NOTES ON THE STREAM NERITIDS (GASTROPODA; PROSOBRANCHIA) OF OCEANIA

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Abstract—Five stream neritid genera *Clithon, Neritilia, Neritodryas* and *Septaria* inhabit Oceania. The simplest way to separate the genera is to examine the shape of their opercula. Variations in the shape, colour and markings of the shell tend to make identification of the species difficult. At least 33 species of freshwater neritids are found throughout Oceania. Apart from the four endemic species from the Hawaiian islands, the species that inhabit Oceania are also found in South East Asia and New Guinea. Fifteen species have so far been reported from North Pacific islands and twenty nine species from South Pacific islands.

Introduction

The two most important prosobranch gastropod families that inhabit the rivers and streams of the Pacific islands are the Thiaridae and the Neritidae. In general the Thiaridae have long turret-shaped shells while the Neritidae have streamlined shells with a large body whorl. The Neritidae are usually found in fast flowing streams although a few species inhabit the tidal regions at the mouth of rivers.

Gastropods were collected from the streams of most Pacific island groups during the nineteenth century. These were described by Lamarck (1815/22), Reeve (1856), Mousson (1869, 1870) and Gassies (1863). More recent surveys of freshwater gastropods have been made on Guam (Raulerson, 1979), Palau (Bright & June, 1979), Hawaii (Maciolek, 1975), New Caledonia (Franc, 1956; Starmühlner, 1976), Guadalcanal (Solomon Is.), Efate (Vanuatu), Tahiti (Starmühlner, 1976) and Viti Levu (Fiji) (Starmühlner, 1976; Haynes, 1985). Prof. Starmühlner surveyed Upolu and Tutuila (Samoa) and Tongatapu and Eua (Tonga) in 1985 (Personal Communication). The author surveyed the Fiji islands of Ovalau, Taveuni, Gau, Kadavu and Vanua Levu from 1983–85 (Haynes, in press) and Savai'i (W. Samoa) and Vava'u (Tonga) in 1986.

The aims of this paper are to describe some ways in which stream neritids can be identified, to indicate difficulties in identification caused by within species variation and to discuss species distribution throughout the region.

Identification of Neritidae

The Neritacea, a primitive group of Prosobranchia, are abundant and diverse in the tropics. The freshwater (Neritidae) and terrestrial (Helicinidae) families are thought to

have evolved from the marine genus *Nerita* (Bourne, 1908). It has been suggested (Bourne, 1908; Govindan & Natarajan, 1972) that the move into freshwater has occurred on several occasions and that each freshwater genus (*Theodoxus, Clithon, Neritina, Neritilia, Neritodryas* and *Septaria*) probably represents a separate line of evolution.

The freshwater neritid genera found in Oceania are *Clithon* Montford, *Neritina* Lamarck, *Neritilia* Martens, *Neritodryas* Martens and *Septaria* Ferussac. *Theodoxus* Montfort is the genus name given to several European species of freshwater neritids. The most widespread of these is *Theodoxus fluviatilus* (Linnaeus).

Members of the genus *Septaria* (formerly known as *Navicella*) are easily distinguished from the other four Oceania genera because they have a limpet-like form and no visible operculum. The operculum is embedded in the powerful muscle which enables the animal to hold onto a rock surface in the fastest current. Sometimes the genus *Septaria* is placed in a separate family Septariidae (Golikov & Starobogatov, 1975). Baker (1923) used the radula to identify the neritid genera, while Martens (1878/79) used the operculum. Martens' method is simpler and more convenient for field ecologists. Figs. 1 a–f show the opercula of the four superficially similar genera *Neritilia, Neritodryas,, Clithon* and *Neritina. Neritilia* has only one small (6 mm), usually brackish water species (*Neritilia rubida* [Pease]) in Oceania. It has a simple operculum with one small apophysis (Fig. 1 f). The genus *Neritodryas* has two species, *Neritodryas cornea* (Sowerby) and *N. subsulcata* (Linnaeus). The inside of the operculum has two apophyses. The upper one is distinctive in that it is long and curved with several longitudinal ridges ending in a scalloped lobe. The lower apophysis is a round peg (Fig. 1 c).

