Land Snails of Ulithi Atoll, Caroline Islands: A Study of Snails Accidentally Distributed by Man

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DURING THE SECOND WORLD WAR I had occasion to visit briefly on Mogmog Islet, Ulithi Atoll, Western Caroline Islands, and to collect the land snails reported herein. The collection was divided, and one part, including all specimens of several less abundant species, was sent to the late Dr. C. Montague Cooke, Jr. of the Bernice P. Bishop Museum. In unsorted "sweepings" he found a few species which I had overlooked. It was his intention to publish the data in a paper on comparative faunal studies of the Mid-Pacific Islands, but death intervened. Some years later I had the opportunity to study more carefully the set I retained, using the extensive collection and library at the University of Michigan Museum of Zoology. More recently, a grant from the National Science Foundation (NSF GB-2753) has made it possible to complete the study.

The collection is significant in several ways. Although there have been very few papers on the nonmarine mollusca of the Pacific atolls, this fauna seems to be larger than any previously reported (Hedley, 1899; Pilsbry, 1900; Reigle, 1964; and the bibliography of the latter paper). Most if not all of the species are disseminated by man, thus providing not only an antithetical example of a fauna of high endemicity, but also shedding new light on the vexing problem of zoogeography of the land snails of the Indo-Pacific area. The pitifully slow rate at which data on the Indo-Pacific land snails have accumualted has been due in large part to the inadequate descriptions and lack of illustrations of many species. The present study afforded opportunity to illustrate and redescribe several species thus neglected. Moreover, two species have interesting growth patterns which have not been previously reported, but which are of systematic importance.

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Mogmog Islet is one of several which inclose the lagoon of Ulithi Atoll. The closest islands to Ulithi (10° 5′ N, 139° 43′ E) are Fais, 45 miles to the east; Yap, 110 miles westward; and Guam, 400 miles to the north. Between World War I and World War II these islands had been a Japanese protectorate, as were the Marianas north of them, and the Palau Islands to the west. Several hundred Micronesians who called Mogmog home had been evacuated at the time of my visit. Writing at the turn of the century, Christian (1899:18–20) noted that there was a tradition of annual commerce between the Caroline Islands and Guam, carried on in native canoes. Also, the natives of Yap and Peleliu (in the Palau Islands) "used to go on long voyages of trading and conquest," and the natives of Ulithi "have from ancient times been subject to Yap, and they come down every February to pay them tribute."

Much of Mogmog Islet, which is only a few acres in extent, had been cleared of undergrowth when I visited it in August 1945. It was then being used as a recreational area for U. S. Navy personnel. The seaward margin of Mogmog is about 8 or 10 ft above the beach, which it fronts precipitously. From this meager elevation the land slopes gently down to the lagoon. Along the outer edge of the islet was a narrow strip of land on which the undergrowth was left relatively undisturbed. This zone was covered with large chunks of loose coral rock. The land snails were picked from the organic mulch which had collected between them. Near the center of Mogmog was a depression of about ½ acre, in which grew several species of emergent freshwater plants. The surface of this pond had been heavily oiled.

Besides the snails which I collected, a number of other land animals were in evidence. A species of terrestrial flatworm was abundant, and there was one species each of an isopod, a millipede, and a centipede. Of insects, I noted

at least four species of ants, several kinds of flies, a small cockroach, a locust, several beetles, a butterfly, and a moth, as well as dermaptera, isoptera, and homoptera (one scale insect was very common). Most surprising was the presence of mosquitoes and dragonflies, both of which require freshwater for the completion of their life cycles. There was also a small lizard (a skink) and one or more species of small forest birds.

Of plants, there were several species of broadleaf trees as well as pandanus and a few other shrubs. But, to a nonbotanist, these were eclipsed by the overwhelming abundance of the coconut palm. Contrary to popular opinion, the coconut palm, which is ubiquitous throughout the Pacific islands at lower elevations, does not constitute a natural forest. It is probably not even native to the area. The coconut groves are entirely the result of being planted and maintained (at least through replanting) by human agency. More detailed discussion of this subject will be found in Hedley (1899), O. F. Cooke (1910), Taylor (1950), Bates (1956), and Wiens (1962). From this it follows that the atolls forested with coconut palms are essentially cultivated areas. Wiens (1962) cites quite a few other plants which are introduced and maintained by human agency on atolls.

Some pertinent excerpts from Dr. C. M. Cooke's letters to me follow:

A number of genera [from Mogmog] such as *Koroia, Nesopupa, Georissa,* and *Palaina* are rarely, if ever, found on a typical atoll. From the list of the genera, the fauna appears to be that of a raised atoll such as Fais. I might hazard the guess that Ulithi is slightly raised with the islets composed of hard coral limestone. In typical, low lying atolls the interior of the islet is made up entirely of coral rubble. These typical atolls have a very restricted fauna made up mostly of species that are accidentally distributed by man.

In 1941 we received a small collection from Fais. This island is east of Ulithi and about 65 feet high, with no lagoon. The genera and species of land shells coincide almost exactly with those we now know to inhabit Ulithi. Species from both these isalnds are quite distinct from those known to inhabit Yap.

