

Nonmarine Mollusks from Archaeological Sites on Tikopia, Southeastern Solomon Islands¹

CARL C. CHRISTENSEN² and PATRICK V. KIRCH³

ABSTRACT: Eighteen species of nonmarine mollusks are recorded from the island of Tikopia, southeastern Solomon Islands. Material studied was obtained from eight archaeological sites; a small sample of live-collected specimens was also examined. Fifteen species of terrestrial mollusks were present in this material: six are believed to be indigenous to the island (although none is precinctive to it), eight were introduced by humans, and the status of one is uncertain. Three additional species inhabiting estuarine, strandline, or aquatic environments were found. The terrestrial mollusks of Tikopia are typically New Hebridean, although prosobranchs and large pulmonates are poorly represented in the fauna. Radiocarbon dates associated with several of the archaeological samples demonstrate that most of the adventive species colonized the island during the prehistoric period: *Lamellidea pusilla*, *Gastrocopta pediculus*, and *Lamellaxis gracilis* were present on the island by ca. 900 B.C., and by ca. A.D. 1400 *Liardetia samoensis*, *Wilhelminia mathildae*, and *Coneuplecta microconus* had become established. Two exotic subulinids have been introduced during the modern era. The numerical predominance in all archaeological samples of individuals of adventive species indicates that the Tikopian environment was significantly modified by humans during the prehistoric period, probably as a result of agricultural practices.

SUBFOSSIL SHELLS of nonmarine mollusks recovered during archaeological excavations may serve as useful indicators of past environmental conditions. In regions where the habits of mollusks are well known the technique of "snail analysis" (analogous to pollen analysis) can attain a high degree of precision in determining the vegetation associated with assemblages of subfossil mollusks (Evans 1972). Little work of this nature has been attempted in Melanesia, Micronesia, and Polynesia, due largely to our inadequate knowledge of the systematics and ecological tolerances of nonmarine mollusks there. Studies by Kirch (1975) and

Wallace (1979), in which evidence from subfossil land snail assemblages was used to document vegetational changes in Hawaiian and New Zealand sites, respectively, are almost the only recent reports of such investigations known to us.

Samples of nonmarine mollusks obtained during archaeological studies undertaken in 1977 by Kirch on Tikopia, southeastern Solomon Islands, provided an opportunity to apply the technique of snail analysis in environmental reconstruction. The results of this analysis are consistent with the conclusion that the insular environment was subject to significant human modification during the prehistoric period. The material documents the presence on Tikopia prior to European contact of several land snail species believed to be adventive in origin (introduced by humans) and, together with a small collection of modern land mollusks obtained in 1966, provides the first available data on the nonmarine mollusks of the

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²Bernice P. Bishop Museum, Department of Zoology, P.O. Box 19000-A, Honolulu, Hawaii 96819.

³Bernice P. Bishop Museum, Department of Anthropology, P.O. Box 19000-A, Honolulu, Hawaii 96819.

