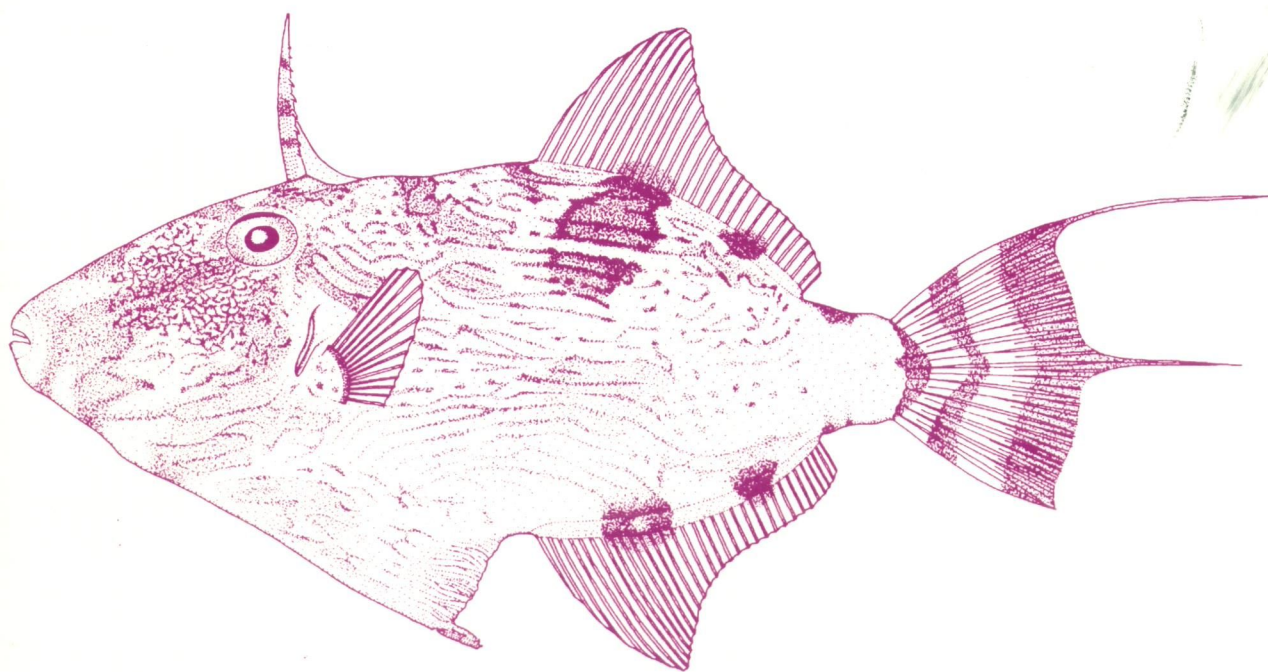


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Review of the monacanthid fish genus *Paramonacanthus*, with descriptions of three new species

by
J. Barry Hutchins



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Tel. (09) 328 4411

Fax. (09) 328 8686

E-mail ouseya@museum.wa.gov.au

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Cover: *Paramonacanthus otisensis* from New South Wales (drawn by S. Morrison).

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Review of the monacanthid fish genus *Paramonacanthus*, with descriptions of three new species

J. Barry Hutchins

Department of Aquatic Zoology, Western Australian Museum,
Francis Street, Perth, Western Australia 6000, Australia

Abstract – The monacanthid fish genus *Paramonacanthus* consists of 11 species, three of which are described as new: *P. arabicus* sp. nov. from the Arabian Gulf, *P. choirocephalus* (Bleeker) from northwestern Australia, Indonesia, Thailand, and the Philippines, *P. frenatus* (Peters) from East Africa, *P. japonicus* (Tilesius) from northern Australia, New Caledonia, Fiji, Indonesia, Bay of Bengal, Philippines, and Japan, *P. lowei* sp. nov. from eastern Australia, *P. matsuurai* sp. nov. from the Ogasawara Islands, *P. nematophorus* (Günther) from the Red Sea, East Africa and the Seychelles archipelago, *P. otisensis* (Whitley) from eastern Australia, *P. pusillus* (Rüppell) from northwestern Australia, Indonesia, Philippines, Japan, China, Thailand, Sri Lanka, the Red Sea/Gulf of Aden, and South Africa, *P. sulcatus* (Hollard) from Indonesia, Malaysia, Thailand, China, and Taiwan, and *P. tricuspis* (Hollard) from India, Maldives, Andaman Islands, and Thailand. Full descriptions are presented for the three new species, and diagnostic descriptions given for the remaining eight species. Comments on phylogeny are included as a guide to the relationships of *Paramonacanthus*.

INTRODUCTION

Members of the monacanthid genus *Paramonacanthus* Bleeker are small fishes (to 150 mm SL) which inhabit flat sandy and silty bottoms of the Indo-West Pacific. Most species form small schools close to the substrate where they are often caught by trawlers. However, because their dorsal spines are easily entangled in the mesh of the trawl net, they are despised by fishermen working these boats.

Paramonacanthus has proved a difficult genus taxonomically because of the similar body form and drab colouration possessed by most of its members. Sexual dimorphism has also added to this difficulty as the male and female forms of some species differ noticeably in body and fin shape (see Sexual Dimorphism below). Furthermore, some members have been adjudged sufficiently distinct to warrant placing them in other genera, particularly *Laputa* (Whitley) and *Arotrolepis* (Fraser-Brunner). Fraser-Brunner (1941), for example, recognised eight species of *Paramonacanthus*, two species of *Laputa*, and three species of *Arotrolepis*. The present study, the first comprehensive revision of *Paramonacanthus*, recognises 11 species—three of which are new—from a total of 30 nominal species, and includes both *Laputa* (as used by Fraser-Brunner, 1941) and *Arotrolepis* in the synonymy of *Paramonacanthus*. One species which is often included in either *Paramonacanthus* or *Arotrolepis*—*Monacanthus*

filicauda Günther, 1880—is shown to belong to an undescribed genus. Following the species accounts, a tentative phylogeny is presented as a guide to the relationships of *Paramonacanthus*.

METHODS

Methods of counting and measuring follow those of Hutchins (1977, 1986a). Osteological nomenclature follows that of Tyler (1962, 1980), Hutchins and Swainston (1985) and Hutchins (1986). Terminology of the lateral line system generally follows Coombs *et al.* (1988). Scales from the region designated as either “midside of body” or just “midbody” are located on the epineural rib-line below the centre of the interdorsal space (scales were usually subjected to a fine, high-pressure jet of water to remove mucus for ease of viewing the spinules). Institutional codes follow Leviton *et al.* (1985).

Material examined during the investigation consisted mostly of whole, wet specimens. Selected specimens were cleared and stained using the trypsin digestive method of Taylor (1967), while additional material was skeletonised and partly disarticulated. Radiographs of whole specimens were also studied.

The illustrations of the lateral line sensory system (Figure 7) were made from cleared and stained skins. Each sensory pore is indicated by a dot, whereas each sensory papilla (= papillate

superficial neuromast) is illustrated as an upright, fingerlike structure (the latter is enlarged to make it more visible). In addition, the origins of the spinous dorsal and soft dorsal fins are indicated as a guide to the location of the numerous branches of the system.

Relationships within the Monacanthidae were evaluated using the phylogenetic method first described by Hennig (1950, 1966) and summarised by Wiley (1981). The outgroup comparison method (Watrous and Wheeler, 1981; Maddison *et al.*, 1984) was used to determine character polarity. The primary outgroup for the family was the Balistidae following Matsuura (1979) and Tyler (1980).

Sexual Dimorphism

Sexual dimorphism is pronounced in the majority of species of *Paramonacanthus*. Males are generally more slender, with more convex dorsal profiles to their snouts and prominently elevated soft dorsal and anal fins (see Figure 12 for example). On the other hand, females are relatively deep bodied with straight to concave snouts and rather low fins. However, some males are even more slender than usual (Figures 9a, 9d, 12e, 24b) and some females are deeper than normal (Figure 12d). The strangest variation occurs in those deep-bodied individuals that have more male than female characteristics (Figure 12c). These differences are reflected in variations in the osteology (Figure 1) and myology between the sexes, a subject pursued in more detail by Hutchins (1992). He described the changes that occur to the maturing male for the following structures: predorsal neural spines (become deformed); spaces between each of the anterior basal pterygiophores of the soft dorsal and anal fins (become greatly enlarged); the muscles controlling the anterior rays of these fins (do not digest in trypsin); and the anterior rays of the dorsal and anal fins (become thickened, more elongate, with enlarged basal flanges). The female generally retains the osteological conditions of the juvenile. In addition, the male's caudal fin (not including filaments) is usually relatively shorter than that of the female, and the more slender the male, the shorter the caudal fin (Figure 9). The pelvis of the male is often differently shaped than that of the female; in particular, the base of the dorsoposterior flange can be much wider in the male (Figures 3a-b). Differences in squamation are also evident in some species (scales from the midbody region of males generally possess smaller, more tightly packed spinules, producing a smoother feel to the skin than in females (Figures 6b-d)). Finally, males of certain species have elongated filamentous rays in either the soft dorsal or caudal fins, a feature absent from females and juveniles (Figures 12, 22 for example).