In my work on the faunas of the Pacific Islands I have divided the islands into three types. First, the high volcanic islands. Some of these may be quite old. The shell fauna of these islands contain endemic genera, subgenera and many species. Hawaii, Samoa, the Marianas, and all the important groups belong to this type. The lowland fauna may include many of the "wides" that are probably man-distributed. The second type is the raised coral island such as Fais in the Carolines; Makatea, Henderson, etc., in the Tuamotu. This type of island is not very old. They may have a few endemic species but not endemic genera. Quite a large portion of the fauna is man-distributed species. The third type of island is the low coral atoll. Some of these atolls may have as many as ten species but as the islands are apparently subjected to being washed over by hurricanes, all their shell species can be attributed to man's accidental introduction.

The fauna of Ulithi falls in the second lot and that is why I hazard a guess that, near the center of each islet there should be a slightly raised coral reef rock.

Dr. Cooke's surmise that Mogmog represents an island of the intermediate type is evidently based on two facts: (1) the number of species of land snails is larger than is known from any other atoll, and (2) not all of these snails have as yet the notoriety of being tourist snails. The unusually large land snail fauna may be due in part to more deliberate and thorough collecting of Mogmog than other atolls have received. Some species have not previously been incriminated as tourist snails, possibly because so little is known about them. Perhaps the richer fauna of Ulithi is only an indication of more frequent commerce than may occur at atolls with smaller snail faunas.

The physical characteristics of Ulithi indicate that it is a typical atoll. Its slight elevation could have been the result of storm action. This is suggested by the small extent and location of the higher areas, as well as by the nature of the material—loose coral rubble—which provided the higher ground. Rubble on the seaward edge of atolls seems to be a common phenomenon, caused by storm action (Hedley, 1896; Wiens, 1962). Wiens noted reports of a severe typhoon in 1906 which "almost destroyed" Ulithi. Even if the elevation of Ulithi is due partly to regional uplift, as is probably the case at Fais, the land height at Ulithi would seem to be too slight to escape the ravages of complete but temporary submersion caused by the Pacific typhoons.

Some of the snails of Mogmog are widely distributed in the Pacific and beyond, and have long been recognized as tourist snails. But of the rest, it is significant that the other localities from which they are known, the Palau Islands,

Guam, and Japan, are all centers with which the Micronesians and Japanese had intensive commerce. The frequent devastation which many atolls including Ulithi experience in typhoons suggests that such atolls may have their land snail faunas periodically much reduced if not obliterated. If we may assume that this happened on Mogmog in 1906, then it follows that all the species of snails found in 1945 arrived between those dates.

Recently I proposed several hypotheses as criteria which may be useful for recognizing exogenous nonmarine mollusca of a given fauna (Harry, 1964). These criteria were derived from my experience with the nonmarine mollusca in temperate North America, and the freshwater mollusca of the Antilles. To what extent they will suffice in the islands of the Pacific has yet to be determined, but we may review them in regard to the snails of Ulithi.

We can be absolutely certain that a snail is introduced into a given area only if it is known that the species was not present in the fauna prior to a certain date, and by having first hand knowledge of the time and method of its introduction. Unfortunately, such information is rarely available. In the Pacific islands, *Achatina fulica* is almost the only example. It is notable that this snail is not known as yet from any atoll, although it lives on the coastal area of some high islands, such as Saipan, where I collected it in 1944. In most cases, circumstantial evidence must be relied on to evaluate a given species as being exogenous.

Most tourist snails have a wide geographic distribution. In the case of the present fauna, all of the species are known to occur on at least one other island, and for some a very extensive range has already been recorded. There is more of such data for the pulmonates than for the prosobranchs, because the prosobranchs have received much less systematic study. All but the *Pythia* and the slug (Vaginulidae) are small in size, and this might have the double advantage of allowing them to be easily concealed and transported both as eggs and as adults. It is a singular fact that of nonmarine mollusca, at least, the tourist species of very largest size are nearly always introduced deliberately, and usually for food (some Helicidae, *Achatina fulica,* Ampullariidae; see Harry, 1964). But snails of intermediate size, as *Rumina, Bradybaena,* some Lymnaeidae, and perhaps *Pythia* and the slug of the Ulithi snails, are to be grouped with the microfauna, since they are only introduced by man accidentally into new areas. Pilsbry (1900) has made the interesting observation that, although regions outside the Pacific area have contributed terrestrial snails as tourists to the Pacific islands (e.g., *Gulella* and *Lamellaxis* of the Ulithi list), those islands have in turn provided no member to the list of tourist snails of other parts of the world. This statement is valid only if we speak of the Indo-Pacific islands rather than merely the Pacific islands *s.s.* Nevertheless, the accidental dissemination of land snails by man within the Pacific area is probably greater than has been previously recognized.

Tourist snails tend to remain in an environment highly modified by man, and do not, through their own natural ability, invade the more natural surrounding areas. This principle is probably as valid for introduced snails as it is for other introduced organisms (Bates, 1956: 788). Thus, man not only is the agent of introduction, but also is responsible for maintaining the environment which allows them to become established in their new locality. At least the biotic environment of atolls such as Ulithi, which are under coconut cultivation, are man-effected situations. Much more ecological work needs to be done on atoll snails to investigate the second part of this hypothesis. Probably there are ecological divisions to be recognized among different atolls, even though superficially their biotas appear very much the same.

There are relatively few species of tourist snails (generally so recognized) which are common to the several low and intermediate islands which have been most intensively studied: of the 17 snails found on Ulithi, only 1 species is recorded among the 22 of Makatea (C. M. Cooke, 1934), only 2 occur among the 11 on Rongelap (Reigle, 1964), and only 2 occur among the 11 on Funafuti (Hedley, 1899). None of the islands cited has more than a few species in common. This may be due in part to diverse patterns of human movement among

these islands. It is equally probable that it indicates ecological diversity.

