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A Revision of Australian *Teramachia*

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ABSTRACT

Based on a comparison of type material *Teramachia dalli claydoni* Poppe, 1986 and *T. dupreyae* Emerson, 1985 are synonymized with *T. dalli* (Bartsch, 1942) and *T. johnsoni* (Bartsch, 1942) respectively. Additional data on the occurrence of both species on the continental slope off the North West Shelf of Western Australia, based on specimens in the Western Australian Museum, is provided. Data presented include information on the shells, radulae, operculae, and geographic and vertical distribution.

INTRODUCTION

Until recently there has been little published information about the molluscs inhabiting the continental shelfs and slopes off the northern coast of Australia; no information was available from the northwest of the continent. In the early 1980's the Commonwealth Scientific and Industrial Research Organisation (CSIRO) conducted extensive surveys on the North West Shelf and slope to search for commercial fish stocks using the research vessel 'Soela'. Marine biologists from the Western Australian Museum participated in several of the 'Soela' cruises and collected a large number of benthic marine invertebrates, including molluscs. The CSIRO work detected commercial quantities of scampi and several commercial trawlers were licensed to fish on the shelf. Large numbers of shells were collected by the trawlers and are now being sold by shell dealers on a worldwide basis.

There have been scattered references to the previously unknown molluscs of the North West Shelf in the scientific literature, but there has as yet been no comprehensive listing. The first report was that of Kosuge (1985), who reported on the presence of 21 species in the North West Shelf fauna. The species reported by Kosuge and others in the Western Australian Museum demonstrate that the fauna has a close affinity with the deep water fauna long known to exist in the area between the Philippines and southern Japan. This suggests that when deep water sampling is conducted in the intermediate areas such as Indonesia the fauna will be found to be continuous. Just how closely the northwestern Australian and

Philippines-Japan faunas are related is not yet clear. In general differences can be found between shells from the Philippines-Japan and northwestern Australia, but whether the differences are sufficient to warrant the description of new species probably varies between species and in individual cases varies with the taxonomic judgment of the malacologist examining the shells. The initial report of Kosuge (1985) and the first of a series of papers on turrids (Kosuge, 1986) did not include new species. Similarly I (Wells, 1985) reported the presence of *Thatcheria mirabilis* Angas, 1877 from the North West Shelf. On the other hand, three new species and subspecies have been named from the North West Shelf: *Typhis wellsi* by Houart, 1985; *Teramachia dalli claydoni* by Poppe (1986) and *Teramachia dupreyae* by Emerson (1985).

This paper has two purposes: to demonstrate that *T. dalli claydoni* and *T. dupreyae* are synonyms of *T. dalli* (Bartsch, 1942) and *T. johnsoni* (Bartsch, 1942) respectively, and to provide additional information on the northwestern Australian populations.

Teramachia dalli (Bartsch, 1942)

Prodallia dalli Bartsch, 1942. The Nautilus 56: 9-13, pl. 2.

Teramachia dalli (Bartsch, 1942) Kosuge, 1985. Bulletin of the Institute of Malacology of Tokyo 2: 59, pl. 23, f. 6.

Teramachia dalli claydoni Poppe, 1986. APEX (Informations scientifiques de la Societe Belge de Malacologie) 1: 29-31, pl. 2, f. 11, 13, 14.

Material examined:

Philippines-Japan:

Holotype:

Teramachia dalli (Bartsch, 1942). From 393 fathoms (719 m) off Cape Santiago, Luzon I., Philippines. Smithsonian Institution (USNM) 231758.

Northwestern Australia:

Holotype:

Teramachia dalli claydoni Poppe, 1986. About 280 km north north-east of Port Hedland, Western Australia. Western Australian Museum (WAM) 189-86.

Other material (shells only):

WAM 3200-83 (3 specimens) 400 to 401 m, 18°05′S; 118°10′E. WAM 3201-83 (2) 440 to 442 m, 18°05′S; 118°08′E. WAM 3202-83 (1) 404 to 406 m, 18°44′S; 117°08′E. WAM 797-84 (5) 352 m, 15°35′S; 121°09′E. WAM 825-84 (1) 500 to 504 m, 15°08′S; 121°03′E. WAM 826-84 (1) 389 to 390 m, 17°59′S; 118°23′E. WAM 827-84 (1) 296 to 308 m, 15°09′S; 121°21′E. WAM 829-84 (2) 448 to 450 m, 15°09′S; 121°05′E. WAM 832-84 (1) 401 to 410 m, 15°12′S; 121°05′E. WAM 833-84 (3) 396 to 400 m, 18°04′S; 118°14′E. WAM 835-84 (1) 500 to 504 m, 15°40′S; 120°37′E. WAM 1122-84 (1) 400 m, 18°03′S; 118°16′E. WAM 1650-84 (1) 348-350 m, 14°21′S; 122°02′E. WAM 1845-84 (1) 440 m, 16°54′S; 119°52′E. WAM 120-87 (3) 356 m, 14°50′S; 121°31′E. WAM 121-87 (1) 500 to 504 m, 15°09′S; 121°03′E. WAM 122-87 (2) 530 to 560 m, 17°59′S; 118°11′E. WAM 123-87 (1) 500 to 506 m, 14°39′S; 121°28′E.

