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A review of the deep-water volute genus *Calliotectum* (Gastropoda: Volutidae)

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ABSTRACT

Calliotectum Dall, 1890, until now a monotypic deep-water volute genus from the Eastern Pacific, is shown to be a senior synonym of *Teramachia* Kuroda, 1931 from the Western Pacific. *Pakaurangia* Finlay, 1926 (originally Thiaridae; Miocene of New Zealand) and *Butonius* Martin, 1933 (originally Fusinidae; Neogene of Indonesia) are new synonyms. *Calliotectum* has a fossil record in the Neogene of the Pacific region (Okinawa, Indonesia, New Zealand and Ecuador), with a total of 5 species. All fossil records are from deep-water facies. Seven Recent species of *Calliotectum* are recognised, all from deep water in tropical latitudes. Three species occur in South-East Asia and the Eastern Indian Ocean, at 200-1660 m depth. Of these, *C. tibiaeforme* is treated as a polytypic species, with *C. johnsoni* and *C. dupreyae* considered to be geographical forms. *Calliotectum piersonorum* sp. nov. and *C. egregium* sp. nov. are described from the South-West Pacific at 450-1060 m depth. Single species occur each in the East Pacific and in the Caribbean.

RÉSUMÉ

Révision des volutes bathyales du genre *Calliotectum* (Gastropoda: Volutidae).

Calliotectum Dall, 1890 était jusqu'ici considéré comme un genre monotypique de Volutidae du Pacifique oriental. Sa synonymie comprend désormais *Pakaurangia* Finlay, 1926 (décrit comme Thiaridae ; Miocène de Nouvelle-Zélande), *Teramachia* Kuroda, 1931 (du Pacifique occidental), et *Butonius* Martin, 1933 (décrit comme Fusinidae ; Néogène d'Indonésie). Cinq espèces sont connues de formations néogènes à faciès bathyal de la région Pacifique : Okinawa, Indonésie, Nouvelle-Zélande, Equateur. Le genre *Calliotectum* est représenté par 7 espèces actuelles d'eau profonde aux latitudes

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tropicales. Trois espèces vivent en Asie du Sud-Est et dans l'Est de l'océan Indien, entre 200 et 1660 m. *Calliotectum tibiaeforme* est traité comme une espèce polytypique, et *C. johnsoni* et *C. dupreyae* sont considérés comme de simples variants géographiques. *Calliotectum piersonorum* sp. nov. et *C. egregium* sp. nov. sont décrits du Sud-Ouest Pacifique, par 450-1060 m. Enfin, deux espèces sont présentes, l'une dans le Pacifique oriental, l'autre dans le domaine caraïbe.

INTRODUCTION

Until now, volutes of the genus *Calliotectum* Dall, 1890 have been referred by shell collectors and malacologists working on Recent faunas to the genus *Teramachia* Kuroda, 1931. For many years, these volutes were rare in public and private collections. At the time of the monograph by Weaver & DuPont (1970), *Teramachia dalli, T. johnsoni, T. mirabilis* and *T. smithi* were altogether known by only seven specimens collected between 1910 and 1940. Only the fifth nominal species, *T. tibiaeformis* was known from large numbers. Since 1970, several thousand specimens have been taken in South-East Asia (Greene, 1975) and later from new fishing grounds off Western Australia (Slack-Smith, 1982; Douté, 1990), which led to the description of new species and/or subspecies. The present revision was initiated when new material of *Calliotectum* was discovered in deep water in the South-West Pacific, which subsequently led to the reevaluation of the nominal taxa.

The reason for the apparent scarcity of *Calliotectum* is that they are among the deepest-living volutes. Harasewych & Kantor (1991) listed only 8 volute species reported from depths greater than 2000 m. Species of *Calliotectum* all occur between 200 and 1660 m depth, with *C. tibiaeforme* occasionally ranging shallower. In South-East Asia and Western Australia, examples of *Calliotectum* species appear to be not particularly rare on soft bottoms. Conversely, even at appropriate depths, specimens are scarce off New Caledonia, where hard bottoms predominate. From a total of 154 dredge hauls and trawlings made between 500 and 900 m in New Caledonia in 1985-1989 (Richer de Forges, 1990), 14 hauls yielded a total of 18 specimens; of 427 hauls between 200 and 500 m, only one (448 m) yielded one shell of *Calliotectum*, and 102 hauls deeper than 900 m were all negative.

In the present paper, we review the generic synonymy of *Calliotectum*; we revise the taxonomy of the Indo-Pacific species, including the description of two new species from the SW Pacific, and we list the nominal fossil species.

ABBREVIATIONS AND TEXT CONVENTIONS

Repositories

LACM	: Los Angeles County Museum of Natural History, Los Angeles
MNHN	: Muséum national d'Histoire naturelle, Paris
NZGS	: Institute of Geological and Nuclear Sciences [formerly New Zealand Geological Survey], Lower Hutt
NZOI	: National Institute of Water and Atmospheric Research [formerly New Zealand Oceanographic Institute], Wellington
RMNH	: Nationaal Natuurhistorisch Museum, Leiden
USNM	: National Museum of Natural History, Washington DC

Other abbreviations

lv	: live-collected specimen
dd	: dead-collected specimen
shell	: empty shell, condition unknown at time of collect.

Family Volutidae Rafinesque, 1815

Subfamily Calliotectinae Pilsbry & Olsson, 1954

Suprageneric classification

Dall (1890) believed *Calliotectum* to lack a radula and placed the genus in the family Pleurotomidae [= Turridae], where it stayed until Thiele (1929: 345) transfered it to Volutidae. Pilsbry & Olsson (1954: pl. 3, fig. 16) examined the radula of a syntype of the type species and erected the subfamily Calliotectinae, placing *Teramachia* (and its synonym *Prodallia*) and *Howellia* in that subfamily. This classification was followed by Weaver & DuPont (1970). Subsequently, Bayer (1971) transfered *Teramachia* to the family Turbinellidae, based on interpretation of the radulae of *Teramachia meekiana* (Dall, 1889) and *Teramachia chaunax* Bayer, 1971. This opinion was followed by Beu & Maxwell (1990), who classified Calliotectinae as a subfamily of Turbinellidae, to include *Pakaurangia*, which they recognized as a senior synonym of *Teramachia*.

As had already been pointed out by Emerson & Old (1979), this placement cannot be maintained. Bayer (1971) and Beu & Maxwell (1990) were mistaken in including *Teramachia meekiana* and *T. chaunax* in the genus *Teramachia*. The radula of these species is triserial and, indeed, shows great similarity to the radula of *Turbinella pyrum* (Linnaeus, 1758). The close similarity between the Atlantic species *T. meekiana* and *T. chaunax* and the Pacific *T. barthelowi* (Bartsch, 1942) in shell morphology led Quinn (1981) to place them in a new turbinellid genus, *Cyomesus*. We agree with the view (Rehder, 1972) that *Teramachia barthelowi*, *T. meekiana* and *T. chaunax* are turbinellids, properly placed in the genus *Latiromitra* Locard, 1897 [type species: *L. specialis* Locard, 1897], of which *Cyomesus* Quinn, 1981 is a synonym (Bouchet & Warén, 1985).

The radulae of *Calliotectum vernicosum, Teramachia tibiaeformis* and *T. dalli* were figured by Pilsbry & Olsson (1954), Habe (1952) and Wells (1989) respectively. The radula of a specimen of *T. dalli* 161 mm high is 3.6 mm long, and bears 57 tricuspid rachidian teeth, and the radula of a specimen of *T. tibiaeforme* 140 mm high is 3.2 mm long, and bears 50 teeth (Wells, 1989). The central cusp is similar to (*C. vernicosum*) or longer than (other species) the lateral cusps. The base of each cusp has a shallow socket into which the cusps from the preceeding row interlocks. The radulae of the various species (Figs 1-9) are all similar (as already recognized by Rehder, 1972) and indicate that Calliotectinae belongs in the family Volutidae, not Turbinellidae. For radulae of Turbinellidae, see Bouchet & Warén (1985, 1988) and Harasewych (1987).

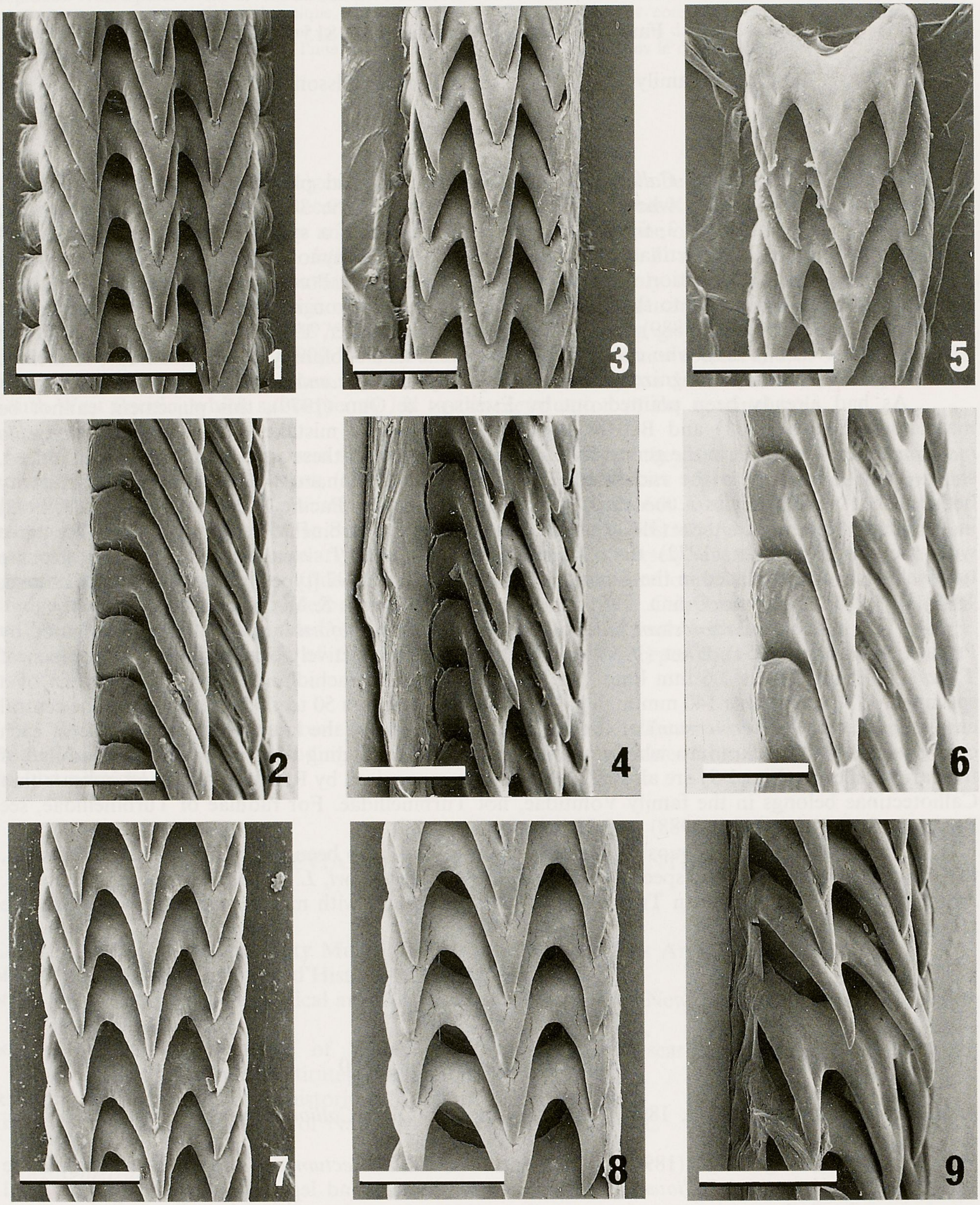
There are thus two groups of species that, at times, have been placed in, or associated with, the name *Teramachia*: (1) the species of *Latiromitra* (*L. barthelowi*, *L. chaunax*, *L. meekiana*, and *L. specialis*), properly classified in Turbinellidae; (2) true volutes with monoseriate radulae, which are revised in the present paper.

Generic nomenclature

Genus ***Calliotectum*** Dall, 1890

Mangilia (Calliotectum) Dall, 1890: 304. Type species (OD): *Calliotectum vernicosum* Dall, 1890; Galapagos, Recent.

