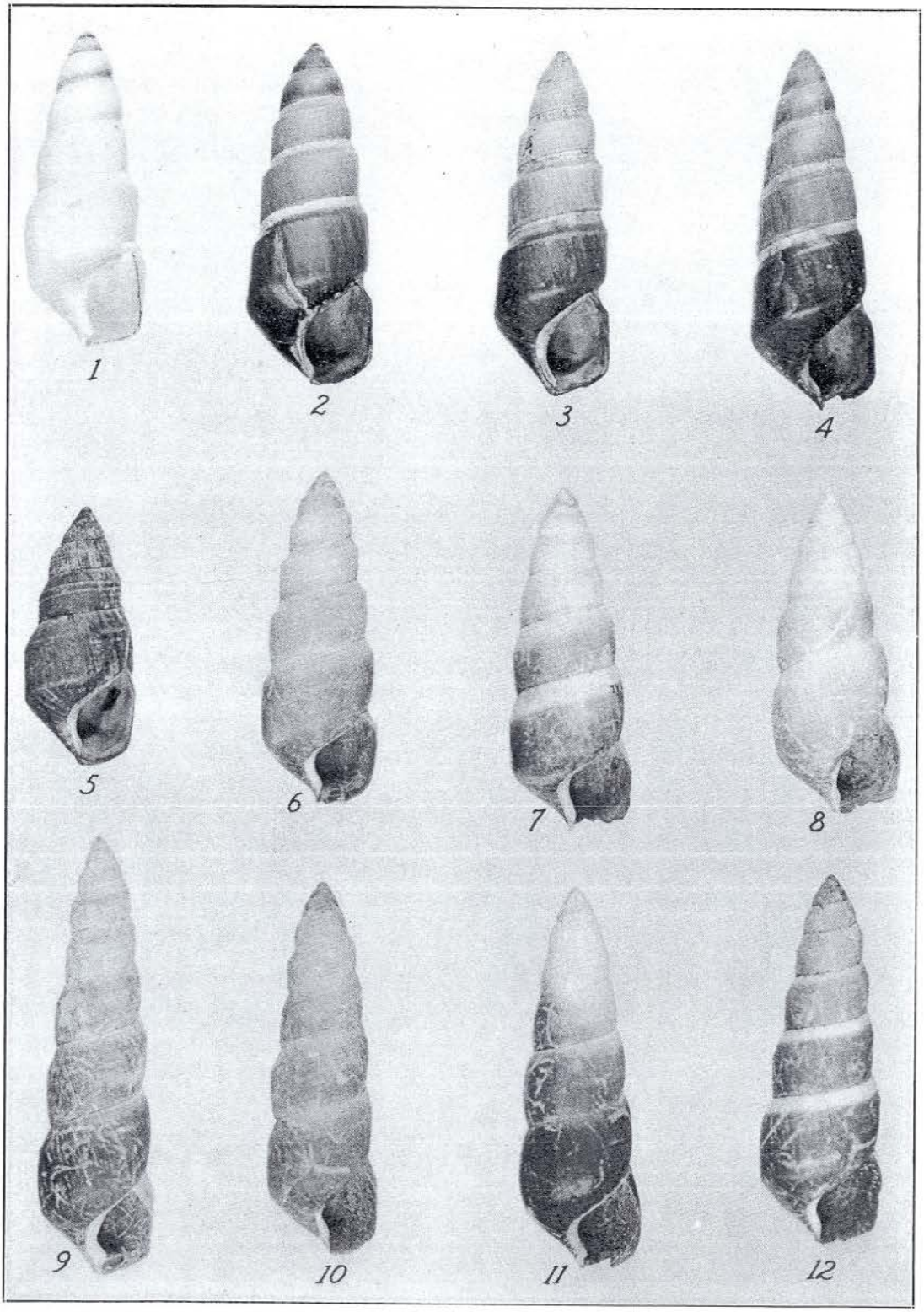
C. ANCEOPHILA AND C. KALALAUENSIS.



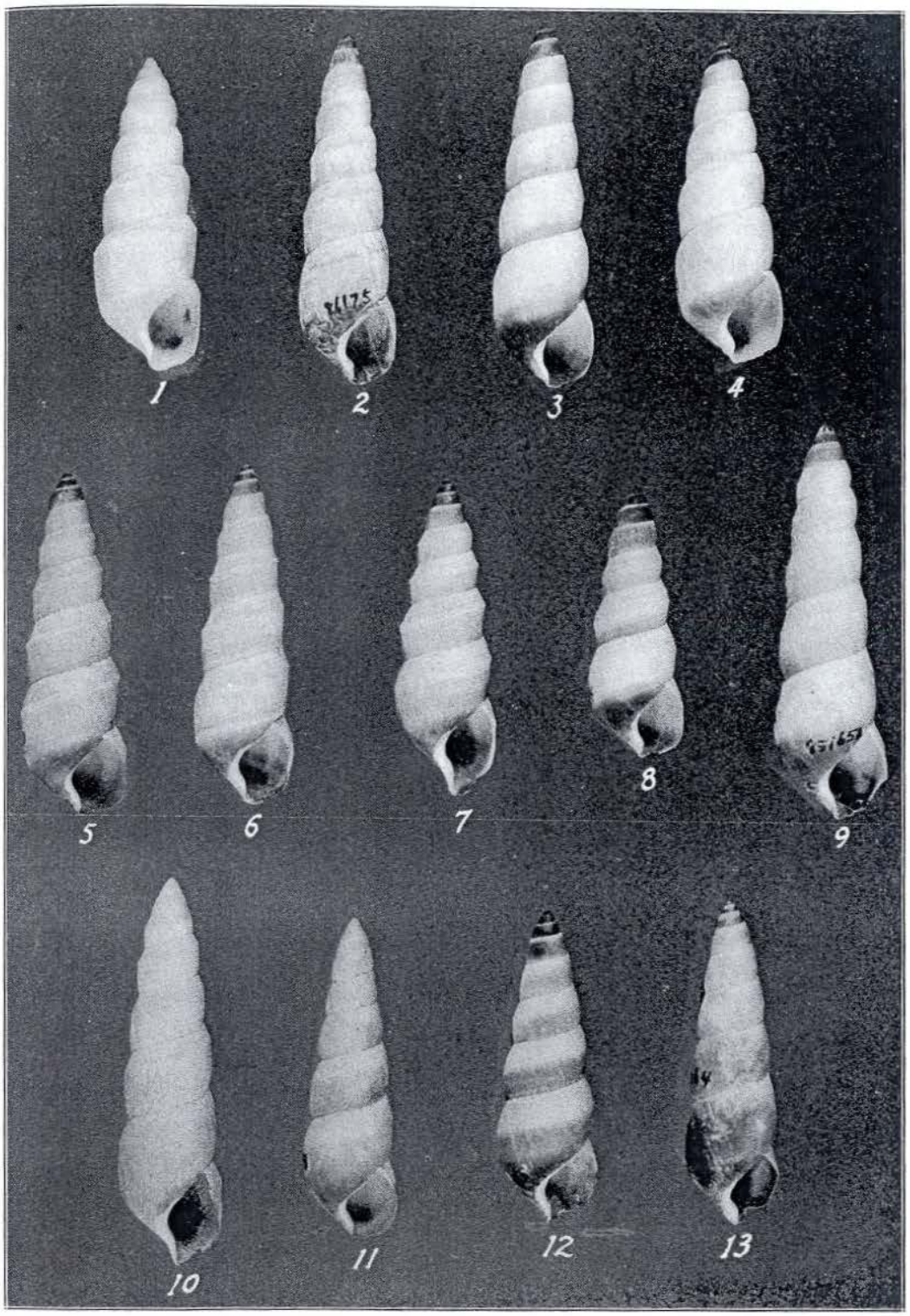
C. BICOLOR.