Tourist snails often have no close relative native to the area in which they are introduced. This rule may have frequent exceptions (Harry, 1964). Among the present fauna of Ulithi there is no single species which is certainly a native, i.e., which has evolved on that island. Thus we can not apply this criterion here. There are nearly as many genera and families as there are species on Ulithi. The chief exception is the Omphalotropidae, which contains two or three species of one genus.

Introduced snails often occur in greater abundance in their new home than in the area where they evolved as indigenous snails. Most of the snails reported herein were abundant. But until we know the natural areas in which the species of the present fauna evolved, such comparisons can not be made for them.

SYSTEMATIC ACCOUNT

Because the pulmonates have been relatively well studied, only the more recent monographic literature is cited for each species. Recent works with extensive descriptions and figures are available for a few of the prosobranchs also, but for several it was necessary to describe and figure them anew, since they have received no adequate treatment in the literature. All the records of species from Fais cited below are given on the authority of Dr. C. M. Cooke.

Order PULMONATA

Family ELLOBIIDAE

Pythia scarabaeus (Linné)

Notes on the growth changes in the shell, and other data on this very common species were presented in an earlier paper (Harry, 1951). The confused nomenclature in this genus allows only *ex cathedra* identification of species at present. The possibility that some species might be tourist snails should be kept in mind in further systematic studies of the group.

Family VAGINULIDAE

Several specimens of (apparently) a single species were collected, but were lost through unsuccessful attempts to maintain them alive. Lacking data on the internal anatomy, we can not provide even a generic identification. Members of this group have been incriminated as tourist snails (H. B. Baker, 1925; Solem, 1959).

Family TORNATELLINIDAE

Lamellidea subcylindrica? Mollendorff

All of the few specimens were given to Dr. Cooke, who noted that his identification was tentative. The species was described and illustrated by Pilsbry and Cooke (1915), and mentioned in Cook and Kondo (1960:183). The latter note that it occurs on several islands of the Marianas.

Family PUPILLIDAE

Nesopupa ponapica Mollendorff

Pilsbry (1920) reported this only from "Caroline Islands, Mpomp, Ponape," but Mollendorff (1900) thought it might be only a subspecies of *N. tantilla* (Gould), which is widely distributed in Polynesia.

Gastrocopta pediculus Shuttleworth

Pilsbry (1918) reported that this species has been found on nearly every inhabited atoll and high island of Polynesia, Micronesia, and Melanesia where small land shells have been sought. He also reported it in Hawaii, the Philippines, and New South Wales, Australia.

Family SUBULINIDAE

Opeas oparanum Pfeiffer

Pilsbry (1907) could recognize only this species and *Lamellaxis gracilis* Hutton from all of Polynesia, where they are known to be widely distributed by commerce. Several other species of this family are known to be widely distributed in the Pacific islands today.

Family ZONITIDAE

Discoconulus sp. (juvenile)

H. B. Baker (1941) recorded only a single species in this genus, in his monograph of the Zonitidae of the Pacific. While all his records

of it are from the Caroline Islands, he thought it was imported from Japan.

Kororia palauensis Semper

This species also occurs on Fais. Baker (1941) gave an account of the anatomy and distribution. He thought this species was distributed by human agency.

Family STREPTAXIDAE

Gulella bicolor Hutton

This species also occurs on Fais. Germain (1921) gave an extensive synonymy and other data on the occurrence of this snail in Mauritius. It is also found in India, Malaya, and several places in the Pacific islands. I collected it in Saipan in 1944 and in Puerto Rico in 1954. The University of Michigan Museum of Zoology has material from Brazil, French Guiana, Barbados, Panama, and elsewhere. It is undoubtedly a tourist snail, found in the same general area where *Opeas* occurs. The fact that it is less abundant and not so widely distributed as the latter may be due to its carnivorous habits.

Order PROSOBRANCHIA

Family HYDROCENIDAE

Hydrocena (*Georissa*) *laevigata* Quadras and Mollendorff

Hydrocena (*Georissa*) *laevigata* Quadras and Mollendorff 1893, Nachr. d.d. Malak. Ges., p. 42. Not figured. Type locality: Mariana Islands. This species was moderately abundant, and it also occurs on Fais.

Shell (Fig. 1) thick, translucent, amber colored. It is dextral, conic-turbinate in shape, with the whorls evenly rounded, subcircular. Specimens of maximum size have an imperforate umbilicus, and about three suture whorls. The initial whorl is smooth but not polished. It is usually separated abruptly from the later whorls by a transverse line, immediately beyond which there are numerous linear spiral grooves. On the apical part of the body whorl these become vague, and they usually do not continue on the later parts of this whorl, where they are replaced by faint incremental lines. The aperture is subcircular, its height being slightly shorter than the height of the spire. The outer lip is simple. In submature and mature shells there is a thick columello-parietal plate.

The internal partition of the shell is partly resorbed (Fig. 2), leaving a narrow shelf which is apparently a remnant of the partition, and not a secondary structure, such as that of *Pythia* (Harry, 1951). The partition is complete about ¾ whorl in from the aperture. The base of the cavity of the penultimate whorl extends downward to form a conical cavity behind the columello-parietal plate.