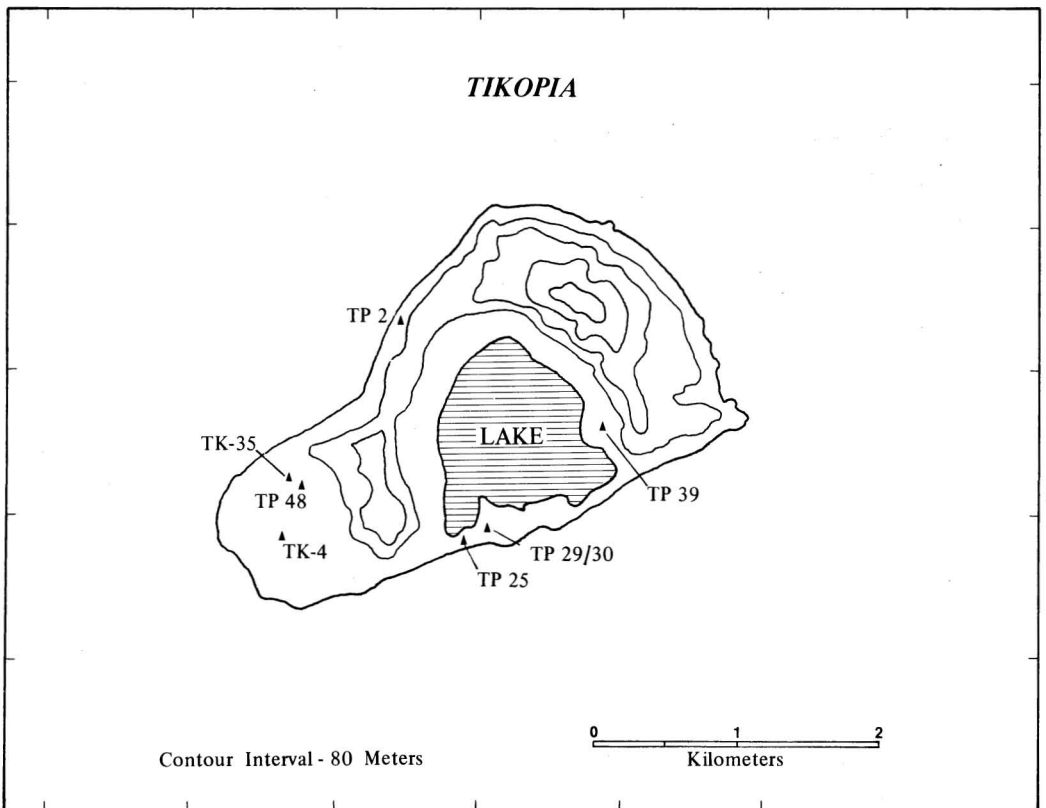
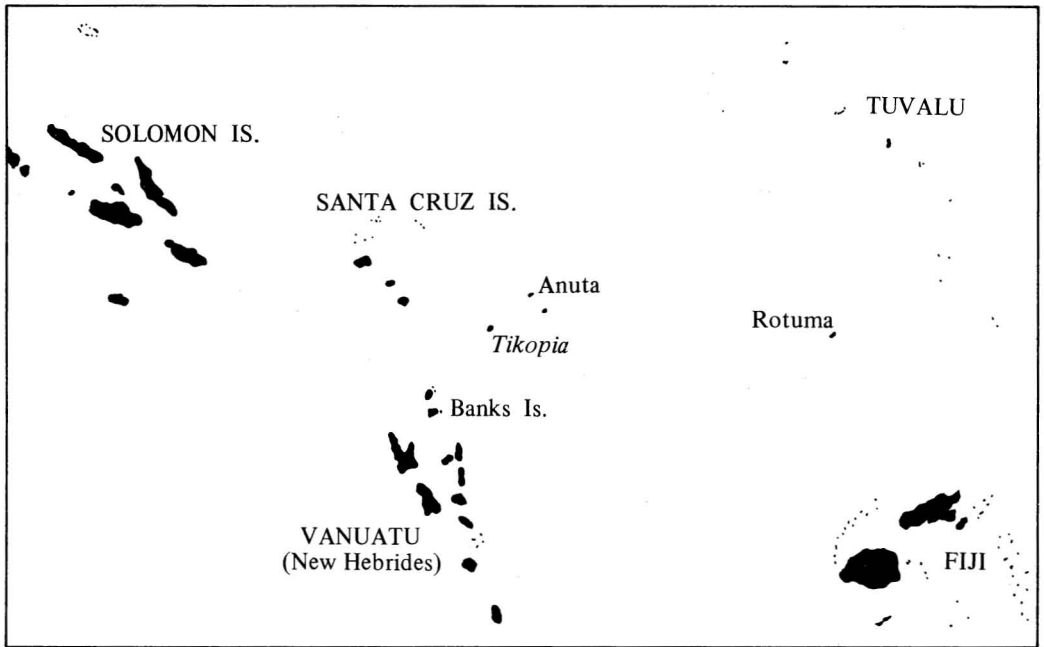


FIGURE 1. Location of Tikopia Island and of Tikopian archaeological sites.

island. Although the studies of Solem (1959, 1962, 1963) have made the nonmarine molluscan fauna of the New Hebridean and Santa Cruz islands among the best studied in Oceania, no report of the Tikopian fauna has previously been published.

GEOGRAPHICAL SETTING

Tikopia (latitude 12°17' S, longitude 168°48' E) is a small high island of volcanic origin situated 233 km southeast of Vanikoro Island (Santa Cruz group) and 213 km north of Vanua Lava (Banks group, New Hebrides); its closest neighbor is tiny Anuta, 139 km to the east (Figure 1a). Although geographically associated with the New Hebridean archipelago (now the nation of Vanuatu), Tikopia and the Santa Cruz Islands are administratively part of the Solomon Islands.

Tikopia has a land area of about 6 km² and a maximum elevation of 360 m. The island consists of a volcanic cone with a central crater that has been breached on its southern side by the sea. Reef and sand-dune development have built a tombolo across this gap, and the central crater depression is filled with a brackish lake. On the western (leeward) side of the volcanic mass a constructional plain up to 1 km across has

been built up of biocarbonate sediments. Potassium-argon dating (Hughes forthcoming) indicates that Tikopia is of late Pleistocene age (< 80,000 years). Ocean depths exceeding 2000 m separate the island from others in the region.

Tikopia is inhabited by a population of about 1300 Polynesian-speaking persons who cultivate all but the steepest cliffs of the island's fertile slopes. Little remains of the native vegetation that must once have covered the island. Archaeological investigations (Kirch and Yen in preparation) have documented continuous human occupation of the island since at least 900 B.C.

CONTEXT OF ARCHAEOLOGICAL SAMPLES

Molluscan samples were obtained from eight archaeological sites (TK-) or test pit (TP-) localities, the stratigraphic contexts and radiocarbon ages of which are summarized in Table 1. Specimens from TK-4, TP-2, TP-39, and TP-48 were sieved from soil taken with charcoal samples; those from TP-25, TP-29, and TP-30 were recovered by flotation from midden soil. A single specimen was obtained from an additional site (TK-35). Specimens obtained are listed in Table 2.