Although Dall (1890) formally introduced *Calliotectum* as a subgenus of *Mangilia*, he used the binomen *Calliotectum vernicosum* in the text and legend to the illustration. Until recently *Calliotectum vernicosum* was known only from the original two syntypes, but Dr J. McLean has brought together several fine lots of this species, including live-taken specimens and large adults, which permit a reevaluation of the taxon.



FIGS 1-9. — Radulae of *Calliotectum*. — **1-2,** *C. vernicosum*, Peru, 1200 m. — **3-4,** *C. dalli*, Philippines, MUSORSTOM 2: stn CP 81. — **5-6,** *C. egregium*, Wallis, MUSORSTOM 7: stn CP 562. — **7,** *C. piersonorum*, New Caledonia, BIOCAL: stn DW 51. — **8-9,** *C. tibiaeforme*, Arafura Sea, KARUBAR: stn CP 83. Scales lines 100 µm (1-5, 7-9) and 50 µm (6).

Pakaurangia Finlay, 1926 **(syn. nov.)**. Type species (OD): *Melanopsis waitaraensis* Marwick, 1926; New Zealand, Tongaporutuan (Tortonian; Late Miocene).

Pakaurangia was first introduced as a genus of Thiaridae (Cerithioidea). WENZ (1939: 692) even made *Pakaurangia* a subgenus of *Melanopsis* and FLEMING (1966: 47) also accepted it as a genus of Thiaridae. BEU & MAXWELL (1990) penetratingly recognized *Pakaurangia* as an earlier synonym of *Teramachia*, transferred it to the subfamily Calliotectinae, by them included in the family Turbinellidae (see above), and emphasized the deep-water origin of the deposits containing the type species.

Teramachia Kuroda, 1931. Type species (by monotypy): *Teramachia tibiaeformis* Kuroda, 1931. Japan, Recent.

OLSSON (1964) placed *Teramachia* in the synonymy of *Calliotectum*, but his opinion was subsequently ignored. Based on a comparison of adult *Teramachia* species with the juvenile syntypes of *Calliotectum vernicosum*, EMERSON & SAGE (1986) explicitly refuted this synonymy and maintained the distinction between the two genera. Even when full grown specimens of both genera are considered, *Teramachia tibiaeformis* differs from *Calliotectum vernicosum* by its appressed instead of channelled suture; flaring and moderately thickened instead of sharp outer lip; well instead of weakly demarcated siphonal canal; rather low, broad axial ribs; and thinner more lightly coloured periostracum. However, these differences become insignificant when additional species are considered. In *C. piersonorum*, the outer lip is thickened as in *Teramachia tibiaeformis*, but the siphonal canal is very short as in *Calliotectum vernicosum*. In *Calliotectum dalli*, the suture is channelled as in *C. vernicosum,* but the outer lip is flared and thickened as in *Teramachia tibiaeformis*. We consider the differences enumerated to be of specific rather than generic importance, and formally synonymize *Teramachia* with *Calliotectum*.

Butonius Martin, 1933 **(syn. nov.)**. Type species (by monotypy): *Fusus (Butonius) pectinatus* Martin, 1933; Indonesia, Late Miocene-Pliocene.

Butonius was introduced as a subgenus of *Fusus* to include *F. pectinatus*, originally described based on a single shell from the Waisiu deposits of Buton Island, Central Indonesia. BEETS (1942: 284) added a second species, *F. (Butonius) perinusitatus*, based on new material from the Kabungka deposits of the same island, and recorded a second shell of the type species.

Fusus pectinatus and *Calliotectum vernicosum* differ by the absence of a labial varix in *F. pectinatus* and lack of demarcated siphonal canal in *C. vernicosum*. Otherwise, the two share the same general shell morphology, sculpture of broad axial ribs separated by deep grooves and deeply channeled suture. *F. pectinatus* is probably directly ancestral to *Calliotectum dalli*, and it is therefore relevant to compare anatomical characters of *C. dalli* with those of *C. vernicosum*. Radular teeth show only subtle differences in the proportion of the central vs. lateral cusps (Figs 1-4) and the two species share digitate osphradial leaflets, a character so far unique in the Volutidae (M.G. HARASEWYCH, comm. pers.). Based on these characters, we synonymize *Butonius* with *Calliotectum*.

Howellia Clench & Aguayo, 1941. Type species (OD): *Howellia mirabilis* Clench & Aguayo, 1941; Caribbean, Recent.

The similarity of *Howellia mirabilis* to *Teramachia* species was noted by CLENCH & TURNER (1964), and they were formally synonymized by WEAVER & DUPONT (1970: 176).

Prodallia Bartsch, 1942. Type species (OD): *Prodallia dalli* Bartsch, 1942; Philippines, Recent.

The unavailability of the name *Prodallia* in a 1915 banquet brochure has been discussed by MACNEIL (1961). *Prodallia* was first validly introduced in 1942, and synonymized with *Teramachia* by PILSBRY & OLSSON (1954), an opinion which has been followed by all subsequent authors.

Species revision

Included species:

Calliotectum dalli (Bartsch, 1942); Taiwan to NW Australia, Recent [= *C. pectinatum*?]
C. egregium sp. nov.; SW Pacific, Recent
C. fischeri (Olsson, 1964); Ecuador, Pliocene
C. pectinatum (Martin, 1933); Indonesia, Pliocene
C. marci (Koperberg, 1931); Indonesia, Plio-Pleistocene
C. mirabile (Clench & Aguayo, 1941); Caribbean, Recent
C. piersonorum sp. nov.; New Caledonia, Recent
C. shinzatoense (MacNeil, 1961); Okinawa, Pliocene [= *C. marci*?]
C. smithi (Bartsch, 1942); Philippines, Recent
C. tibiaeforme (Kuroda, 1931); S Japan to W Australia and SW Pacific, Recent [= *C. marci*?]
C. vernicosum Dall, 1890; Peru-Ecuador, Recent
C. waitaraense (Marwick, 1926); New Zealand, Miocene.

A total of 5 Neogene and 7 Recent species of *Calliotectum* are known. The Indo-Pacific species are reviewed in detail below, including description of two new Recent species. For the East Pacific and Caribbean taxa, we refer to Emerson & Sage (1986) who provided excellent illustrations of the species involved.

Excluded species: to be classified in *Latiromitra* Locard, 1897 (Turbinellidae)
Teramachia barthelowi (Bartsch, 1942)
T. chaunax Bayer, 1971
T. meekiana (Dall, 1889).

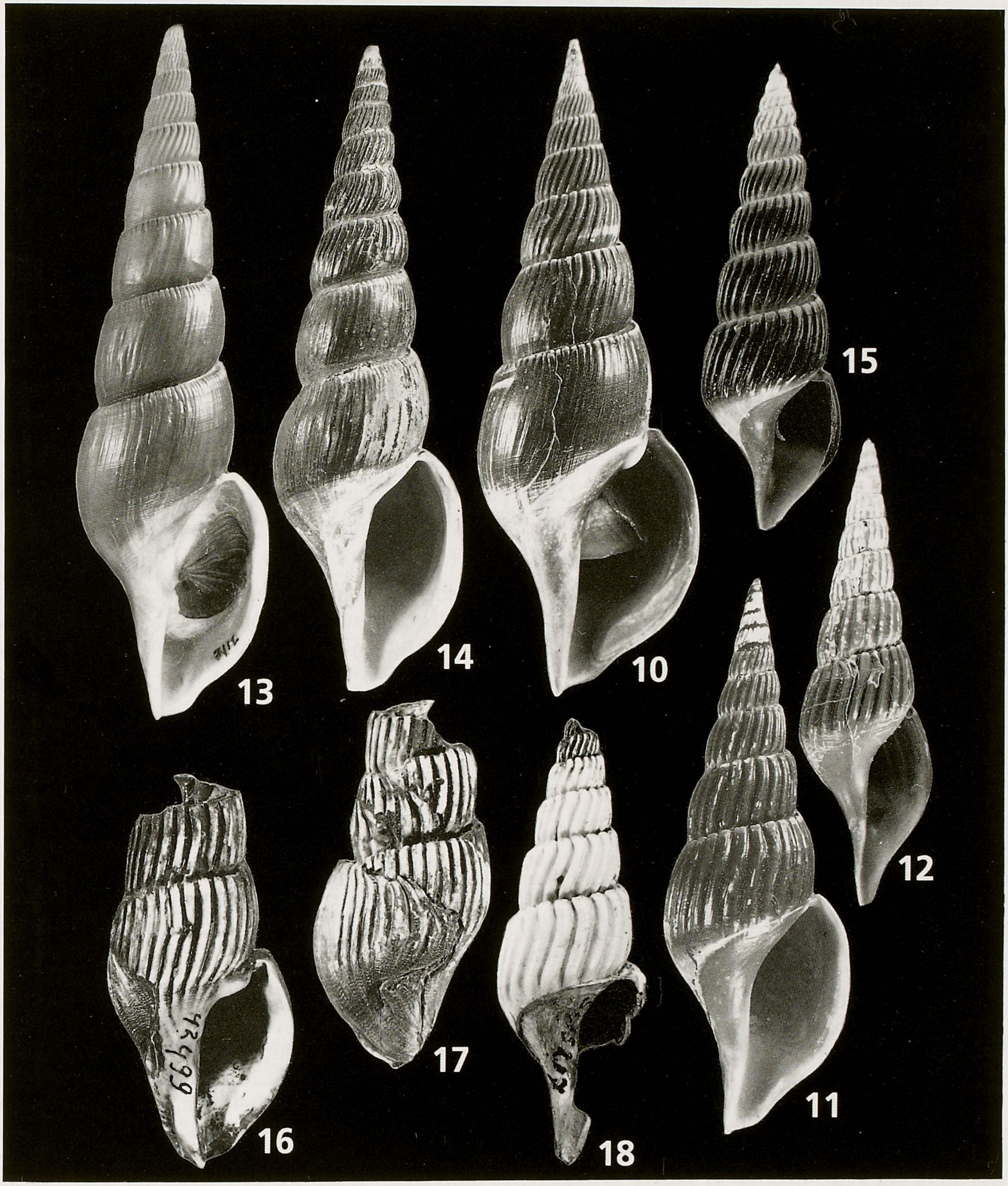
Calliotectum dalli (Bartsch, 1942)

Figs 3-4, 10-15

C. dalli is very distinctive, and differs from all other Recent *Calliotectum* by its deep sutural channel and thick, dark, shiny periostracum. For many years the type specimens, taken in the Philippines by the *"Albatross"* expedition (1915), were the only known specimens and the species has remained very rare in public and private collections, until the discovery of Australian populations in the mid 1980s.

Australian shells differ from Philippine shells by their paler brown colour, and in that shells of the same size have more whorls (although this is difficult to quantify because the top whorls are always broken), which are much flatter. Philippine shells are dark olive brown, have a much broader outline and more convex whorls.

These differences led to the description of *C. dalli claydoni* as a geographical subspecies. This distinctness has been challenged by Wells (1989), who synonymized *C. dalli claydoni* with *C. dalli dalli*. Wells' arguments were that measurements of the holotype of *C. dalli* fit within the range of variation of the Australian material, and that convexity of the whorls was also a variable feature. We agree with Wells that recognition of subspecies may vary with the taxonomic judgment of the malacologist examining the shells. However, we have now seen additional material from the Philippines and Taiwan, and several hundred Australian *claydoni* in private collections. We find that we can tell the geographical origin of every single shell, based on conchological characteristics. As long as no material is available from the large geographical gap between the Taiwan-Philippine region, on one hand, and NW Australia-Arafura Sea, on the other hand, we prefer to maintain the subspecific status of the two groups of populations.



FIGS 10-18. — *Calliotectum*. — **10,** *C. dalli dalli*, Philippines, MUSORSTOM 2: stn CP 79, 128 mm. — **11,** *C. dalli dalli*, Philippines, MUSORSTOM 2: stn CP 50, small adult, 84 mm. — **12,** *C. dalli dalli*, Philippines, MUSORSTOM 2: stn CP 38, juvenile 47 mm. — **13,** *C. dalli claydoni*, Western Australia, off Port Hedland, 137 mm. — **14,** *C. dalli claydoni*, Arafura Sea, KARUBAR: stn CP 70, 132 mm. — **15,** *C. dalli claydoni*, Arafura Sea, KARUBAR: stn CP 91, juvenile, 50 mm. — **16-17,** *C. pectinatum*, holotype of *Fusus perinusitatus*, Neogene of Buton, 62 mm. — **18,** *C. pectinatum*, Neogene of Buton, syntype RMNH 15217, 63 mm.