The operculum (Fig. 3) is flattened, calcareous, semihyaline, smooth internally, and with an apophysis arising from the slightly elevated nuclear area near the base. The apophysis is narrow, elongate, directed obliquely outward in a gentle curve. It consists of two fused pieces, one not extending to the tip, but the line of fusion is vague. The outer surface of the operculum is covered by a thin, polished, horny layer, reflected along the entire labial margin to form a narrow free membrane. The concentric lamination of the calcareous part, poorly defined and centering around a basal nucleus, is visible through the horny layer.

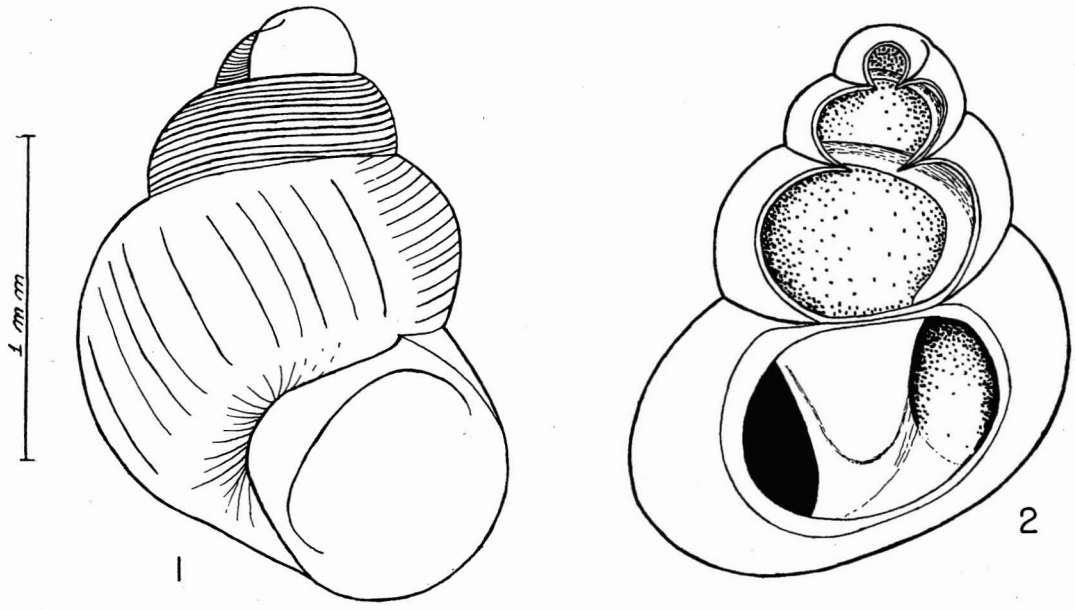
Family PUPINIDAE

Pupina complanata (Pease)

Registoma complanatum Pease 1860, Proc. Zool. Soc. London, p. 440. Not figured. Type locality: "The Island of Ebon, Marshall's group."

Dr. Cooke noted that the Ulithi species was doubtfully present on Fais, and was nearer to *P. complanata* Pease than to *P. berenchleyi* Smith 1891. Clench (1949) has recently monographed this group, providing good descriptions and figures of both species. He recorded *P. complanata* from several localities in the Marshall Islands (type locality) and the Caroline Islands. Mollendorff (1900) cited it as a traveling snail.

The numerous shells from Ulithi present a partial growth series which reveals one of the most remarkable growth patterns to be found in land snails, and one which seems not to have been previously reported. The most juvenile shells (Figs. 4 and 5) have a definitely cyclophorid appearance, with an open umbilicus



FIGS. 1–2. *Hydrocena laevigata.* 2, *Hydrocena laevigata,* opened to show internal shell resorption.

