

ENDEMIC LAND SNAILS FROM THE PACIFIC ISLANDS AND THE MUSEUM RECORD: DOCUMENTING AND DATING THE EXTINCTION OF THE TERRESTRIAL ASSIMINEIDAE OF THE GAMBIER ISLANDS

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ABSTRACT

Two species of terrestrial Assimineidae historically inhabited the Gambier Islands, eastern Polynesia. Both were endemic to the island group and are now extinct. One is a new species of *Cyclomorpha*, *C. secessa* n. sp., which was already extinct when it was first collected in 1934. The other is *Omphalotropis margarita*, a giant species of *Omphalotropis*, which is represented in museums by material collected alive in the nineteenth century. It was originally described in error from Rapa and the 'Fox Islands', but is here shown to have probably been collected on Akamaru, the first European settlement in the Gambier Islands. At least 90 historical specimens in eight museums together suggest that the species became extinct between the 1850s and the early 1900s. Literature and museum records of *Cyclomorpha flava* from the Gambier Islands are regarded as erroneous; that species is endemic to the western Tuamotus and has, for decades, been used in Polynesian shell craft.

INTRODUCTION

The Gambiers are an isolated group of small, volcanic islands, situated at the easternmost end of the Tuamotu Archipelago in eastern Polynesia. Their geological age is 6 Ma (Bellon, 1974) and, despite having an area of just 2600 hectares, they reach an elevation of 440 m. The Bishop Museum Mangarevan Expedition visited the island group in 1934 and made extensive mollusc collections (Cooke, 1935). In view of the high extinction threats faced by Pacific island land snails (e.g. Cowie, 1992; Hadfield, Miller & Carwile, 1993; Preece 1998; Coote, Loeve, Meyer & Clarke, 1999), the Gambiers were revisited in 1997 in an attempt to document the conservation status of their native mollusc fauna. The two surveys have documented an extraordinary diversity of land snails historically present on the islands, with 34 endemic species and four endemic genera in the families Euconulidae (Baker, 1940; Bouchet & Abdou, 2001), Endodontidae and Punctidae (Solem, 1983; Abdou & Bouchet, 2000). The 1997 survey also revealed that a massive extinction of the endemic biota has taken place (Bouchet, 1998), with only two of these 34 species still extant.

The purpose of the present paper is to further document the diversification and extinction history of the land snail fauna of the Gambiers. We describe and discuss the records of the two species of terrestrial Assimineidae that historically inhabited the island group, both of which are now extinct, and reject records of a third species. One is a new species of *Cyclomorpha*, which was already extinct when it was collected by the Bishop Museum Mangarevan Expedition in 1934. The second is a giant species of *Omphalotropis*, which is represented in museums by material collected alive in the nineteenth century, although often with erroneous locality data. Despite the small land area of the Gambiers, this species exhibits significant microgeographical variation in size, which allows us to hypothesize on the probable origin of the type lot with some certainty.

MATERIALS AND METHODS

Fieldwork was carried out in the Gambier Islands by the senior author in September 1997. Twenty-four stations were sampled, and more than 50,000 shells of native and introduced snails were

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collected. Ten stations yielded shells of terrestrial Assimineidae of the genus *Omphalotropis*, represented by hundreds of specimens. Subsequently, the material collected by the 1934 Mangarevan Expedition was examined during a visit to the Bishop Museum (BPBM) by the senior author in September 1998. Finally, between 1999 and 2001, the holdings of major museums with nineteenth century land snail collections were searched for material of *Cyclomorpha* and terrestrial Assimineidae from the Gambier Islands: The Natural History Museum, London (BMNH); National Museum of Wales, Cardiff (NMW); Institut Royal des Sciences Naturelles de Belgique, Brussels (IRSNB); Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt a. M. (SMF); Museum für Naturkunde der Humboldt-Universität, Berlin (ZMB); Muséum National d'Histoire Naturelle, Paris (MNHN); Museum of Comparative Zoology, Harvard (MCZ); Academy of Natural Sciences, Philadelphia (ANSP); Australian Museum, Sydney (AMS).

SYSTEMATIC DESCRIPTIONS

Clade Caenogastropoda Cox, 1960

Superfamily Rissoidae Gray, 1847

Family Assimineidae H. & A. Adams, 1856

Subfamily Omphalotropidinae Thiele, 1927

***Cyclomorpha* Pease, 1871**

Cyclomorpha Pease, 1871: 464. Type species *Cyclostoma flavum* Broderip, 1832, by original designation.

***Cyclomorpha secessa* new species**

Type material: Holotype BPBM 264012, and 3 paratypes BPBM 138841; type locality: Akamaru, Gambier Is, collected by the Mangarevan Expedition in 1934.

Etymology: From the Latin adjective *secessus* (-a, -um), meaning remote, with reference both to the geographical occurrence of the species and its distinctiveness from other *Cyclomorpha* species.

Description (Fig. 1A–D): Shell rounded spherical, solid, consisting of 5 whorls, last whorl occupying 83% of total shell height. Protoconch/teleoconch transition indistinct; first 1.5 whorls smooth, assumed to represent protoconch, diameter 1100 µm.