Table 1 Monacanthid genera belonging to Groups A, B and C (modified after Hutchins, 1988)

Group A	Group B	Group C
<i>Acreichthys</i>	<i>Acanthaluteres</i>	<i>Anacanthus</i>
<i>Chaetodermis</i>	<i>Aluteres</i>	<i>Brachaluteres</i>
<i>Colurodontis</i>	<i>Amanses</i>	<i>Oxymonacanthus</i>
<i>Lalmohania</i>	<i>Cantherhines</i>	<i>Paraluteres</i>
<i>Leprogaster</i>	<i>Cantheschenia</i>	<i>Pseudaluteres</i>
<i>Monacanthus</i>	<i>Eubalichthys</i>	<i>Rudarius</i>
<i>Paramonacanthus</i>	<i>Meuschenia</i>	Undescribed genus
<i>Pervagor</i>	<i>Nelusetta</i>	
<i>Stephanolepis</i>	<i>Pseudomonacanthus</i>	
Undescribed genera (2)	<i>Scobinichthys</i>	
	<i>Thamnaconus</i>	

SYSTEMATICS

Monacanthid genera can be divided into three groups based on the conditions of two characters (Hutchins 1988). Group A consists of genera with a movably articulated pelvic fin rudiment and branchiostegal count of 1+4=5. Group B genera possess a non-movable pelvic fin rudiment and branchiostegal count of 1+5=6. Genera in Group C possess either a non-movable pelvic fin rudiment or lack all traces of the rudiment, and have a branchiostegal count of 1+4=5 (one genus has 1+3=4). *Paramonacanthus* belongs to Group A (Table 1).

GENUS PARAMONACANTHUS

Paramonacanthus Bleeker, 1865: 99 (type species, *Monacanthus curtiorhynchus* Bleeker, 1855, by original designation).

Arotrolepis Fraser-Brunner, 1941: 184 (type species, *Monacanthus sulcatus* Hollard, 1854, by original designation).

Scurrilichthys Fraser-Brunner, 1941: 184 [type species, *Arotrolepis (Scurrilichthys) barbarae* Fraser-Brunner, 1941, by original designation and monotypy].

Laputa: Fraser-Brunner, 1941 (not *Laputa* Whitley, 1930).

Diagnosis

Distinguished from all other monacanthid genera that possess a movable pelvic fin rudiment by the elevated anterior portions of the soft dorsal and anal fins in males and associated changes to the underlying bones and muscles (see section on sexual dimorphism above). Other distinctive features include a dorsal ridge on the ethmoid, the absence of enlarged spines or spinules on the caudal peduncle, and the usual presence of elongate, filamentous fin rays in either the soft dorsal or caudal fin of the male.

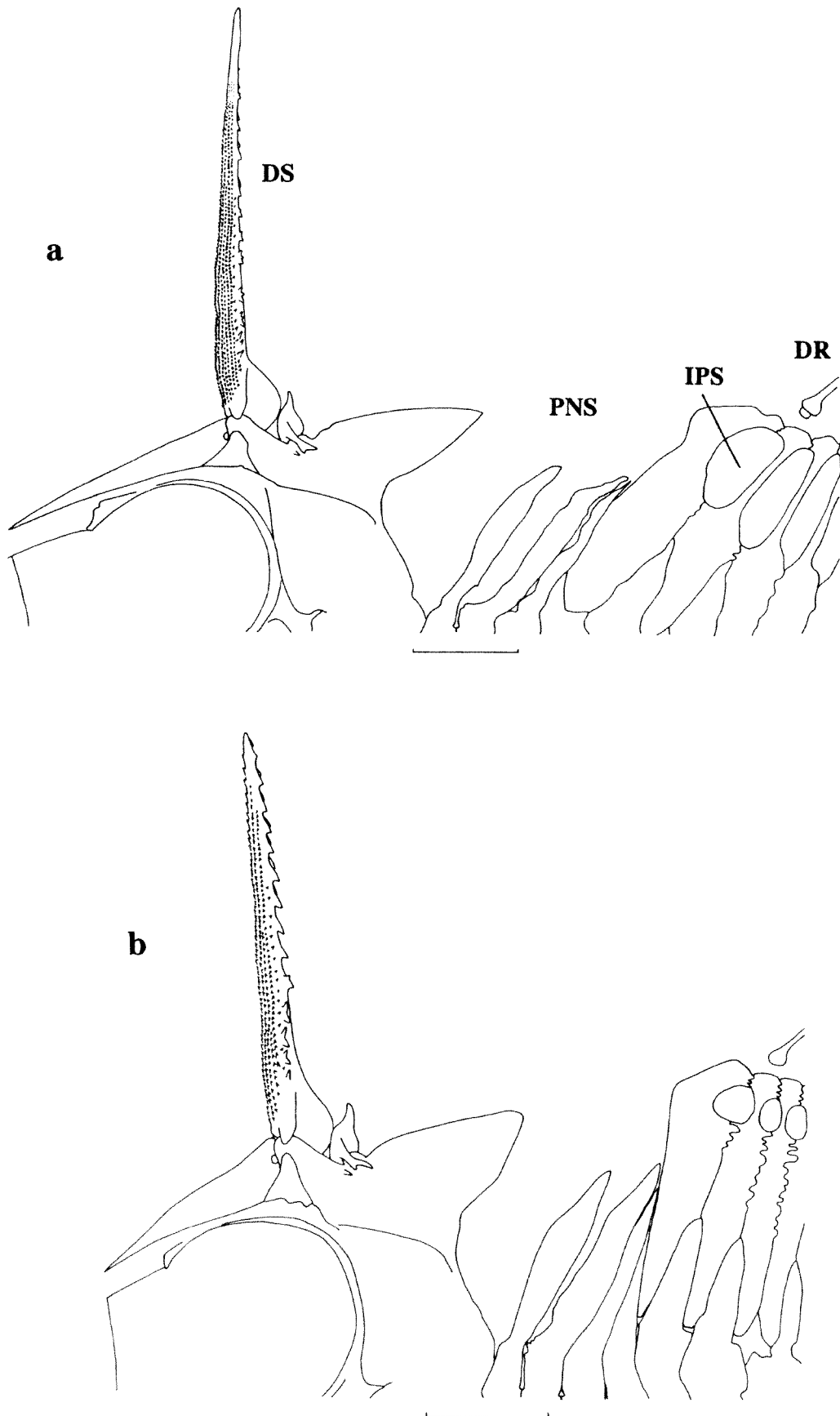


Figure 1 Sexual dimorphism in the osteology of *Paramonacanthus choirocephalus*: **a**, male, 88 mm SL (WAM P.29754-001); **b**, female, 67 mm SL (WAM P.29754-001) (both illustrations based on cleared and stained material). Abbreviations: **DR**, first soft dorsal ray; **DS**, first dorsal spine; **IPS**, interpterygiophore space; **PNS**, predorsal neural spines. Horizontal line equivalent to 5 mm.

Description

Soft dorsal rays 24–33 (Table 2); anal rays 24–34, normally one more than soft dorsal count; pectoral rays 10–13, usually 11 or 12; branchiostegals 1+4=5; vertebrae 7+12 = 19 (6+13 = 19 in one species only).

Body compressed, moderately slender in male to somewhat deeper in female, width 1.9–2.8 in head length and depth 1.9–3.2 in SL; head moderately long, length 2.6–3.2 in SL; dorsal profile of snout when viewed laterally straight to convex in male, straight to concave in female and juvenile, length 3.4–4.8 in SL; eye diameter 2.7–4.8 in head length, 0.7–1.1 in interorbital width; gill opening a short slit, length 3.7–6.9 in head length, positioned in advance of pectoral fin base, centred below posterior third of eye or slightly behind rear margin of eye; pelvic flap small to moderate in size, posterior margin not forming a large projecting flap of skin.

Mouth small, terminal, lips not obviously fleshy; dentition consisting of three outer and two inner teeth on each side of upper jaw; three teeth on each side of lower jaw, posterior tooth small; anterior pair of teeth in both jaws with pointed extremities; gill rakers on first gill arch 14–24.

First dorsal spine originating over posterior half of eye to slightly behind its rear margin; spine moderately slender and moderately short, length 1.1–2.7 in head length; spine circular to depressed in cross-section, tapering to acute tip (unless damaged); spine of small juvenile (25–35 mm SL) with four rows of barbs, anterior face with two adjacent rows of downward- and/or upward-directed barbs, posterolateral faces each with one row of larger downward-directed barbs, projecting either laterally or mostly posterolaterally; with increasing SL, barbs becoming more numerous and relatively smaller in size (Figures 1–2), anterior barbs tending to obsolescence (difficult to

distinguish proximally from minute spinules that cover anterior face of spine), posterior barbs sometimes becoming more multibranching, especially proximally; second dorsal spine small, hidden in skin at rear base of first spine; shallow groove in interdorsal space for receiving first dorsal spine when folded rearwards, or groove absent; soft dorsal and anal fins elevated anteriorly, more prominently in male (profile of outer margin of fins posterior to apex concave in male, straight to convex in female and juvenile), longest dorsal ray at apex of fin 1.3–3.5 in head length, usually slightly longer than longest anal ray (second soft dorsal ray of male either elongate and filamentous or not elongate); length of soft dorsal base 2.6–3.4 in SL, equal to or slightly longer than anal base (bases of fin membranes either perforated or not perforated); origin of soft dorsal fin either slightly in advance of, above, or slightly behind anal fin origin; interdorsal space flat to somewhat elevated in lateral view, length 1 to 2 times greater than length of first dorsal spine; base of pectoral fin below a point slightly anterior to or slightly posterior to rear margin of eye; caudal fin short to moderately long, length (without filaments) 0.9–1.9 in head length, posterior margin either rounded or arrowhead-shaped, with or without elongate filaments in male; caudal peduncle either tapered (male) or not tapered (female and juvenile), small to moderate in size, length 2.5–5.7 in head length and 0.9–1.9 in its depth; pelvic fin rudiment (Figures 3–5) short to moderate in size, length 1.1–2.8 in eye diameter, consisting of five encasing scales with small to moderate barbs, an anterior pair (segment 1), a middle pair (segment 2), and a single posterior scale (segment 3); scales of segment 2 rarely separated from each other by a prominent space; segments 1 and 2 bound to rear of underlying pelvis with connective tissue, segment