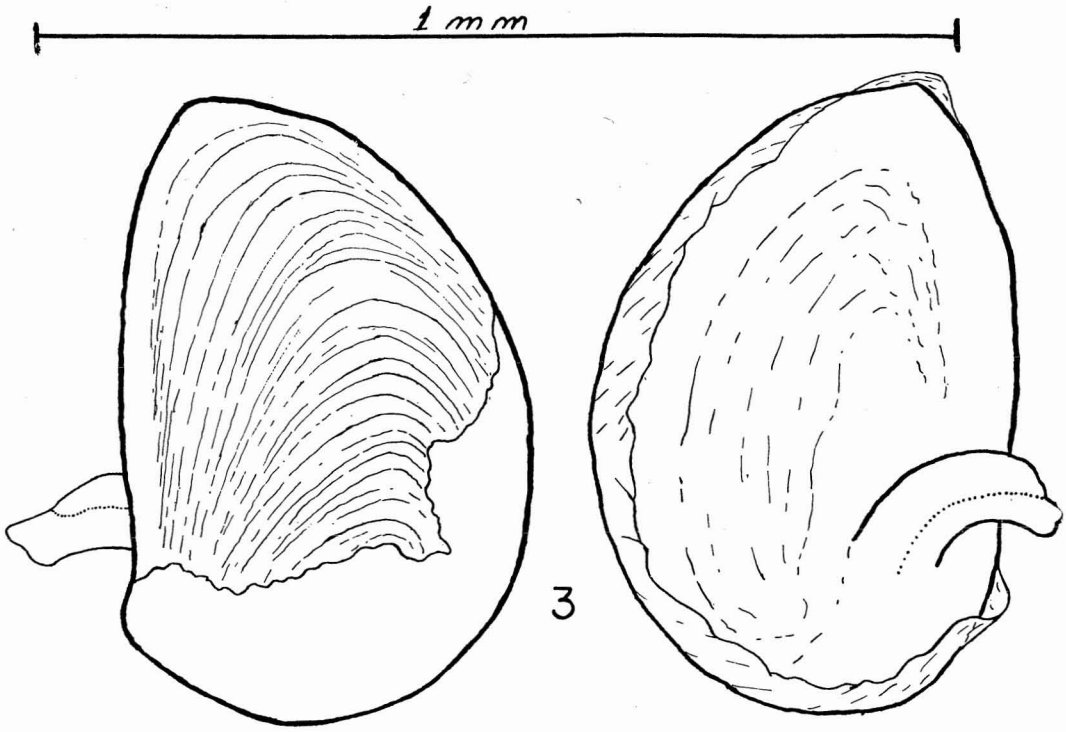
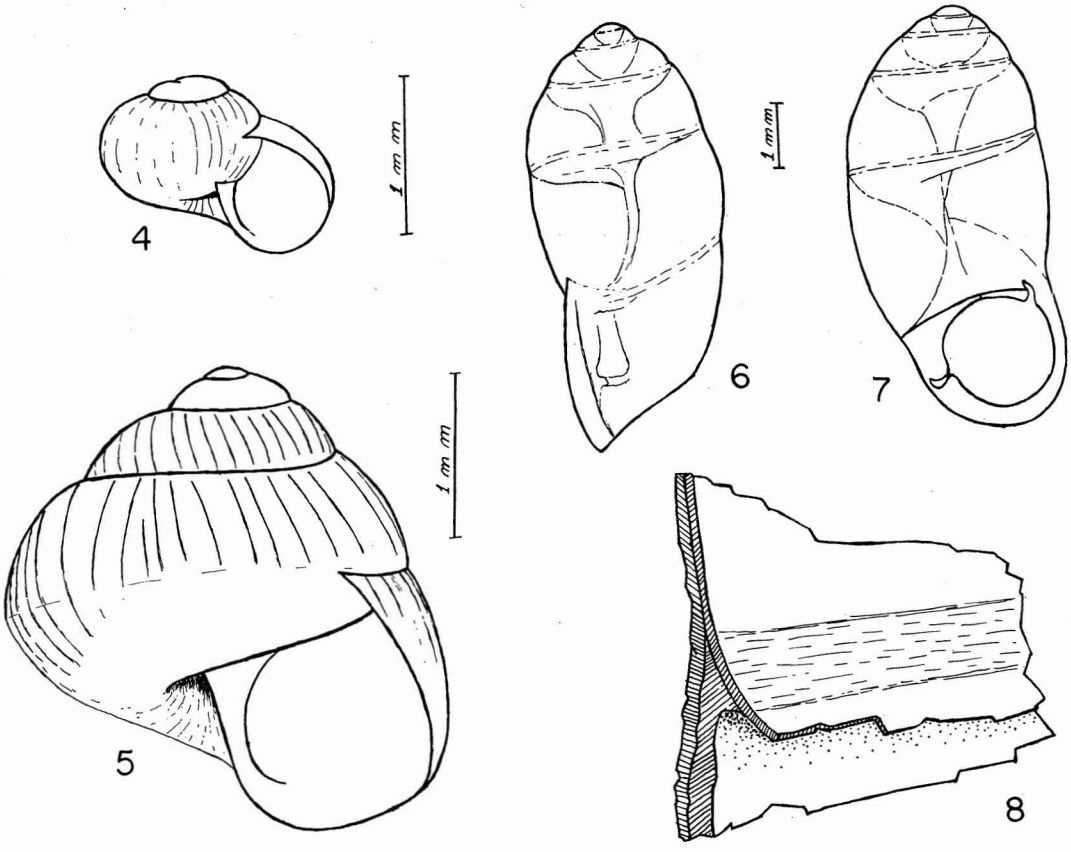


FIG. 3. *Hydrocena laevigata,* operculum.

and prominent transverse sculpture of indented lines. The texture is smooth, but very dull compared with the high polish of mature shells. As more whorls are added the umbilicus gradually closes, and one side of the shell becomes flattened. The plane of the aperture utlimately coincides with the peripheral flattening of the shell. These two features, the closing of the umbilicus and peripheral flattening of the shell, are as much a hallmark of determinate growth as the terminal elaboration of the aperture, which is also present in this genus. Figures 6 and 7 were drawn from specimens in transmitted light, revealing the internal structure of the mature shell. After all the whorls of the shell have been formed, the whole of the outer surface of the shell is covered with a thin, colorless, polished, and glassy layer of shell material, so that not only the sculpturing of the early whorls, but also the sutures, are obliterated. Figure 8 shows a fragment of a mature shell with the hyaline secondary layer obliterating the suture.

The animal of the Ulithi species was not observed, but several mature, preserved specimens of *P.* (*Kanapa*) *brazieri* Crosse, from unknown locality, were studied. These had the mantle margin thin, flush with the lip of the shell, and without papillae or other appendages. The cephalopedal mass was typical of a cyclophorid, with no appendages which might have been reflected over the shell. Exactly how this hyaline layer is formed must await study of the live animal. It seems to be a generic or family characteristic, developed independently in such groups as the Cypraeidae.



FIGS. 4–8. *Pupina complanata:* 4 and 5, juveniles. 6 and 7, two views of the same shell as seen in transmitted light, to show internal structure. 8, a fragment of a mature shell, showing the relation of the hyaline layer to the shell's structure.