The genus *Neritina* has many species in Oceania. The operculum has a yellow, dark red or horn-coloured, membranous fringe along the exterior margin. The upper of the two inside apophyses is a long thin curved ridge and the lower a short peg (Fig. 1 d and e).

Clithon is another multi-species genus and has a similar membranous fringe, but it is usually orange. On the inside the upper apophysis is short and stout and is joined to a thick triangular lower peg (Fig. 1 b). the outside is often granulated and a groove runs along the middle parallel to the outside margin (Fig. 1 a).

The opercula of two Hawaiian meritids (Fig. 1 g and h) closely resemble one another and the operculum of *Neritinia pulligera* (Linnaeus) (Fig. 1 d and e) showing that both these Hawaiian species (*granosa* and *vespitina*) should be placed in the genus *Neritina. Neritina vespitina* Sowerby was placed with two other Hawaiian neritids in the genus *Theodoxus* by Kay (1979). The other two species, *Clithon cariosus* (Wood) and *Clithon neglectus* (Pease), should be placed in the genus *Clithon* according to Wenz (1938).

Identification of the species of the genera *Clithon, Neritina* and *Septaria* is difficult because of the number of names given each species in the past and because, in some cases, well-defined species have been combined unwisely. The most useful literature for identifying neritids of Oceania are Riech (1937), Wenz (1938), Benthem-Jutting (1956), Starmühlner (1970, 1976) and Haynes (1984).

Variation Within Species

A significant problem encountered when attempting to identify a neritid gastropod is the wide variation within a species in the shape, markings and colour of the shells. This