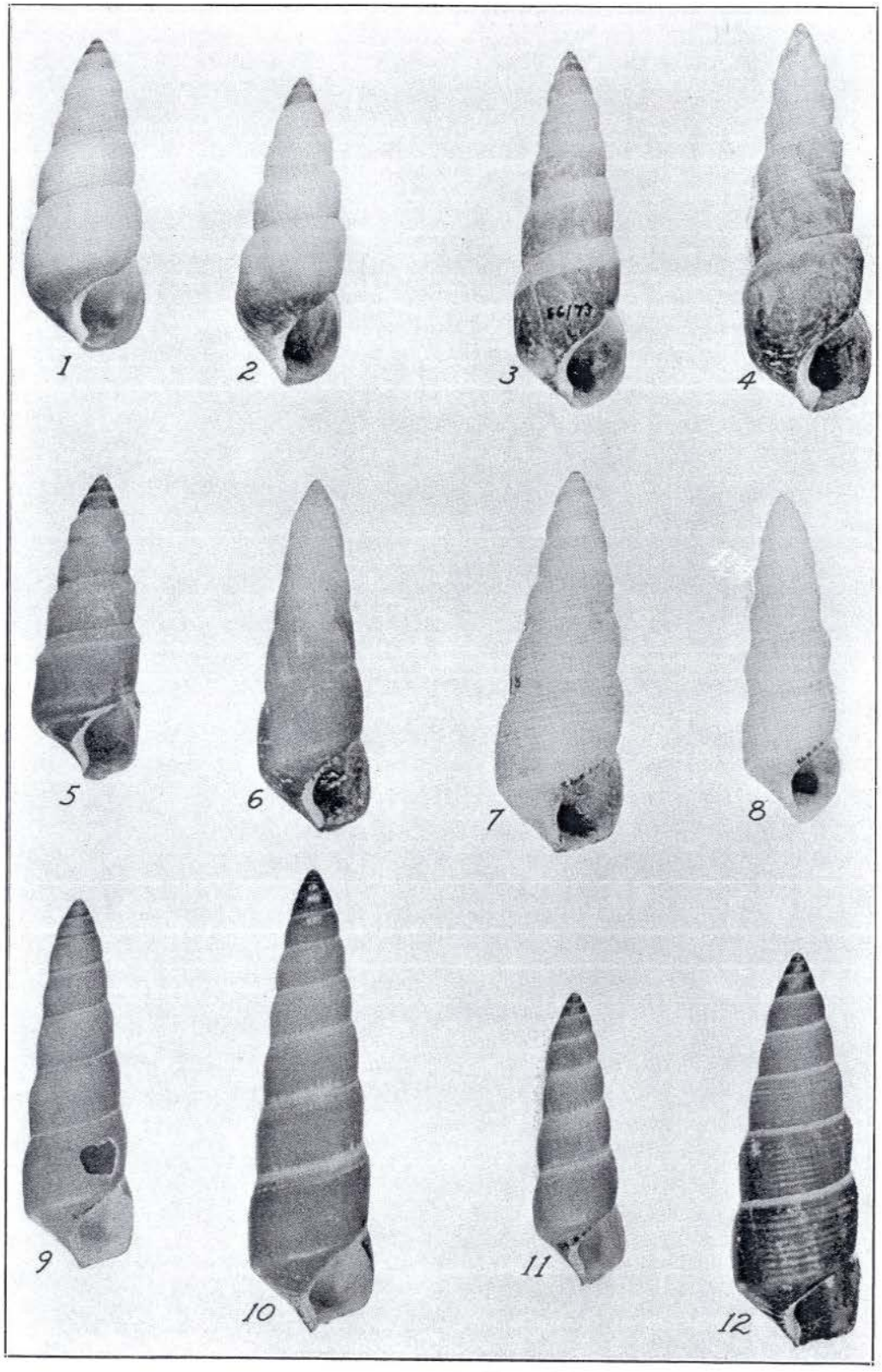
C. BICOLOR ANGULATA AND C. CUMINGIANA MEINECKEI



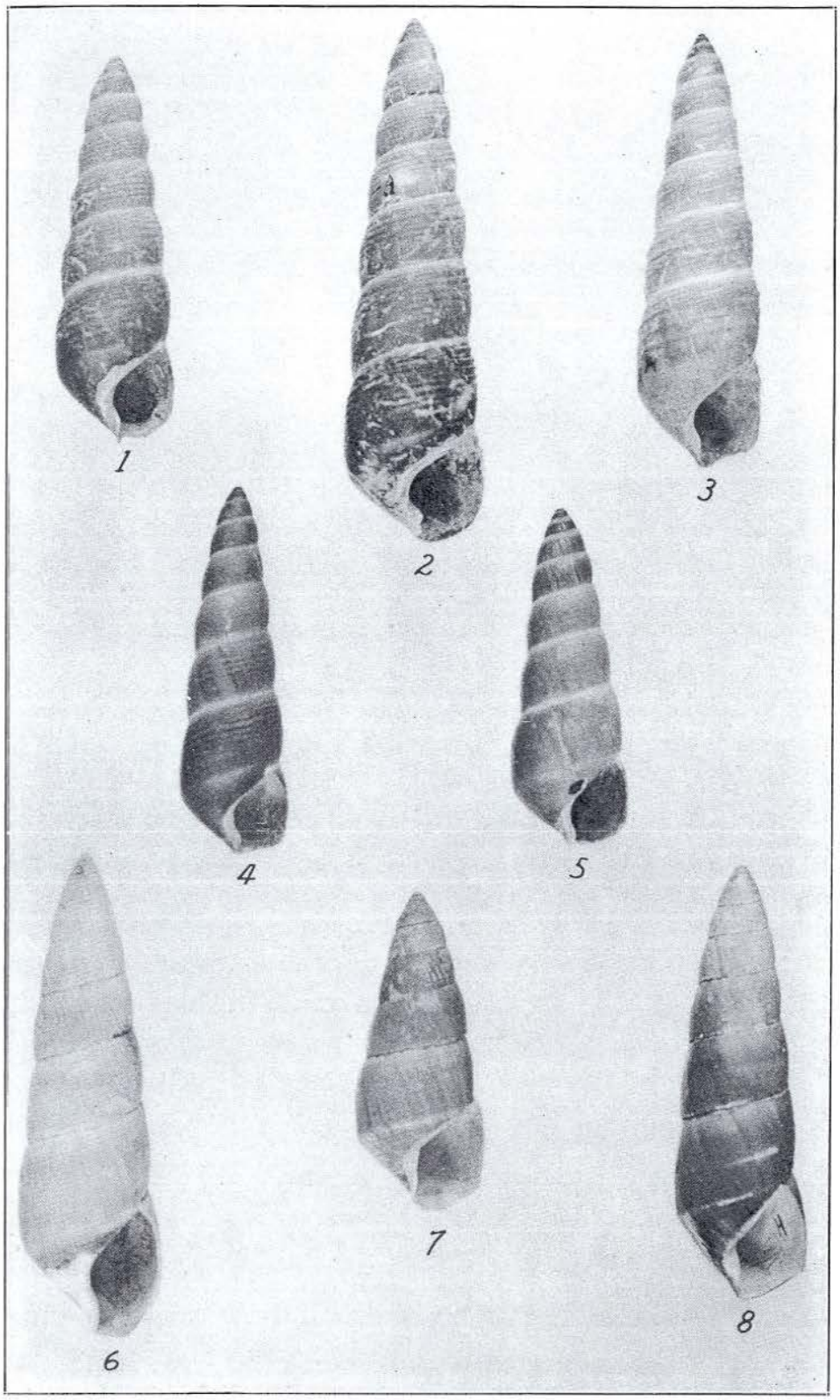