Family DIPLOMMATINIDAE

Palaina ovatula Mollendorff

Palaina ovatula Mollendorff 1897, Nachr. d.d. Malak. Ges. 29:42. Not figured. Type locality: Ponape, Caroline Islands.

Dr. Cooke identified this merely to genus, but noted that the same species occurs on Fais. The Bryant Walker Collection at the University of Michigan contains specimens from Ponape which agree closely with the shells from Mogmog, except that they are slightly more ovate. The 38 shells from Mogmog examined are rather uniform in size, form and sculpture. All were slightly weathered, being light grey or dull white, and semiopaque by transmitted light. None contained the operculum or animal.

Shell (Fig. 9) sinistral, ovate-cylindrical, rimate-umbilicate, with 3¾ suture whorls. The apex is obtuse, depressed. The whorls are evenly rounded, though somewhat distorted, the later whorls of the spire being slightly flattened. The plane thus produced coincides with the apertural plane. The aperture is subcircular, strongly bilabiate by a heavy, multilamellate costa just before the slightly reflected outer lip. The parietal lip is entirely adnate to the body whorl, and encroaches slightly on it. The latter character is somewhat variable. The aperture has no teeth or lamellae. The initial 1¾ whorls are smooth but not polished, beyond which gradually appear minute, lamelliform costae, closely spaced. These gradually increase in size for about 1 whorl, after which they maintain uniform size and spacing until the last half of the body whorl, where they become larger and less closely spaced.

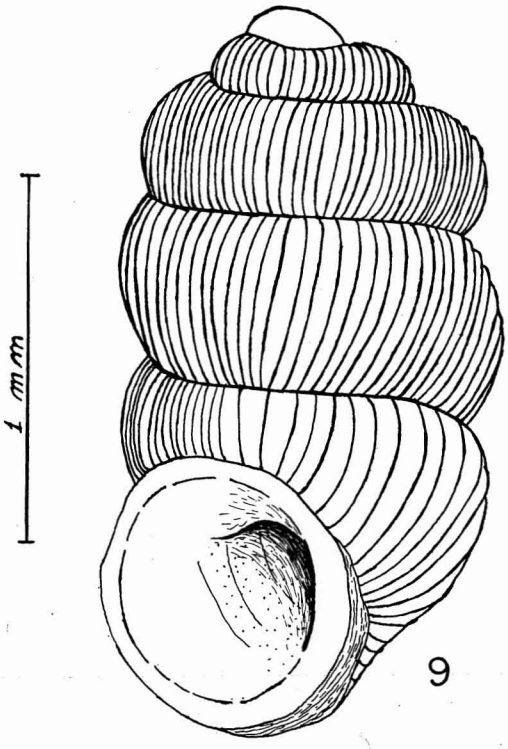


FIG. 9. *Palaina ovatula.*

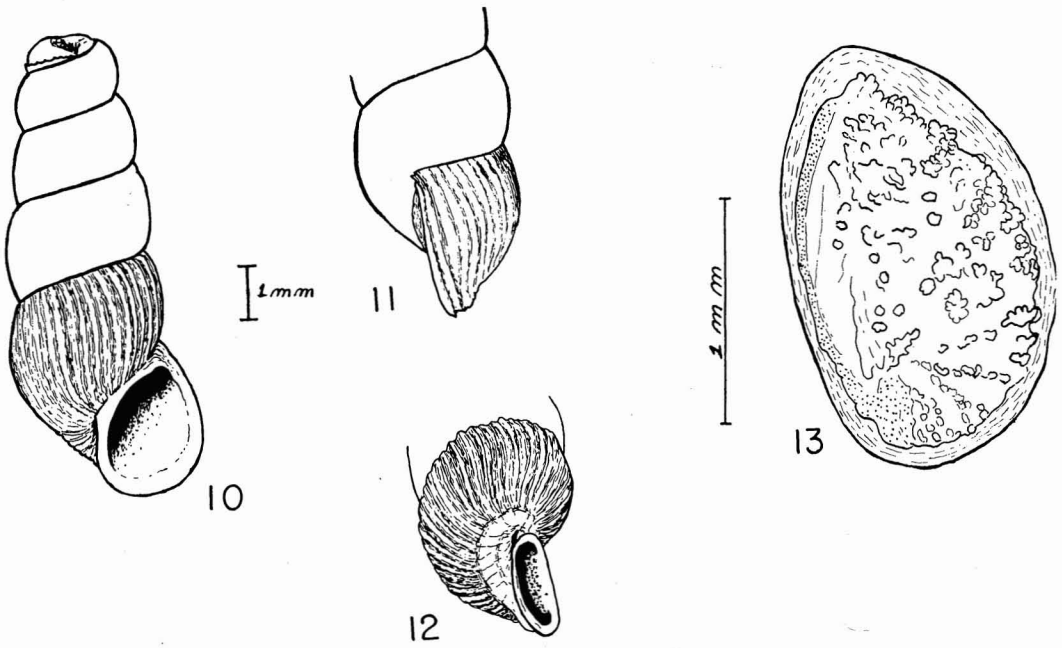
Family TRUNCATELLIDAE

Truncatella (*Taheitia*) *mariannarum* Quadras and Mollendorff

Dr. Cooke considered the Mogmog specimens very similar if not identical to specimens from Guam, which is the type locality. It also occurs on Fais. Clench and Turner (1948) have recently given a review of this group, but did not describe or figure this species, which seems not to have been previously figured.