Teleoconch whorls very convex, shouldered, with narrow, flat sutural ramp, suture impressed. Sculpture consisting of raised spiral cords, three on exposed part of first teleoconch whorl, interspaces broader than cords; six on penultimate whorl, interspaces about as broad as cords; spiral sculpture fading out on last whorl, except four or five low, broad cords encircling the umbilicus. Umbilicus broad, *c.* 20% of diameter, deep, extending to apex, bordered by subangular umbilical rim, and bearing inside a strong, broad and raised umbilical funicle. Aperture ovate, with two angular points at junction of outer lip with parietal wall and at base of shell, where umbilical rim and umbilical funicle converge. Outer lip very prosocline, inner lip forming a thick callus in parietal region and narrow, concave, columellar wall. Shell colour dirty white.

Dimensions of holotype: height 9.0 mm, breadth 8.6 mm, aperture height 4.5 mm, breadth 3.8 mm.

Remarks: *Cyclomorpha secessa* differs from the type species of the genus, *C. flava* (Fig. 1E), by its larger adult size (*C. flava* reaches 7–8 mm), broader umbilicus with distinctly angular umbilical rim and broad umbilical funicle (in *C. flava*, the umbilical rim is regularly convex, and the funicle is a narrow, sharp, almost vertical thread, resulting in a much more rounded aperture), and coarser spiral sculpture (there are 8–10, closely set, spiral cords on the penultimate whorl of *C. flava*). Conversely, *Cyclomorpha secessa* differs from *C. obligata* (Gould, 1847) (Fig. 1F), from Makatea (Tuamotu Islands), by its less coarse spiral sculpture (there are only three very strong, spiral cords, separated by deep furrows, on the penultimate whorl of *C. obligata*). In *C. obligata*, the shell is very solid, much heavier than in *C. flava* and *C. secessa*, the umbilicus is also narrower, not rimmed and the umbilical funicle is a low, broad ridge.

Cyclomorpha flava (Broderip, 1832)

Cyclostoma flavum Broderip, 1832: 59 [Anaa (Tuamotu Is, French Polynesia); syntypes: 'Anaa', 4 specimens (at least two with operculum and dried soft parts), BMNH 42.5.10.460–463 (Fig. 1E); 'Anaa', 3 specimens (at least two with operculum and dried soft parts), ex Cuming, BMNH 20020543].

Gambier records: *Cyclomorpha flava* is well known from the western atolls of the Tuamotus, but one literature reference [Pfeiffer 1876: 234 ('Ins. Anaa, Gambier')] and two museum samples record it from the Gambiers: 'I. Gambier', 2 specimens (one with operculum and dried soft parts), Dautzenberg collection (before 1925; IRSNB); 'Gambier Island/1864/ex Hidalgo/Pfeiffer, 31', 8 specimens (seven with dried soft parts and operculum), Melville-Tomlin collection (NMW). In 1997, the first author was himself shown by a resident of Rikitea, Mangareva, a bowl containing many hundreds of shells destined to be pierced and mounted for shell necklaces. The shells were said to have been collected *c.* 1970 at Kouaku, one of the islets of the Gambier barrier, but a focused search by the author and two local assistants failed to produce any there, or at any other place in the Gambiers. None of the authors and/or collectors involved in the literature and museum records ever visited the Gambiers or Polynesia, and the actual sources of their specimens and information are unknown. The Mangarevan Expedition of 1934 did not collect *Cyclomorpha flava* in the Gambiers. We regard Pfeiffer's literature record and the locality accompanying the specimen of *C. flava* in IRSNB and NMW as erroneous, and we believe that *C. flava* does not occur in the Gambiers.

Omphalotropis Pfeiffer, 1851

Omphalotropis Pfeiffer, 1851: 176. Type species *Bulimus hieroglyphicus* Potiez & Michaud, 1838, by subsequent designation (Nevill, 1878).