C. CUMINGIANA, C. CUMINGIANA MEINECKEI, AND C. DOLEI ISENBERGI.



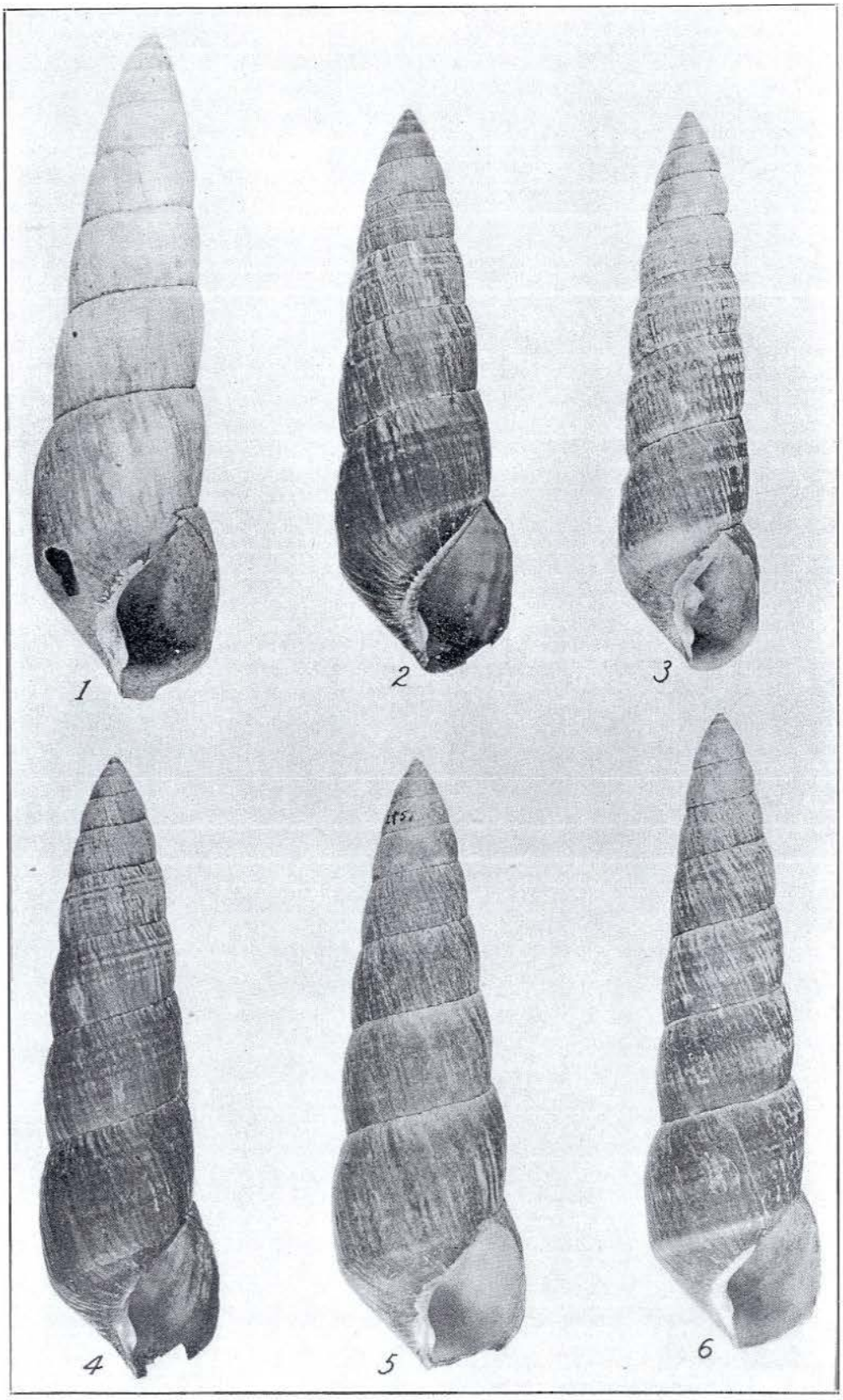
C. DOLEI.