Adult specimens from Mogmog (Figs. 10, 11, and 12) are about uniform in size, of 9 mm altitude, decollate, and of about 3¾ (suture) whorls. The fine costae number about 40, or slightly less, to the body whorl. On the body whorl there is a moderately vague, linear constriction paralleling the suture a short distance below it. Above this constricting line the costae have a more distinct bladelike aspect than below. The constriction is less prominent on the last fourth of the body whorl and on the whorls of the spire. The base is imperforate, with a basal ridge moderately developed on the last half of the body whorl. Aperture symmetrically ovoid, scarcely expanded, unilabiate, the costae in even size-series before the lip, with none enlarged. Parietal lip moderately thickened, but entirely adnate to the body whorl. The costae do not extend over the basal ridge.

Apex of 1¼ whorls, minutely and uniformly costate transversely, with an abrupt transition to the grosser costae of the later shell. Costae of early predecollate shell more acute than those of postdecollate whorls. The color is uniform chestnut brown.



FIGS. 10–13. *Truncatella mariannarum.* 10, 11, and 12, sculpture is shown on body whorl only. 13, *Truncatella mariannarum,* operculum.

Operculum (Fig. 13) with external calcareous plate of moderate thickness, showing vague arcuate-radiate grooving which is more evident toward the periphery. The calcareous plate has a waxy texture. It does not extend to the edge of the operculum.

This species is about the same size and shape as *T. guerinii* A and J.B. Villa 1841, which I have collected on Manus (Admiralty Islands) and Peleliu (Palau Islands). The major difference seems to be that *T. guerinii* has larger costae, which are more sharply defined than in *T. mariannarum* Q. and M. 1894. The two species seem readily separable, with no intermediate forms in the several lots which I have examined. Yet their similarity suggests that they are closely related, and that they may be only subspecifically distinct, or perhaps even phenotypic variations of one species. *T. guerinii* is widely distributed in the Indo-Pacific area, as Solem (1959:197) has noted.

Family ASSIMINEIDAE

Assiminea nitida Pease

The few specimens of this species were all sent to Dr. Cooke. Garrett (1884) gave an extensive synonymy of *A. nitida,* and noted that it is generally distributed throughout southern Polynesia. Abbott (1949) has figured a cotype of this species and given a description (Abbott, 1958), as well as described several new subspecies. As he noted, it is likely that this has its wide distribution, now known to be from east Africa to the eastern Pacific, owing to the agency of "man and birds."

Family OMPHALOTROPIDAE

Omphalotropis granum Pfeiffer

Hydrocena granum Pfeiffer 1854, Proc. Zool. Soc. London, p. 307. Not figured. Type locality: Isle of Pines, Australian Sea.

Omphalotropis submaritima Quadras and Mollendorff 1894, Nachr. d.d. Malak. Ges., p. 33. Not figured. Type locality: Mariana Islands.

Two specimens of this species were found among the remaining lot of *O. fragilis* after I had divided the material with Dr. Cooke. This may be what he designated merely as *Omphalotropis* sp., from unsorted material which I sent him. The above synonymy is proposed tenta-

tively, as I have seen no material which was undoubtedly the type, cotype, or paratype of Pfeiffer's nominal species. However, the Walker Collection at the University of Michigan contained several lots which are apparently of this same species, and which show it occurs in Lifu (Loyalty Islands), the New Hebrides, New Caledonia, and Guam. The following redescription of this species is based on seven cotypes of *O. submaritima* (University of Michigan Museum of Zoology 77604), which is apparently a synonym.

Shell (Fig. 14) dextral, ovate-conic, solid, pellucid, of 4½ suture whorls. The spire is moderately elevated, its profile forming an acute angle, but with the apex blunted. The suture is simple and deeply set, with the plano-convex whorls being arched sharply just below it, giving the spire a stepped profile. Body whorl vaguely, obtusely angled at periphery. The umbilicus is rimate and concealed by the partially reflexed columellar lip. The aperture is ovate-conic, with outer and basal lip simple, straight, and sharp. The umbilicus is circled by a flat carina, of moderate width, which is variable in prominence. It begins above at the parieto-columellar lip junction, and ends at the baso-columellar junction by a slight angulation of the lip. The color of the shell is corneous yellow. There is occasionally a faint, narrow band of white over the peripheral angulation of body whorl. In fresh shells the embryonic and first whorl are sculptured with minute, closely-set spiral lines, visible only at higher magnification. Later whorls are smooth, but not polished. The operculum resembles that of *O. fragilis* (see below).

The size is variable, though generally uniform among shells of a given lot. Occasionally a specimen may be nearly twice the size of the one figured, with, of course, a proportional increase in the number of whorls. The color also is variable, some lots being light brown, or with a brown band above and below the periphery. The name *"Omphalotropis maritima* Montrouzier" seems to be a nude name, which was first printed in Paetel's catalogue. However, it accompanies many of the older museum lots, and may have given rise to the inapt trivial name applied to this species by Quadras and Mollendorff.

Solem (1959:200) has independently recognized that *O. submaritima* Quadras and Mollendorff is a junior synonym of *O. granum* Pfeiffer, and he has also included *"O. maritima* Montrouzier" with them parenthetically. The *O. setocincta* Ancey 1890 which he recognized from the New Hebrides and figured (Solem, 1959: Plate 27, figs. 8, 9) is so close to the specimens from Ulithi and to the cotype of *O. submaritima* which I have drawn (Fig. 14) as to suggest that they represent the same species.