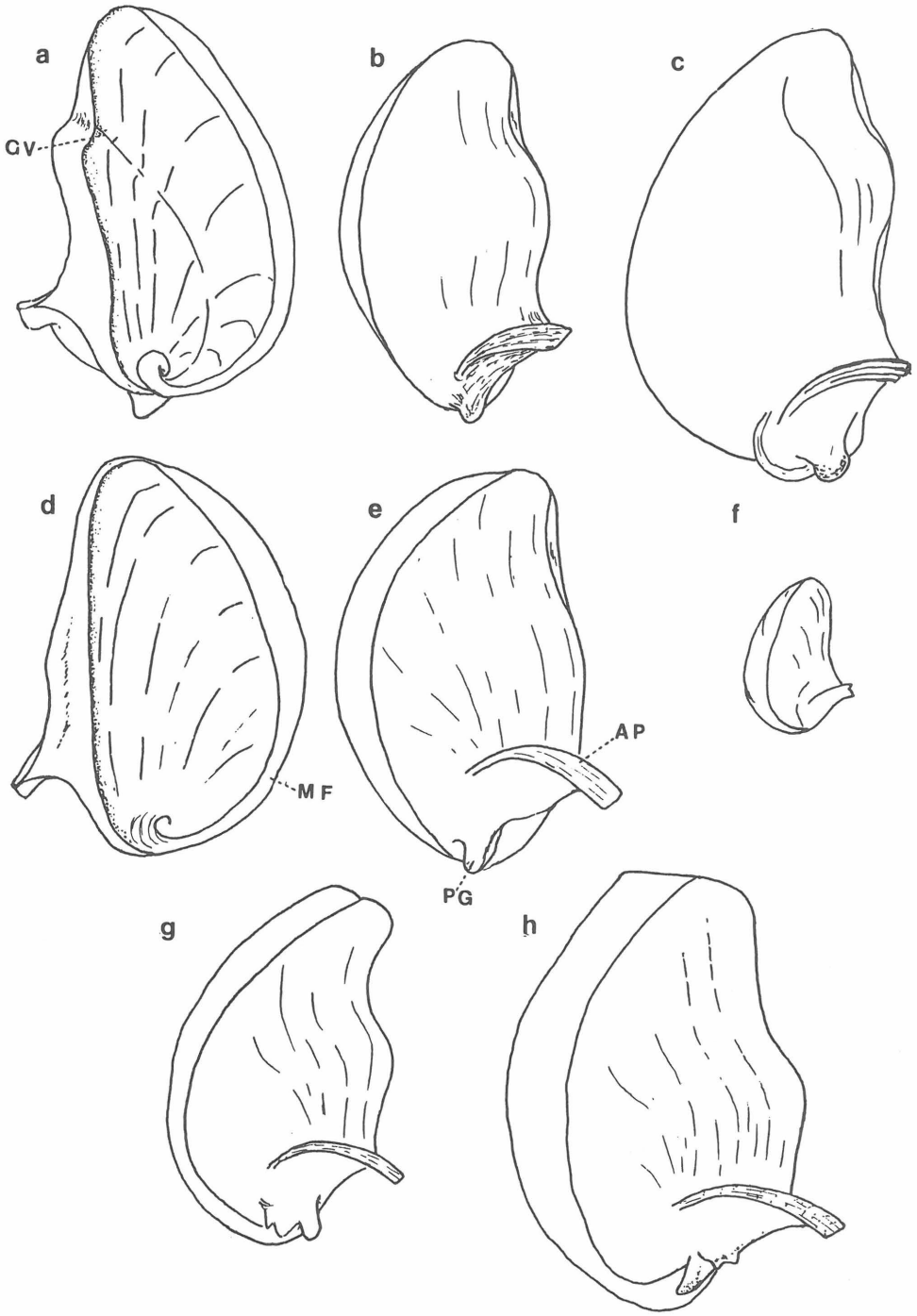

Figure 1. Diagrams of Neritidae opercula. a. *Clithon pritchardi* (outside) b. *C. pritchardi* (inside) c. *Neritodryos subsulcata* (inside) d. *Neritina pulligera* (outside) e. *N. pulligera* (inside) f. *Neritilia rubida* (inside) g. *Neritina vespitina* (inside) h. *Neritina granosa* (inside)

AP, upper apophysis; GV, groove; MF, membranous fringe; PG, peg (lower apophysis).

Figure 2. *Septaria porcellana*. Some variations in shell shape and shell markings.

variation occurs in many tropical species. Grüneberg (1976, 1982) worked on the variation in colour and pattern on the shells of *Clithon oualaniensis* (Récluz), a small brackish Indo-Pacific species. He found that although the axial and spiral patterns were genetic in origin, they were not strictly discontinuous. He therefore considered them to be pseudopolmorphic rather than polmorphic in character (Grüneberg, 1982). A similar condition exists in the shell shape and markings in the widely distributed species *Septaria por-*

cellana (Linnaeus). Fig. 2 shows the variation in the shells of specimens collected from streams on Vanua Levu, Fiji.

A variable character in *Clithon* species is the presence or absence of spines. *Clithon diadema* (Récluz) and *Clithon spinosus* (Budgin) always have spines, but the shells of *Clithon corona* (Linnaeus) and *Clithon pritchardi* (Dohrn) may be with or without spines. Starmühlner (1976) suggested that spines were present when these species lived in brackish water and were absent when they lived in freshwater. This hypothesis was not confirmed when *Clithon priitchardi* were collected along the length of streams in Fiji. One hundred and sixty two *C. pritchardi* collected in this way were measured and the presence or absence of spines noted. The results suggested (Fig. 3) that small, and presumably younger snails were likely to be spined while some snails 15 cm and over appeared to lose their spines.

Distribution of Neritid Species Within Oceania

The neritid species, which have been reported by various authors (Riech, 1937; Benthem-Jutting, 1956; Starmühlner, 1970, 1976; Raulerson, 1979; Bright and June, 1979; Haynes 1984), or which have been collected by the author, from each island or island group are given in Table 1. South East Asia has neritid species (e.g. *Neritina labiosa* and *Neritina zigzag*) that have not been reported from Oceania, but most Oceania neritids have been found in S.E. Asia and New Guinea. *Clithon corona, C. oualaniensis, Neritina pulligera* and *Neritina turrita* (Gmelin) have been found in Pliocene and Pleistocene rocks in E. Java, Indonesia (Benthem-Jutting, 1956) and therefore it seems likely that many neritid species originated in the S.E. Asia region.