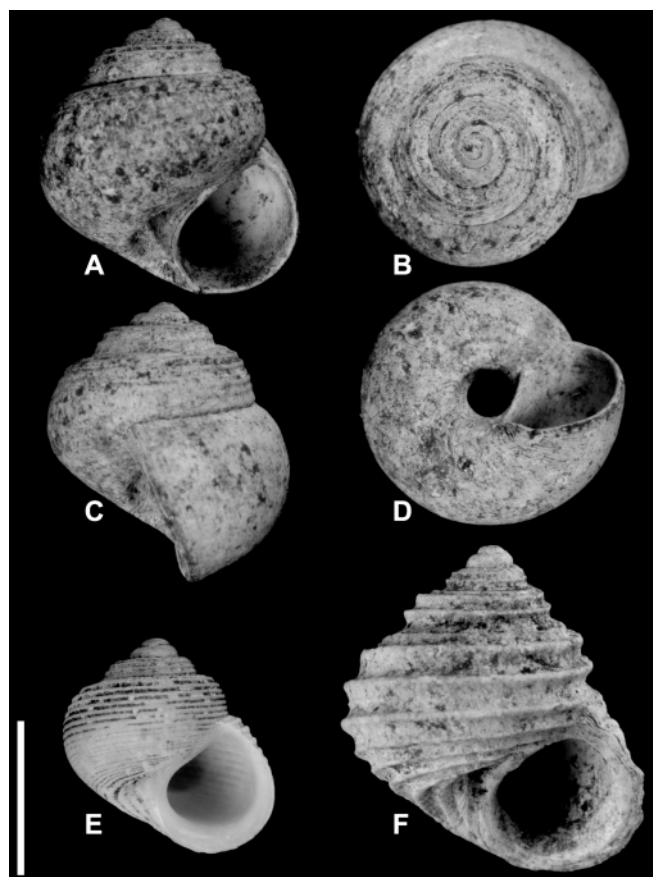


Figure 1. Terrestrial assimineids of the genus *Cyclomorpha* from eastern Polynesia. A–D. *Cyclomorpha secessa* n. sp., holotype (BPBM 264012), height 9.0 mm, Akamaru, Gambier Is. E. *Cyclomorpha flava* (Broderip, 1832), one of four syntypes (BMNH 42.5.10.460–463), height 7.0 mm, Anaa, Tuamotu Is. F. *Cyclomorpha obligata* (Gould, 1847), specimens from Soyer collection (MNHN), height 10.6 mm, Makatea, Tuamotu Is. Scale bar = 5 mm.

Omphalotropis margarita (Pfeiffer, 1851) new combination

Cyclostoma margarita Pfeiffer, 1851: 244 ['Insula Rapâ' (Austral Is, Polynesia; in error); possible syntypes: 3 specimens (height 7.0, 7.0, 7.4 mm; at least one with operculum and dried soft parts), ex Cuming, marked 'Rapa', 'Type?' (BMNH, 20020544; Fig. 2A). The fact that Pfeiffer (1853: 252) stated the operculum to be unknown raises doubts as to the type status of this material]. Pfeiffer, 1853: 252, pl. 34, figs 9–10.

Cyclophorus margarita—Pfeiffer 1852: 86. Reeve 1861: species 60.

Cyclomorpha margarita—Pease, 1871: 476. Pfeiffer 1876: 112 ('Ins. Gambier, Rapa'). Kobelt & Möllendorff, 1898: 154. Kobelt, 1906: 118 ('Rapa, Gambier-Inseln').

Hydrocena vulpina Pfeiffer, 1857: 112 (**syn. nov.**) ['Fox Islands'; two syntypes, one adult, height 7.3 mm (fresh), one juvenile, height 5.2 mm (collected dead, small hole in last whorl), ex Cuming, BMNH 20001348 (Fig. 2B)].

Cyclomorpha vulpina—Kobelt & Möllendorff, 1898: 154. Kobelt, 1906: 119 ('Fox Islands').

Historical material examined (collected before 1934): 'I. Fox', 4 specimens (with operculum and dried soft parts), Denis collection (before 1945), MNHN. 'I. Fox', 2 specimens (with operculum and dried soft parts), original label: 'ac. Gt' (= achat Gêret?), Letellier collection (before 1949; MNHN). 'I. Fox', 2 specimens (with operculum and dried soft parts), no collector/date (MNHN). 'Fox Insel', 3 specimens (with operculum and dried soft parts), ex coll. Ehrmann ex Sowerby & Fulton (SMF

261054). 'Fox Insel', 4 specimens (2 with operculum and dried soft parts), ex Möllendorff collection (SMF 144666). 'Fox Id.', 7 specimens (6 with dried soft parts and operculum), Melvill-Tomlin collection (NMW). 'Fox Island', 2 specimens (1 with operculum and dried soft parts), G. W. Tryon, Jr collection (ANSP 13396). 'Fox Insel', 2 specimens (fresh, but empty, one loose operculum), acquired from French dealer, Paetel collection (ZMB 104160). 'Ile Gambier', 9 specimens (mostly with operculum and dried soft parts), Lesson 1842 (original label: 'Mr Lesson/7bre 1842'; 'Ile Gambier' on a second label, different handwriting and paper; MNHN). 'Akamaru, Tahiti' [sic; Akamaru is one of the Gambier], 1 specimen (dead, old), Sykes collection (before 1954; BMNH). 'Iles Gambier', 2 specimens (one with operculum and dried soft parts), Letellier collection (before 1949; MNHN). 'Sandwich' (in error), 12 specimens (mostly with operculum and dried soft parts), ex Laboratoire de Géologie de la Sorbonne (before 1952; MNHN). 'Rikitea', 21 specimens (dead, but many with fresh colours), collected by Seurat, accessioned 1906 (MNHN). 'I. Gambier', 2 specimens (with operculum and dried soft parts), Dautzenberg collection, acquired from G eret ex coll. Ancey 15.xii.1908 (IRSNB). 'I. Gambier', 1 specimen, Dautzenberg collection ex W. Blume 31.v.1924 (IRSNB). 'Mangareva, Tuamotu', 6 specimens (all with operculum and dried soft parts; BPBM 115400). 'Mangareva, Tuamotu', 6 specimens (all with operculum and dried soft parts), identified as *C. lessoni* (MS name; BPBM 115401). 'Ins. Tuamotu', 3 specimens (two with operculum and dried soft parts), ex coll. ? [illegible], ex Rolle (SMF 187107). 'Marutea, Paumotu', 1 specimen (dead, fresh), pres. C. Hedley (AMS C34778).