Table 2 Fin ray counts for species of *Paramonacanthus*

	Dorsal rays											Anal rays										Pectoral rays					
	24	25	26	27	28	29	30	31	32	33		24	25	26	27	28	29	30	31	32	33	34	10	11	12	13	
<i>arabicus</i>			3	19	39	24	1								10	32	35	11							14	69	3
<i>choirocephalus</i>				3	12	20	12	3								3	9	21	15	6					1	46	7
<i>frenatus</i>	7	7	4									3	4	8	1										1	16	1
<i>japonicus</i>		1	13	20	14	5						1	8	26	14	3									8	42	4
<i>lowei</i>				2	11	5	2							3	16	2									1	19	1
<i>matsuurai</i>							3									1	2								2	1	
<i>nematophorus</i>	2	21	20	6								1	8	21	18	2									6	39	8
<i>otisensis</i>					6	19	15	4									4	14	18	7	1					34	10
<i>pusillus</i>		3	15	19	8	11	6					2	17	14	7	13	10								8	39	15
<i>sulcatus</i>								1	4	5	3									1	3	6	3				12
<i>tricuspis</i>			1	20	24	6										4	18	25	4						10	41	

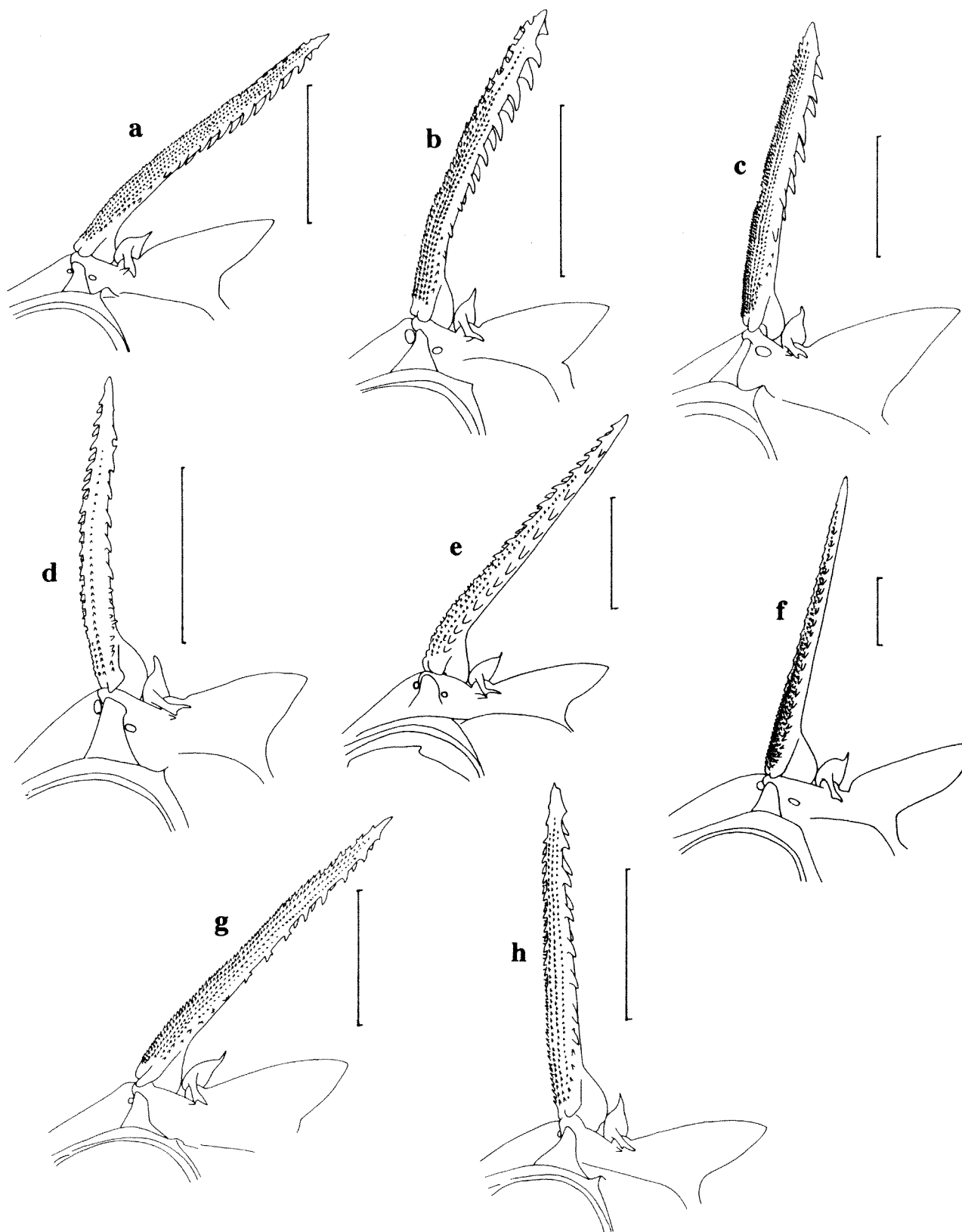


Figure 2 Variation in osteology of the spinous dorsal fin of: **a**, *Paramonacanthus nematophorus*, male, 57 mm SL (WAM P.30945-001); **b**, *P. nematophorus*, female, 35 mm SL (WAM P.30945-001); **c**, *P. frenatus*, 64 mm SL (WAM P.30946-001); **d**, *P. lowei*, 43 mm SL (WAM P.29775-001, paratype); **e**, *P. pusillus*, 56 mm SL, (WAM P.26565-001); **f**, *P. lowei*, 153 mm SL (AMS I.11127, paratype); **g**, *P. japonicus*, 49 mm SL (WAM P.29755-001); **h**, *P. sulcatus*, 42 mm SL (BPBM 18608) (all illustrations, except **f** which was based on a radiograph, were drawn from cleared and stained material). Anterior end of each specimen facing left, and vertical line equivalent to 5 mm.

3 movably articulated with rear end of pelvis; rudiment generally not broadly joined to rear margin of ventral flap.

Anterior midbody scales small, imbricate, circular in small juvenile, each with one simple central spinule, scales becoming elliptical in shape with increasing SL and spinules usually increasing in number, forming 1–4 transverse series of simple to multibranching spinules (Figure 6) (some species with only one spinule per scale in adult); caudal peduncle without elongate spinules, bristles or spines; scales on head usually larger, more circular in shape, with more robust spinules than on midbody, especially those covering dorsal and ventral profiles; skin smooth to slightly coarse; cutaneous tentacles small to comparatively large, generally larger in female and juvenile than male; main features of lateral line sensory system include no infraorbital or abdominal papillae, but supra-abdominal pore branch either present or absent (Figure 7).

Colour when fresh: ground colour whitish to brownish, with darker markings tending to form irregular, oblique cross-bands and/or longitudinal stripes on body; network of fine dark lines sometimes on head, often reduced to wavy dark lines along ventral half; several species with thin bright blue lines on ventral surface of head; dorsal and anal fins mostly hyaline to pale orangish, caudal fin with 2–3 darker curved cross-bands.

Colour in preservative: pale brown to dark brown with darker markings as described above.

Distribution

The range of this genus extends from the Red Sea and South Africa in the western Indian Ocean to the Marshall Islands and Fiji in the Central Pacific (Figures 10, 15, 29). Its members are all tropical, although some species reach temperate waters of both southern Japan and south-eastern Australia.

Remarks

Bleeker (1865) described his new genus *Paramonacanthus* to accommodate species with a movable pelvic fin rudiment but lacking the following features (species with these characteristics were placed in *Monacanthus* or *Chaetodermis*): high angular dorsal profile to the body, spines or bristles on the caudal peduncle, and rough scales. He included seven species in the genus, three from Japan [*Paramonacanthus oblongus* (Schlegel, 1850), *P. broekii* (Bleeker, 1858), and *P. trachyderma* (Bleeker, 1860)], and four from the East Indies [*P. choirocephalus* (Bleeker, 1852), *P. nemurus* (Bleeker, 1852), *P. curtorhynchus*, and *P. cryptodon* (Bleeker, 1855)]. However, Bleeker was unaware at the time that these seven represented the male and female forms of only two species, here determined to be *P. japonicus* (Tilesius, 1810) and *P.*

choirocephalus (see Table 3). Later, Bleeker (1873) added two more species to the genus, namely *P. knerii* (Steindachner, 1867) and *P. nematophorus* (Günther, 1870), both being described from China (the inclusion of the former species was an error, see below).