A detailed report on the archaeological

TABLE 1
ARCHAEOLOGICAL CONTEXT AND AGE OF SAMPLES

SITE/TEST PIT	LAYER	STRATIGRAPHIC CONTEXT	RADIOCARBON DATE*
TK-4	II	Prehistoric midden deposit; earliest settlement site on island	891 ± 90 B.C.
TK-35	IV	Prehistoric midden deposit	ca. A.D. 50†
TP-2	II	Prehistoric midden deposit	55 ± 100 B.C.
TP-25	I	Historic-period midden deposit	
TP-25	II	Gray dune sand with limited midden material	
TP-25	III	Late prehistoric midden deposit	A.D. 1407 ± 75
TP-29	I	Historic-period midden deposit	
TP-30	II	Historic-period midden deposit	
TP-39	II	Historic-period midden deposit	< 90 years B.P.
TP-48	III	Prehistoric midden deposit	190 ± 95 B.C.

* Radiocarbon ages corrected for secular variation after Michael and Ralph (1972).

† Based upon C¹⁴ age determination from the same stratigraphic zone in adjacent test pits.

TABLE 2

ABSOLUTE ABUNDANCE OF NONMARINE MOLLUSKS IN TIKOPIAN ARCHAEOLOGICAL SITES, BY SPECIES

SPECIES	ECOLOGICAL GROUP*	TK-4 Ly II	TK-35 Ly IV	TP-2 Ly II	TP-25 Ly I	TP-25 Ly II	TP-25 Ly III	TP-29 Ly I	TP-30 Ly II	TP-39 Ly II	TP-48 Ly III
<i>Omphalotropis setocincta</i>	TI	—	—	1	5	9	3	2	8	10	3
<i>O. acrostoma</i>	TI	—	—	—	—	—	—	2	—	4	—
(?) <i>O. sp.</i>	TI	—	—	—	—	1	—	—	—	—	—
<i>Succinea sp. cf. kuntziana</i>	TI	—	—	—	1	—	—	—	—	—	—
<i>Mocella euryomphala</i>	TI	2	—	—	—	1	—	—	—	—	—
<i>Ouagapia perryi</i>	TI	—	—	2	—	2	2	1	3	5	1
<i>Nesopupa sp.</i>	TI?	—	—	—	—	—	—	1	—	—	—
<i>Lamellidea pusilla</i>	TA	1	—	—	3	14	5	18	26	+	—
<i>Gastrocopta pediculus</i>	TA	+	—	2	4	13	1	5	5	+	5
<i>Liardetia samoensis</i>	TA	—	—	—	1	3	1	1	—	4	—
<i>Wilhelminaia mathildae</i>	TA	—	—	—	—	—	2	—	4	2	—
<i>Coneuplecta microconus</i>	TA	—	—	—	—	—	1	—	—	1	—
<i>Lamellaxis gracilis</i>	TA	3	1	2	48	108	83	180	114	37	9
<i>Opeas pumilum</i>	TA	—	—	—	—	—	—	16	—	—	—
<i>Subulina octona</i>	TA	—	—	—	—	—	—	2	1	—	—
<i>Truncatella guerinii</i>	ES	—	—	—	—	—	—	1	—	1	—
" <i>Assiminea</i> " sp.	ES?	1	—	—	—	—	2	32	20	—	3
<i>Melanoides sp.</i>	A	—	—	—	—	—	—	1	—	—	—
Unidentified	?	2	—	—	—	—	—	—	—	—	—
Total number of shells†		9	1	7	62	151	100	262	181	64	21
Total number of species (excluding unidentified shells)		5	1	4	6	7	9	13	8	10	5

*TI = Terrestrial, Indigenous; TA = Terrestrial, Adventive; ES = Estuarine or Strandline; A = Aquatic.

†Nonapical shell fragments (+) not counted.

investigations of Tikopia will be published elsewhere (Kirch and Yen in preparation); the following notes briefly describe the setting and character of each locality from which molluscan samples were obtained.

The oldest archaeological site on Tikopia is TK-4, a small settlement situated atop an ancient shoreline dune on the leeward lowland sandy plain (Figure 1*b*). Layer II at TK-4, radiocarbon dated to ca. 900 B.C., represents the initial colonization of the island by a human population, probably Austronesian speakers with affinity to the Lapita Cultural Complex.

Sites TK-35 and TP-48 are both part of a deeply stratified series of sand-dune midden deposits spanning a period of ca. 2500 years. Layer III in TP-48 represents the latter portion of the Kiki Phase, the first period in the island's prehistoric cultural sequence; Layer IV in TK-35 represents the early portion of the subsequent Sinapupu Phase. On the island's north coast, Layer II in TP-2 is contemporaneous with the TK-35 locality.

TP-25, TP-29, and TP-30 are situated along the sand spit or tombolo that separates Tikopia's lake from the ocean. Archaeological and geomorphological studies (Kirch and Yen in preparation) clearly demonstrate that this tombolo is a relatively recent formation, with an age probably not greater than 600 years.

TP-25 lies in the hamlet of Potu sa Taumako, near the point where the tombolo joins the stable volcanic crater rim. This area is thus likely to be the oldest part of the tombolo. Layer III in TP-25 is of late prehistoric age, while the temporally succeeding Layers II and I date to the historic period (after ca. A.D. 1800).