Material examined from Mangarevan Expedition (all empty shells, collected by D. Anderson, Y. Kondo & C. M. Cooke Jr, May–June 1934). *Agakauitai*: stn 195, N.W. side of island, back of beach, hillside, 100 ft inland, on sandy soil, 172 specimens (BPBM 138920–138922; Fig. 3F). *Akamaru*: stn 97, NW side, flat, 20–200 ft inland, alt. 6 ft, on cliff, 46 specimens (BPBM 138841–138844); stn 107, flat, alt. 3–5 ft in wave cutting, 162 specimens (BPBM 138863–138864); stn 128, 'probably from near beach stn 107', 27 specimens (BPBM 138867). *Aukena*: stn 82, Flat, 20 ft inland, alt. 10 ft, 41 specimens (BPBM 138691–138694); stn 88, Flat, 100 ft inland, alt. 6 ft, along trail near gap, 302 specimens (BPBM 138732–138740); stn 102, first cove east of gap, 175 specimens (BPBM 138782–138784); stn 103, second cove east of gap, 32 specimens (BPBM 138811). *Mangareva*: stn 142, Gahutu, flat, 150 ft inland, alt. 6 ft, 46 specimens (BPBM 138956–138959); stn 277, Gahutu, NE end of island, flat, inland 100–200 yards on open ground, 190 specs (BPBM 138993–138994); stn 155, gardens of Rikitea, alt. 5 ft, 6 specimens (BPBM 139006); stn 197, NE of Vaituatai Bay, flat, inland 2–6 ft, alt. 1–3 ft, 3 specimens (BPBM 139027); stn 280, Taku, flat, on trail, 26 June 1934, 11 specimens (BPBM 139031). *Tarava'i*: stn 123, 200 ft inland, along trail through village on open ground, flat, 2 specimens (BPBM 138880; Fig. 3E).

Modern material examined (all MNHN, all empty shells collected by P. Bouchet, September 1997): *Akamaru*: coastal fallow land near former village, 23°10.7' S, 134°54.7' W (AKA 1), 357 specimens (Fig. 3G). *Aukena*: central isthmus, bare sandy ground, 23°07.6' S, 134°54.0' W (AUK 1), 64 specimens (Fig. 3J); north-east part of island, 23°07.5' S, 134°53.9' W (AUK 2), 7 specimens (Fig. 3K); Mata Kuiti Point, light soil mixed with white marine sand, 23°08.05' S, 134°55.1' W (AUK 3), 99 specimens (Fig. 3I). *Kouaku*: motu vegetation on sandy soil, 23°12.0' S, 134°51.6' W, 4 specimens (Fig. 3H). *Mangareva*: Rikitea, north of the village, in layer of marine sand under brown top soil, 23°06.4' S, 134°58.1' W (MGR 1), 2 specimens (fresh, with colour; Fig. 3C); Vaituatai, in spoil earth from small excavation, 23°06.1' S, 134°57.7' W (MGR 2), 15 specimens (some fresh, with colour; Fig. 3B); Ganhutu, lawn in coconut plantation, 23°04.6' S,

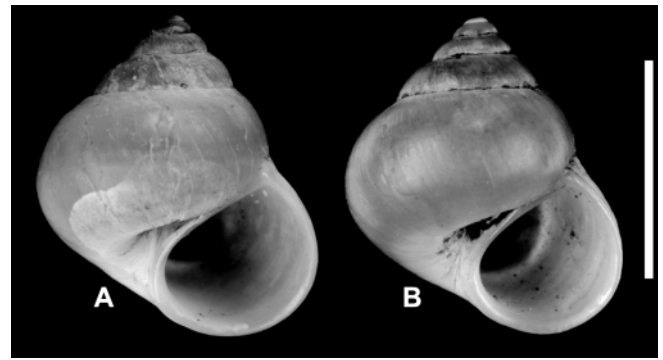


Figure 2. Type specimens of the nominal species now treated as *Omphalotropis margarita* from the Gambier Is. **A.** *Cyclostoma margarita* Pfeiffer, 1851, one of three syntypes (BMNH 20020543), height 7.4 mm, said to be from Rapa, Austral Is (error, see text). **B.** *Hydrocena vulpina* Pfeiffer, 1857, one of two syntypes (BMNH 20001348), height 7.3 mm, said to be from 'Fox Islands' (see text). Scale bar = 5 mm.

134°56.6' W, 222 specs (Fig. 3A); Gatavake, open ground, 23°06.95' S, 134°58.75' W, 65 specimens (Fig. 3D). *Tarauru Roa*: coastal vegetation on sandy soil, 23°06.0' S, 134°52.0' W, 7 specimens (Fig. 3L).