Other material (alcohol preserved with animal intact):
WAM 3204-83 (1) 658 to 660 m, 18°32′S; 116°49′E. WAM 3205-83 (1) 465 to 466 m, 18°09′S; 118°03′E. WAM 3206-83 (1) 381 to 383 m, 18°44′S; 117°98′E. WAM 3234-83 (1) 375 m, 18°06′E; 118°12′E. WAM 858-84 (1) 496 to 504 m, 12°48′S; 122°56′E. WAM 859-84 (1) 500 to 506 m, 14°39′S; 121°28′E. WAM 861-84 (2) 530 to 560 m, 17°59′S; 118°11′E. WAM 863-84 (1) 500 to 504 m, 15°08′S; 121°03′E. WAM 864-84 (8) 484 to 494 m, 13°17′S; 122°37′E. WAM 1071-84 (2) 494 to 496 m, 13°44′S; 122°13′E.

Range off northwestern Australia:
The present WAM material indicates that the species is distributed along the continental slope off the North West Shelf from 12°48′S; 122°57′E to 18°53′S; 116°10′E, a distance of 900 km (Fig. 1) in depths of from 296 to 660 m.

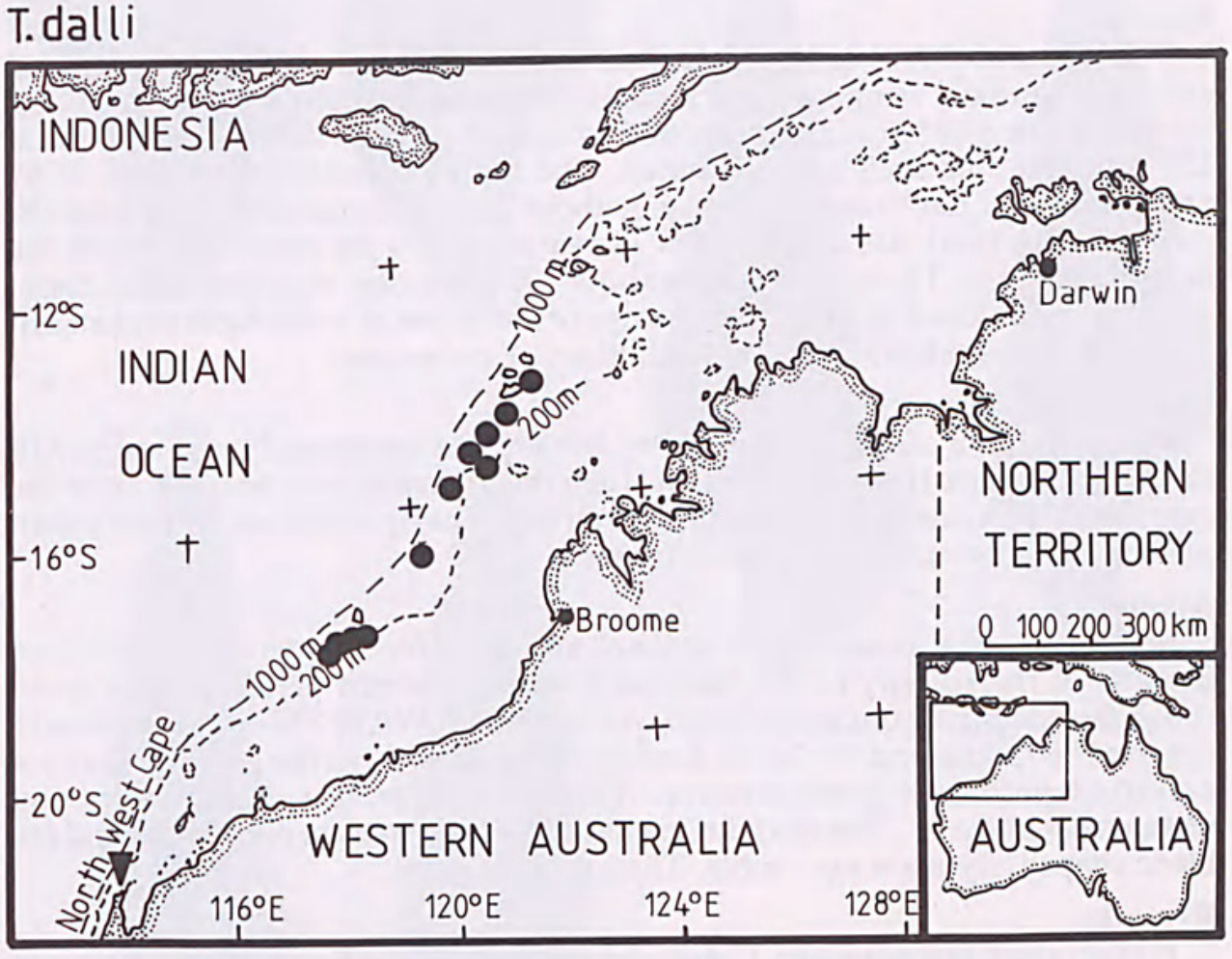


FIGURE 1: Geographical distribution of *Teramachia dalli* off northwestern Australia.