TP-29 and TP-30 lie in the hamlet of Potu sa Kafika. Excavations here indicate that the tombolo formed a substantial dune only in historic times. The samples from TP-29 and TP-30 therefore date within the last two centuries.

TP-39 is located at Rangaruru, a low-lying sand spit that juts into the lake along its eastern margin. A charcoal sample from

Layer II indicates a recent age (less than 90 years).

In addition to these archaeological specimens, we studied a small sample of live-collected terrestrial snails, taken at Ngatoraromanongi (elevation 3–4 m) by Pa Raromanongi and Pa Faleleu on 10 August 1966 and donated to the Bishop Museum by Dr. Torben Monberg.

All specimens are deposited in the collection of the Division of Malacology of the Bishop Museum.

SYSTEMATIC REVIEW

Family Truncatellidae

Truncatella guerinii A. Villa and J. B. Villa, 1841

Truncatella guerinii is widely distributed in the Indo-Pacific region, occurring from the coast of Africa to Japan, New Caledonia, and the Society Islands. It is probably to be found throughout the New Hebrides and is the only member of the family yet recorded there (Solem 1959). Peake (1968) reported it as a common inhabitant of the upper strandline zone in the Solomon Islands, a habitat typical of the genus.

Family Assimineidae

"*Assimineae*" sp.

Figure 2*a*

A number of specimens were obtained of an unidentified assimineid closely resembling *Assimineae nitida* (Pease) but lacking the raised subsutural thread characteristic of that species. Although they are tentatively assigned here to the genus *Assimineae*, they differ from *A. nitida* in much the same way as a poorly known Cook Island *Paludinella* often confused with that species (Abbott 1958). Resolution of this matter will require anatomical study, not possible with the present material. *Assimineae* is a genus of estuarine or strandline-dwelling snails, while *Paludinella* is wholly terrestrial in habit (Abbott 1958).