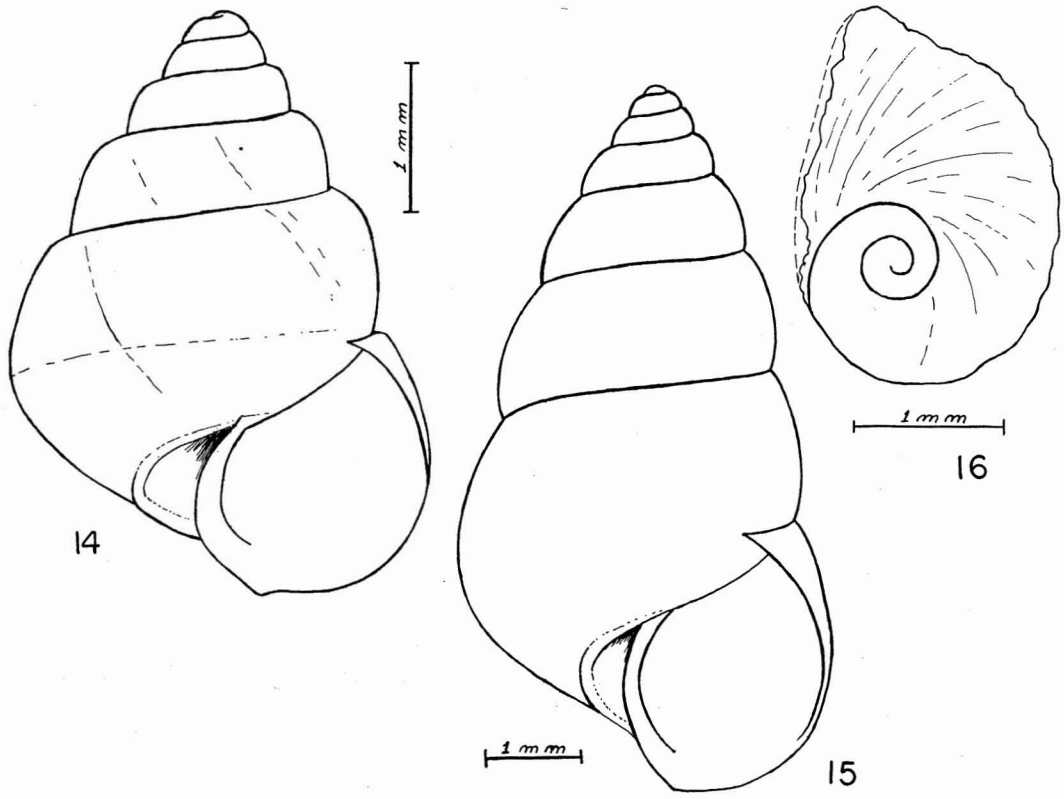
Omphalotropis fragilis Pease

Hydrocena fragilis Pease 1860, Proc. Zool. Soc. London, p. 439. Not figured. Type locality: Ebon, Marshall Islands.

Dr. Cooke noted that this species also occurs on Fais.

The shell (Fig. 15) is dextral, thin, translucent, turbinate, rimate-umbilicate. The apex is bluntly rounded, with the first two postapical whorls somewhat more convex than later whorls, which are only slightly, but evenly, rounded. The suture is prominently impressed. Periphery of juvenile shells (5 suture whorls) distinctly angled, and usually with a vague, linear callus, but this disappears on shells of maximum size (6¼ suture whorls) which show scarcely any angulation of the periphery. The base is slightly inflated, with a carina circumscribing the small umbilicus, typical of the genus. Aperture ovate, with the columellar lip slightly reflected, and with an angle at the end of the omphalotropid circumumbilical callus, at the junction of the basal and columellar lips. Apical whorls are smooth, without sculpture. There is no sharp dividing line between apex and later whorls. The silky texture of later whorls is caused by numerous, minute, vague, spiral lines. These are evenly distributed from suture to umbilicus, but variable in their presence in different shells.

Although the shell shape is remarkably constant, the color is extremely variable. Shells may be uniformly colored, either very light yellow or dark reddish-brown. Several spiral bands of dark brown may be present, and may be variable in width and number. Transverse bands of dark maroon, irregular and discontinuous, may occur



FIGS. 14–16. *Omphalotropis*. 14, *Omphalotropis submaritima* = (*granum*), cotype, from Guam (University of Michigan Museum Zoology No. 77604). 15, *Omphalotropis fragilis*. 16, *Omphalotropis fragilis*, operculum.

alone or in combination with the spiral bands.

Shells of maximum size have 6¼ suture whorls and measure 6.0 mm high, and 3.3 mm greater diameter. The operculum (Fig. 16) is corneous, light brown, and paucispiral.

Possibly the *Omphalotropis zebriolata* Mousson cited by Hedley (1899:417) from Funafuti and many other Pacific islands is identical or closely related, but I have had no access to material which would settle this problem.

Omphalotropis suturalis Quadras and Mollendorff

Omphalotropis suturalis Quadras and Mollendorff 1894, Nachr. d.d. Malak. Ges. 26: 22. Not figured. Type locality: Mariana Islands.

The few specimens were all sent to Dr. Cooke, who noted that he could not separate the Ulithi specimens from those of Guam.

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