Calliotectum pectinatum may be the valid name of this species (see Remarks under that name).

Calliotectum dalli dalli (Bartsch, 1942)

Figs 3-4, 10-12

Prodallia dalli Bartsch, 1942: 10-11, pl. 2, figs 1, 4.

Type material. — Holotype USNM 231758.

Type locality. — *"Albatross"* stn 5119, off Cape Santiago, Luzon, 725 m [394 fms].

Material examined. — Off Taiwan, 1 dd (coll. Goto).
Philippines. MUSORSTOM 2: stn CP 38, 12°53′ N, 122°27′ E, 1650-1660 m, Sibuyan Sea, 1 juv. lv. — Stn CP 50, 13°37′ N, 120°33′ E, 810-820 m, off NW Mindoro, 1 lv, 1 dd. — Stn CP 79, 13°44′ N, 120°32′ E, 682-770 m, off NW Mindoro, 2 lv, 1 dd (figured by Bouchet, 1981: 10). — Stn CP 81, 13°34′ N, 120°31′ E, 856-884 m, Sibuyan Sea, 1 lv (all MNHN).

Distribution. — South of Taiwan and the Central Philippines (not recorded from the Southern Philippines), alive in 770-1650 m. Other than the material examined, *C. dalli* is known from *"Albatross"* stn 5248, off Lubang Island, 776 m [422 fms], USNM 231759 (Bartsch, 1942) and off SW Taiwan, 200-400m (Lan, 1980).

Remarks. — The size of adult shells (with expanded thickened outer lip) varies considerably. The sample, however, is too small for us to determine if this variation is geographical, bathymetrical, or individual. The largest shell is 163 mm high and comes from 682-770 m (MUSORSTOM 2: stn CP 79), the smallest is 79 mm high and comes from 856-884 m (MUSORSTOM 2: stn CP 81).

Calliotectum dalli claydoni (Poppe, 1986)

Figs 13-15

Teramachia dalli claydoni Poppe, 1986: 27-37, pls 2, 3.

Type material. — Holotype in the Western Australian Museum.

Type locality. — 280 km north-east of Port Hedland, Western Australia in about 475 m ("250 fms").

Material examined. — The type material and 7 shs from off Scott Reef and off Broome, Western Australia (Coll. Douté, Bail, Goto).
Indonesia. KARUBAR: stn CC 40, 07°46′ S, 132°31′ E, 443-468 m, 1 dd. — Stn CC 56, 08°16′ S, 131°59′ E, 552-549 m, 2 lv, 3 dd. — Stn CC 57, 08°19′ S, 131°53′ E, 603-620 m, 1 dd. — Stn CP 69, 08°42′ S, 131°53′ E, 356-368 m, 1 dd. — Stn CP 70, 08°41′ S, 131°47′ E, 410-413 m, 3 lv, 1 dd. — Stn CP 72, 08°36′ S, 131°33′ E, 676-699 m, 4 lv, 1 dd. — Stn CP 73, 08°29′ S, 131°33′ E, 840-855 m, 2 dd. — Stn CP 77, 08°57′ S, 131°27′ E, 346-352 m, 1 dd. — Stn CP 91, 08°44′ S, 131°05′ E, 884-891 m, 1 lv, 3 dd.

Distribution. — Along the continental slope off the Arafura Sea, (between Irian Jaya and Australia) to 18°53′ S-116°10′ E, alive in 413-884 m, shells from 296 m (Wells, 1989; this paper).

Remarks. — Adult *C. dalli claydoni* measure between 125 and 174 mm in shell height.

Calliotectum egregium sp. nov.

Figs 5-6, 19-24, 64-65

TYPE MATERIAL. — Holotype in MNHN.

TYPE LOCALITY. — BATHUS 3, stn CP 767, 22°11′ S, 165°59′ E, 1060-1450 m.

MATERIAL EXAMINED. — **New Caledonia**. MUSORSTOM 4: stn DC 168, 18°48′ S, 163°11′ E, 720 m, North of New Caledonia, 2 lv.
BATHUS 1: stn CP 661, 21°05′ S, 165°50′ E, 960-1100 m, 1 lv.
BATHUS 3: stn CP 767, 22°11′ S, 165°59′ E, 1060-1450 m, 1 lv (holotype). — Stn DW 789, 23°51′ S, 169°49′ E, 671-674 m, 1 dd. — Stn CP 844, 23°06′ S, 166°46′ E, 908 m, 1 lv small adult. — Stn CC 848, 23°02′ S, 166°53′ E, 680-700 m, 1 lv subadult.
Loyalty Islands. MUSORSTOM 6: stn DW 489 and stn DW 493, 20°48′ S, 167°06′ E, 700 m, 2 dd.
Vanuatu. MUSORSTOM 8: Stn DW 987, 19°23'S, 169°35′ E, 1040-1050 m, 1 juv. lv. — Stn CP 993, 18°49′ S, 168°54′ E, 780-783 m, 1 juv. lv. — Stn CP 994, 18°48′ S, 168°56′ E, 641-649 m, 1 juv. lv. — Stn CC 996, 18°52′ S, 168°56′ E, 764-786 m, 1 adult and 1juv. lv. — Stn CP 1035, 17°56′ S, 168°44′ E, 765-780 m, 1 small adult lv. — Stn CC 1056, 16°33′ S, 167°56′ E, 602-620 m, 1 lv. — Stn CP 1080, 15°57′ S, 167°28′ E, 799-850 m, 2 lv subadults.
Wallis and Futuna. MUSORSTOM 7: stn DW 523, 13°12′ S, 176°16′ W, 455-515 m, 1 juv. dd. — Stn DW 534, 12°23′ S, 176°42'W, 440-500 m, 1 old dd. — Stn DW 535, 12°30′ S, 176°41′ W, 340-470 m, 1 juv. dd. — Stn DW 539, 12°27′ S, 177°27′ W, 700 m, 1 juv. dd. — Stn DW 540, 12°27′ S, 177°28′ W, 600 m, 1 juv. dd. — Stn DW 547, 12°26′ S, 177°26′ W, 455 m, 1 juv. dd. — Stn CP 552, 12°16′ S, 177°28′ W, 786-800 m, 1 juv. lv. — Stn DW 557, 11°48′ S, 178°18′ W, 600-608 m, 1 juv. dd., 1 fragm. — Stn CP 562, 11°48′ S, 178°22′ W, 775-777 m, 1 juv. lv. — Stn CP 564, 11°46′ S, 178°27′ W, 1015-1020 m, 2 fragm. — Stn CP 567, 11°47′ S, 178°27′ W, 1010-1020 m, 1 juv. lv. — Stn DW 571, 12°31′ S, 176°52′ W, 502-508 m, 1 juv. lv. — Stn DW 626, 11°54′ S, 179°32′ W, 597-600 m, 1 juv. lv.
Kermadec Islands. R.V. *"Tangaroa"*, NZOI stn P946, Colville Ridge, 25°59′ S, 179°18′ W, 660 m, 1 dd (NZOI).

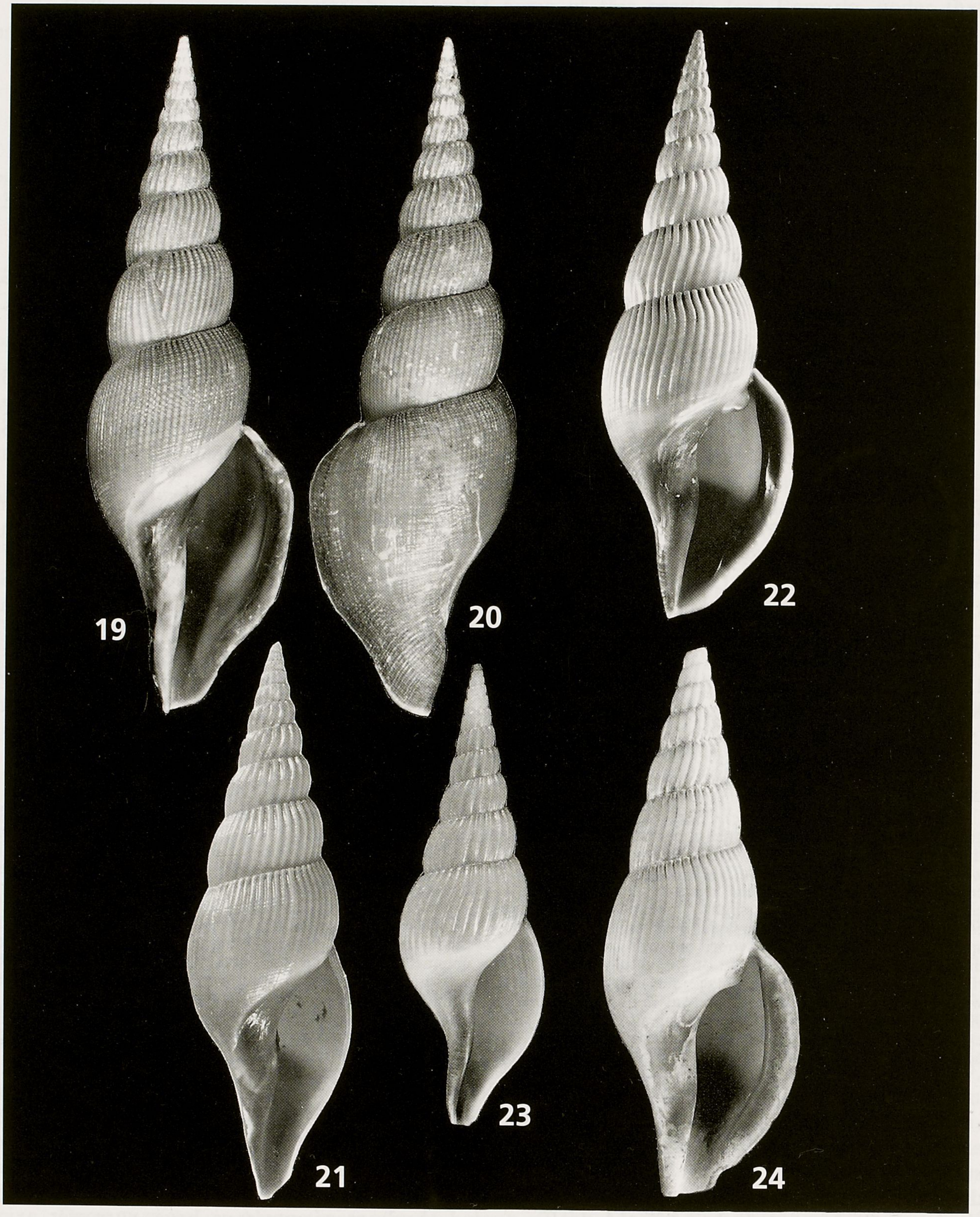
DISTRIBUTION. — SW Pacific, alive in 500-1060 m.

DESCRIPTION. — (Holotype). Shell fusiform, slender, glossy, consisting of 12.5+ whorls (uppermost part, probably the protoconch and one teleoconch whorl, missing); last adult whorl occupying 55% of total shell height; adapical teleoconch whorls slightly turreted, remaing whorls regularly convex; suture impressed, slightly channeled. Sculpture consisting of strong, flexuous axial ribs, and much fainter spiral groves from the 5th whorl onwards, resulting in a distinct finely clathrate sculpture on last adult whorl. Axial ribs sharp, comparatively stronger and fewer (16 on 6th whorl) on spire whorls, more numerous (59 on penultimate, 90 on last adult whorl) and lower on adult whorls; ribs extending to behind peristome, fading in abapical part of last adult whorl, below periphery. Thin but distinct incremental lines. Spiral sculpture consisting on spire whorls of simple incised lines, on last 3 whorls of broader groves (27 on penultimate whorl) forming gentle undulations at their intersection with axial ribs; on last adult whorl, interspaces between groves forming distinct spiral cords below periphery and on canal. Outer lip thick, flaring; columellar area arched, thinly calloused; siphonal canal broad, distinctly set off, moderately long. Ground colour olive-brown, outer lip, columellar area and base with siphonal canal chocolate brown, inner lip callus semitransparent white. Dimensions: height 126.5 mm, breadth 38.5 mm.