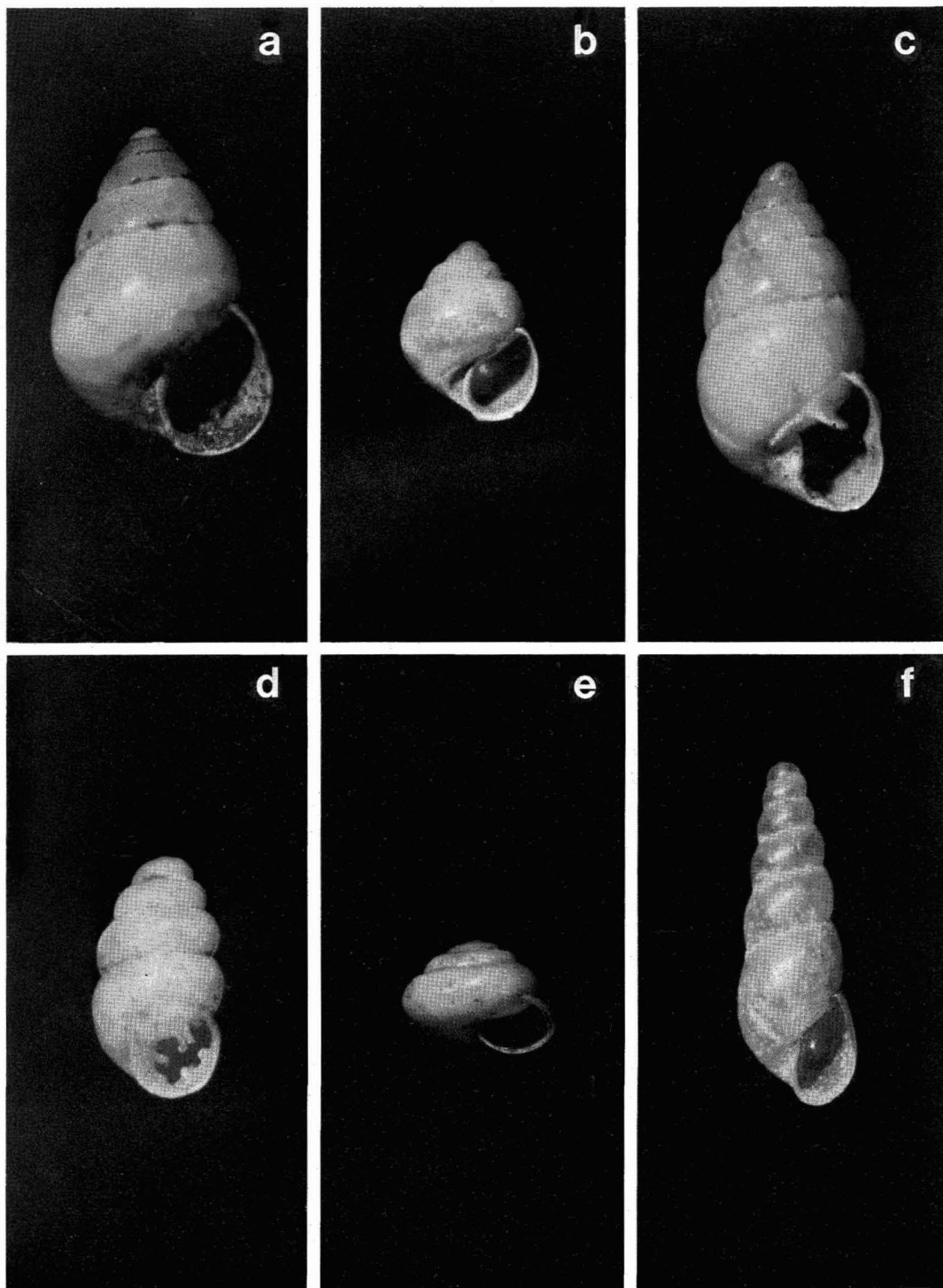


FIGURE 2. Shells of Tikopian nonmarine mollusks (not to scale): a, "*Assimineae*" sp. (shell height 3.1 mm); b, *Omphalotropis setocincta* (3.4 mm); c, *Lamellidea pusilla* (3.4 mm); d, *Gastrocopta pediculus* (2.4 mm); e, *Liardetia samoensis* (2.3 mm); f, *Lamellaxis gracilis* (6.6 mm; specimen from Huahine, Society Islands).

Omphalotropis setocincta Ancey, 1890

Figure 2b

This species has not been reported to occur outside the New Hebrides and adjacent islands, although it may prove to be conspecific with related forms inhabiting the Marianas, Fiji, and New Caledonia (Solem 1959, 1962, 1978). Solem (1959) reported living individuals among decaying coconuts and other debris in coastal areas, but not under strandline conditions.

Omphalotropis acrostoma Solem, 1962

This species has previously been reported to occur on two islands in the New Hebrides (Solem 1962, 1963). In addition to material from archaeological sites, our Tikopian specimens include four recent shells obtained by Torben Monberg in 1966.

(?) *Omphalotropis* sp.

This record is based upon a single apical shell fragment, apparently of a species of *Omphalotropis*.

Family Thiaridae

Melanoides sp.

A single worn and immature specimen of *Melanoides* was found. Starmühlner (1976) reported the occurrence of six species of the genus in the streams and rivers of the New Hebrides and the Santa Cruz Islands.

Family Achatinellidae

Lamellidea pusilla (Gould, 1847)

Figure 2c

Lamellidea pusilla is widely distributed in Polynesia and Micronesia, commonly occurring on atolls and other low islands. In Melanesia it has been reported from Fiji (Cooke and Kondo 1960), Espiritu Santo in the New Hebrides (Solem 1959), and the Solomon Islands (Kondo 1975). Cooke and Kondo (1960) and Solem (1978) believed this species to have been transported by Pacific islanders to many of the islands it now inhabits.

Family Partulidae

Partula sp. cf. *auraniana* Hartman, 1888

A number of living individuals of a species of the *Partula auraniana* group (as defined by Solem 1959) were obtained on Tikopia by Monberg in 1966, although none has been recovered from archaeological sites. The *P. auraniana* group is restricted to the northern islands of the New Hebridean region.

Family Pupillidae

Nesopupa sp.

Species of *Nesopupa* occur throughout the Pacific islands, but none has been reported from the New Hebrides or the Santa Cruz Islands. With the exception of Hawaiian taxa, Pacific *Nesopupa* are poorly known, and the single Tikopian specimen seen cannot be identified at this time. Although most Pacific *Nesopupa* species are high-island snails and none is known to have been transported by humans, representatives of the genus are occasionally found on atolls (Harry 1966; BPBM collection).

Gastrocopta pediculus (Shuttleworth, 1852)

Figure 2d

Gastrocopta pediculus occurs throughout Polynesia, Micronesia, and Melanesia (including the New Hebrides), and also in the Philippines, Indonesia, and Australia (Pilsbry 1916–1918; Solem 1959, 1962). Pilsbry (1916–1918) believed this characteristic inhabitant of atolls and low-elevation regions of high islands to have been transported by Pacific islanders throughout Oceania.

Family Succineidae

Succinea sp. cf. *kuntziana* Solem, 1959

The single succineid collected on Tikopia is too worn for positive identification but is probably *Succinea kuntziana*, the only member of the family known to occur in the New Hebridean region. The species is restricted to those islands, but is closely related to and possibly conspecific with taxa inhabiting neighboring island groups. S.

kuntziana sometimes occurs in association with cultivated plants (Solem 1959, 1962, 1963).

Family Charopidae

Mocella euryomphala Solem, 1959

This species has previously been reported to be restricted to the New Hebrides (Solem 1959, 1962, 1963).

Family Helicarionidae

Liardetia samoensis (Mousson, 1865)

Figure 2e

Liardetia samoensis is widely distributed in Polynesia, Micronesia, and Melanesia (including the New Hebrides). It is a member of the so-called atoll fauna (Solem 1959) but is not restricted to low elevations. It has been identified as a species probably dispersed throughout the Pacific islands by commerce (Baker 1938, 1941; Solem 1959, 1962, 1963), possibly during the prehistoric period (Solem 1978).

Wilhelminaia mathildae Preston, 1913

Identification of these specimens follows Solem (1959, 1960), who reported the species to occur in the Solomon and Caroline islands, the New Hebrides, and probably also in Indonesia. Baker (1941) believed the wide range of this snail (which he placed in the genus *Discoconulus*) to be due to dispersal by humans. Solem (1959) considered it a member of the atoll fauna.