Shell:
Shell large, elongate, turreted, up to 174 mm long with a high spire (Figs. 2-7). Protoconch broken off in all specimens, up to 13 slightly convex whorls remaining. Numerous, pronounced axial ribs extend from suture to suture. Posteriorly axial ribs have formed small nodules. Ribs less pronounced on upper two whorls of adults, or even three whorls in large shells, where they do not extend completely to lower suture. 36 to 40 ribs on last whorl in which they are complete.

Growth striae present on all whorls as are fine spiral striae. Sutures deep, channeled. Aperture flared in adult shells, columella smooth, without plaits. Distinct siphonal canal present at anterior end. Shell covered with thin periostracum, shell brown or black, lighter on anterior half of body whorl, ribs near suture and suture itself lighter. Aperture and columella purple.

Shell measurements:

Forty-four specimens of *T. dalli* from off northwestern Australia were measured (Fig. 8), ranging in length from 47 to 174 mm. The mean size of these shells was 119 ± 32 mm. All of these shells were decolate. Thirteen adult shells with a fully inflated lip were measured in detail (Table 1). These specimens ranged from 102 to 152 mm long, with a mean of 134 ± 15 mm, and were 30 to 52 mm wide (mean 39 ± 6 mm). The width/length ratio varied from 0.25 to 0.33 (mean 0.29 ± 0.02). Measurements of the holotypes of both *T. dalli* and *T. dalli claydoni* fit within the range demonstrated by the northwestern Australian material.

Radula:

The radula of WAM 858-84, an animal with a shell 161 mm long, was prepared and photographed using standard scanning electron microscope techniques (Figs 9 and 10). The most striking feature of the radula is its small size, 3.6 mm long and 250 μm wide, for such a large animal. The radula consists of a ribbon of 57 rachidian teeth. Each tooth is tricuspid, about 220 μm broad at the base and 280 μm high. The tooth has convex sides, increasing to 250 μm across just below the base of the cusps. The central cusp is about 100 μm longer than the lateral cusps. Each cusp is pointed at its tip, but the tips of a number of cusps were broken off. There is a faint indentation near the bottom of each cusp.

Operculum:

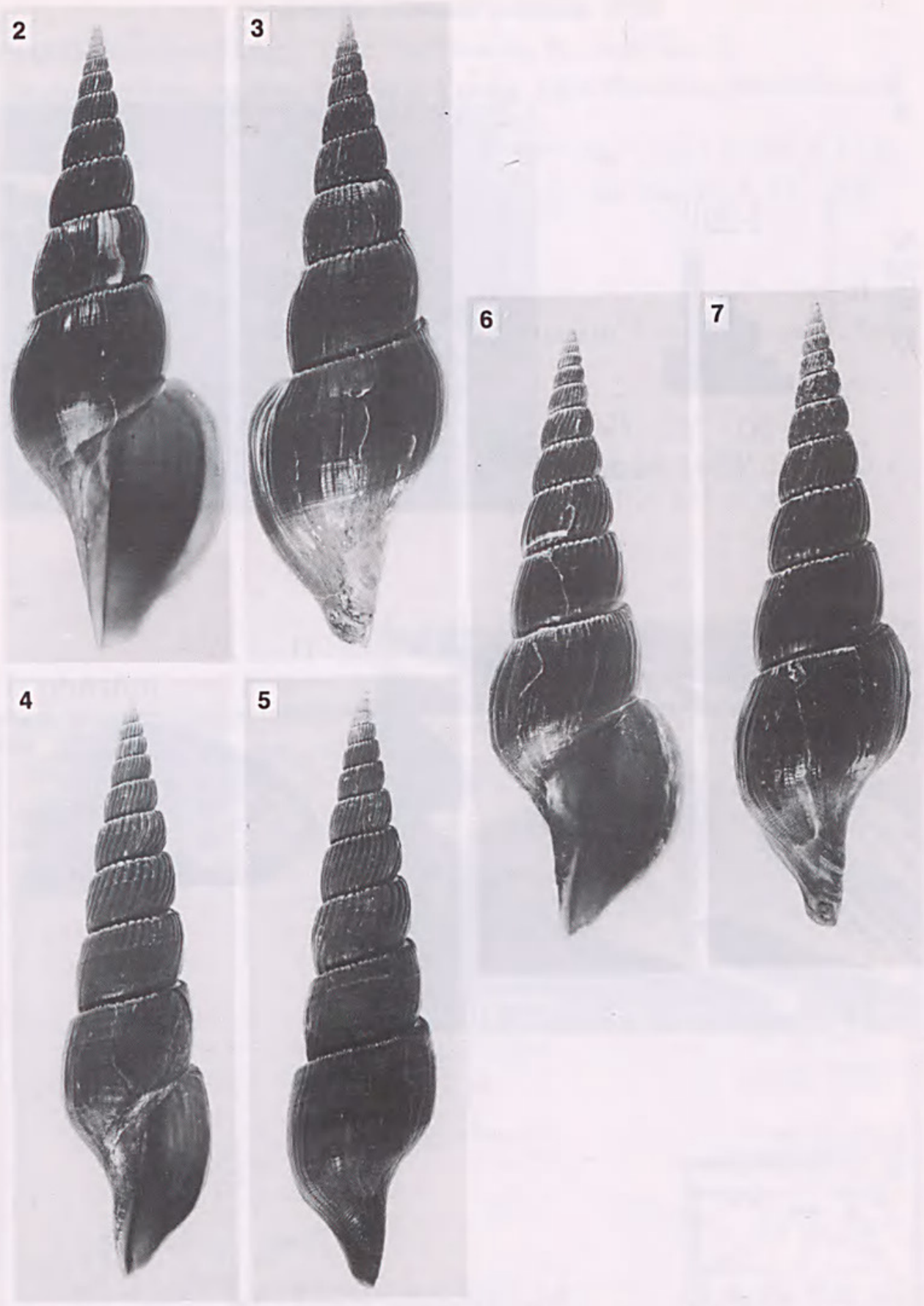
The operculum of WAM-84 is horny, brown, and measures 29 mm long by 16 mm wide (Fig. 11). It is nearly straight along the columellar side but convex on the outer edge. A series of numerous growth striae is clearly visible on the operculum surface. The operculum is thin and fragile.