The light brown protoconch consists of ca. one whorl, diameter 1.0 mm, sculptured by slightly irregular spiral threads (Figs 64-65).

REMARKS. — *C. egregium* differs from its congeners by its distinctive spiral sculpture, extending onto the last adult whorl. It somewhat resembles *C. dalli* in the high gloss and channelled suture, but the axial ribs are more numerous at equivalent stages of growth, and the suture is distinctly less channeled. Some worn specimens, e.g. the shell from the Kermadecs, are superficially similar to *C. piersonorum*, but differ by the less convex whorls, more numerous, hence narrower, axial ribs, and darker ground colour.

All larger specimens have scars and repairs following attacks by crustaceans and many of the specimens are juveniles and/or worn adults or subadults.



FIGS 19-24. — *Calliotectum egregium*. **19-20,** holotype, New Caledonia, BATHUS 3: stn CP 767, 126.5 mm. — **21,** New Caledonia, MUSORSTOM 4: stn DC 168, subadult, 76 mm. — **22,** New Caledonia; BATHUS 3: stn CP 844, small adult with thickened lip, 70.5 mm. — **23,** Wallis, MUSORSTOM 7: stn CP 552, juvenile, 47 mm. — **24,** Kermadec, NZOI stn P946, 75 mm.

Calliotectum fischeri Olsson, 1964

Calliotectum fischeri Olsson, 1964: 129, pl. 23 fig. 4

TYPE MATERIAL. — Holotype USNM 643941 (not seen).

TYPE LOCALITY. — Quebrada Camerones, Esmeraldas Province, Ecuador; Pliocene.

REMARKS. — We have not examined material of this species, which beside the holotype is known only from a few fragments from the type locality, one of which is figured by EMERSON & SAGE (1986). *C. fischeri* is characterized by its broad profile, with low shouldered whorls, sculptured by densely packed sigmoid axial ribs.

Calliotectum marci (Koperberg, 1931)

Figs 25-27

Borsonia marci Koperberg, 1931: 45, pl. 1 figs 9-10.
B. marci fatuensis Koperberg, 1931: 45, pl. 1, fig. 9.
B. marci fekuensis Koperberg, 1931: 46, pl. 1, fig. 10.

TYPE MATERIAL. — 3 syntypes in the Mineralogisch-Geologisch Museum, University of Technology, Delft, Netherlands, reg. number KA-13960-13962.

TYPE LOCALITY. — Nono Fatoe Fekoe, Timor, Indonesia; Pliocene.

MATERIAL EXAMINED. — The type material.

REMARKS. — When *Calliotectum marci* was described in the turrid genus *Borsonia*, KOPERBERG had before her 3 juvenile specimens, but nevertheless succeeded to introduce 3 nominal taxa. She divided *B. marci* into two subspecies, but failed to retain the nominal *marci* for any of the two.

ROBBA *et al.* (1989: 83, pl. 2, fig. 8) reported a 30 mm high fragment of a *Teramachia* species from a lower Pleistocene deposit at Tinu, West Timor. They identified it as *T. johnsoni* [= *Calliotectum tibiaeforme*] and noticed that *Borsonia marci* was "strikingly similar", but did not formally synonymize the two nominal taxa, pending examination of Koperberg's type material. We agree that the juvenile type specimens of *C. marci* resemble juveniles of *C. tibiaeforme* more than any other Recent *Calliotectum* species, but we think that a critical evaluation of the name *marci* should ideally be based on adult or subadult specimens from the type locality or other similar deposits in Timor. From a nomenclatural point of view, it must be noted that *Borsonia marci* (11 November 1931) has 19 days priority over *Teramachia tibiaeformis* (November 1931, hence deemed to be 30 November 1931).

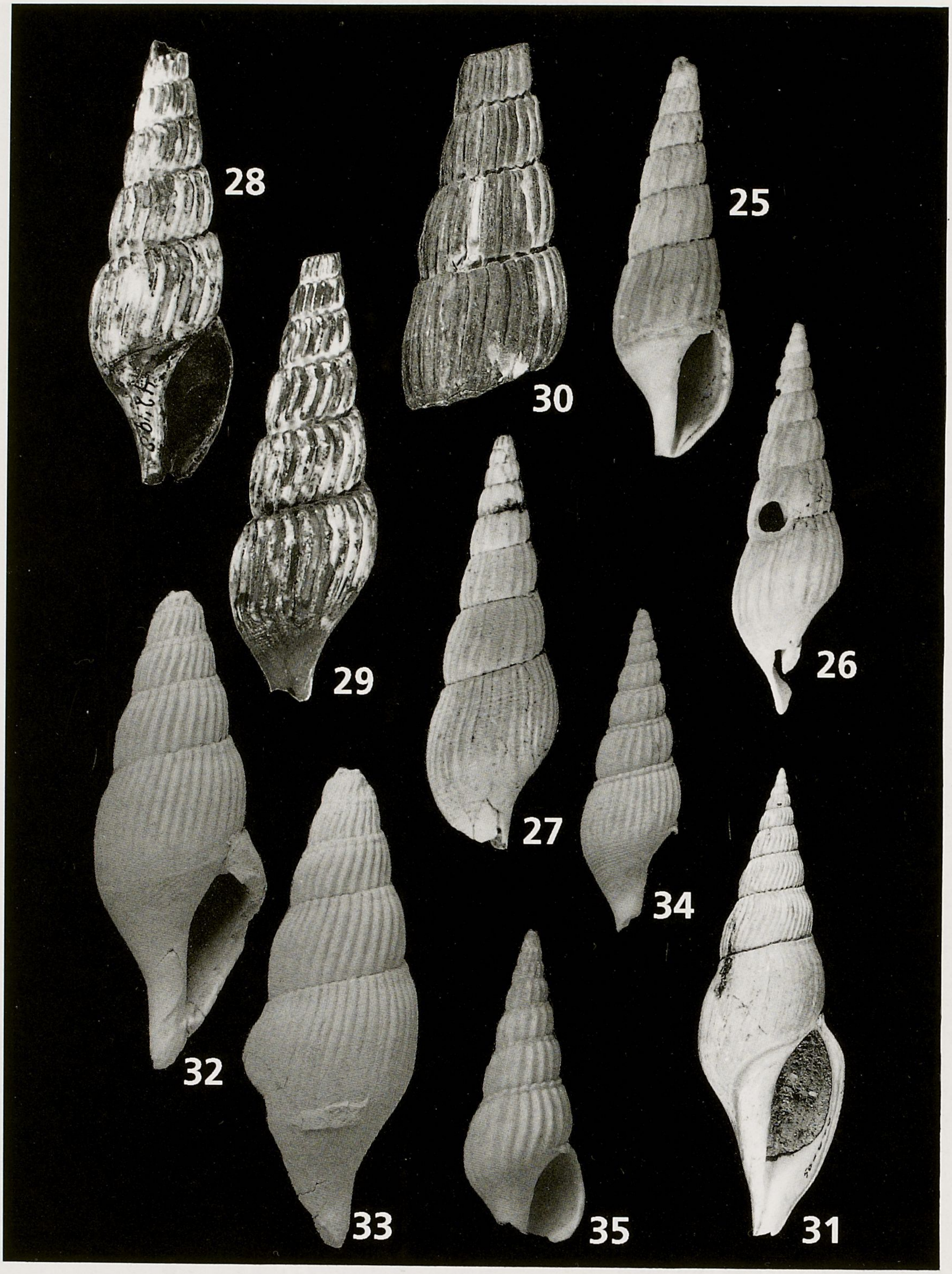
Calliotectum mirabile (Clench & Aguayo, 1941)

Howellia mirabilis Clench & Aguayo, 1941: 177, pl. 14, fig. 2.

TYPE MATERIAL. — Holotype MCZ 135291.

TYPE LOCALITY. — Off Matanzas, Cuba, *"Atlantis"* stn 3483, 23°12′ N, 81°23′ W, 520 m.

DISTRIBUTION. — Beside the holotype, *C. mirabile* is known from only one shell collected crabbed on the Little Bahama Bank in 465 m (EMERSON & SAGE, 1986).



FIGS 25-35. — Fossil *Calliotectum*. — **25-27,** *C. marci*, syntypes, Pliocene of Timor, 28 mm (25-26) and 37 mm (27). — **28-29,** *C. pectinatum*, Neogene of Buton, syntype RMNH 42498, 84 mm. — **30,** *C. pectinatum*, paratype of *Fusus perinusitatus* RMNH 42500, Neogene of Buton, 49 mm. — **31,** *C. shinzatoense*, holotype, Pliocene of Okinawa, 69.4 mm. — **32-33,** *C. waitaraense*, holotype, Miocene of New Zealand, 45.6 mm. — **34-35,** *C. waitaraense*, Miocene of New Zealand, NZGS locality 4784, 20.6 and 19.6 mm.

REMARKS. — We have not examined material of this species and refer to EMERSON & SAGE (1986) for description, illustration and comparative remarks. *C. mirabile* reaches 93 mm in shell length.

Calliotectum pectinatum (Martin, 1933)

Figs 16-18, 28-30

Fusus (Butonius) pectinatus Martin, 1933: 23, pl. 3, figs 20-20a.

Synonym:

Fusinus (Butonius) perinusitatus Beets, 1942: 284, pl. 28, figs 70-72. (**syn. nov.**)

Other references:

Fusus (Butonius) pectinatus — MARTIN, 1935: 111.
Fusinus (Butonius) pectinatus — BEETS, 1942: 284, pl. 28, fig. 69; 1953: 247.

TYPE MATERIAL. — *F. pectinatus*: 2 syntypes RMNH 15217, 42498. — *F. perinusitatus*: holotype RMNH 42499, paratype RMNH 42500.

TYPE LOCALITY. — *F. pectinatus* and *F. perinusitatus*: asphaltic sands of Kabungka, Buton Island, Indonesia.

MATERIAL EXAMINED. — The type material.

DISTRIBUTION. — Asphaltic sands of Kabungka and Waisiu, Buton Island, Indonesia.

REMARKS. — When MARTIN (1933) and BEETS (1942) named the two nominal species of *Butonius*, the asphaltic deposits of Buton were then believed to be of Upper Oligocene age. However, BEETS (1953) later reconsidered the problem and concluded instead that the deposits dated from Upper Miocene to Pliocene and corresponded to a deep-water fauna.

BEETS cited a stronger spiral sculpture and less calloused outer lip as characteristics differentiating *F. pectinatus* from *F. perinusitatus*, but we failed to recognize two species among the four specimens examined. In fact, BEETS had already noted that "*F. perinusitatus* might prove to be synonymous with *F. pectinatus* when more material becomes available".

Calliotectum pectinatum comes very close to *C. dalli* and they may be conspecific (in which case *C. pectinatum* is the oldest name). BEETS (1953) cited several Recent deep-sea species among the fauna from the asphaltic sands of Buton. *Calliotectum pectinatum* and *C. dalli* share a deeply channeled suture, an axial sculpture of broad and high ribs separated by deep grooves, and fine spiral sculpture on the last adult whorl. *C. pectinatum* has similar general proportions to *C. dalli claydoni*, but its shell is heavier, with a more strongly calloused outer lip and stronger axial sculpture. Whereas there is little doubt that *C. pectinatum* is the immediate predecessor of *C. dalli*, we prefer to keep different names for the Upper Miocene-Pliocene and Recent forms. This view should be reevaluated if additional fossil material falls within the range of variation of Recent *C. dalli*, or alternatively if Recent populations of *C. dalli* are discovered that have strongly built and heavy shells as in *C. pectinatum*.

Calliotectum piersonorum sp. nov.

Figs 7, 36-39, 66-67

TYPE MATERIAL. — Holotype and 2 paratypes MNHN.

TYPE LOCALITY. — BIOCAL, stn DW 51, 23°05′ S, 165°45′ E, 680-700 m, South of New Caledonia.