Coneuplecta microconus (Mousson, 1865)

Coneuplecta microconus inhabits the islands of Melanesia and Polynesia from the New Hebrides to Fiji, Tonga, and Samoa. Solem (1959) regarded it as a member of the atoll fauna, but the species has also been reported to occur at elevations of up to 600 m (Solem 1962). This is another species thought to have been transported by humans (Baker 1941, Solem 1962), possibly in precontact times (Solem 1978).

Family Rhytididae

Ouagapia perryi (Smith, 1897)

This species has previously been reported

from the New Hebrides and from the isolated island of Rotuma (Solem 1962).

Family Subulinidae

Lamellaxis gracilis (Hutton, 1834)

Figure 2f

Lamellaxis gracilis [including "*Opeas*" *oparanum* (Pfeiffer), according to Solem (1978)] is a snail of uncertain origins that has become widely dispersed by commerce. Pilsbry (1906) remarked that it is "probably the most widely distributed land snail in the world" and suggested that it may first have been carried to the Pacific islands by the Polynesians. Other workers (Cooke 1934, Solem 1978) have supposed it to be an immigrant of the modern era. Solem (1959, 1962, 1963) reported its occurrence on several New Hebridean islands. *L. gracilis* is by far the most abundant of the species represented in Tikopian archaeological sites. A single live-collected specimen documents its continued presence on the island.

Opeas pumilus (Pfeiffer, 1840)

This species has become dispersed throughout the tropics by modern commerce (Pilsbry 1906, Solem 1978). New Hebridean records are given by Solem (1959, 1962, 1963).

Subulina octona (Bruguière, 1792)

Subulina octona is thought to be native to tropical America but is now circumtropical in distribution due to dispersal by commerce. Its appearance in the Pacific late in the nineteenth century is well documented (Cooke 1926, Solem 1964). A number of living individuals of this species were obtained on Tikopia by Monberg, and Solem (1959, 1962) has provided New Hebridean records.

FAUNISTIC ANALYSIS

Because only cursory field observations have been made of the modern nonmarine mollusks of Tikopia, our knowledge of the fauna is probably incomplete. Nevertheless,

sufficient data are available to permit a preliminary analysis of its affinities.

Eighteen species of nonmarine mollusks are represented in Tikopian archaeological or modern collections. Fifteen are terrestrial in habit, and three others are found in strand-line, estuarine, or aquatic habitats. Members of the latter group are either species of wide distribution in the Indo-Pacific region (*Truncatella guerinii*) or are of uncertain taxonomic status ("*Assiminea*" sp. and *Melanoides* sp.). These factors limit their significance in an analysis of the affinities of the Tikopian fauna and they will not be discussed further here. *Nesopupa* sp., a terrestrial form, will likewise be omitted from further consideration as only the single Tikopian specimen has been reported from the New Hebridean region. The remaining fourteen terrestrial species may be classified either as indigenous to Tikopia or as of apparently adventive origin.

Six species of terrestrial snails are apparently indigenous to Tikopia. *Omphalotropis acrostoma*, *Partula* sp. cf. *auraniana*, and *Mocella euryomphala* are precinctive to the New Hebrides and adjacent islands; *Ouagapia perryi* occurs there and on the island of Rotuma, north of Fiji. The status of *Omphalotropis setocincta* and *Succinea kuntziana* (the latter species only tentatively identified here) is uncertain; both are restricted to the New Hebridean region, but each is closely related to (and possibly conspecific with) taxa occurring elsewhere in the southwestern Pacific. Both may be found in association with cultivated plants (Solem 1959), but as neither has previously been identified as adventive we consider them indigenous pending clarification of their status.

The indigenous land mollusks of Tikopia are almost wholly New Hebridean in their affinities, a finding in keeping with the island's geographical location. Although our knowledge of the Tikopian fauna may admittedly be incomplete, when compared with the main islands of the New Hebrides and the Santa Cruz Islands, Tikopia appears to be markedly deficient in terrestrial prosobranchs and larger pulmonates; such prominent members of the New Hebridean biota

as cyclophoracean operculates and the pulmonate genera *Dendrotrochus*, *Trochomorpho*, and *Placostylus* have not been found on the island [although most of these are well represented in archaeological sites in the Santa Cruz Islands (Christensen in preparation)]. Their absence, if not an artifact of inadequate collecting, may reflect the relative isolation of Tikopia and its geologically recent origin.

The remaining eight Tikopian terrestrial snails (*Lamellidea pusilla*, *Gastrocopta pediculus*, *Liardetia samoensis*, *Wilhelminaia mathildae*, *Coneuplecta microconus*, *Lamel-laxis gracilis*, *Opeas pumilum*, and *Subulina octona*), all previously recorded from the New Hebrides, have been identified by others as known or suspected adventives (references in SYSTEMATIC REVIEW, above). These wide-ranging anthropophilic species are the dominant terrestrial mollusks on Tikopia. Indigenous taxa predominate in the high islands of the New Hebrides, and on none of the twelve islands from which five or more species of terrestrial mollusks have been reported do adventive taxa constitute as much as 30 percent of the total (data from Solem 1959, 1962, 1963). On the other hand, adventive species generally outnumber other terrestrial mollusks on atolls and other low islands (Cooke 1934, Hedley 1899, Harry 1966, Reigle 1964). The Tikopian fauna is thus intermediate between those of typical high islands of the region and those of atolls.