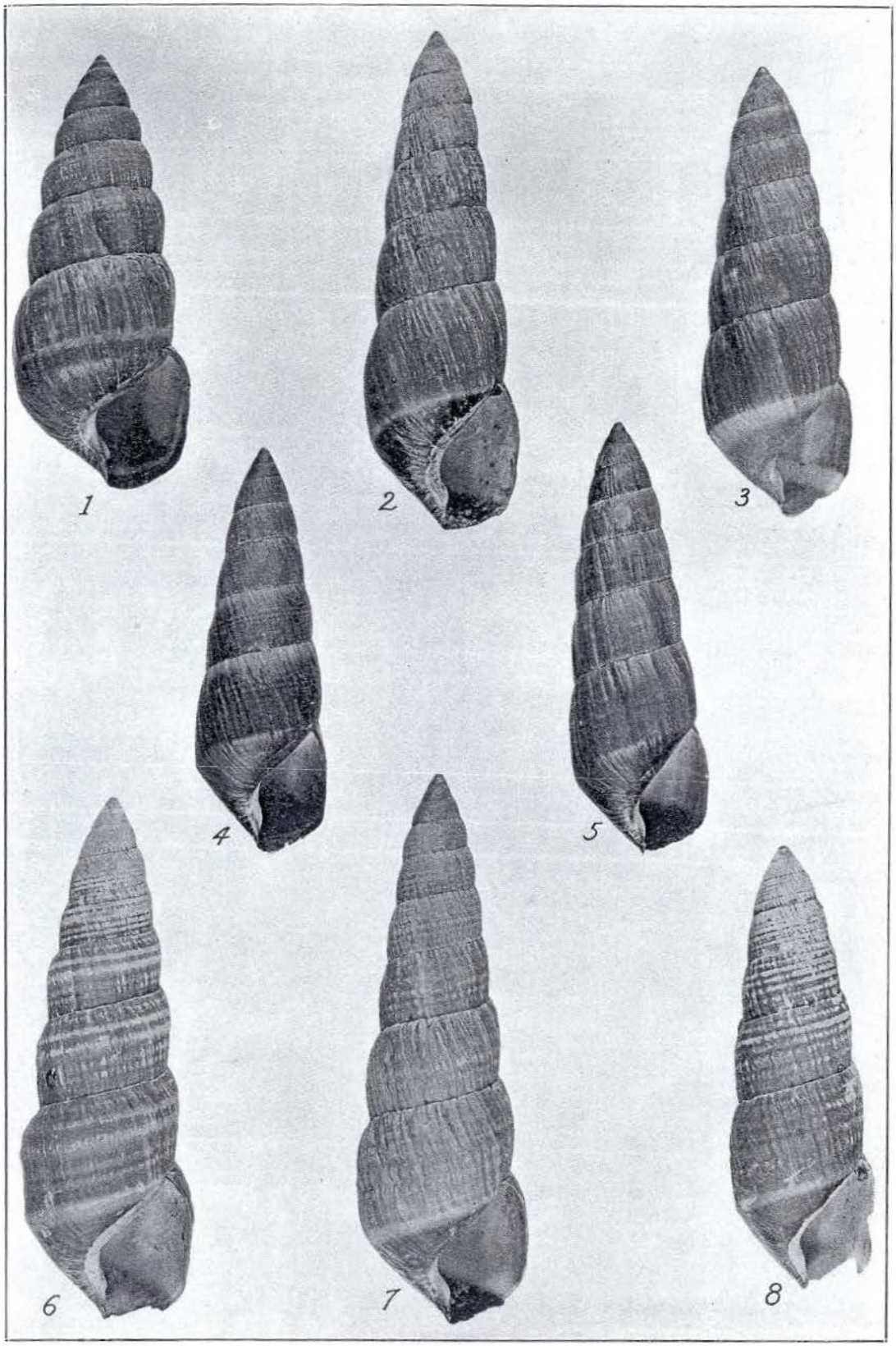
C. DOLEI AND C. COCHLEA.



C. COCHLEA AND C. HYATTIANA.



C. TURRICULA.



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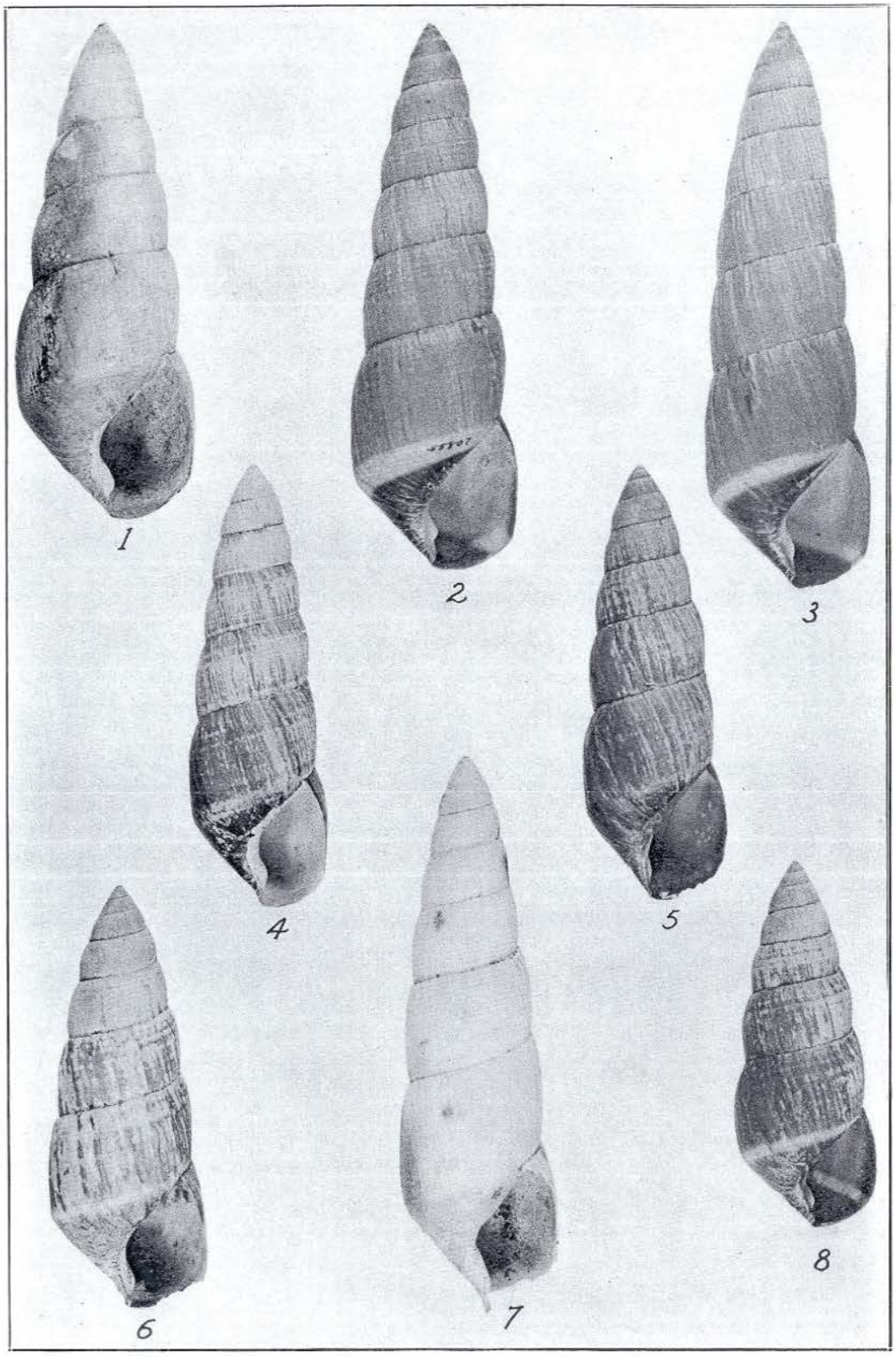