Remarks. The type locality of *Cyclostoma margarita* is certainly erroneous, as the species has never subsequently been recorded from Rapa, other than by repeating Pfeiffer (1851). It is not present among the rich material of Assimineidae collected in Rapa by the *Mangarevan Expedition* in 1934. Strangely enough, Pfeiffer himself described the same species again 6 years later, this time from 'Fox Islands', the name of which must have inspired the specific epithet *vulpina*. We have searched unsuccessfully all sorts of nineteenth century geographical atlases and dictionaries, as well as modern gazetteers, for 'Fox Islands'. To our knowledge, the name does not appear anywhere else in the malacological literature. We believe it may have been a short-lived European name, soon abandoned in favour of the Gambier Islands. The nominal species *Hydrocena vulpina* was never been illustrated. Kobelt (1906) regarded the two nominal species, *margarita* and *vulpina*, as valid, and differentiated them in a key, with *vulpina* having a discontinuous peristome and *margarita* an almost continuous peristome. However, based on our examination of their respective type material, synonymization of *Hydrocena vulpina* with *Cyclostoma margarita* is straightforward. Furthermore, the type material of both is referable to the population of *O. margarita* from Akamaru (see below).

Cyclostoma margarita and *Hydrocena vulpina* have been placed in *Cyclomorpha* since Pease (1871) and Kobelt & Möllendorff (1898), respectively. However, based on the smooth, thinner shell with narrow umbilicus, we transfer the single taxonomic species to *Omphalotropis*. It is remarkable among *Omphalotropis* species by its very large adult size, height up to 12 mm, when most species of *Omphalotropis* measure 4–8 mm.

Omphalotropis margarita is known from Mangareva, Aukena, Akamaru, Agakauitai, Tarava'i, Kouaku and Tarauru Roa; it was not found on Kamaka (the historical record of *O. margarita* from Marutea in AMS is not absolutely rejected, but is very suspicious; there are two atolls with the name Marutea in the Tuamotu; Marutea Sud is the nearest atoll, c. 200 km to the north of the Gambier group). Despite the small land area and the short distances between islands of the Gambier, *O. margarita* exhibits much microgeographical variation (Fig. 3). Specimens from Akamaru are the smallest, and those from Mangareva and Aukena are the largest, albeit with variation within each island (Table 1). The size of the adult type specs of both *Cyclostoma margarita* and *Hydrocena vulpina* corresponds most closely with that of the