The species confined to Oceania are *Clithon pritchardi, Clithon chlorostoma* (Broderip), *Septaria sanguisuga* (Reeve), *Septaria suffreni* (Récluz), *Neritina macgillvrayi* (Reeve), *Neritina porcata* Gould and the four endemic Hawaiian species. Thirty three species are found throught Oceania. Some of these inhabit Indian Ocean islands. *Neritina auriculata* Lamarck, *N. pulligera* and *Clithon longispina* (Récluz) are found on Madagascar, *N. auriculata* and *Septaria lineata* (Lamarck) on Sri Lanka (Starmühlner, 1979) and *Neritina variegata* (Lesson), *Neritina squamipicta* Récluz, *N. pulligera, N. auriculata, Clithon corona, Septaria porcellana* and *Neritilla rubida* on the Andaman Islands (Starmühlner, 1982). *Clithon oualaniensis, Neritina pulligera* and *Septaria lineata* have been reported from Northern Australia (Riech, 1937).

The origin of the four endemic Hawaiian neritid species is uncertain. It is probable that the ancestor of the two *Clithon* species (*C. cariousus* and *C. neglectus*) originated in South-East Asia because only the neritid genera *Neritina* and *Neritilia* are represented in Central America and the Caribbean islands. *Neritina punctulata* Lamarck, which is similar to many species found in Oceania, inhabits the torrential streams of the Lesser Antilles islands of St. Lucia (Mckillop & Harrison, 1980), St. Vincent (Harrison & Rankin, 1976) and Guadaloupe (Starmühlner & Therezien, 1983). However, the shell of *Neritina vespitina,* with its wide columella area and wings, resembles that of the Indo-Pacific neritid *Neritina auriculata* as well as that of the Central American species *N. latissima* (Fig. 4).

The total number of species that have been found in each island group is shown in Fig. 5. There have been no reliable reports of neritids being found in Tonga or the Cook