Fraser-Brunner (1941) recognised only eight species in the genus (*P. choirocephalus*, *P. nemurus*, *P. curtorhynchus*, *P. nematophorus*, *P. otisensis* Whitley, 1931, *P. barnardi* Fraser-Brunner, 1941, *P. whitleyi* Fraser-Brunner, 1941, and *P. horae* Fraser-Brunner, 1941), three of which were described as new. However, he too included male and female forms as separate species. In addition, Fraser-Brunner (1941) described the new genus and subgenera *Arotrolepis* (*Arotrolepis*) and *Arotrolepis* (*Scurrilichthys*). In the former taxon he placed *Monacanthus sulcatus* and *Monacanthus filicauda* and in the latter he included his new species *Arotrolepis* (*Scurrilichthys*) *barbarae*. Fraser-Brunner separated these new subgenera from *Paramonacanthus* on the basis of relatively minor differences in squamation. Because of the great variation in scale structures present in *Paramonacanthus* (e.g., see the species account of *P. choirocephalus*), neither taxon is recognised here (*sulcatus* and *barbarae* are placed in *Paramonacanthus*, the latter a synonym of *otisensis*, and *filicauda* at present remains unaccommodated, see below). Furthermore, Fraser-Brunner incorrectly believed that another new species described in this paper—*cingalensis*—, a *Paramonacanthus*-like monacanthid from India, should be included in *Laputa* (Whitley, 1930). This assumption was based on structural differences in the first dorsal spine between *cingalensis* and other members of *Paramonacanthus*. Unfortunately, Fraser-Brunner was unable to examine *Monacanthus* (*Paramonacanthus*) *knerii* Steindachner, 1867, the type species of *Laputa*. If he had, he would have noticed that it represents a species totally different to other *Paramonacanthus*. It is in fact a juvenile specimen of *Meuschenia freycineti* (Quoy and Gaimard, 1824) from southern Australia, a member of the family division referred to above as Group B. Thus *Laputa* must be relegated to the synonymy of *Meuschenia* (Whitley, 1929); furthermore, *cingalensis* is here shown to be a junior synonym of *Paramonacanthus pusillus* (Rüppell, 1828) (Table 3).

De Beaufort and Briggs (1962) provided detailed descriptions of five species of *Paramonacanthus* from the Indo-Australian region (*choirocephalus*, *nemurus*, *curtorhynchus*, *cryptodon*, and *nematophorus*). However, they preferred to leave all of them in the genus *Monacanthus*. They completely ignored two of the Australian species dealt with by Fraser-Brunner (1941) (*otisensis* and *whitleyi*), but tentatively relegated *horae* to the synonymy of *choirocephalus*.

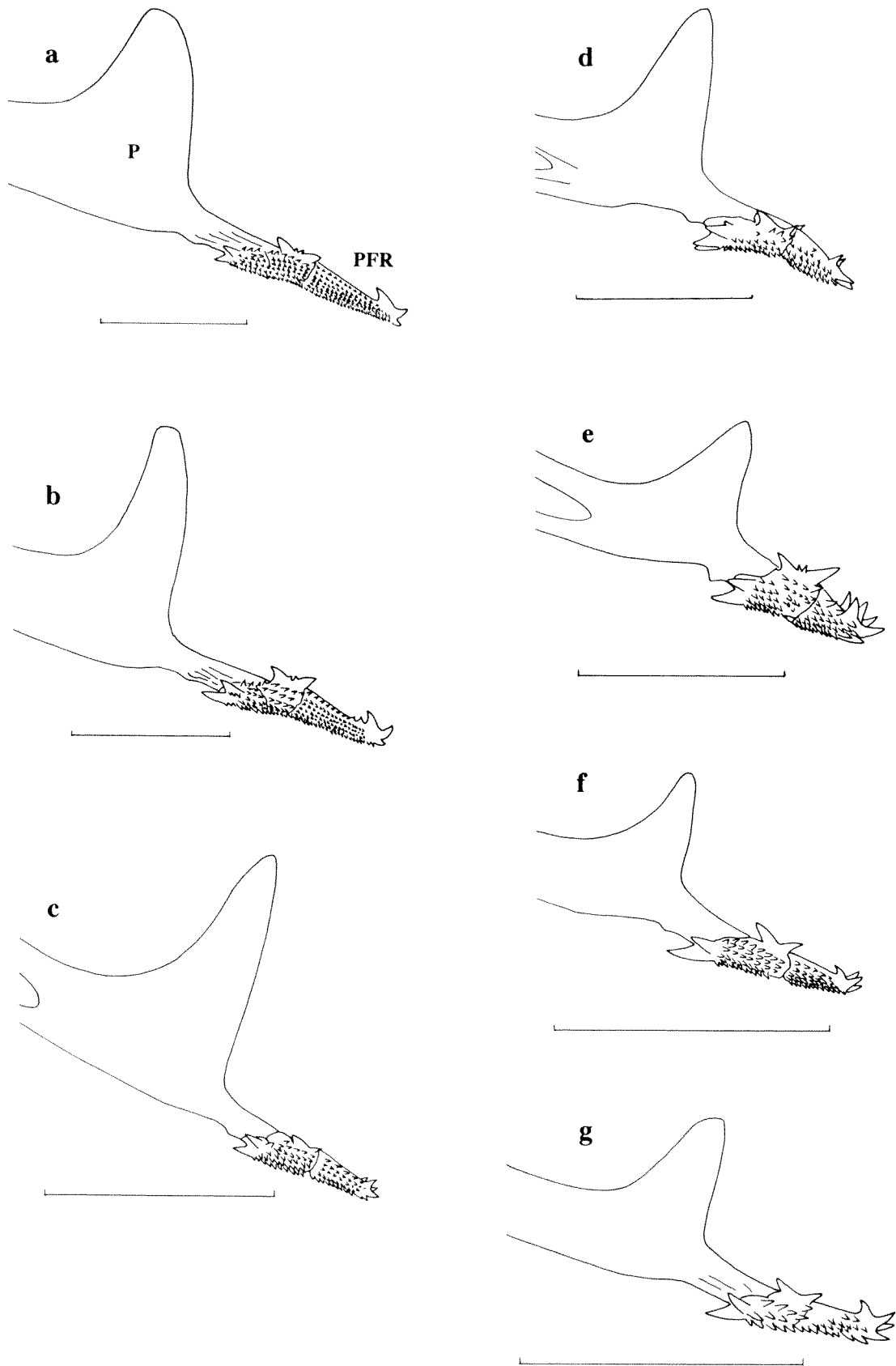


Figure 3 Pelvic fin rudiment (PFR) and rear portion of the pelvic bone (P) of: **a**, *Paramonacanthus choirocephalus*, male, 88 mm SL (WAM P.29754-001); **b**, *P. choirocephalus*, female, 67 mm SL (WAM P.29754-001); **c**, *P. japonicus*, 49 mm SL (AMS I.20753-018); **d**, *P. pusillus*, 70 mm SL (WAM P.29758-001); **e**, *P. frenatus*, 64 mm SL, (RUSI 4079); **f**, *P. nematophorus*, 57 mm SL (BPBM 19815); **g**, *P. sulcatus*, 42 mm SL (BPBM 18608) (all illustrations based on cleared and stained material). Anterior end of specimen facing left, and horizontal line equivalent to 5 mm.

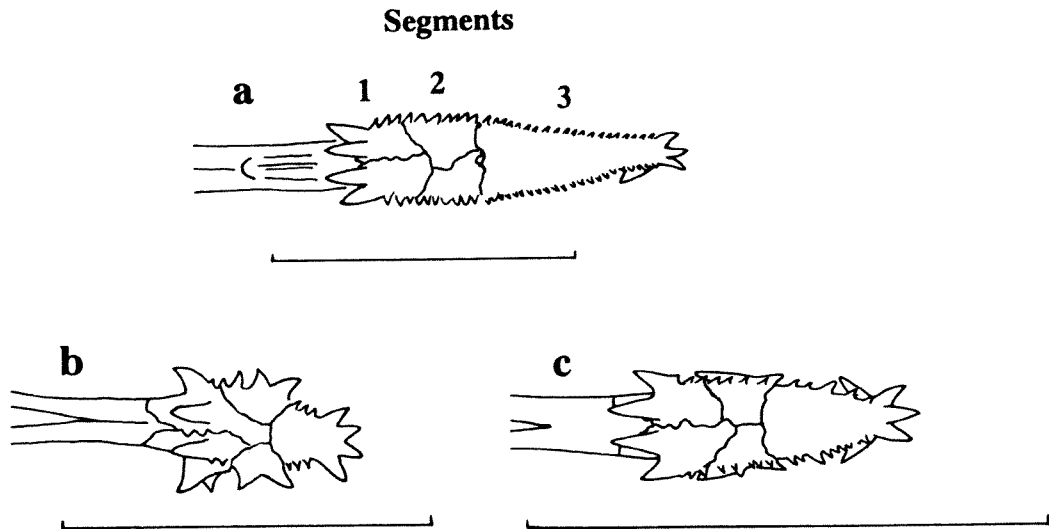


Figure 4 Pelvic fin rudiment (ventral view) showing arrangement of encasing scales of: **a**, *Paramonacanthus choirocephalus*, 67 mm SL (WAM P.29754-001); **b**, *P. pusillus*, 56 mm SL (WAM P.26565-001); **c**, *P. sulcatus*, 42 mm SL (BPBM 18608) (based on cleared and stained material). Spinules on ventral surface of rudiment omitted for clarity, anterior end of each specimen facing left, and horizontal line equivalent to 5 mm.

Hutchins (1988) in his phylogenetic investigation of the family recognised five species of *Paramonacanthus* [*japonicus*, *choirocephalus*, *tricuspis* (Hollard, 1854), *sulcatus*, and *otisensis*) and four species of a reportedly undescribed genus, referred to for convenience as “*Laputa*” [*frenatus* (Peters, 1855), *nematophorus*, *nipponensis* (Komahara, 1939), and an undescribed species (here described as *lowei* sp. nov.)]. Most of the differences separating the two genera were osteological, none of which was synapomorphic to either genus (see Comments on Phylogeny at the rear of this paper). Only one apomorphy was discovered that indicated monophyly for the members of the undescribed genus (males have a dark stripe on the anal fin extending posteriorly from the apex of the fin). The value of this character is here considered not sufficient to warrant separation of the taxa into separate genera. Hutchins also found an osteological feature shared between “*Arotrolepis*” *filicauda* and an undescribed species which indicated their monophyly (see Comments on Phylogeny at the end of this paper).