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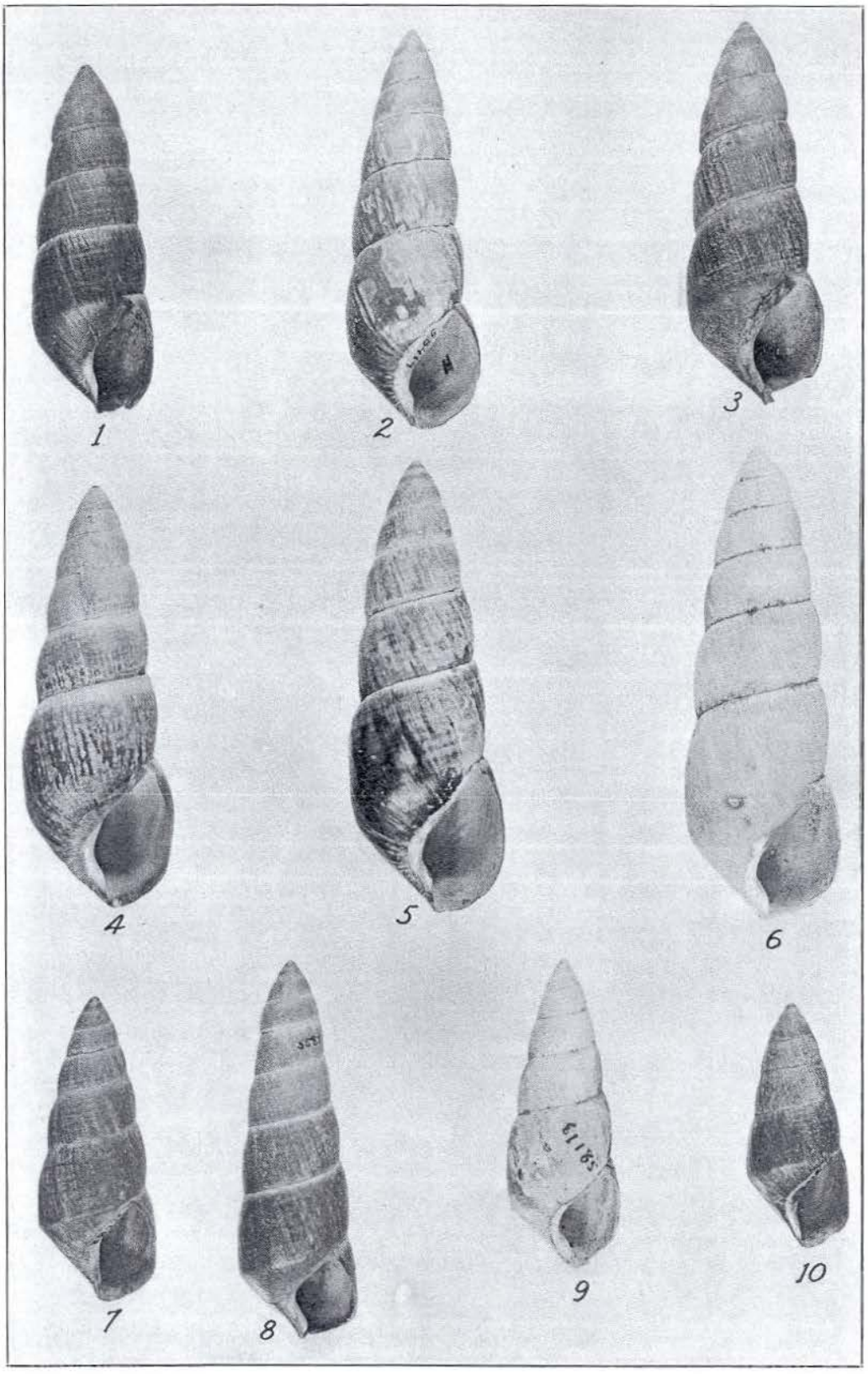
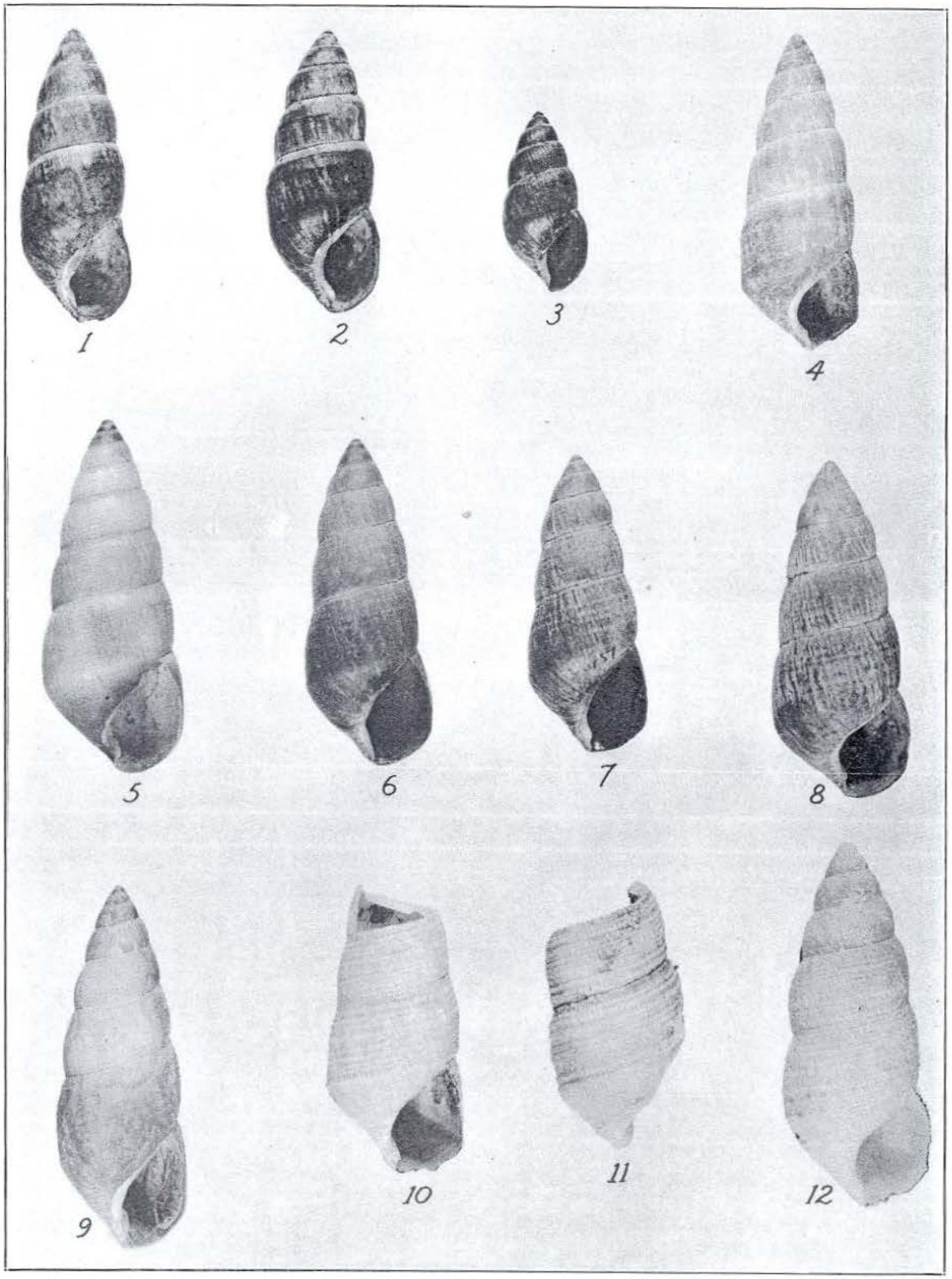
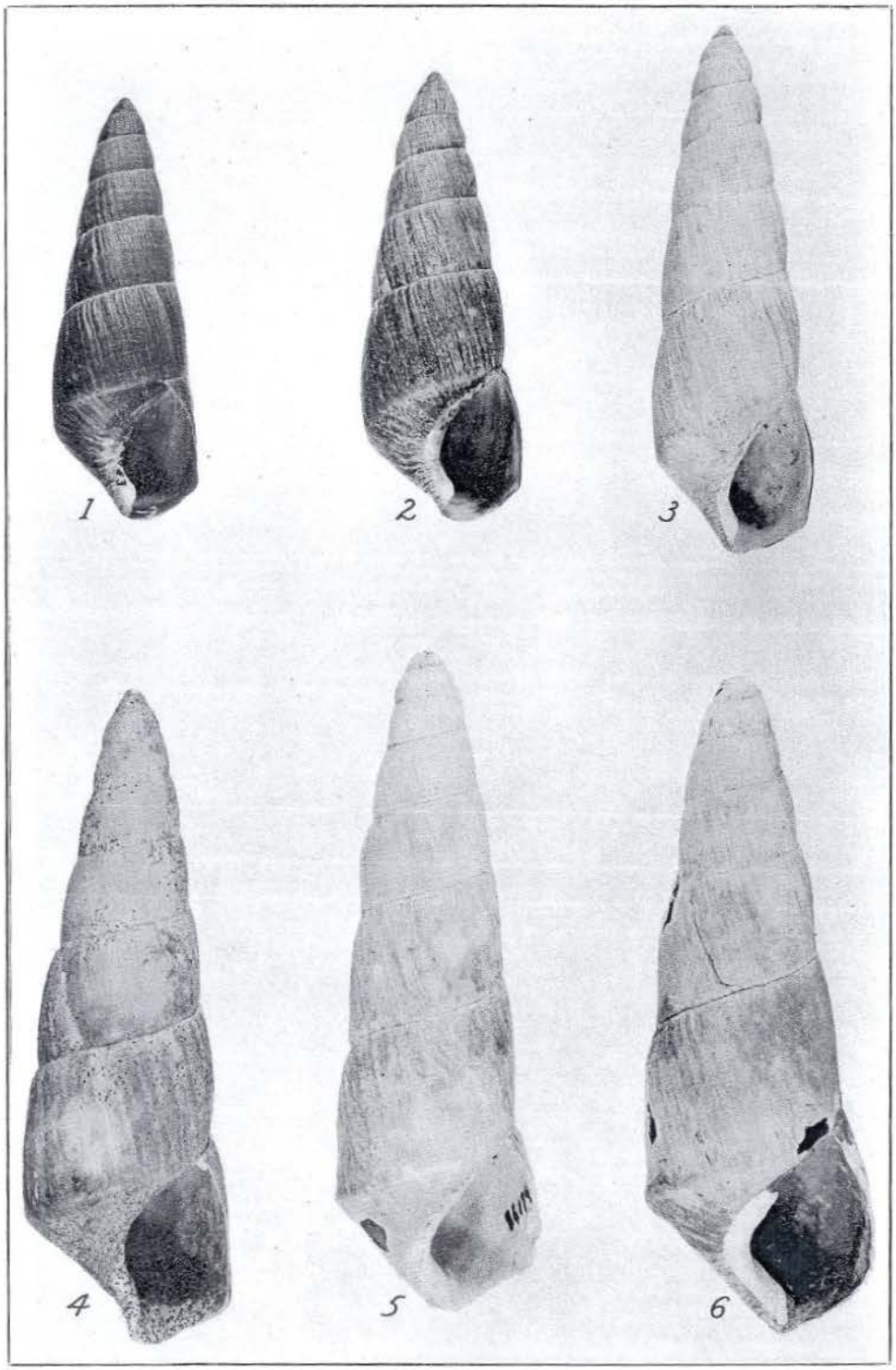