ADVENTIVE TERRESTRIAL MOLLUSKS ON TIKOPIA

Almost all of the terrestrial mollusks native to the islands of Melanesia, Micronesia, and Polynesia are highly localized in occurrence; few range beyond the limits of a particular archipelago and many are restricted to a single island. Most Tikopian species, on the other hand, are widely distributed in the islands of the Pacific, undoubtedly as a result of accidental island-to-island transport with cultivated plants and other articles of human commerce. Adventive dispersal of land mollusks in Oceania has been discussed by Cooke (1926) and Solem (1959, 1964), among

others, but as Peake (1968) has noted, the immigrant status of adventive taxa may not be readily apparent. The ecological and distributional characteristics of adventive non-marine mollusks are distinctive, however: such species are typically inhabitants of environments modified by humans (where they may outnumber or even completely displace native snails), show little tendency to invade undisturbed habitats, have no close relatives in the region into which they have been introduced, and are of taxa known to occur elsewhere as adventives (Harry 1964, 1966). These criteria, and the contrastingly restricted geographical ranges of most of the truly indigenous land snails of the Pacific islands, serve to identify any species widely distributed in this region and characteristically a resident of atolls and disturbed environments on high islands as a probable adventive. Study of assemblages of fossil or subfossil mollusks from dated paleontological or archaeological contexts can assist in the recognition of suspected exotic taxa: for example, the absence of *Gastrocopta pediculus* and *Lamellidea oblonga* from the extensive Pleistocene and early Holocene sediments of the Hawaiian Islands was cited by Pilsbry (1916–1918) and Cooke and Kondo (1960), respectively, as evidence of their arrival there within the period of human occupation. For more recent immigrants, precise historical knowledge of the circumstances of their introduction may be available, and the collections of early naturalists can provide valuable information regarding the dates of their establishment in particular localities. The spread of the giant African snail (*Achatina fulica*) is particularly well documented (Mead 1961, 1979), and much is known concerning the dispersal of other land mollusks disseminated by modern commerce. Two Tikopian species (*Opeas pumilum* and *Subulina octona*) can be identified as modern immigrants based upon the known chronology of their dispersal elsewhere in the Pacific.

Pilsbry (1906, 1916–1918), Cooke (1926), Cooke and Kondo (1960), and Solem (1959, 1978) have postulated adventive dispersal during the prehistoric era to explain the

widespread occurrence in Oceania of certain nonmarine mollusks. These assertions have been based upon modern distribution records rather than archaeological evidence; the report by Kirch (1973) of the presence of *Lamellidea oblonga* and *Gastrocopta pediculus* in a Marquesan site is the only published account from Oceania known to us that documents the occurrence of adventive land snails in dated prehistoric context. Archaeological investigations on Tikopia have provided important new information in this regard and demonstrate the prehistoric occurrence there of six adventive land snail species including *Lamellaxis gracilis*, thought by Cooke (1934) and Solem (1978) to be a modern arrival in the islands of the Pacific.

Radiocarbon samples from Layer II of Site TK-4, the earliest archaeological site found by Kirch and Yen (in preparation) on Tikopia and believed by them to be contemporaneous with initial human settlement of the island, have yielded a date of ca. 891 B.C. A soil sample from that level contained shells of five species of nonmarine mollusks (Table 2), including *Lamellidea pusilla*, *Gastrocopta pediculus*, and *Lamellaxis gracilis*. The last two of these were also present in Layer III of TP-48 (radiocarbon date ca. 190 B.C.) and Layer II of TP-2 (radiocarbon date ca. 55 B.C.). A single shell of *Lamellaxis gracilis* was recovered during laboratory preparation of a bone obtained from Layer IV of Site TK-34 (radiocarbon date ca. A.D. 50). Layer III of TP-25 (radiocarbon date ca. A.D. 1407) contained shells of *Lamellidea pusilla*, *G. pediculus*, and *Lamellaxis gracilis* as well as of three other adventive species (*Liardetia samoensis*, *Wilhelminaia mathildae*, and *Coneuplecta microconus*). Modern immigrants (*Opeas pumilum* and *Subulina octona*) were restricted to recent soils (Layer I of TP-29 and Layer II of TP-30).

The presence of supposedly adventive taxa in even the earliest archaeological samples suggests the possibility that these species could instead be native to the island. Unfortunately, no samples of an age antedating human settlement were available for study, so their absence from the

island in prehuman time cannot be demonstrated. In the case of *Lamellaxis gracilis*, however, the anthropophilic habits of this snail, its circumtropical occurrence as a "culture snail," and the absence of related endemics in the region argue strongly for adventive status, although its residence in the Pacific islands is obviously of long duration (suggesting that the species' origin is to be sought in the tropics of the Old World). Similarly, there are no endemic species of *Gastrocopta*, *Liardetia s. s.* (the subgenus to which *Liardetia samoensis* belongs), or of *Wilhelminaia* in Oceania; Tikopian representatives of these genera are probably immigrants from Indonesia or Southeast Asia. *Lamellidea*, on the other hand, is a genus endemic to the Pacific islands and *Lamellidea pusilla* must therefore be autochthonous to this region, although like *Coneplecta microconus* (also autochthonous to Oceania) it has apparently been transported by humans beyond the limits of its natural geographic range.