Animal:

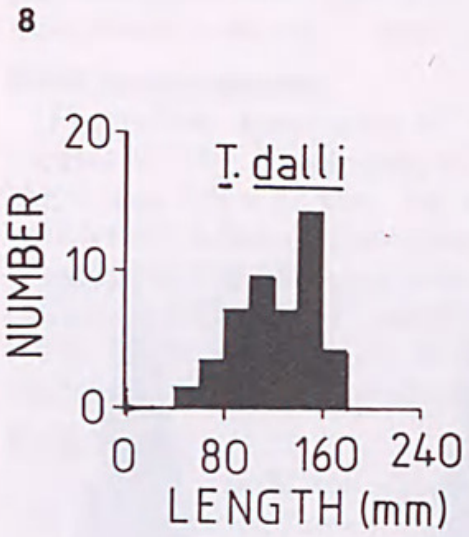
Several animals preserved in alcohol are available for detailed dissection. Because of the scarcity of the material it was considered preferable not to do rough dissections for this paper. However the shell of WAM 858-84 was broken to remove the radula and the lower portion of the body is visible. The animal is a uniform light brown in preservative. The foot is large, broad at the front and rectangular in shape. The tentacles are at the anterior margin of the head and are blade shaped. Eyes are not visible. The siphon is short.

Remarks:

Poppe (1986) distinguished *T. dalli claydoni* from *T. dalli* on the basis of a more elongated spire, slenderer shape, and more numerous whorls, but all of these features are variable within the northwestern Australian population, and the range of variation encompasses the holotype of *T. dalli*. Poppe (1986) also found that the whorls of *T. dalli claydoni* are less convex, particularly the upper whorls. I agree with this on the basis of a comparison of the holotypes, but the differences are not consistent in the Australian population and therefore they are not a basis for specific or subspecific distinction. As there do not appear to be any other distinguishing characters from the holotype of *T. dalli*, the northwestern Australian population must be considered to be conspecific with *T. dalli* and not separable at a subspecific level.



FIGURES 2, 3: Holotype of *Teramachia dalli* (Bartsch, 1942). USNM 231758.
FIGURES 4, 5: Holotype of *Teramachia dalli claydoni* from off northwestern Australia.
FIGURES 6, 7: Specimen of *Teramachia dalli* from off northwestern Australia.



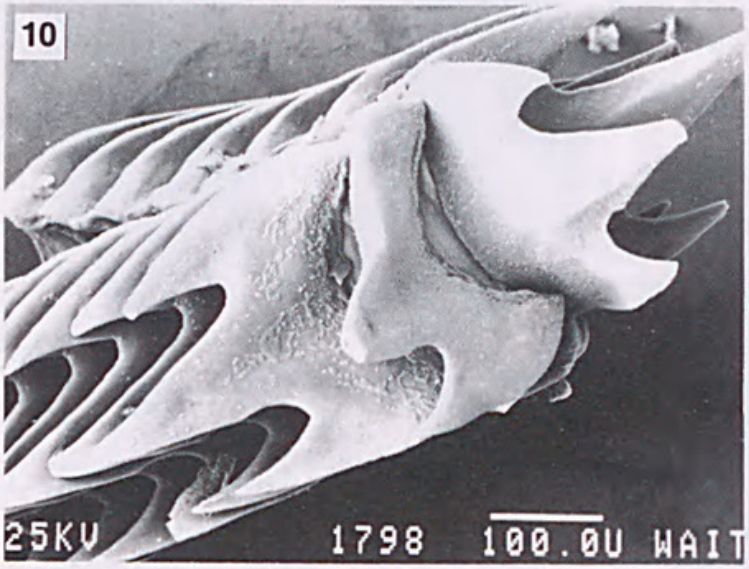


FIGURE 8: Size frequency histogram and *T. dalli* collected off northwestern Australia.
FIGURES 9, 10: Radula of *Teramachia dalli* from off northwestern Australia (WAM 858-84). Scale bar is 100 μm long.
FIGURE 11: Operculum of *Teramachia dalli* from off northwestern Australia (WAM 858-84).

Teramachia johnsoni (Bartsch, 1942)

Prodallia johnsoni Bartsch, 1942. The Nautilus 56: 12, pl. 2, f. 3.

Teramachia johnsoni (Bartsch, 1942). Kosuge, 1985. Bulletin of the Institute of Malacology of Tokyo 2: 59, pl. 23, f. 1.

Teramachia johnsoni williamsorum Rehder, 1972. The Veliger 15: 8-9, f. 1,2,4.