MATERIAL EXAMINED. — **Chesterfield Islands**. MUSORSTOM 5: stn DW 355, 19°37′ N, 158°44′ E, 580 m, 1 dd.
New Caledonia. BIOCAL: stn DW 33, 23°10′ S, 167°10′ E, 675-680 m, 1 worn adult, 5 juv. — Stn DW 51, 23°05′ S, 165°45′ E, 680-700 m, 1 lv, 1 dd (holotype), 3 fragm. — Stn CP 52, 23°36′ S, 167°47′ E, 540-600 m, 1 dd.
MUSORSTOM 4: stn DW 220, 22°58′ S, 167°38′ E, 505-550 m, 1 lv. — Stn DW 223, 22°57′ S, 167°30′ E, 545-560 m, 1 dd. — Stn CP 215, 22°56′ S, 167°17′ E, 485-520 m, 1 dd.
SMIB 1: stn DW 7, 22°56′ S, 167°16′ E, 500 m, 1 dd.
SMIB 2: stn DW 17, 22°55′ S, 167°15′ E, 448 m, 2 dd (paratypes).
SMIB 4: stn DW 61, 23°00′ S, 167°22′ E, 520-550 m, 1 broken dd.

DISTRIBUTION. — Chesterfields and Norfolk Ridge, shells in 450-700 m, alive in 550-680 m.

DESCRIPTION. — (Holotype). Shell solid, porcellaneous, fusiform consisting of one protoconch and 8.3 teleoconch whorls. Protoconch smooth, white, diameter 1.3 mm. First three teleoconch whorls turreted, remaining whorls convex with adpressed, but slightly channelled, suture. Last adult whorl occupying 58% of total shell height. Sculpture consisting of strong, broad axial ribs, rather rounded in section; they number 24 on the penultimate, and 26 on the last adult whorl, where they become obsolete abapically. Aperture ovate, with flaring convex outer lip. Siphonal canal short. Ground colour creamy white; suture, columellar region, base and outer lip purplish brown. Dimensions: height 59.0 mm, breath 19.5 mm.

Largest paratype 96 mm high.

REMARKS. — *C. piersonorum* differs from its congeners by its smaller adult size, absence of spiral sculpture, its axial sculpture extending on the last adult whorl, and colour pattern. It has a superficial resemblance to the Japanese form of *C. tibiaeforme*, but in the latter the last two whorls are smooth, and there is a much darker subsutural band. The protoconch is larger than in the other species of *Calliotectum* where it has been observed (1.3 vs 1.0 mm).

The specific epithet honors Dr and Mrs PIERSON of Nouméa, longtime collectors of New Caledonian shells, and authors of *Porcelaines mystérieuses de Nouvelle-Calédonie*.

Calliotectum shinzatoense (MacNeil, 1961)

Fig. 31

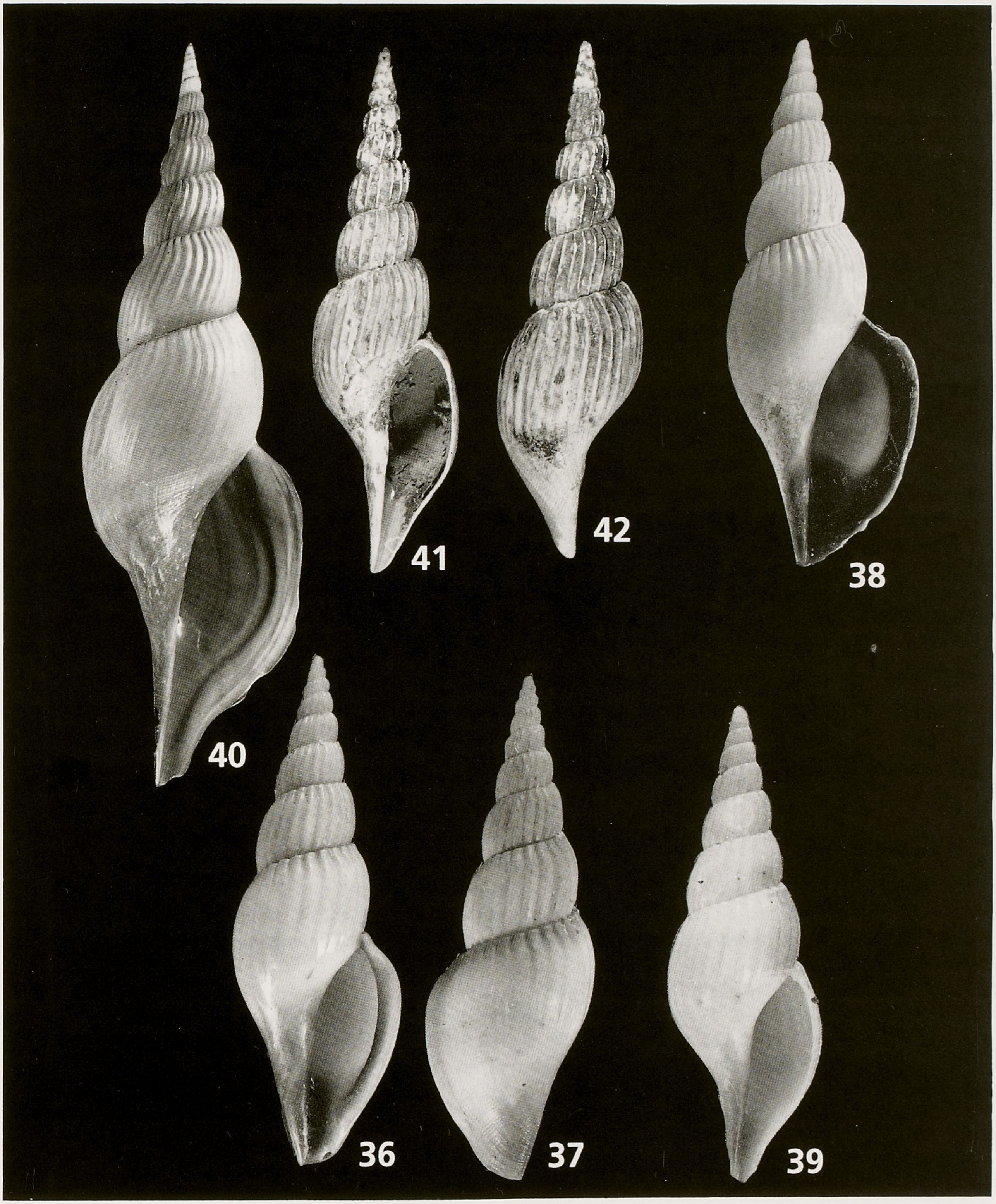
Teramachia shinzatoensis MacNeil, 1961: 96, pl. 9, fig. 1.

TYPE MATERIAL. — Holotype USNM 562840.

TYPE LOCALITY. — About 0.3 miles [= ca. 0.5 km] south of Shinzato, Okinawa, Japan; Pliocene.

MATERIAL EXAMINED. — The holotype.

REMARKS. — NODA (1980: pl. 5, figs 23, 26, 27; 1988: pl. 10, figs 5, 6, 18) recorded numerous specimens (at least 12) from the same geological formation on Okinawa, but identified them as *Teramachia johnsoni*, noting that *T. shinzatoensis* differs "in having 18-19 axial ribs and smooth surface on penultimate to body whorls". However, we find it questionable that *Calliotectum shinzatoense* represents a distinct species, as the characters of the holotype appear to fall within the range of variation of *C. tibiaeforme*. When he named *Teramachia shinzatoensis*, MACNEIL (1961: 18) attributed the fauna of the Shinzato formation to "very late Miocene or early Pliocene" but, based on evidence from planctonic Foraminifera, NODA (1980: 7) gave an Upper Pliocene age. He also reported that 23.7% of the gastropods from the Shinzato Formation still occur in Recent faunas (NODA, 1980: 6). *C. shinzatoense* may be a synonym of *C. tibiaeforme* and/or *C. marci*.



FIGS 36-42. — *Calliotectum*. — **36-37,** *C. piersonorum*, holotype, New Caledonia, BIOCAL: stn DW51, 59 mm. — **38,** *C. piersonorum*, paratype, New Caledonia, SMIB 2: stn DW17, 96 mm. — **39**, *C. piersonorum*, New Caledonia, MUSORSTOM 4: stn DW 223, 37 mm. — **40,** *C. smithi*, Philippines, between Bohol and Cebu, 157 mm. — **41-42,** *C. smithi*, Philippines, MUSORSTOM 3: stn CP128, juvenile, 52 mm.

Calliotectum smithi (Bartsch, 1942)

Figs 40-42

Prodallia smithi Bartsch, 1942: 11-12, pl. 2, fig. 5.

TYPE MATERIAL. — Holotype USNM 231760.

TYPE LOCALITY. — *"Albatross"* stn 5528, off Balicasag, Bohol, 803 m.

MATERIAL EXAMINED. — *"Albatross"* stn 5124, off Maestre de Campo Island, 515 m, 1 paratype (USNM 235394).
Philippines. MUSORSTOM 2: stn CP 46, 13°26′ N, 122°17′ E, 445-520 m, Lubang Island, 1 dd. MUSORSTOM 3: stn CP 122, 12°20′ N, 121°42′ E, 673-675 m, SW of Mindoro, 2 juv. dd. — Stn CP 128, 11°50′ N, 121° 42′ E, 815-821 m, S of Mindoro, 2 juv. dd. — Stn CP 135, 11°58′ N, 122°02′ E, 486-551 m, W of Panay, 1 lv, 1 dd (all MNHN).
Off southern Mindanao (Coll. Douté, Bail, Goto), 7 shells.

DISTRIBUTION. — Philippine Islands, alive in 486-551 m, shells to 815 m.

REMARKS. — *C. smithi*, formerly very rare, is now regularly caught alive in tangle nets by fishermen. The shells are purple brown with a pale zone on the lower half of the last whorl. The apex is lighter in colour.

For distinguishing characters from *C. tibiaeforme*, see that species.

Calliotectum tibiaeforme (Kuroda, 1931)

Figs 8-9, 43-56

Teramachia tibiaeformis Kuroda, 1931: 45, figs 2, 3.

Synonyms:

Prodallia johnsoni Bartsch, 1942: 12, pl. 2, fig. 3. (**syn. nov.**)
Teramachia johnsoni williamsorum Rehder, 1972: 7-10, figs 1-7.
Teramachia dupreyae Emerson, 1985: 102-107.

TYPE MATERIAL. — *Teramachia tibiaeformis*: holotype in the Teramachi collection (whereabouts unknown). — *Prodallia johnsoni*: holotype USNM 238419. — *Teramachia johnsoni williamsorum*: holotype USNM 707229. — *T. dupreyae*: holotype AMNH 213477.

TYPE LOCALITY. — *Teramachia tibiaeformis*: off Kii, Japan, depth unknown. — *Prodallia johnsoni*: *"Albatross"* stn 5424, off Cagayan I., Sulu Sea, 620 m. — *Teramachia johnsoni williamsorum*: off Tung-Chiang, Taiwan, in 50-275 m. — *T. dupreyae*: 200 miles NW of Broome, Western Australia, off McDonnell Reef, 400 m.

DISTRIBUTION. — From Southern Japan to off Southwestern Australia and the tropical South West Pacific. Reported from the Upper Pliocene Shinzato Formation of Okinawa (NODA, 1980, 1988).

REMARKS. — Our concept of *C. tibiaeforme* differs markedly from that of our predecessors: we consider the Japanese topotypical populations as the northernmost extension of the range of a variable species known to the South as *Teramachia johnsoni* and *T. dupreyae*. As long as they were known only from disjunct populations in Japan and the Philippines, the distinction between *T.*

tibiaeforme and *T. johnsoni* appeared clear-cut, and recognition at species level warranted. Later, populations from Taiwan and NW Australia became known, each with characteristics that were the basis for the naming of *T. johnsoni williamsorum* and *T. dupreyae* respectively. Admittedly, groups of populations are morphologically recognizable on a geographical basis (Poppe & Goto, 1992), and it may be tempting to treat them as subspecies. However, giving a formal name to every group of populations is untenable, as still more populations from intermediate or adjacent areas are discovered. We believe that the reason why the named forms are presently partly disjunct is because inadequate sampling has been done in intermediate areas (Indonesia, New Guinea). Consequently, we interpret all these populations as geographical variants of a single species, and recommend avoidance of the use of subspecies to designate discrete groups of populations.