The distribution of the genus fits well with the hypothesis of Springer (1982) that the Pacific Plate is a distinct biogeographic region. Only *Paramonacanthus japonicus* has been found on the plate, at Rongelap and Bikini Atolls; the remaining species all inhabit areas within the Indo-West Pacific region. These Pacific Plate records involve only a single specimen from each locality, and may represent infrequent dispersals from populations further to the west (see the species account of *P. japonicus* for additional remarks on these specimens).

The generic name *Paramonacanthus* means “near *Monacanthus*” (*Monacanthus* is equivalent to “single spine”). The gender is masculine.

Key to the species of *Paramonacanthus* (Species accounts are presented alphabetically)

- 1a. Soft dorsal rays 30–33 (rarely 30); anal rays 31–34 (rarely 31); pectoral rays 12–14, usually 13; midbody scales each with single posteriorly curved simple spinule, spinules forming prominent longitudinal series on side of body *sulcatus*
- 1b. Soft dorsal rays 31 or fewer (rarely higher than 30, see Table 2); anal rays 33 or fewer (rarely higher than 32); pectoral rays 10–13, usually 11 or 12; spinules on midbody scales not forming prominent longitudinal series as above 2
- 2a. First dorsal spine depressed in cross-section, with four rows of downward-directed barbs, those on each lateral edge projecting laterally (Figures 2d–f) 3
- 2b. First dorsal spine more circular in cross-section, with two rows of small, mostly upward-directed barbs on anterior face (obsolete in large specimens) and one row of larger downward-directed barbs on each posterolateral face, those in latter series projecting posterolaterally (Figures 1, 2a–c, 2g) 5
- 3a. Dorsal profile of snout mostly convex (straight to convex); lines and/or narrow stripes usually present on body 4

- 3b. Dorsal profile of snout mostly straight (straight to concave); lines and/or narrow stripes never present on body *matsuurai* sp. nov.
- 4a. Body usually with narrow white lines; second ray of soft dorsal fin of male elongate and filamentous; no elongate rays in caudal fin; dusky band on anal fin of male relatively wide, width equal to or greater than width of pupil; hump on dorsal profile of snout of male absent *lowei* sp. nov.
- 4b. Body without narrow white lines (pale elongate blotches sometimes present); second ray of soft dorsal fin not elongate; upper and lower rays of caudal fin of male usually elongate and filamentous; dusky band on anal fin margin narrow, width much less than width of pupil; hump on snout of male often present *pusillus*
- 5a. Pectoral fin rays 10–12, rarely 12 6
- 5b. Pectoral fin rays 11–13, normally 12 8
- 6a. Soft dorsal rays 24–27, rarely above 26; male with narrow dusky to black stripe along margin of anal fin; no elongate and filamentous rays in caudal fin 7
- 6b. Soft dorsal rays 25–29, rarely below 26 (Table 2); dusky stripe along margin of anal fin absent; second uppermost caudal ray, and occasionally middle rays, elongate and filamentous in male *japonicus*
- 7a. Body depth 2.0–3.0 in SL (usually 2.4 or greater in specimens over 50 mm SL); second soft dorsal ray elongate and filamentous in male; spotting on midside of body continuing anterior to gill slit ... *nematophorus*
- 7b. Body depth 1.9–2.4 in SL; second soft dorsal ray not elongate and filamentous; spotting on midside of body not continuing anterior to gill slit *frenatus*
- 8a. Supra-abdominal branch of lateral line present; anal rays usually 29–32 (mean =30.5) 9
- 8b. Supra-abdominal branch of lateral line absent; anal rays usually 27–30 (mean =28.5) 10
- 9a. Dark brown circular to elliptical blotch on midside of body prominent, bisected diagonally by posterior abdominal branch of lateral line; scattered dark brown spots usually on body; second uppermost caudal ray usually elongate and filamentous in male *choirocephalus*
- 9b. Dark blotch on midside of body rather irregular in shape, mostly faint and poorly contrasted, often merging with adjacent blotches; scattered dark brown spots on body rare or absent; second uppermost and middle caudal rays usually elongate and filamentous in male, latter generally more prominent *otisensis*
- 10a. Distinctive dark brown blotch below anterior half of soft dorsal fin bisected by narrow longitudinal pale line; midbody scales usually with one rather large multibranch spinule per scale, producing velvety to rather coarse feel (some slender males may have smaller spinules giving a smoother feel) *arabicus* sp. nov.
- 10b. Distinctive dark brown blotch below anterior half of soft dorsal fin bisected by relatively wide wedge-like pale stripe; midbody scales usually with numerous small spinules arranged in 1–2 transverse series per scale, producing smooth feel (some large females with multibranch spinules producing coarser feel) *tricuspis*

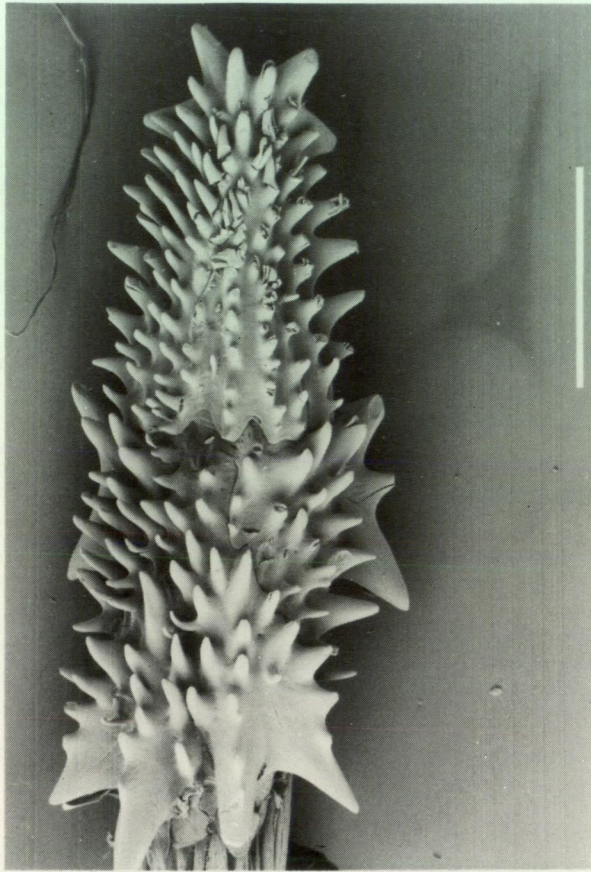
***Paramonacanthus arabicus* sp. nov.**

Figures 5b, 6e, 8, 9, 10; Tables 2, 3, 4

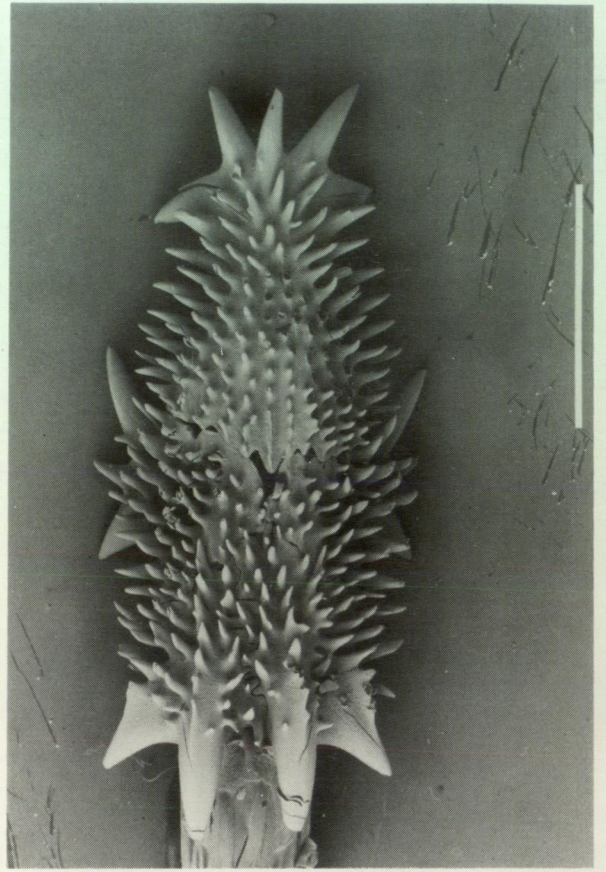
Paramonacanthus tricuspis (non Hollard, 1854): Hutchins, 1986b: 263 (in part).*Paramonacanthus* sp.: Randall, 1995: 379, figs 1119, 1120**Holotype**

WAM P.31180–001, 67 mm SL, male, near Tanajib Bay (near Safaniya [28°00'N, 48°50'E]), Arabian Gulf, Saudi Arabia, otter trawl, B. Stanaland and K. Allen, 4 June 1982.