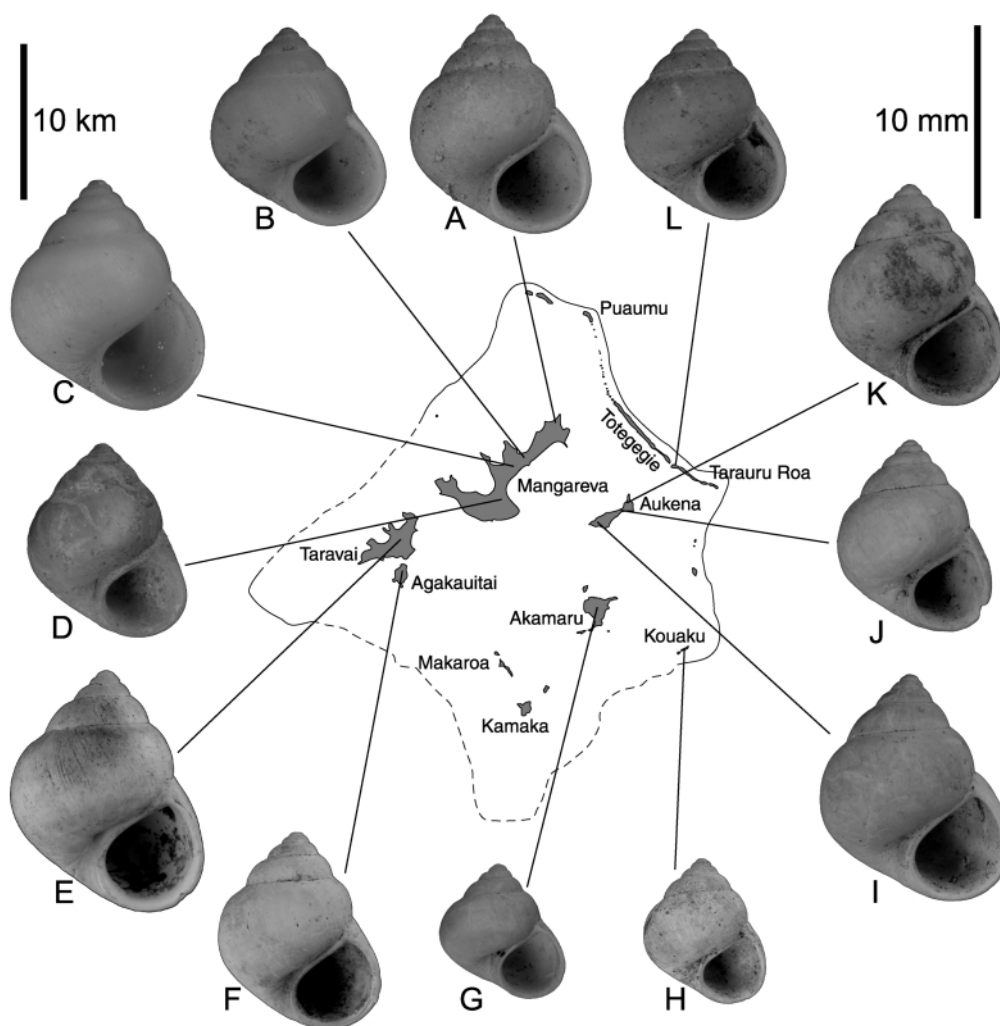


Figure 3. Microgeographical variation of *Omphalotropis margarita* in the Gambier Islands. **A.** Mangareva, Ganhutu, 12.0 mm. **B.** Mangareva, Vaituatai, 10.3 mm. **C.** Mangareva, Rikitea, 12.0 mm. **D.** Mangareva, Gatavake, 10.1 mm. **E.** Taravai, 11.4 mm. **F.** Agakauitai, 10.2 mm. **G.** Akamaru, 7.0 mm. **H.** Kouaku, 7.6 mm. **I.** Aukena, Mata Kuiti Point, 12.0 mm. **J.** Aukena, central isthmus, 10.0 mm. **K.** Aukena, north-east part, 11.5 mm. **L.** Tararuru Roa, 10.0 mm. Specimens E and F collected by the *Mangarevan Expedition* in 1934, all other specimens collected by the senior author in 1997. Scale bars = 10 mm and 10 km for shells and geographical features, respectively.

Akamaru population, suggesting that these specimens, originally said to be from 'Rapa' and 'Fox Islands', came from Akamaru. The specimens from the collection of Lesson, acquired by MNHN in 1842, also correspond to this small form. Today, the 'capital' of the Gambier is Rikitea, on the island of Mangareva. However, historically, Akamaru is the island where European settlement first took place, with the 'Bishop's Palace' established there in 1834. This historical pre-eminence of Akamaru is consistent with land snails being first collected there, rather than on the larger island of Mangareva, which was converted to Christianity only a few years later.

DISCUSSION

Terrestrial Assimineidae in eastern Polynesia

The supraspecific classification of the family Assimineidae has not been reviewed since Thiele (1927) and the species-level systematics is in still greater need of revision. Whereas the subfamily Assimineinae occurs worldwide, and includes essentially fresh- or brackish-water species, the subfamily Omphalotropidinae includes terrestrial species from the Indo-Pacific region.

The subfamily Omphalotropidinae has not been monographed since Kobelt (1906), who recognized 163 valid species; scattered additions have been published since (e.g. Cooke & Clench, 1943). Regional diversity in the South Pacific is high, with many highly localized species, e.g. 16 species are known from Fiji, with up to four sympatric species in the Lau Islands (Solem, 1978). At the generic level, the genera *Electrina* Baird, 1850 and *Rapanella* Cooke & Clench, 1943 are endemic to Rapa, *Garrettia* Paetel, 1873 is endemic to the Cook Islands, and *Fijianella* Cooke & Clench, 1943 is endemic to the Lau group of Fiji. Of the two species historically occurring in the Gambiers, *Cyclomorpha* is endemic to the Tuamotu-Gambier chain, but *Omphalotropis* (as broadly understood by Kobelt, 1906; Thiele, 1927; Wenz, 1939) has a broad distribution in the Indian and Pacific oceans. The family is poorly represented further east than the Gambiers; a single species was recorded (as *Assimineea* sp.) from Henderson and Pitcairn by Preece (1995). In conclusion, when viewed in a regional context, the terrestrial assimineids of the Gambiers represent outliers of a fauna that has its maximum diversity further west in the high islands of the Society, Austral, Cook and Lau archipelagoes, and the species-level endemism reflects the geographical isolation and geological age of the island group.

EXTINCT TERRESTRIAL ASSIMINEIDS

Table 1. Mean adult size of *Omphalotropis margarita* from eight populations on four islands in the Gambier group. See text for geographical coordinates of stations.

Population	Mean adult size (mm)	No. specs measured
Akamaru	7.02	32
Aukena: central isthmus	8.86	19
Aukena (AUK 2)	10.26	5
Aukena: Mata Kuiti Pt	11.82	26
Agakauitai	10.40	29
Mangareva: Gatavake	10.47	12
Mangareva: Vaituatai	11.04	7
Mangareva: Ganhutu	12.03	27
<i>Cyclostoma margarita</i> type material	7.4, 7.0, 7.0	3
<i>Hydrocena vulpina</i> type material	7.3	1

Dating the extinction of terrestrial Assimineidae in the Gambier Islands

When the Mangarevan Expedition visited the Gambiers in 1934 they found considerable environmental degradation; only a small patch of native forest remained at the base of the cliff of Mt Mokoto. In 1997, with the exception of that still persisting patch of forest, the rest of the islands was completely devoid of natural vegetation, and was either covered with 'grass' (*Miscanthus*) or replanted with aliens (mostly *Casuarina* and *Albizia*). Such habitats harbour introduced species of land snails, but no endemic/native species. The narrative of the Mangarevan Expedition makes it clear that considerable effort was spent by skilled collectors to find living specimens of the native snails, but only empty shells of most species were found (Cooke, 1935). The islands of Mangareva, Aukena and Akamaru are very rugged, and the localities where the shells of *Omphalotropis margarita* were collected in 1934 and 1997 are small coastal plains that are now (and presumably were in 1934) completely modified for small-scale subsistence agriculture. Conversely, Tarauru Roa and Kouaku are flat islands of the atoll barrier. Tarauru Roa is profoundly transformed by a coconut plantation, but Kouaku has essentially retained its native vegetation. On all five islands, shells of *O. margarita* were found in superficial sandy soil with shell accumulations, except at two localities: Rikitea and Vaituatai, on the island of Mangareva, where the shells of *Omphalotropis* were found in a sandy horizon under 40–60 cm of brown soil, presumably resulting from the erosion of a nearby hill.