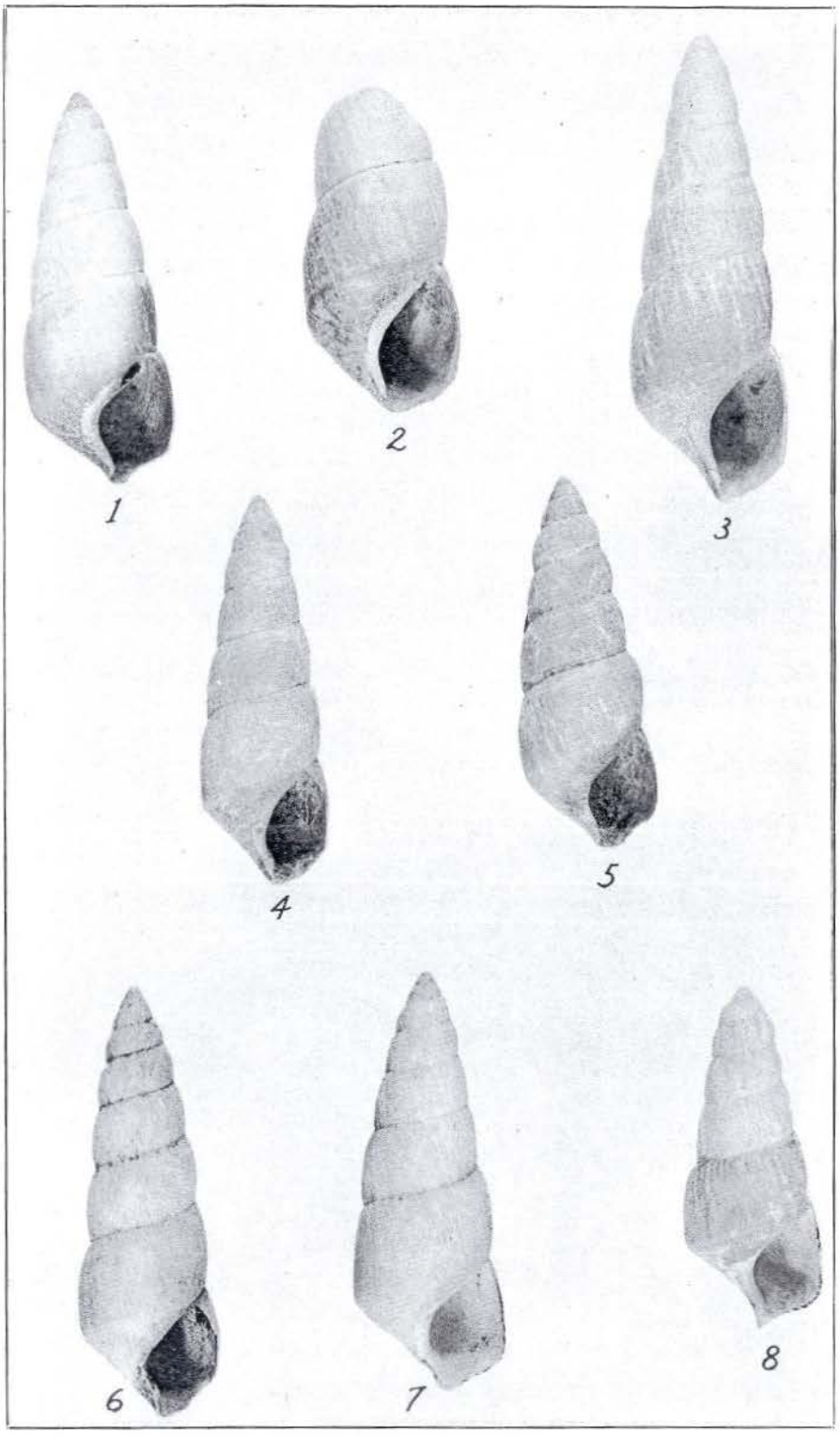
C. OLIVACEA, C. OLIVACEA (NEW SUBSPECIES ?), C. OLIVACEA BALDWINI, AND C. OLIVACEA PROPINQUELLA.