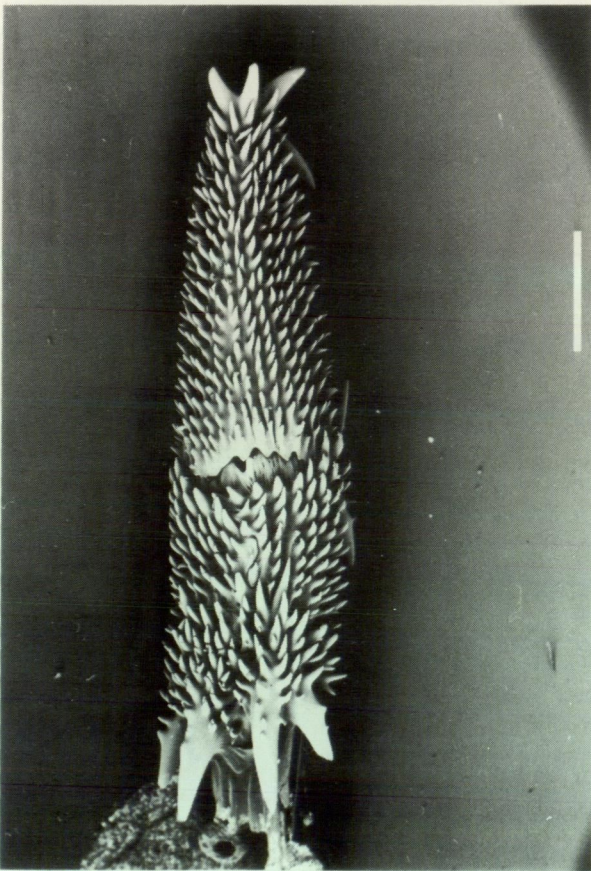
Paratypes90 specimens, 11–74 mm SL, from the Arabian Gulf: AMS I.37401–001, 7 specimens, 46–71 mm SL, off Bahrain, trawled at 16–18 m, W.F. Smith-Vaniz, 14 February 1977; BMNH 1996.10.29:2–7, 6 specimens, 41–62 mm SL, Tarut Bay, Saudi Arabia, otter trawl, B.E. Stanaland, *et al.*, 25 July 1972; BPBM 21213, 54 mm SL, shallow flats off Bahrain, J.E. Randall, 13 February 1977; BPBM 21291, 2 specimens, 49–52 mm SL, off Manama, Bahrain, rock and sand in 2 m, J.E. Randall and G.R. Allen, 23 February 1977; BPBM 29497, 14 specimens, 44–62 mm SL, off Bahrain, trawled, J.E. Randall, 9 November 1983; BPBM 30911, 4 specimens, 50–70 mm SL, Half Moon Bay, Saudi Arabia, sand and seagrass, 6–9 m, J.E. Randall *et al.*, 7 September 1985; BPBM 35415, 53 mm SL, off Safaniya, Saudi Arabia, 17–18 m, trawled, R.C. Clark *et al.*, 14 May 1992; USNM 342554, 63 mm SL, off Bahrain (26°39'N, 51°05'E), trawled at 23–24 m, W.F. Smith-Vaniz, 14 February 1977; USNM 342555, 61 mm SL, off Bahrain (26°30'N, 51°03'E), trawled at 14–17



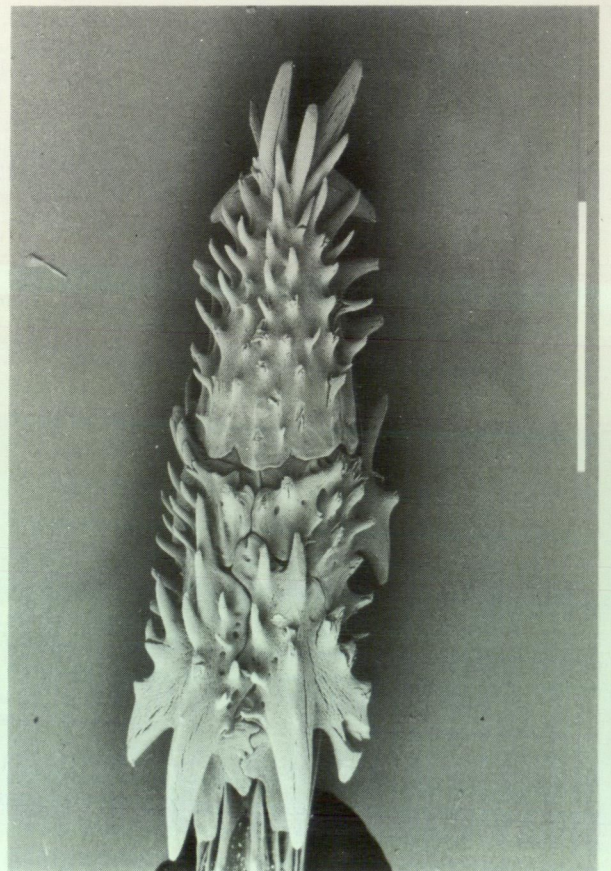
b



d



a



c

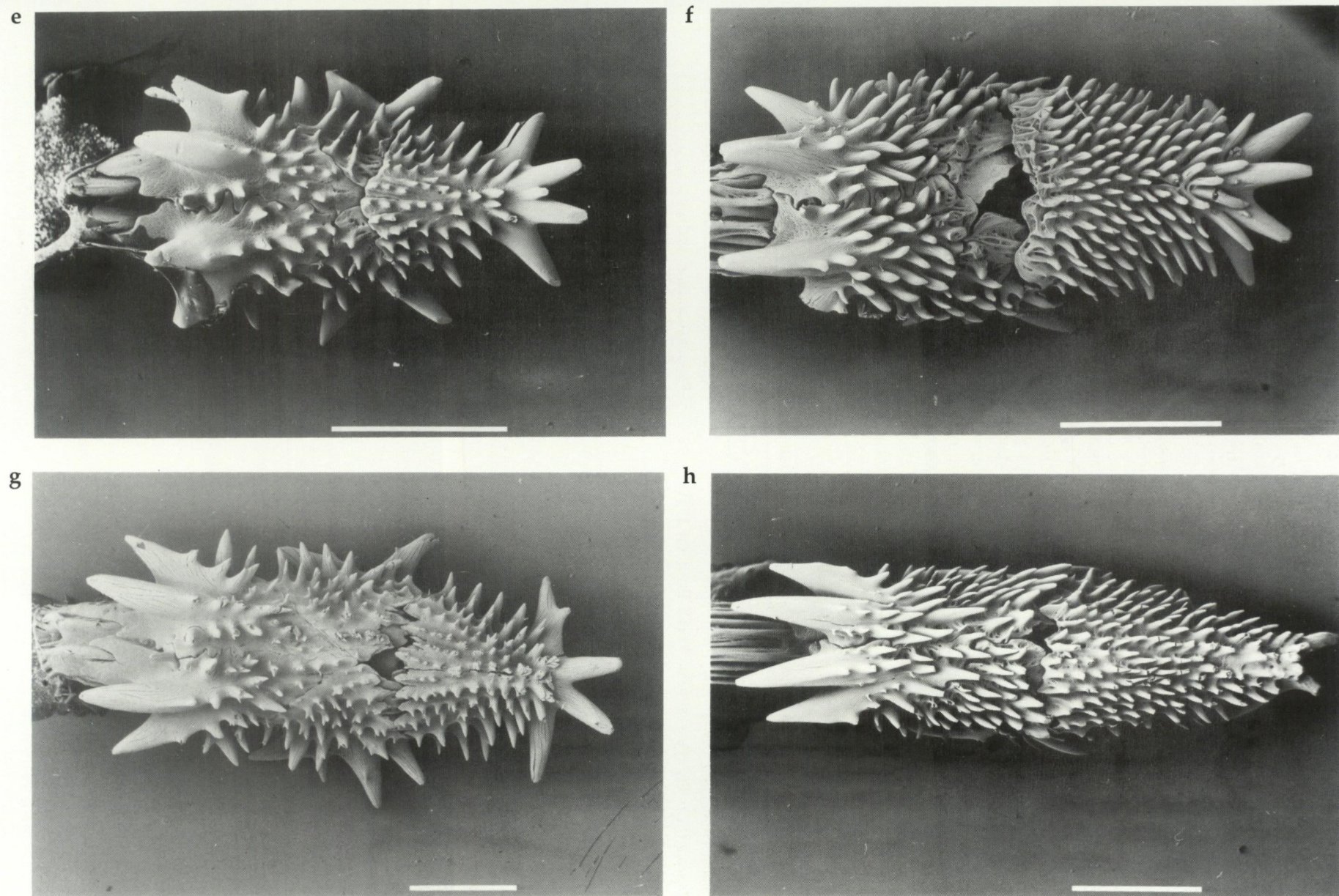


Figure 5 Scanning electron micrograph of the pelvic fin rudiment of: **a**, *Paramonacanthus choirocephalus*, 69 mm SL; **b**, *P. arabicus*, 71 mm SL; **c**, *P. sulcatus*, 42 mm SL; **d**, *P. nematophorus*, 58 mm SL; **e**, *P. pusillus*, 56 mm SL; **f**, *P. frenatus*, 58 mm SL; **g**, *P. pusillus*, 94 mm SL; **h**, *P. otisensis*, 67 mm SL (integumentary sheath of all rudiments removed to make encasing scales more visible). Anterior end of rudiment facing left, and horizontal white line equivalent to 1 mm. Photography by C. Bryce.

m, W.F. Smith-Vaniz, February 1977; WAM P.25977-010, 11 specimens, 33-69 mm SL, Bahrain, Bahrain Fisheries Dept, 1974; WAM P.25979-003, 3 specimens, 50-68 mm SL, north of Qatar Peninsular, W.F. Smith-Vaniz, February 1977; WAM P.25980-007, 2 specimens, 50-54 mm SL, north of Qatar Peninsular (26°11'N, 50°43'E), trawled at 23 m, W.F. Smith-Vaniz, 14 February 1977; WAM P.25988-001, 3 specimens, 55-60 mm SL, off Bahrain (26°31'N, 51°22'E), trawled at 30-35 mm SL, 28 February 1977; WAM P.29813-001, 2 specimens, 45-61 mm SL (cleared and stained), Tarut Bay, Saudi Arabia, trawled, B.E. Stanaland *et al.*, 25 July 1972; WAM P.31179-001, 3 specimens, 53-67 mm SL, Jana Island, Saudi Arabia, J.E. Burchard, quinaldine, 11 July 1973; WAM P.31181-001, 14 specimens, 11-28 mm SL, Jebel, north of Safaniya, Saudi Arabia, beach seine, K. Allen, *et al.*, 7 June 1982; WAM P.31182-001, 2 specimens, 36-48 mm SL, Tanajib Cliff, Saudi Arabia, L. McCarthy, 2 September 1982; WAM P.31183-001, 3 specimens, 34-47 mm SL, Safaniya, Saudi Arabia

(28°00'N, 48°50'E), otter trawl, L. McCarthy, *et al.*, 4 October 1982; WAM P.31184-001, 7 specimens, 18-45 mm SL, Tanajib desalinator, Saudi Arabia, B.E. Stanaland, 2 November 1982; WAM P.31185-001, 54 mm SL, Tanajib Cliff, Saudi Arabia, rotenone, L. McCarthy, 2 September 1982; WAM P.31186-001, 60 mm SL, off Manifa Gosp, Saudi Arabia, otter trawl, L. McCarthy, *et al.*, 4 October 1982; WAM P.31187-001, specimens, 74 mm SL, Dammam Channel, Saudi Arabia, trawl, J.E. Burchard, 10 March 1971.