The 1934 and 1997 findings contrast sharply with the situation in the nineteenth century, as documented by museum samples; many were obviously collected alive, as evidenced by the dried soft parts and opercula. The dates accompanying museum samples, however, have different meanings. A date may represent the year a private collection was acquired by a museum; this is clearly the case with the dates 1949 and 1954 accompanying samples from the Letellier collection in MNHN and Sykes collection in BMNH, respectively. A date may also represent the year a private collector acquired specimens for his own collection; this is the case with the dates 1908 and 1924 accompanying samples acquired by Philippe Dautzenberg, respectively, from Ancey and from Blume, neither of whom visited Polynesia. All these collectors traded with each other and with dealers, and the material in their collections may have been collected several decades earlier. This, in fact, leaves us with only a few samples that carry unambiguous information of relevance to the present discussion.

1842. This is the date accompanying the oldest museum record of *Omphalotropis margarita*, a MNHN lot of 9 specs, mostly live collected, with the indication 'Lesson 1842'. René-Primevère

Lesson, a naturalist, never visited the Gambiers, but his brother Pierre-Adolphe Lesson, a medical doctor, is known to have called at the Gambiers in 1840 aboard the vessel *Pylade* (Vallaux, 1994). Alternatively, Lesson's specimens may have been collected during the expedition of the *Astrolabe* and *Zélée*, under Dumont d'Urville, which called at the Gambiers in August 1838.

1851, 1857. These are the dates of the descriptions of the two nominal species, *Cyclostoma margarita* Pfeiffer, 1851 (the BMNH type lot contains at least one specimen with operculum and dried soft parts) and *Hydrocena vulpina* Pfeiffer, 1857 [although there is no evidence that the type lot in BMNH was collected alive, the original description states '*Operc. tenue, castaneum, paucispirum*' (operculum thin, chestnut-brown, with few whorls)]. The short-lived locality name 'Fox Islands' accompanying eight lots in five museums suggests that all, including the type lot of *Hydrocena vulpina* may, in fact, originate from a single large, live-collected, sample that was split again and again by dealers and collectors. Although 1851 and 1857 are not the dates of collection of the specimens, it is likely that, because of the high competition among taxonomists for the descriptions of new species in those days, only a few years must have passed between the collection of the material and its description by Pfeiffer.

1902–1904. Seurat, a zoologist working for MNHN, was based in Mangareva in 1902–1904. Although his interest was mainly marine biology (Seurat, 1903), he collected 21 specimens of *O. margarita* (accessioned in MNHN in 1906); all are empty shells, although with fresh colours. It is probable that, had the species been as plentiful alive in 1903–1904 as it apparently was in the 1850s, Seurat would have collected some specimens.

Museum records thus point to an extinction of *Omphalotropis margarita* sometime between the 1850s and the 1900s. Dating the extinction of *Cyclomorpha secessa* is more problematic as the species was already extinct when first collected by the Mangarevan Expedition in 1934. We can only hypothesize that it must have been rare and/or ecologically restricted already in the nineteenth century, because it is not present (except for the type lot) in museum collections when, conversely, a total of at least 90 specimens of *Omphalotropis margarita* were present in at least eight museums before 1934.

The extinction of the endemic assimineids of the Gambier is just one more facet of the environmental crisis that has affected the native land snail fauna of this island group (Abdou & Bouchet, 2000; Bouchet & Abdou, 2001). Extinction on very isolated Polynesian islands such as Easter Island has been so complete that its modern land mollusc fauna consists exclusively of introduced species (Boyko & Cordeiro, 2001).

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REFERENCES

- ABDOU, A. & BOUCHET, P. 2000. Nouveaux gastéropodes Endodontidae et Punctidae (Mollusca : Pulmonata) récemment éteints de l'archipel des Gambier (Polynésie). *Zoosystema*, **22**: 689–707.