Teramachia dupreyae Emerson, 1985. The Nautilus 99: 104-106, f. 1-8.

Material examined:
Philippines-Japan

Holotype:
Teramachia johnsoni (Bartsch, 1942). 340 fathoms (622 m) off Cagayan I., Sulu Sea, Philippines. USNM 238419.

Northwestern Australia:
Paratype D:

Teramachia dupreyae Emerson, 1985. 450 m depth, 200 miles northwest of Broome, between Rowley Shoals and Scotts (sic) Reef. WAM 190-86.

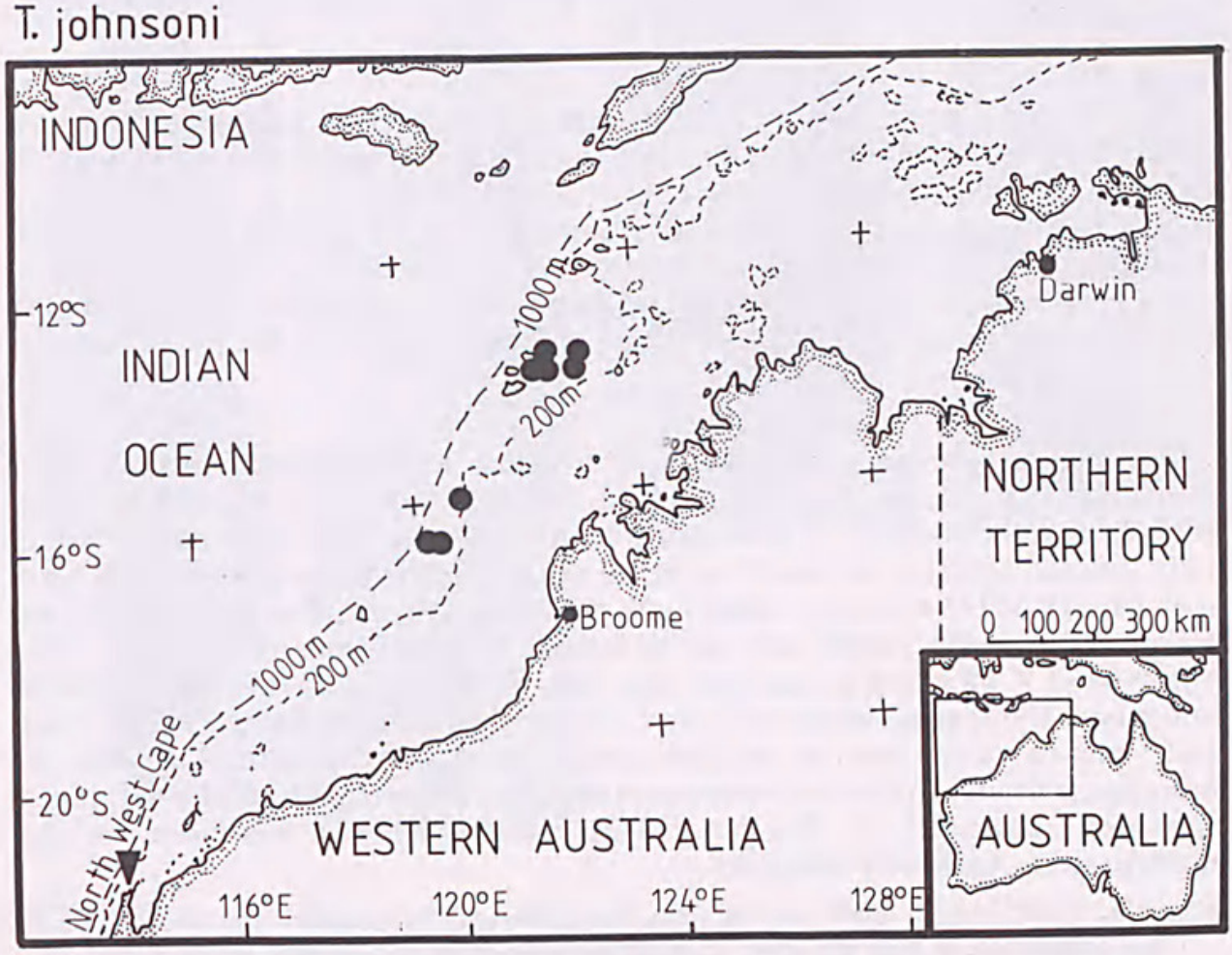


FIGURE 12: Geographical distribution of *Teramachia johnsoni* off northwestern Australia.

Other material:

WAM 798-84 (1 specimen) 450 to 452 m, 16°57′S; 119°48′E. WAM 823-84 (1) 430 to 432 m, 16°58′S; 119°55′E. WAM 830-84 (1) 296 to 298 m, 15°57′S; 120°46′E. WAM 831-84 (1) 390 to 394 m, 13°33′S; 122°54′E. WAM 1122-84 (1) 400 m, 18°03′S; 118°16′E. WAM 1650-84 (1) 348 to 350 m, 14°21′S; 122°02′E. WAM 1843-84 (4) 494 to 496 m, 13°44′S; 122°13′E. WAM 1845-84 (1) 440 m, 16°54′S; 119°52′E. WAM 1866-84 (3) 436 to 448 m, 16°55′S; 119°52′E. WAM 1889-84 (1) 450 to 452 m, 16°57′S; 119°48′E. WAM 1908-84 (7) 432 to 434 m, 16°54′S; 119°52′E. WAM 124-87 (4) 432 m, 16°57′S; 119°52′E. WAM 125-87 (1) 440 to 444 m, 13°27′S; 122°04′E. WAM 126-87 (1) 396 to 400 m, 15°48′S; 120°41′E. WAM 127-87 (1) 306 to 308 m, 13°51′S; 123°01′E. WAM 128-87 (1) 416 to 418 m, 18°26′S; 117°34′E. WAM 129-87 (2) 450 to 452 m, 13°50′S; 122°18′E. WAM 130-87 (2) 430 to 436 m, 16°52′S; 119°51′E.