Diagnosis

A species of *Paramonacanthus* with the following combination of characters: soft dorsal rays 26-30; anal rays 27-30; pectoral rays 11-13 (mostly 12); scales on midside of body each with single, relatively large, prominently branched spinule, although some slender males with smaller weakly branched spinules; dorsal profile of snout convex to slightly concave, without prominent hump just anterior to eye; second uppermost caudal fin ray of

Table 3 Nominal species of *Paramonacanthus* with their present allocation.

Nominal species	Present allocation
<i>Paramonacanthus arabicus</i> sp. nov. (this paper)	<i>Paramonacanthus arabicus</i> sp. nov.
<i>Arotrolepis (Scurrilichthys) barbarae</i> Fraser-Brunner, 1941	<i>Paramonacanthus otisensis</i>
<i>Paramonacanthus barnardi</i> Fraser-Brunner, 1941	<i>Paramonacanthus nematophorus</i>
<i>Monacanthus bertolonii</i> Bianconi, 1855	<i>Paramonacanthus frenatus</i>
<i>Monacanthus broekii</i> Bleeker, 1858	<i>Paramonacanthus japonicus</i>
<i>Monacanthus choirocephalus</i> Bleeker, 1852	<i>Paramonacanthus choirocephalus</i>
<i>Laputa cingalensis</i> Fraser-Brunner, 1941	<i>Paramonacanthus pusillus</i>
<i>Monacanthus cirrosus</i> Kossmann and Rauber, 1877	<i>Paramonacanthus nematophorus</i>
<i>Monacanthus cryptodon</i> Bleeker, 1855	<i>Paramonacanthus japonicus</i>
<i>Monacanthus curtiorhynchus</i> Bleeker, 1855	<i>Paramonacanthus japonicus</i>
<i>Paramonacanthus falcatus</i> Kotthaus, 1979	<i>Paramonacanthus pusillus</i>
<i>Monacanthus frenatus</i> Peters, 1855	<i>Paramonacanthus frenatus</i>
<i>Paramonacanthus horae</i> Fraser-Brunner, 1941	<i>Paramonacanthus tricuspis</i>
<i>Monacanthus isogramma</i> Bleeker, 1857	<i>Paramonacanthus sulcatus</i>
<i>Balistes japonicus</i> Tilesius, 1810	<i>Paramonacanthus japonicus</i>
<i>Paramonacanthus lowei</i> sp. nov. (this paper)	<i>Paramonacanthus lowei</i> sp. nov.
<i>Paramonacanthus matsuurai</i> sp. nov. (this paper)	<i>Paramonacanthus matsuurai</i> sp. nov.
<i>Monacanthus nematophorus</i> Günther, 1870	<i>Paramonacanthus nematophorus</i>
<i>Monacanthus nemurus</i> Bleeker, 1852	<i>Paramonacanthus choirocephalus</i>
<i>Monacanthus (Stephanolepis) nipponensis</i> Kamohara, 1939	<i>Paramonacanthus pusillus</i>
<i>Monacanthus oblongus</i> Schlegel, 1850	<i>Paramonacanthus japonicus</i>
<i>Paramonacanthus oblongus otisensis</i> Whitley, 1931	<i>Paramonacanthus otisensis</i>
<i>Monacanthus pusillus</i> Rüppell, 1828	<i>Paramonacanthus pusillus</i>
<i>Stephanolepis retrospinis</i> Fowler, 1943	<i>Paramonacanthus choirocephalus?</i>
<i>Monacanthus sulcatus</i> Hollard, 1854	<i>Paramonacanthus sulcatus</i>
<i>Monacanthus trachyderma</i> Bleeker, 1860	<i>Paramonacanthus japonicus</i>
<i>Monacanthus tricuspis</i> Hollard, 1854	<i>Paramonacanthus tricuspis</i>
<i>Laputa umgazi</i> Smith, 1949	<i>Paramonacanthus pusillus</i>
<i>Rudarius virgulatus</i> Nalbant and Mayer, 1975	<i>Paramonacanthus pusillus</i>
<i>Paramonacanthus whitleyi</i> Fraser-Brunner, 1941	<i>Paramonacanthus choirocephalus</i>

male elongate and filamentous; dark blotch on side of body below anterior half of soft dorsal fin usually bisected by narrow longitudinal pale line.

Description

Measurements of the holotype and paratypes are presented in Table 4 (counts and proportions in parentheses represent the ranges for the paratypes where different from those of the holotype).

Soft dorsal rays 29 (26–30); anal rays 28 (27–30, usually equal to or one more than soft dorsal count); pectoral rays 12 (12–13); vertebrae 7+12=19 (from cleared-and-stained material and radiographs); branchiostegals 1+4=5.

Body compressed and moderately slender, width 2.2 (2.0–2.4) in head length and depth 2.8 (2.1–3.2) in SL; head moderately long, length 3.0 (2.7–3.2) in SL; dorsal profile of snout when viewed laterally straight to convex in male, straight to slightly concave in female and juvenile, length 4.2 (3.7–4.2) in SL; eye diameter 3.7 (3.0–4.2) in head length, 0.9 (0.7–0.9) in interorbital width; gill opening a short slit, length 4.2 (3.9–4.8) in head length, positioned in advance of pectoral fin base, centred below posterior third of eye to slightly behind eye; pelvic flap generally small in size, noticeably reduced in slender males.

Mouth small, terminal, lips not obviously fleshy; dentition consisting of three outer and two inner teeth on each side of upper jaw (exposed portion of

first inner tooth small but obvious, with rounded extremity, second inner tooth mostly covered by outer teeth); three teeth on each side of lower jaw, posterior tooth small; anterior pair of teeth in both jaws with pointed extremities; gill rakers on first gill arch 14–15 (from 3 paratypes).

First dorsal spine originating over posterior quarter of eye to slightly behind eye; spine moderately slender, short, length 1.8 (1.4–2.6) in head length, circular in cross-section, tapering to acute tip; spine armed with four rows of barbs, comprising two adjacent series of very small upward-directed barbs on anterior face (very small juvenile with additional downward-directed branch on most barbs, disappearing by 20 mm SL), usually difficult to separate from upward-directed spinules covering anterior face of spine in adult, and one row of posterolaterally projecting barbs along each posterolateral edge; shallow groove in interdorsal space for partly receiving spine when folded rearwards; second dorsal spine small, hidden in skin at rear base of first spine; soft dorsal and anal fins elevated anteriorly, more prominently in male (profile of outer margin of fin posterior to apex concave in male, straight to convex in female [Figure 9]), longest dorsal ray at apex of fin 1.8 (1.5–2.5) in head length, slightly longer than longest anal ray; length of soft dorsal base 3.0 (2.9–3.3) in SL, slightly longer than anal base 3.4 (3.1–3.5) in SL (bases of fin membranes

Table 4 Measurements of the holotype and selected paratypes of *Paramonacanthus arabicus*.