- BAKER, H.B. 1940. Zonitid land snails from Pacific islands. Part 2. Hawaiian genera of Microcystinae. *Bernice P. Bishop Museum Bulletin*, **165**: 105–201.
- BELLON, H. 1974. Histoire géochronométrique des îles Gambier. *Cahiers du Pacifique*, **1**: 245–251.
- BOUCHET, P. 1998. Mangareva: splendor and decline of a Pacific island land snail fauna. In: *Abstracts of the World Congress of Malacology*, Washington, DC (R. Bieler & P.M. Mikkelsen, eds), 39. Unitas Macologica.
- BOUCHET, P. & ABDU, A. 2001. A new Recent extinct land snail from the Gambier Islands with remarkable apertural barriers. *Pacific Science*, **55**: 121–127.
- BOYKO, C. & CORDEIRO, J. 2001. The terrestrial Mollusca of Easter Island (Gastropoda, Pulmonata). *Basteria*, **65**: 17–25.
- BRODERIP, W.J. 1832. Characters of new species of Mollusca and Conchifera collected by Mr Cuming. *Proceedings of the Committee of Science and Correspondence of the Zoological Society of London*, **2**: 50–61.
- COOKE, C.M. 1935. Report of C. Montague Cooke, Jr., malacologist and leader, Mangarevan expedition. *Bernice P. Bishop Museum Bulletin*, **133**: 36–56.
- COOKE, C.M. & CLENCH, W.J. 1943. Land shells (Synceridae) from the southern and western Pacific. *Occasional Papers of Bernice P. Bishop Museum*, **17**: 249–262.
- COOTE, T., LOEVE, E., MEYER, J.Y. & CLARKE, D. 1999. Extant populations of endemic partulids on Tahiti, French Polynesia. *Oryx*, **33**: 215–222.
- COWIE, R.H. 1992. Evolution and extinction of Partulidae, endemic Pacific island land snails. *Philosophical Transactions of the Royal Society of London, Series B*, **335**: 167–191.
- HADFIELD, M.G., MILLER, S.E. & CARWILE, A.H. 1993. The decimation of endemic Hawaiian tree snails by alien predators. *American Zoologist*, **33**: 610–622.
- KOBELT, W. 1906. Synopsis der Pneumonopomen-Familie Realiidae. *Jahrbücher des Nassauischen Vereins für Naturkunde*, **59**: 47–144.
- KOBELT, W. & MÖLLENDORFF, O. von. 1898. Catalog der gegenwärtig lebend bekannten Pneumonopomen. *Nachrichtsblatt der Deutschen Malakozoologischen Gesellschaft*, **30**: 129–160.
- PEASE, W.H. 1871. Catalogue of the land-shells inhabiting Polynesia, with remarks on their synonymy, distribution, and variation, and descriptions of new genera and species. *Proceedings of the Zoological Society of London*, **1871**: 449–477.
- PFEIFFER, L. 1851. Descriptions of forty-three new species of Cyclostomacea, from the collection of Hugh Cuming, Esq. *Proceedings of the Zoological Society of London*, **1851**: 242–251.
- PFEIFFER, L. 1852. *Monographia pneumonopomorum viventium*. T. Fischer, Cassel.
- PFEIFFER, L. 1853 [in 1850–1854]. Die gedeckelten Lungenschnecken. (Helicinacea et Cyclostomacea.) Zweite Abtheilung der gedeckelten Cöloponen. In: *Systematisches Conchylien-Cabinet von Martini und Chemnitz*, ed. 2 (H.C. Küster, ed.), **1(19)**. Bauer & Raspe, Nürnberg.
- PFEIFFER, L. 1857. Descriptions of thirty-one new species of land-shells, from Mr Cuming's collection. *Proceedings of the Zoological Society of London*, **1857**: 107–113.
- PFEIFFER, L. 1876. *Monographia pneumonopomorum viventium. Suppl. 3, Monographiae auriculaceorum*, **2**. T. Fischer, Cassel.
- PREECE, R.C. 1995. Systematic review of the land snails of the Pitcairn Islands. *Biological Journal of the Linnean Society*, **56**: 273–307.
- PREECE, R.C. 1998. Impact of early Polynesian occupation on the land snail fauna of Henderson Island, Pitcairn group (South Pacific). *Philosophical Transactions of the Royal Society of London, Series B*, **353**: 347–368.
- REEVE, L. 1861. Monograph of the genus *Cyclophorus*. In: *Conchologia Iconica*, **13**. Lovell Reeve, London.
- SEURAT, L.G. 1903. [Letter of 21 May 1903 from Rikitea, Mangareva]. *Bulletin du Muséum national d'Histoire naturelle, Paris*, **9**: 310–311.
- SOLEM, A. 1978. Land snails from Mothe, Lakemba, and Karoni Islands, Lau Archipelago, Fiji. *Pacific Science*, **32**: 39–45.
- SOLEM, A. 1983. *Endodontoid land snails from Pacific Islands (Mollusca: Pulmonata: Sigmurethra). Part 2. Families Punctidae and Charopidae. Zoogeography*. Field Museum of Natural History, Chicago.
- THIELE, J. 1927. Über die Schneckenfamilie Assimineidae. *Zoologische Jahrbücher, Abt. für Systematik, Ökologie und Geographie der Tiere*, **53**: 113–146.
- VALLAUX, F. 1994. *Mangareva et les Gambier*. Ministère de l'Éducation de Polynésie française and Etablissement Territorial d'Achats Groupés, Tahiti.
- WENZ, W. 1939 [in 1938–1944]. Gastropoda. Teil 1: Allgemeiner Teil und Prosobranchia. In: *Handbuch der Paläozoologie* (O. H. Schindewolf, ed.), **6**: 481–720. Borntraeger, Berlin.