Other material (alcohol preserved with animals intact):

WAM 3207-83 (1) 375 m, 18°06′S; 118°12′E. WAM 3208-83 (1) 380 m, 18°06′S; 118°12′E. WAM 857-84 (2) 389 to 390 m, 17°59′S; 118°23′E. WAM 860-84 (1) 390 to 394 m, 13°33′S; 122°54′E. WAM 862-84 (1) 500 to 504 m, 15°40′S; 120°37′E. WAM 1072-84 (2) 494 to 496 m, 13°44′S; 122°13′E. WAM 1121-84 348 to 350 m, 14°21′S; 122°02′E. WAM 1885-84 (1) 432 m, 16°57′S; 119°52′E.

Range off northwestern Australia:

The present WAM material shows that the species is distributed along the continental slope off the North West Shelf from 13°33'S; 122°54'E to 18°06'S; 118°12'E, a distance of 750 km (Fig. 18) in depths of from 296 to 504 m. The geographical and vertical distributions of *T. johnsoni* closely parallel those of *T. dalli.*

Shell:

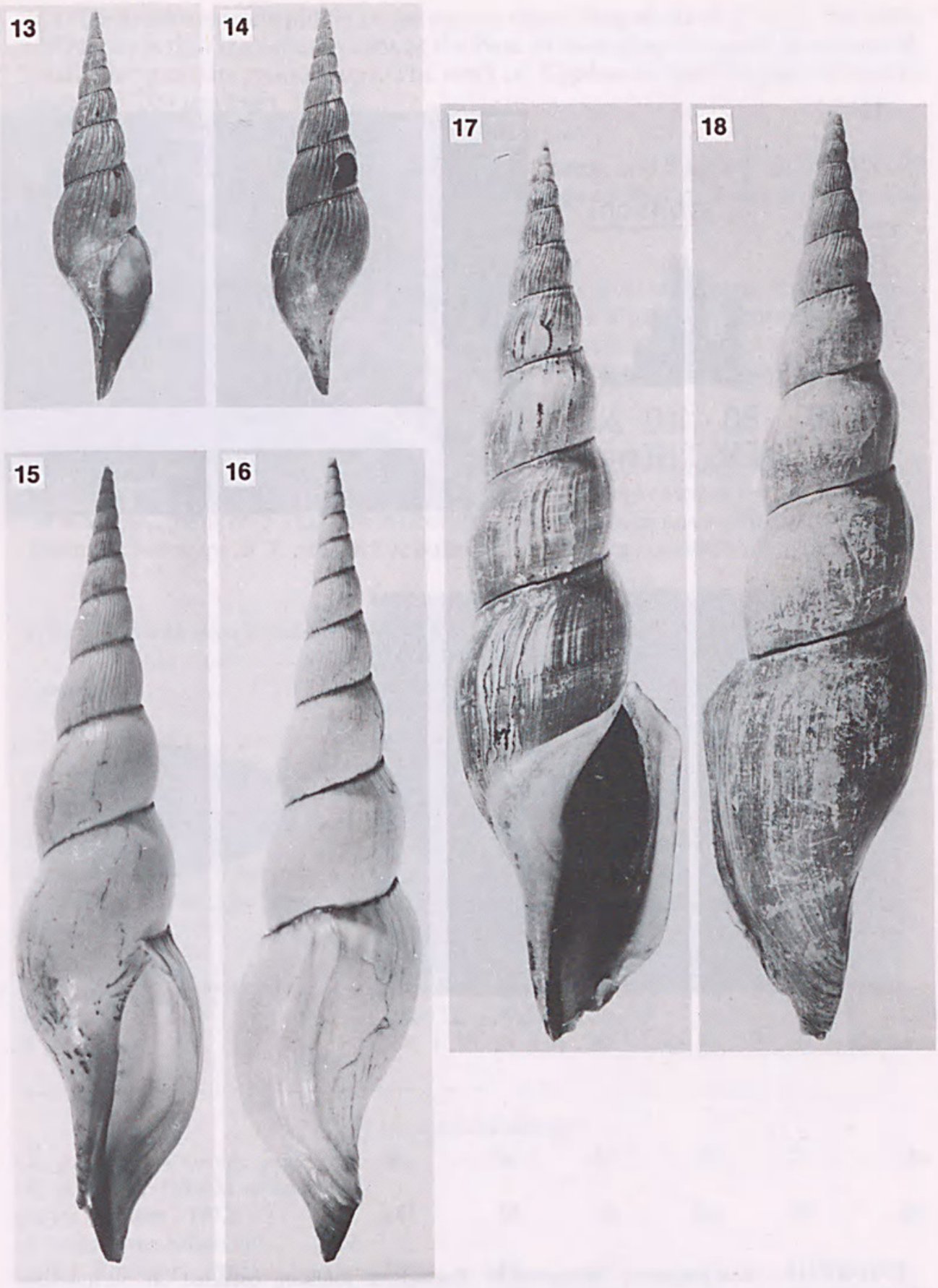
Shell large, elongate, up to 220 mm long, spire high (Figs 13-18). Protoconch absent in all specimens examined, up to 13 whorls remaining. Numerous fine axial ribs on upper whorls disappear by third to last whorl of adults, or fourth to last in large shells. Surface of lower whorls smooth except for growth striae. Sutures distinct but not channeled, and axial ribs do not have nodules posteriorly. Whorls convex. Aperture flared in adults, columella smooth, lacking plaits. Periostracum thin, light brown underlying color white, aperture and columella porcellaneous white.