PALEOECOLOGY

Investigations involving analysis of nonmarine mollusks as a method of paleoenvironmental reconstruction normally include detailed discussion of the habitat preferences of the species represented. Information on the association of individual species of Pacific island terrestrial mollusks with particular plant communities is rarely available, however, and we believe it to be more instructive to categorize Tikopian species either as indigenous or adventive (Table 2) rather than by assignment to ecological groups based on preference for different habitat types (woodland, open country, etc.), as is the practice of workers dealing with better-known molluscan faunas (Evans 1972). Paleoeological inferences can be drawn from such an analysis because adventive mollusks are generally indicative of environments modified by humans while indigenous forms are preferentially associated with undisturbed native vegetation. [The distinction is not absolute, however, and such

taxa as *Omphalotropis setocincta* and *Succinea kuntziana* may coexist with cultivated plants (Solem 1959).] Snails inhabiting aquatic, estuarine, or strandline environments are of course indicative of such conditions.

Examination of the data presented in Tables 2 and 3 shows the outstanding feature of Tikopian snail assemblages to be the strong representation of adventive species and in particular the universal abundance of *Lamellaxis gracilis*. Although the immature state of land snail analysis in Oceania requires that great caution be exercised in the use of such information in paleoenvironmental reconstruction, we believe that the striking predominance of adventive species in all of the Tikopian samples, including those from very early in the sequence of human occupation of the island, provides strong support for the conclusion derived from other archaeological investigations (Kirch and Yen in preparation) that human influence on the Tikopian environment has been profound and of long duration.

CONCLUSION

Although we lack direct evidence of the occurrence of nonmarine mollusks on Tikopia in the period prior to human occupation, the presence in archaeological context and in the modern fauna of several species indigenous to the New Hebridean region and not of anthropophilic habits indicates that probably during that period the island was colonized by a few species inhabiting strandline and aquatic environments and by about half a dozen terrestrial taxa. Archaeological evidence indicates that initial human settlement of Tikopia took place not later than ca. 900 B.C. Modification of the insular environment must have commenced almost immediately, as land clearance for agricultural purposes resulted in displacement of native vegetation. Increasing human population density would have led to intensified agricultural exploitation, and interisland transport of economic plants by humans provided opportunities for the introduction of adventive terrestrial mollusks. As early as ca. 900 B.C.

TABLE 3

RELATIVE ABUNDANCE OF NONMARINE MOLLUSKS IN TIKOPIAN ARCHAEOLOGICAL SITES, BY ECOLOGICAL GROUP (PERCENT)

ECOLOGICAL GROUP	TK-4 Ly II	TK-35 Ly IV	TP-2 Ly II	TP-25 Ly I	TP-25 Ly II	TP-25 Ly III	TP-29 Ly I	TP-30 Ly II	TP-39 Ly II	TP-48 Ly III
Terrestrial, Indigenous	22.2	—	42.9	9.7	8.6	5.0	1.9	6.1	29.7	19.0
Terrestrial, Indigenous (?)	—	—	—	—	—	—	0.4	—	—	—
Terrestrial, Adventive	44.4	100.0	57.1	90.3	91.4	93.0	84.7	82.9	68.8	66.7
Estuarine or Strandline	—	—	—	—	—	—	0.4	—	1.6	—
Estuarine or Strandline (?)	11.1	—	—	—	—	2.0	12.2	11.0	—	14.3
Aquatic	—	—	—	—	—	—	0.4	—	—	—
Unknown	22.2	—	—	—	—	—	—	—	—	—
Total Number of Shells	9	1	7	62	151	100	262	181	64	21

at least three exotic land snails had become established on the island, and by ca. A.D. 1400 (more than a century before the arrival of the first Europeans in the southwestern Pacific) the six adventive species then present were the dominant faunal element in at least some habitats, as environmental modification favored anthropophilic snails at the expense of indigenous forms. European influence in the region commenced with the voyages of Spanish explorers in the sixteenth century; commerce during the succeeding four hundred years has resulted in the establishment on Tikopia of two additional adventive snails. A majority of the terrestrial mollusk species known ever to have inhabited the island evidently reached it with human aid.

In a discussion of New Caledonian terrestrial mollusks Solem (1964) noted that human activities in Oceania are fostering the replacement of diverse endemic land snail faunas by an assemblage of a few species of introduced snails and slugs, anthropophilic in habit and now pan-Pacific or circum-tropical in distribution. Archaeological evidence from studies on Tikopia and elsewhere in the Pacific indicates that although the pace of ecological change in these islands may have been accelerated by modern people, the process of faunal succession has origins extending well back into prehistory. We believe that studies of subfossil and fossil nonmarine mollusks, together with ecological studies of living faunas, will prove to be highly useful in future investigations of human influence on the fragile environments of the Pacific islands.

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