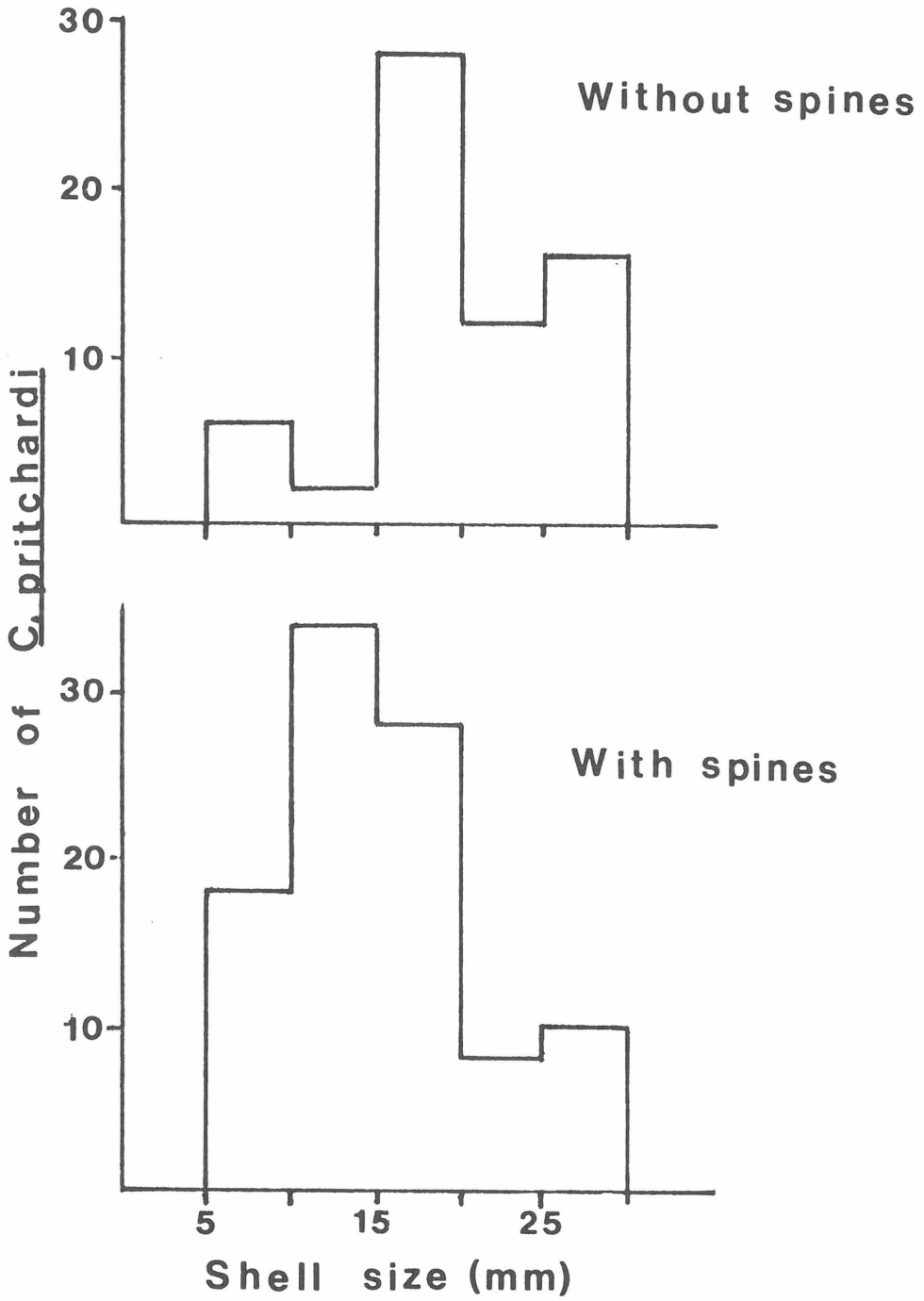

Figure 3. The number of *Clithon pritchardi* with and without spines at different shell lengths.

Table 1. The distribution of Indo-Pacific neritid gastropod species throughout Oceania. A species presence is indicated by +.

	S.E. Asia	N. Guinea	Palau	Guam	Caroline Is. Truk & Ponepe	Hawaii	Solomon Is.	Vanuatu	New Caledonia	Fiji	Samoa	Tahiti
Clithon oualaniensis	+	+					+	+	+	+	+	+
C. corona	+	+		+	+		+	+	+		+	
C. diadema	+	+							+	+	+	+
C. olivaceus	+	+					+	+		+		
C. squarrosus	+	+					+					
C. rarispina	+	+								+		
C. bicolor	+	+							+			
C. nucleolus	+	+					+		+			
C. spinosus	+	+								+		+
C. pritchardi									+	+		
C. chlorostoma											+	+
C. cariosus						+						
C. neglectus						+						
Neritilia rubida	+	+						+		+	+	+
Neritodryas subsulcata	+	+	+		+		+	+		+		
Neritina auriculata	+	+					+	+	+	+	+	+
N. turrita	+	+	+	+					+	+	+	+
N. variegata	+	+	+	+	+		+	+	+	+	+	+
N. asperulata	+	+					+		+			
N. petiti	+	+			+		+	+	+	+	+	
N. pulligera	+	+	+	+	+		+	+	+	+		
N. squamipicta	+			+					+	+		
N. porcata		+					+	+		+	+	
N. turtoni		+					+			+		
N. canalis		+					+	+		+	+	+
N. macgillvrayi					+		+		+	+	+	
N. granosa						+						
N. vespertina						+						
Septaria porcellana	+	+	+	+	+		+	+	+	+	+	+
S. lineata	+	+		+	+					+		+
S. macrocephala		+						+	+	+	+	+
S. suffreni								+		+	+	
S. sanguisuga					+				+	+	+	
TOTAL	20	23	5	7	9	4	16	14	18	23	16	12