Measurements:

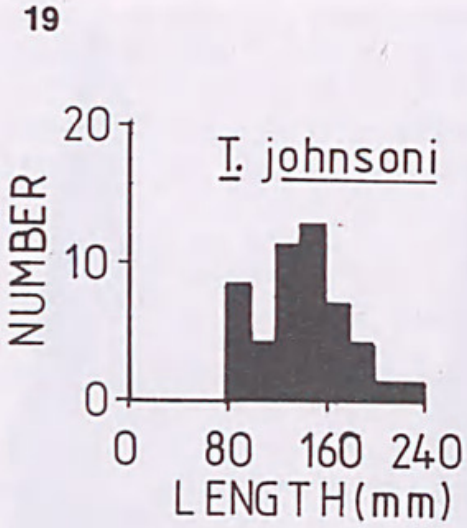
Forty-eight specimens of *T. johnsoni* from off northwestern Australia were measured (Fig. 19), ranging in length from 84 to 220 mm (mean 141 ± 34 mm). As with *T. dalli* the shells of *T. johnsoni* were all decolate. Nine adult shells with a fully inflated aperture measured in detail ranged from 148 to 212 mm in length with a mean of 175 ± 22 mm (Table 1). Widths ranged from 38 to 53 mm (mean 44 ± 5 mm). The width/length ratio varied from 0.23 to 0.27 (mean 0.25 ± 0.01). The holotype of *T. johnsoni* is a juvenile shell only 96 mm long, so the measurements are outside the ranges shown in Table 1. However apart from being 7 mm shorter and 1 mm narrower than the smallest adult from off northwestern Australia the holotype is similar to the northwestern Australian material. An adult Philippines specimen measured by Rehder (1972) falls within the variation of the northwestern Australian material.

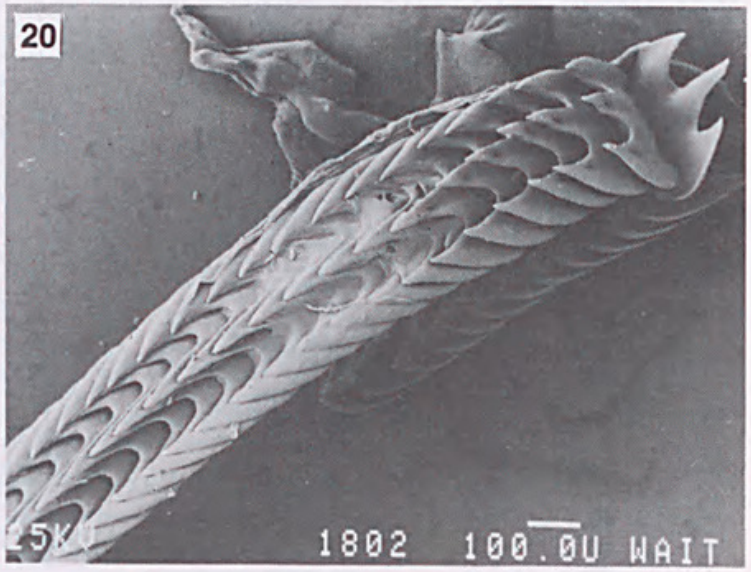
Radula:

The radula of WAM 860-84, an animal with a shell 140 mm long, is 3.2 mm long and 280 μm wide, consisting of a ribbon of 50 rachidian teeth (Figs 20 and



FIGURES 13, 14: Holotype of *Teramachia johnsoni* (Bartsch, 1942). USNM 238419.
FIGURES 15, 16: Paratype D of *Teramachia dupreyae* Emerson, 1985. WAM 190-86.
FIGURES 17, 18: Specimen of *Teramachia johnsoni* from off northwestern Australia.