C. tibiaeforme is extremely variable in shape, sculpture and colouration. There exist slender, almost fusiform shells (Philippines), as well as specimens with broad last adult whorl and expanded outer lip (Western Australia). Axial rib counts vary between 30 (Taiwan) and 42 (NW Australia) on the first whorls. The ribs may extend to the last adult whorl (New Caledonia) or be restricted to the earlier teleoconch whorls (Japan). The colour varies from white (W Australia) to violet brown (Taiwan). A dark subsutural band and/or a darker zone near the siphonal canal may be present. Against this variation, a constant character is the characteristic sculpture of flexuous axial ribs crossed by strong spiral cords on the spire whorls (Figs 54-56).

C. tibiaeforme is nearest to *C. smithi*. The constant specific characters are: (1) the adpressed suture in *C. tibiaeforme* vs. impressed in *smithi*; (2) axial ribs on mid teleoconch whorls with square section vs. triangular section in *smithi*; (3) a dark subsutural band is present in most populations; the only exception is off SW Australia, at the extremity of the range, where the sutural area nevertheless has a dark tinge. Protoconchs consist of about one whorl, diameter ca. 1.0 mm, light brown, with a sculpture of fine spiral lines. Other distinguishing characters vary between populations, as reviewed below.

From a nomenclatural point of view, it must be noted that *Calliotectum marci* (published 11 November 1931) may be a senior synonym of *C. tibiaeforme* (published November 1931, hence deemed to be 30 November 1931); see Remarks under *C. marci*.

Japan form

Figs 43-45

Records and material examined. — **Japan**. Southern Honshu and southwards, 150-500 m (Kira, 1962; Higo & Goto, 1993). — From southern Japan (Coll. Douté, Bail, Goto), 4 shs. — Off Tosa, 180-270 m, 3 lv, 1 dd (LACM 35052, 67093-094). — Off Mikawa, deep water, 1 lv (MNHN).

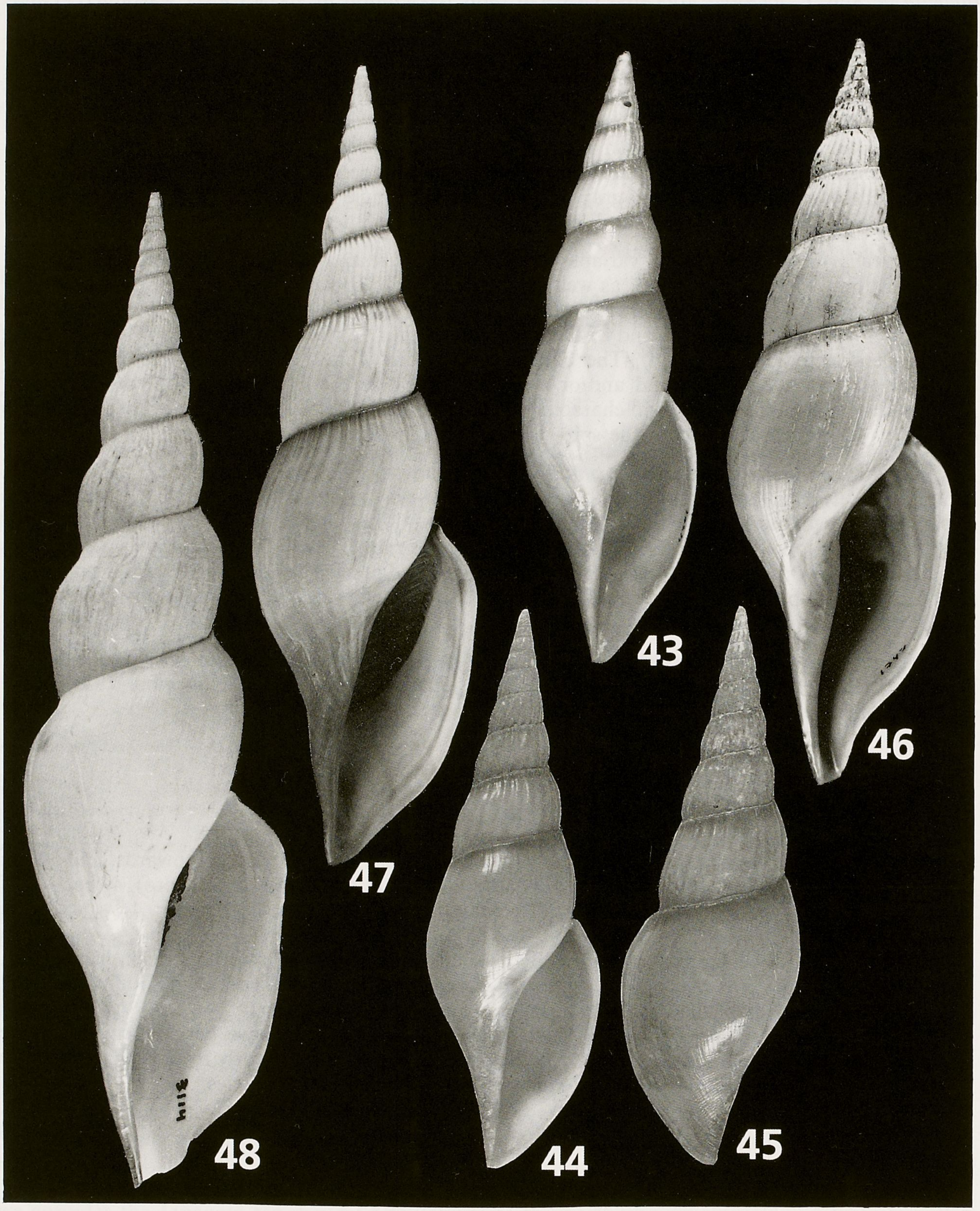
Remarks. — The Japan form differs by its small adult size (63-93 mm), its thick, heavy shell, with fewer axial ribs on earlier whorls, and very short siphonal canal. The base colour varies from pale cream brown to light lilac, with distinct darker subsutural band.

Most Japanese *C. tibiaeforme* in Western collections appear to have been taken in the late 1950s and 1960s. We have seen no recently taken material, but this apparently reflects changes in the Japanese shell market rather than actual changes in abundance of the species.

Taiwan form

Fig. 46

Material examined. — "Off Taiwan", 6 specimens obtained through shells dealers from fishing boats operating from Kaoshiung (Coll. Douté, Bail, Poppe).



FIGS 43-48. — *Calliotectum tibiaeforme*. — **43,** Japan, 94 mm. — **44-45,** off Mikawa, Japan, 62.5 mm. — **46,** off S.Taiwan, 250 m, 132 mm. — **47,** Arafura Sea, 145 mm. — **48,** off Western Australia, form *dupreyae*, 206 mm.

REMARKS. — The Taiwan form is 121-134 mm high, thus much larger than the Japan form. It differs by a broader shell from the similarly coloured (purplish-grey with olive grey periostracum) Philippines specimens. This is the population named *Teramachia johnsoni williamsorum*.

LAN (1979) figured a shell as *Teramachia tibiaeformis*. He stated that it was seasonally available in waters between 200 and 400 m deep. All Taiwan specimens in Western collections have been trawled in the beginning of the 1970s.

Philippines form

Figs 55-56

RECORDS AND MATERIAL EXAMINED. — *"Albatross"* stn 5424, off Cagayan Island, Sulu Sea, 620 m, holotype. — Stn 5535, off Dumaguete, 570 m, 1 lv (REHDER, 1972). — Southern Mindanao, 8 shs (Coll. Douté, Bail, Goto).
MUSORSTOM 2: stn CP 78, 13°49′ N, 120°28′ E, 441-550 m, off NW Mindoro, 2 juv. dd (MNHN).
MUSORSTOM 3: stn CP 128, 11°50′ N, 121°42′ E, off S Mindoro, 815-821 m, 1 juv. dd (MNHN).

REMARKS. — The Philippines form is 109-140 mm high. It is similar to the Taiwan form in colour (purplish-grey with olive grey periostracum), and differs only by being more slender. This is the population named *Teramachia johnsoni*.

Large numbers of specimens have been taken by tangle nets in the central Philippines, and this is the population most frequently illustrated in popular periodicals and books (*e.g.*, OKUTANI, 1983; SPRINGSTEEN & LEOBRERA, 1986).

Arafura Sea form

Fig. 47

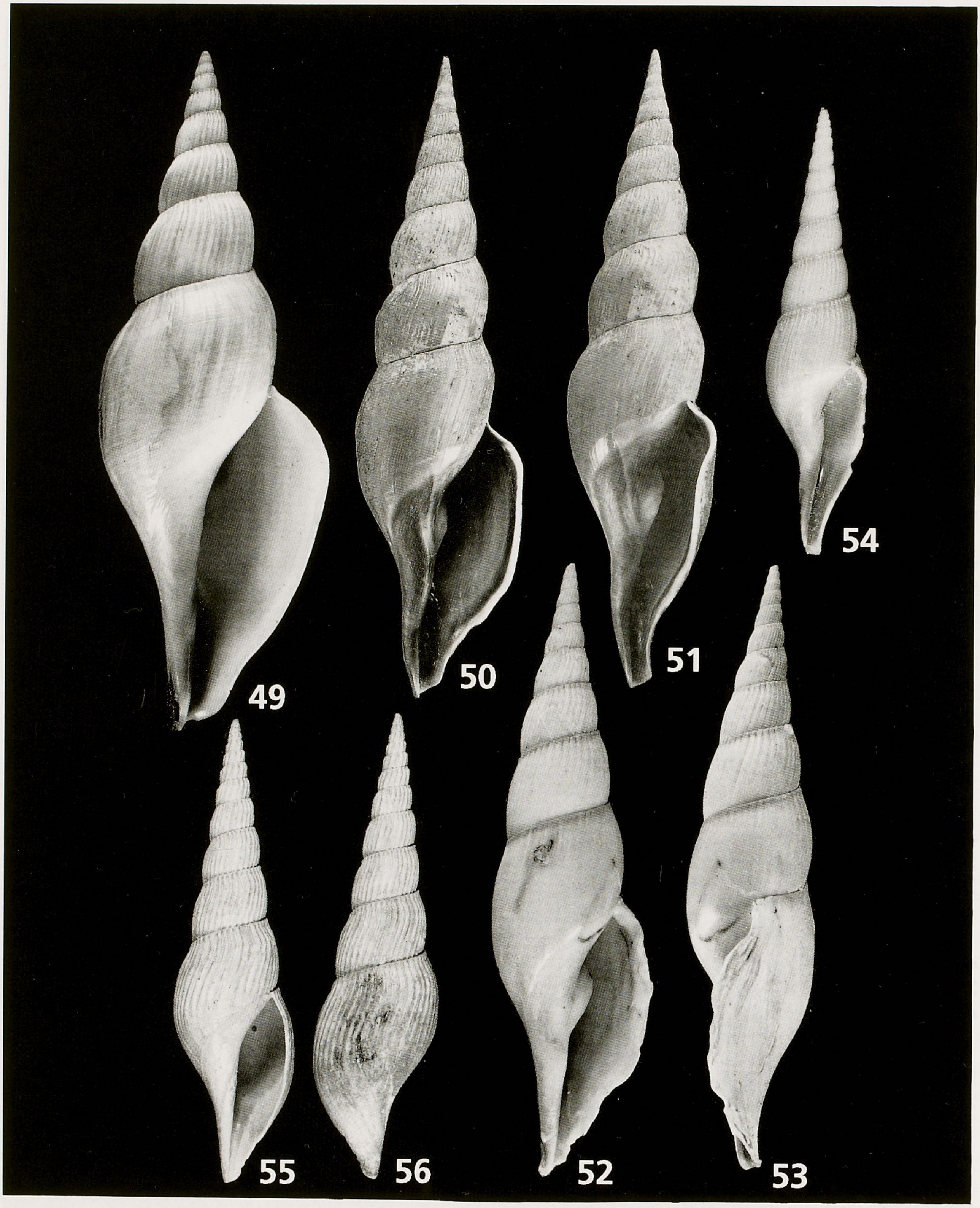
MATERIAL EXAMINED. — **Indonesia**. KARUBAR: stn CP 9, 05°23′ S, 132°29′ E, 368-389 m, 1 dd. — Stn CP 25, 05°30′ S, 132°52′ E, 336-346 m, 1 dd. — Stn CC 48, 08°19′ S, 132°02′ E, 457-461 m, 1 dd. — Stn CP 59, 08°20′ S, 132°11′ E, 399-405 m, 1 lv. — Stn CP 70, 08°41′ S, 131°47′ E, 410-413 m, 1 dd. — Stn CP 83, 09°23′ S, 131°00′ E, 285-297 m, 1 lv (all MNHN).
Australia. 12 specimens "from the Arafura Sea" obtained through Australian shell dealers (Coll. Douté, Bail, Goto).