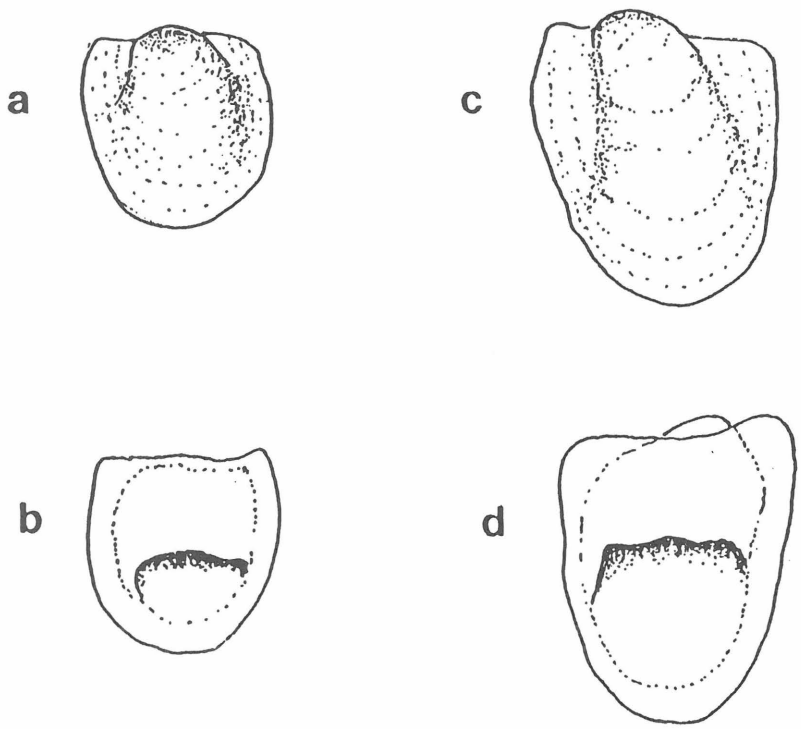

Figure 4. A comparison of the shells of two species of *Neritina, Neritina auriculata* (Indo-Pacific) a. dorsal view b. ventral view *Neritina vespitina* (Hawaii) c. dorsal view d. ventral view.

Islands. Eua is the only Tongan island with running water and Starmühlner, who searched the stream thoroughly, reported finding no neritids (personal communication). The streams of Rarotonga have been investigated by several people, including the author, without any neritids being found. Fiji with 23 species has the greatest diversity of freshwater neritids in Oceania (Table 1). More species may be found in Solomon Islands and Vanuatu as many of the islands in this region of the Pacific have not been sampled. New Caledonia which has been studied on several occasions (Gassies, 1863; Franc, 1956; Starmühlner, 1970) has only 18 species.

Conclusion

In general the stream neritids of Oceania are the same as those that inhabit South East Asia and New Guinea. Many more species appear to have moved southwards into the South Pacific islands than northwards into the North Pacific islands. Some speciation of *Neritina* and *Septaria* has occurred in the torrential streams of South Pacific islands although there is no evidence that suggests that any species is endemic to any particular island.

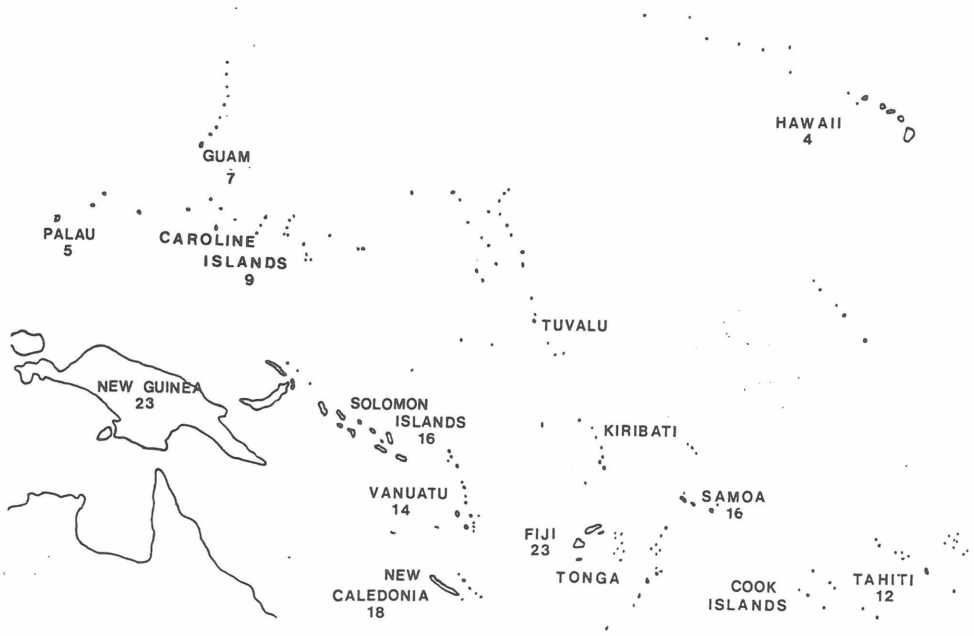

Figure 5. A map of Oceania showing the number of neritid gastropod species found in each island group.

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