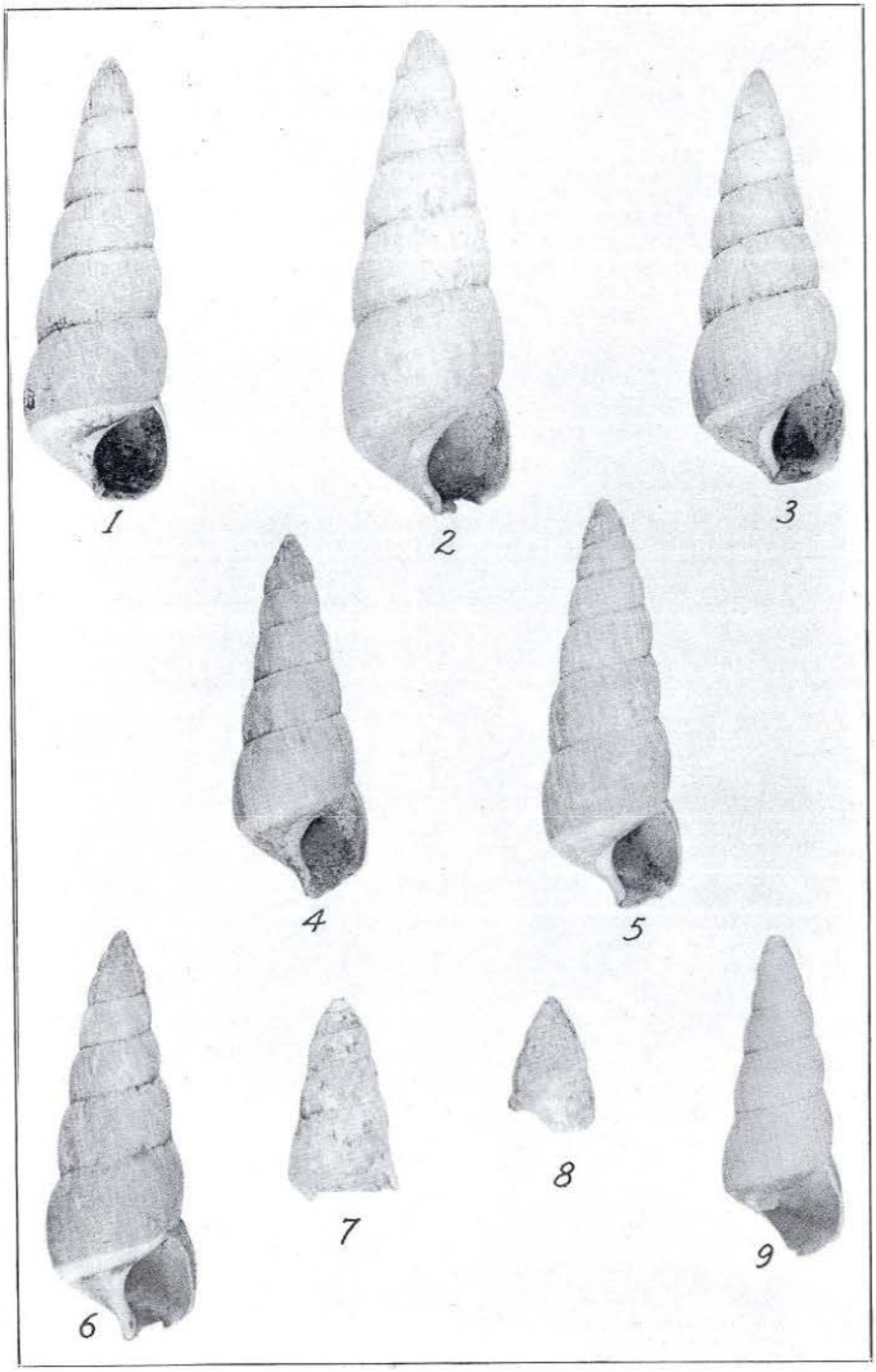
C. OLIVACEA PRIGGEI, C. OLIVACEA INFREQUENS, C. LYMANI, C. TENEBROSA, AND C. LIRATA.