REMARKS. — Shells reach 144 mm in height and are most similar to those from Taiwan, but differ by having more numerous axial ribs, which extend to the penultimate and last adult whorls. Shell colour is quite variable, ranging from white to chocolate brown to lilac, or a mixture of these colours even in a single shell. This form has not received a formal name.

Northwest Australia form

Fig. 48

RECORDS AND MATERIAL EXAMINED. — Continental slope off the North West Shelf from 13°33′ S-122°54′ E to 18°06′ S-118°12′ E in 296 to 504 m (WELLS, 1989). — Off Port Hedland and Broome, 11 specimens (Coll. Douté, Bail, Poppe) from hundreds of specimens examined by the second author in Australia. This population is extensively fished around Scott Reef, NE of Port Hedland, between 170 and 600 m, on soft bottoms.



FIGS 49-56. — *Calliotectum tibiaeforme*. — **49,** off Geraldton, Western Australia, 133 mm. — **50-51,** Vanuatu, MUSORSTOM 8: stn CP 1049, 160 mm. — **52-53,** New Caledonia, MUSORSTOM 4: stn DW 197, 129 mm. — **54,** New Caledonia, MUSORSTOM 6: stn DW 483, juvenile, 58 mm. — **55-56,** Philippines, MUSORSTOM 2: stn CP 78, juvenile, 61 mm.

REMARKS. — Adults of this form are 122-222 mm high, and thus reach the largest size of any population. Their typical white ground colour readily distinguishes them from the Japan, Taiwan, Philippine and Arafura Sea populations. They differ from the Geraldton form by their much higher spire (body whorl: total shell height 48-56%), and fainter spiral striation. This is the population named *Teramachia dupreyae* Emerson, 1985.

Geraldton form

Fig. 49

MATERIAL EXAMINED. — From off Geraldton, Western Australia, 4 specimens (Coll. Douté, Bail, Goto).

REMARKS. — These shells reach only 165 mm, and are thus smaller than large specimens from off the Northwest shelf. They differ from these by their shorter spire (last adult whorl: total shell height 62 %), and by having more widely spaced axial ribs, with stronger spiral striae. They are completely white, except for a discrete brown tinge in the sutural area.

South-West Pacific form

Figs 50-54

MATERIAL EXAMINED (all MNHN). — **New Caledonia**. MUSORSTOM 4: stn DW 197, 18°51′ S, 163°21′ E, 550 m, 1 dd. — Stn CP 242, 22°06′ S, 167°10′ E, 500-550 m, 1 juv. dd.
BATHUS 1: stn DE 696, 20°34′ S, 164°57′ E, 497-520 m, 1 lv. — Stn CP 708, 21°43′ S, 166°39′ E, 550-580 m, 1 juv. dd. — Stn CP 709, 21°42′ S, 166°38′ E, 650-800 m, 1 dd.
BATHUS 2: stn CP 738, 23°02′ S, 166°57′ E, 558-647 m, 1 dd. — Stn CP 762, 22°19′ S, 166°10′ E, 620-700 m, 1 juv. lv.
Loyalty Islands. MUSORSTOM 6: stn CP 466, 21°05′ S, 167°32′ E, 540 m, 1 juv. dd. — Stn DW 483, 21°20′ S, 167°48′ E, 600 m, 1 juv. dd.
Vanuatu. MUSORSTOM 8: stn CP 1047, 16°54′ S, 168°10′ E, 486-494 m, 1 lv. — Stn CP 1049, 16°39′ S, 168°03′ E, 469-525 m, 2 lv. — Stn CP 1054, 16°28′ S, 167°57′ E, 522-527 m, 1 lv. — Stn DW 1072, 15°40′ S, 167°20′ E, 622-625 m, 1 juv. dd. — Stn CP 1124, 15°02′ S, 166°57′ E, 532-599 m, 1 lv.

REMARKS. — The two adults from New Caledonia measure 129 and 151 mm in height, those from Vanuatu 154 and 157 mm. These shells are remarkable by the presence of a callous fold-like development in the columellar region, also discernible in subadults. For several years, we knew a single adult of this form and thought this to be a teratological character. Collection of additional specimens in 1993-94 has forced us to reevaluate this opinion. The material is rather variable in colouration and development of spiral sculpture on the last adult whorl, but it shares with other populations of *C. tibiaeforme* the characteristic sculpture of the spire whorls.

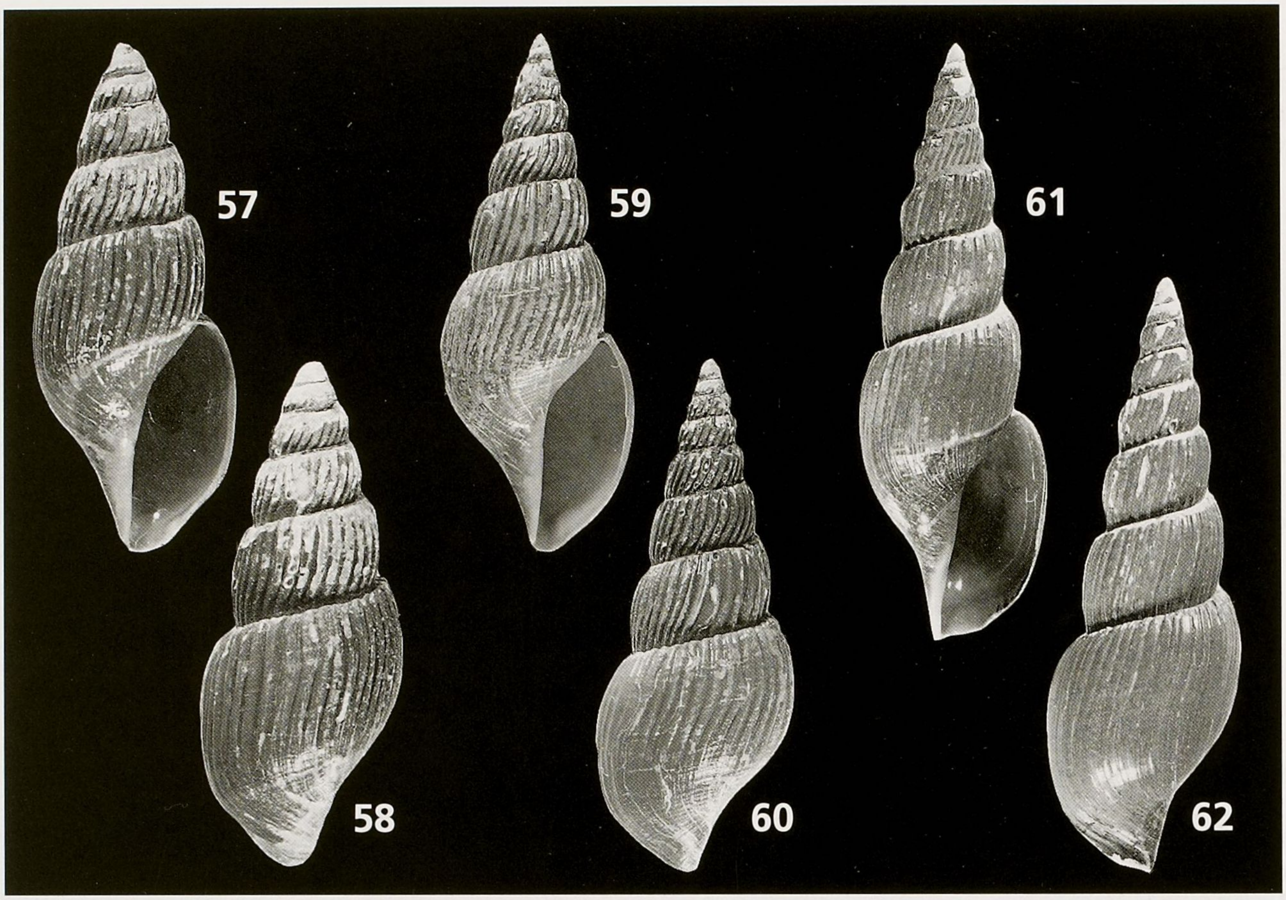
The distribution of this form may extend to North of Fiji, as a one-whorl fragment from Bayonnaise Bank (MUSORSTOM 6: stn DW 626, 11°54′ S, 179°32′ W, 597-600 m) appears to be referable to this species.

Calliotectum vernicosum Dall, 1890

Figs 1-2, 57-62

Calliotectum vernicosum Dall, 1890: 304, pl. 5, fig. 8.

TYPE MATERIAL. — Lectotype, selected by EMERSON & SAGE (1986: 150, figs 9-10), USNM 96555; 4 paralectotypes, USNM 97068, 633904, DMNH 10135.



FIGS 57-62. — *Calliotectum vernicosum*. — **57-58,** Peru, S of Isla Lobos de Afuera, juvenile, 39 mm. — **59-60,** Ecuador, off Puerto Pizarro, subadult, 62 mm. — **61-62,** Ecuador, Golfo de Guayaquil, 85 mm.

TYPE LOCALITY. — *"Albatross"* stn 2807, 00°24′ S, 89°06′ W, 1485 m, Galapagos Islands (lectotype, 2 paralectotypes). — Stn 2793, 01°03′ N, 80°15′ W, 1355 m, off Ecuador (2 paralectotypes).

MATERIAL EXAMINED. — **Peru**. South of Isla Lobos de Afuera, 07°07′ S, 80°46′ W, 1200 m, leg. McLean & Del Solar, 20 Jan. 1974, 2 lv, 2 dd (LACM 74-9). — about 50 miles [= ca 90 km] SE of Isla Lobos de Afuera, 07°46′ S, 80°31′ W, 800 m, leg. McLean & Del Solar, 23 Jan. 1974, 2 lv, 1 juv. lv (LACM 74-19). — W of Barranca, 10°45.8′ S, 78°36.4′ W, 864 m, leg. Del Solar, 15 May 1971, 1 lv (LACM 71-239).
Ecuador. Gulf of Guayaquil, NW of Tumbes, *"Anton Bruun"* cruise 18B, stn 770, 03°15′ S, 80°55′ W, 945-960 m, 10 Sept. 1966, 1 lv, 2 juv. dd (LACM 66-186). — Off Puerto Pizarro, 13 Apr. 1968, 1 lv (LACM).

DISTRIBUTION. — East Pacific, off Ecuador, Peru and the Galapagos, in 800-1485 m.

REMARKS. — The small size of DALL's holotype (height 48 mm) has masked the close similarities of *Calliotectum vernicosum* with the Indo-Pacific species of *Teramachia*, but these become obvious with the 85 mm adult from the Gulf of Guayaquil. *C. vernicosum* is characterized by its moderately channeled suture, extremely short siphonal canal, thin outer lip, lack of spiral sculpture on spire whorls, and its thick reddish brown periostracum.

Calliotectum waitaraense (Marwick, 1926)

Figs 32-35

Melanopsis waitaraensis Marwick, 1926: 317.

TYPE MATERIAL. — Holotype NZGS TM5902.

TYPE LOCALITY. — NZGS locality 1141, coast south of Waiiti stream mouth, North Taranaki, North Island, New Zealand; late Miocene [Tongaporutuan].

MATERAL EXAMINED. — The holotype. **New Zealand.** NZGS locality 1133, Mimi stream, very near type locality, late Miocene, paratype (NZGS TM5903) and several fragments, representing one or more specimens. — NZGS locality 4784, Marsden-Kumara Rd, Westland, South Island, [Clifdenian] middle Miocene, 12 fragments and young specimens. — NZGS locality 3349, Sawyer's Creek, Boddytown near Greymouth, South Island, middle Miocene, 1 fragment. (All material in NZGS).

REMARKS. — A characteristic of *C. waitaraense* is the sculpture of the juveniles, which have axial ribs constricted adapically, forming a subsutural row of rounded tubercles. Spiral sculpture is variable in the material examined, and no specimen has a complete aperture.

MARWICK (1926) considered *Coptochetus zelandicus* Marshall, 1917 to be congeneric with *Calliotectum waitaraense*, a view accepted by FLEMING (1966), but BEU & MAXWELL (1990) place it with doubt in the genus *Exilia* (Turbinellidae: Ptychatractinae).