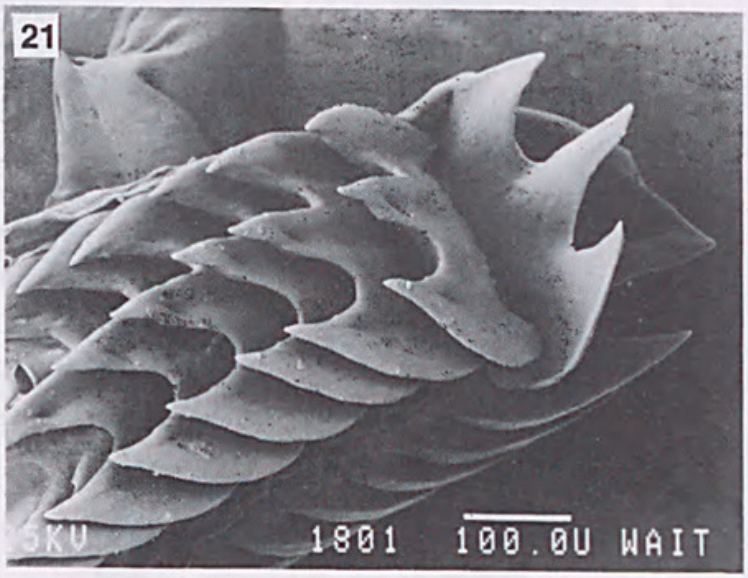


FIGURE 19: Size frequency histogram of *Teramachia johnsoni* collected off northwestern Australia.

FIGURES 20, 21: Radula of *Teramachia johnsoni* from off northwestern Australia (WAM 860-84). Scale bar is 100 μm long.

FIGURE 22: Operculum of *Teramachia johnsoni* from off northwestern Australia (WAM 860-84).

21). The teeth are tricuspid, in shape closely resembling those of *T. dalli*. The main difference is that the indentations at the base of each cusp are more pronounced, particularly on the central cups. The teeth of *T. johnsoni* are 220 μm wide at the base and 200 μm high.

Operculum:

The operculum of WAM 860-84 is brown, horny, and fragile (Fig. 22). It is 24 mm long and 13 mm wide and of the same shape as that of *T. dalli*. Numerous growth striae are clearly visible on the surface.

Animal:

Because of the scarcity of material no animals were dissected, but the lower portion of the animal of WAM 860-84 is visible. It is a uniform light brown with a large foot, indented at the front and T-shaped. The foot is twisted and the shape may be a preservation artefact. The tentacles are anterior and blade shaped and the eyes are not visible. The siphon is short.

Remarks:

Emerson (1985) distinguished *T. dupreyae* from *T. johnsoni* solely on the basis of color, the most characteristic feature being a darkly colored suture. Similarly WAM specimens of *T. dalli* from northwestern Australia have differences in color from the holotype of *T. dalli*, a live collected shell. In my opinion color alone is not

Table 1. Morphometric measurements of *Teramachia dalli* and *T. johnsoni*

Specimen	Length (mm)	Width (mm)	W/L	Aperture Length (mm)	A/L	No. of whorls
			Teramachia dalli			
T. dalli holotype	144	46	.32	58	.40	11
T. dalli claydoni holotype	136	35	.26	49	.36	13
T. dalli claydoni paratypes	173	49	.28	64	.37	14
(after Poppe, 1986)	151	36	.24	47	.31	14
	125	36	.29	45	.36	-
Other W.A. material						
Range	102-152	30-52	.25-.33	27-57	.26-.37	11-13
$\bar{x}$ ± 1 S.D.	134 ± 15	39 ± 6	.29 ± .02	46 ± 9	.34 ± .04	-
			Teramachia johnsoni			
T. johnsoni holotype juv.	96	38	.40	20	.21	10+
T. johnsoni USNM 696513 (after Rehder, 1972)	141	37	.26	64	.45	10+
T. dupreyae holotype (after Emerson, 1985)	185	46	.25	-	-	10+
T. dupreyae paratype D - juv.	197	42	.21	78	.40	11+
Other W.A. material						
Range	148-212	38-53	.23-.27	60-83	.36-.45	9-13
$\bar{x}$ ± 1 S.D.	175 ± 22	44 ± 5	.25 ± .01	69 ± 9	.40 ± .03	-

a sufficient basis for separating the northwestern Australian populations of *T. johnsoni* from the type specimen, and *T. dupreyae* should be considered a synonym of *T. johnsoni.*

Redher (1972) described a subspecies of *T. johnsoni, T. johnsoni williamsorum* based on stouter shells collected off Taiwan. This was considered to be infraspecific variation by Abbott and Dance (1982). Emerson (1985) found both slender and stout forms in *T. dupreyae*, and considered subspecific status for *T. johnsoni williamsorum* was not warranted. Based on the variability of *T. johnsoni* seen in the northwestern Australian material I agree that a subspecific differentiation of slender and stout forms is not necessary.

Slack-Smith (1982) figured a specimen of *T. johnsoni* (as *T. dalli*) from south of Cape Leeuwin, W.A. This specimen is in a private collection and not available for study. There has been only limited trawling off the south and west coasts of Western Australia and no specimens of *Teramachia* are available. Species of other genera collected on the west coast and in the W.A. Museum also occur on the North West Shelf. This suggests that when trawling is done along the slope off the west coast both species of *Teramachia* will be found.

ACKNOWLEDGEMENTS

Dr W.K. Emerson and G.T. Poppe are thanked for depositing a paratype of *T. dupreyae* and the holotype of *T. dalli claydoni* respectively in the W.A. Museum. Dr M.G. Harasewych arranged the loan of the holotypes of *T. dalli* and *T. johnsoni* from the Smithsonian Institution. C.W. Bryce took all of the photographs and prepared the radulae for SEM. Drs W.F. Ponder and T.A. Darragh critically read the manuscript.

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