C. GLOSSEMA, C. KNUDSENI, AND C. PERISCELIS.



C. NECRA, C. NECRA SPALDINGI, AND C. PARADOXA THAANUMI.



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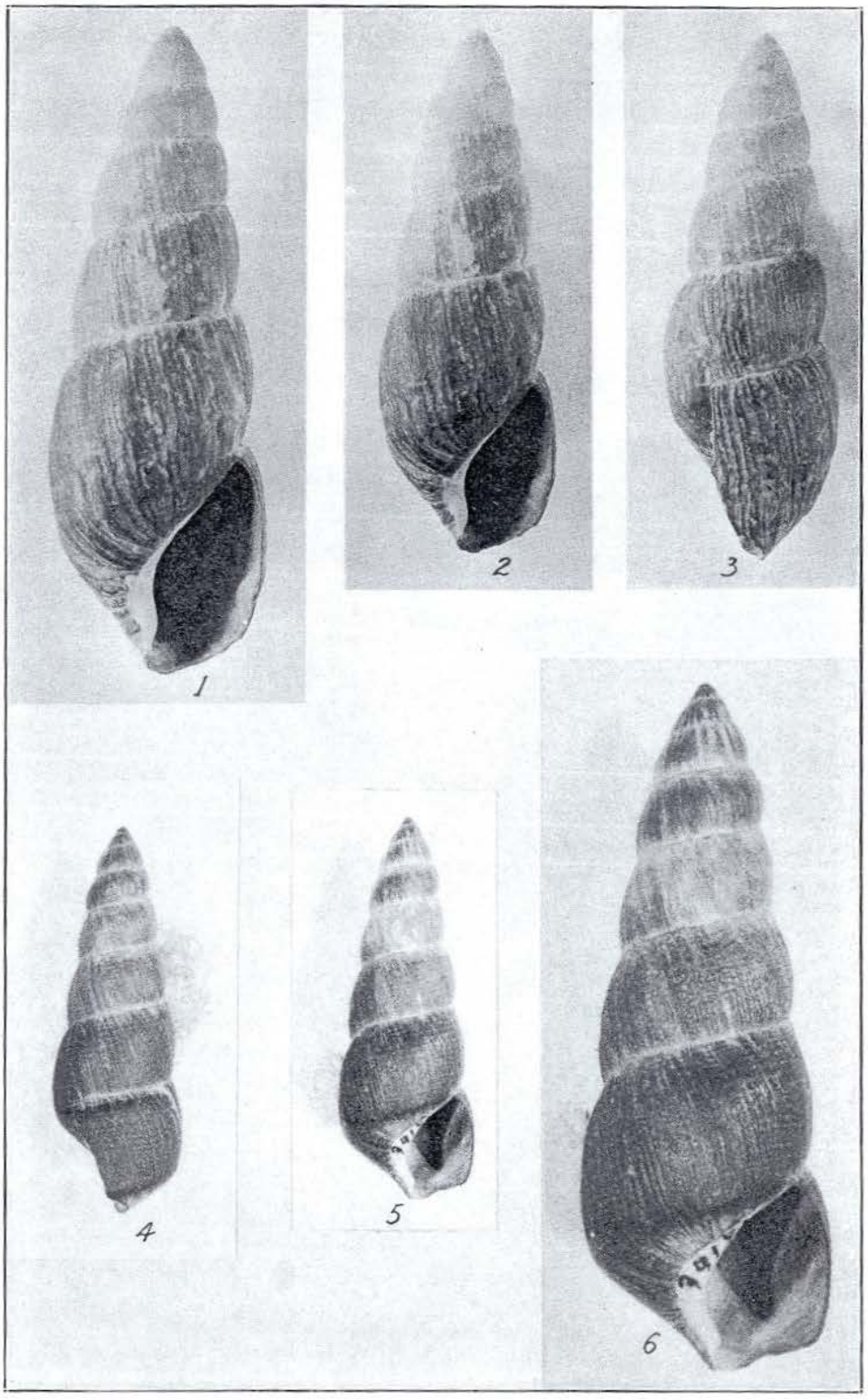

C. PILSBRYI AND C. PARADOXA.