DISCUSSION

Calliotectum has been restricted to deep-water since its first recorded occurence, in the Miocene of New Zealand. The unfamiliar faunal assemblages where the fossils are found led to erroneous interpretations by the paleontologists who discovered them. Because the Buton fauna differed so dramatically from known Neogene deposits in Indonesia, MARTIN (1933) and BEETS (1942) initially interpreted it as an Oligocene shallow water fauna, before recognizing it as an Upper Miocene-Pliocene deep water fauna (BEETS, 1953). Similarly, MARWICK (1926) interpreted the North Taranaki deposit with *C. waitaraense* as a brackish water fauna, and placed *Pakaurangia* (= *Calliotectum*) in the family Thiaridae. MACNEIL (1961) appears to have first recognized the similarity of fossil *Calliotectum* (as *Teramachia*) with the modern deep-water taxon. Indeed, *Calliotectum* is an excellent bathymetric marker (BEU & MAXWELL, 1990; NODA, 1980, 1988; ROBBA *et al.*, 1989), although its paleoecological interest is limited by its relative scarcity.

Bathymetric distribution

Altogether, the 7 Recent species of *Calliotectum* have a bathymetric range extending from ca. 150 m to 1650 m, but in the West Pacific-Australia region the majority of records are in the 200-900 m interval. A maximum of three species may occur sympatrically in the same geographical area, and then there is evidence of bathymetric segregation (Fig. 63). Despite partly overlaping depth distribution, there is no instance when two species have been taken alive together in the same haul, thus suggesting that additional factors, such as bottom type and/or hydrological conditions, further contribute to habitat segregation.

Calliotectum dalli has the broadest range of all species, but the extremes are reached in different parts of the geographical range. In fact, both *C. dalli* and *C. tibiaeforme* occur in significantly shallower water in the Arafura Sea than in the Philippines, which was unexpected since the latter are situated at higher latitudes.

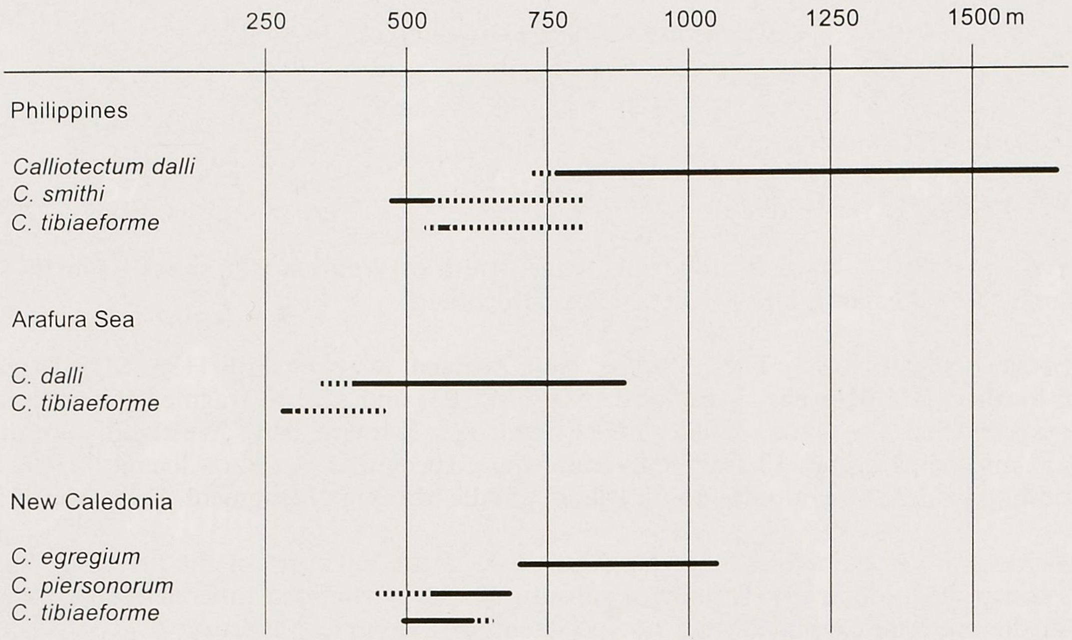


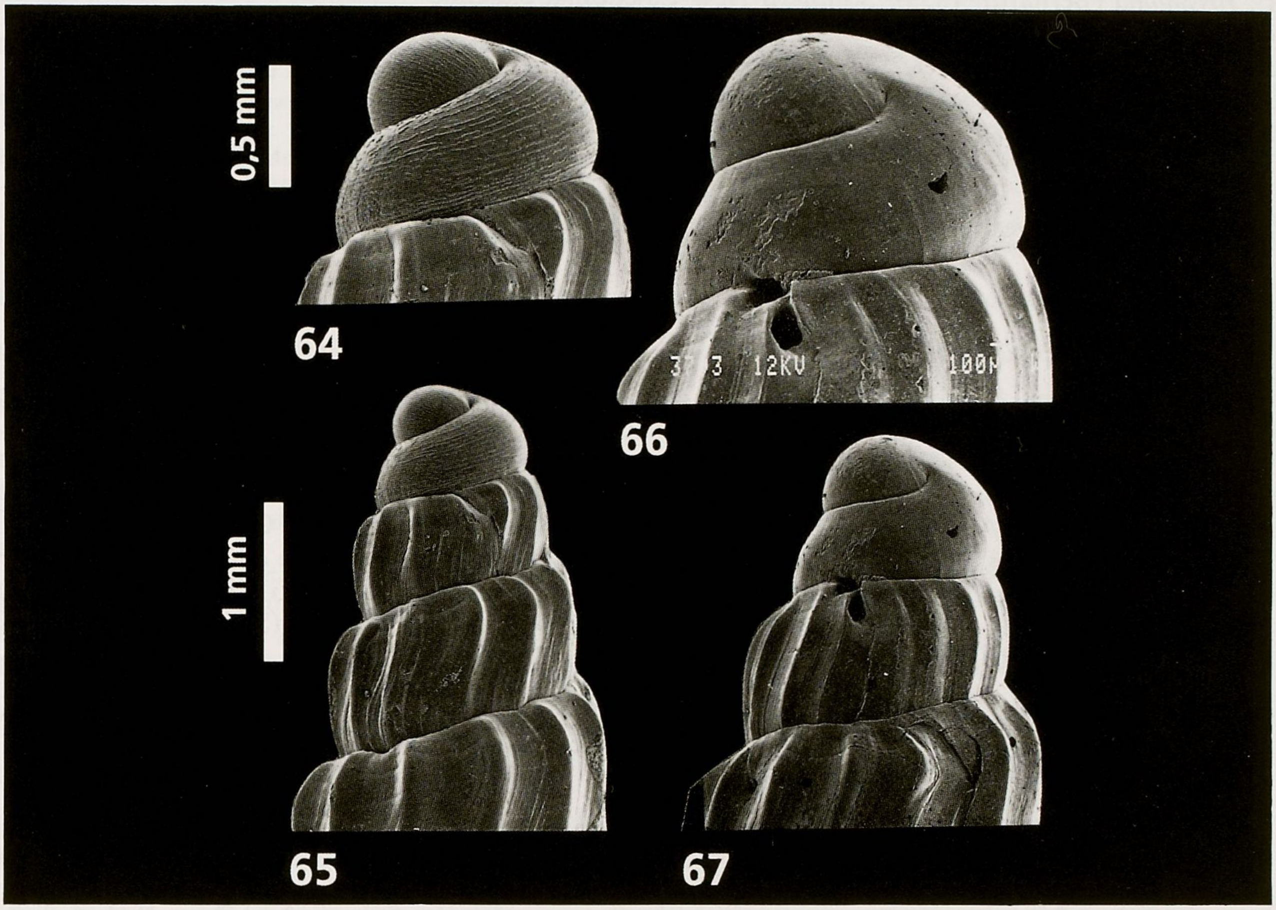
FIG. 63. — Bathymetric distribution of the Indo-Pacific species of *Calliotectum* from discrete geographical regions. Thick line: based on live records; stippled: empty shells or records from shell dealers.

Biogeography

Protoconch morphology indicates non-planktotrophic development (Figs 64-67), but with a diameter in the order of 1 mm, the protoconchs are among the smallest of all Recent volutes. *Calliotectum tibiaeforme* also happens to be the volute with the largest geographical distribution. Also, *C. egregium* is the species that extends the farthest to the East in the Indo-Pacific biogeographical region, on island slopes (Vanuatu, Wallis) that are separated by deep trenches and abyssal plains from populations situated to the West. We suggest that the small size of the postlarva at the time of hatching is compatible with good dispersal capacities that account for extensive horizontal distributions at species level. LEAL & BOUCHET (1991) showed that lecithotrophy is compatible with dispersal over distances of a few hundred kilometers. It is probably significant that *C. piersonorum* has the largest protoconch (1.3 mm) *and* the most restricted range of all Indo-Pacific species.

EMERSON & SAGE (1986) hypothesized that *C. mirabile* is a Pacific plate faunal element carried into the Atlantic on the East Pacific-Caribbean plate in the Eocene (DURHAM, 1985). The fossil record of *Calliotectum* does not extend further back than Pliocene in the East Pacific, and to Miocene in New Zealand. This, of course, does not exclude that Paleogene fossils may one day be discovered. However, if we stick to the available evidence, then the eastwards drift of the East Pacific-Caribbean plate into the Atlantic has happened much too early to have any significance for *Calliotectum* distribution. Instead, the penetration of *Calliotectum* from the East Pacific into the Caribbean through deep passages in Central America until 3 MY ago is compatible with paleontological and tectonic evidence (KEIGWIN, 1982).

If we assume that *Calliotectum* originated in the West Pacific, it remains to explain how it reached the East Pacific. Considering the small size of the protoconch, it cannot even be excluded that *Calliotectum* has a free-swimming, non-feeding, demersal stage between hatching and settlement. This hypothesis is supported by the fact that the protoconch of *C. egregium* is coloured light brown, a character often associated with planctotrophy or demersal non-planctotrophy. We predict that further sampling will reveal the occurence of *Calliotectum* populations as far East as Fiji, Tonga, and perhaps



FIGS 64-67. — Protoconchs and apical whorls of *Calliotectum*. — **64-65,** *C. egregium*, Wallis, MUSORSTOM 7: stn DW 535. — **66-67,** *C. piersonorum*, New Caledonia, BIOCAL: stn DW 33.

the Cook Islands, which are separated from other islands and guyots by distances of less than 600 km (BOUCHET & POPPE, 1988). Further East, in the Central Pacific, distances amount to thousands of kilometers between the Marquesas, Easter Island and Hawaii, and reaching these by dispersal may represent unpassable barriers. Yet, we believe that the most parcimonious hypothesis explaining the occurence of *Calliotectum* in the East Pacific is that of a rare larval dispersal event, followed by speciation.

Catalogue of New Caledonian volutes

The present paper concludes the description of the volute fauna of New Caledonia (BOUCHET, 1979; BOUCHET & POPPE, 1988). A total of 13 species are now known from the area: 4 on the Chesterfield plateau, 11 in New Caledonia proper, and 3 on the Loyalty Ridge. Of 5 shallow water species, 4 are endemic (80%), and of 8 deep-water species, 4 are endemic (50%).

Alcithoe aillaudorum Bouchet & Poppe, 1988; Norfolk Ridge, deep water, endemic
Calliotectum egregium Bouchet & Poppe, 1995; New Caledonia, Loyalty Islands, deep water
C. piersonorum Bouchet & Poppe, 1995; Chesterfield, New Caledonia, deep water, endemic
C. tibiaeforme (Kuroda, 1931); New Caledonia, Loyalty Islands, deep water
Cymbiola deshayesi (Reeve, 1855); Northern New Caledonia, endemic

C. rossiniana (Bernardi, 1859); Southern New Caledonia, endemic
Cymbiolacca thatcheri (McCoy, 1868); Chesterfield, endemic
Lyria deliciosa (Montrouzier, 1859); New Caledonia
L. exorata Bouchet & Poppe, 1988; Chesterfield, deep water, endemic
L. grangei Cernohorsky, 1980; Chesterfield, endemic
L. habei Okutani, 1979; New Caledonia, deep water
L. kuniene Bouchet, 1979; Southern New Caledonia, deep water, endemic
L. planicostata (Sowerby, 1903); New Caledonia, deep water.

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