	Holotype			Paratypes					
	WAM P. 31180-001	WAM P. 31187-001	AMS I.37401-001	BPBM 30911	USNM 342554	USNM 342555	AMS I.37401-001	BPBM 30911	AMS I.37401-001
Standard length	67	74	71	70	63	61	58	50	46
Head length	22	24	24	26	20	20	20	18	17
Body depth	24	28	27	22	24	24	24	21	22
Body width	10	11	10	12	10	9.2	9.6	9.2	7.6
Snout length	16	18	18	19	15	15	14	12	12
Eye diameter	6.0	6.4	6.3	6.6	6.4	6.0	6.3	6.0	5.6
Interorbital width	5.6	5.7	5.5	5.4	5.2	5.4	4.9	4.1	4.5
Gill slit length	5.2	6.1	5.0	5.6	4.9	4.7	4.7	4.4	4.1
Snout to dorsal spine	22	25	25	26	22	21	20	19	17
Lower jaw to pelvic fin rudiment	37	41	*	40	35	35	35	31	28
Dorsal spine length	12	17	12	10	*	11	12	10	11
Interdorsal space	16	19	18	17	17	16	15	12	13
Longest dorsal ray	12	13	16	14	11	12	11	7.7	6.8
Longest anal ray	11	11	13	11	11	10	9.6	6.1	6.0
Longest pectoral ray	8.4	8.4	8.9	7.0	8.7	8.3	7.8	6.5	5.9
Length of caudal fin	17	17	18	14	18	18	17	12	15
Length of dorsal fin base	22	24	24	22	20	20	20	16	15
Length of anal fin base	20	23	23	22	20	19	18	15	14
Length of caudal peduncle	8.9	7.0	7.5	7.1	6.4	7.1	7.1	5.5	4.4
Depth of caudal peduncle	8.0	8.8	8.3	7.9	7.7	7.0	7.4	5.6	5.8
Length of pelvic fin rudiment	3.0	4.3	*	3.3	3.6	3.1	3.1	2.8	2.6

* Measurement not taken due to damage



b



d



a



c

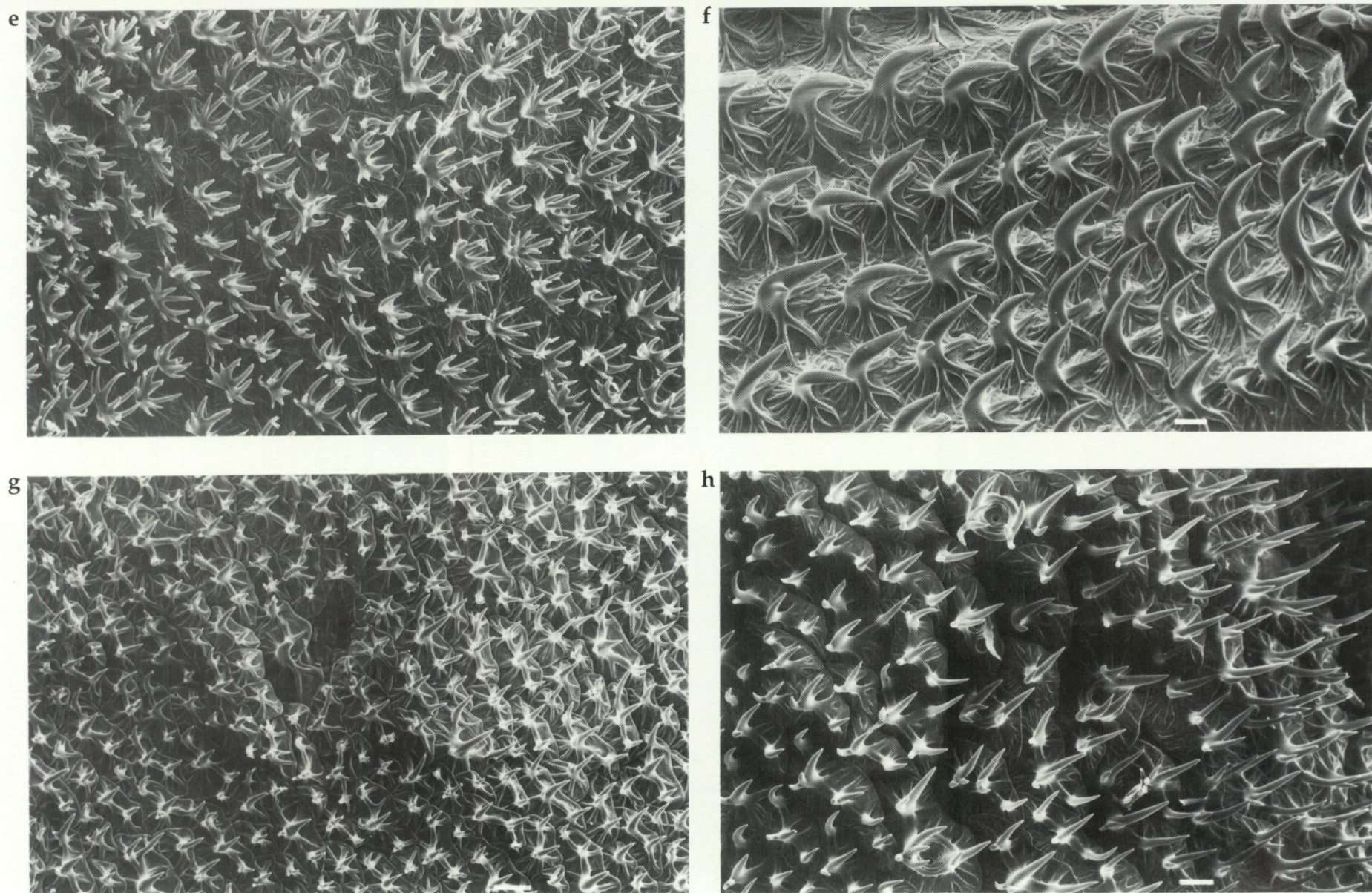


Figure 6 Scanning electron micrograph of midbody scales of: **a**, *Paramonacanthus otisensis*, female, 71 mm SL; **b**, *P. choirocephalus*, male, 88 mm SL; **c**, *P. choirocephalus*, female, 91 mm SL; **d**, *P. choirocephalus*, female, 77 mm SL; **e**, *P. arabicus*, female, 71 mm SL; **f**, *P. sulcatus*, male, 90 mm SL; **g**, *P. japonicus*, male, 65 mm SL; **h**, *P. japonicus*, female, 57 mm SL (integumentary sheath of all samples removed to make scales more visible). Anterior end of specimen generally facing lower left hand corner, and horizontal white line equivalent to 0.1 mm. Photography by C. Bryce.

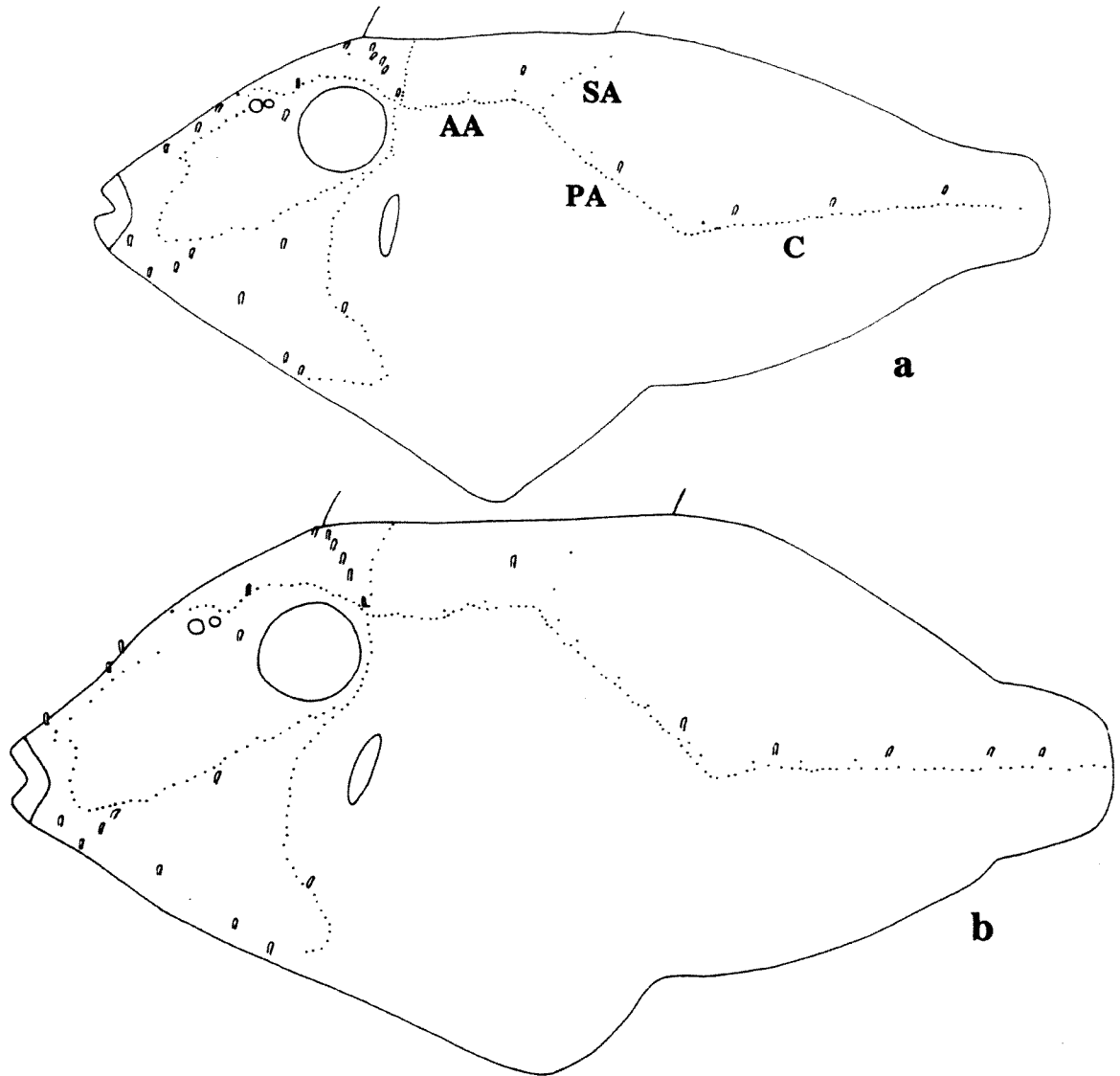


Figure 7 Lateral line sensory system of two species of *Paramonacanthus*: **a**, *P. otisensis*, 61 mm SL; **b**, *P. pusillus*, 70 mm SL (abbreviation: AA, anterior abdominal branch; PA, posterior abdominal branch; SA, supra-abdominal branch; C, caudal branch; see also Methods section above for additional information on illustrations).

perforated); origin of soft dorsal slightly in advance of anal fin origin; interdorsal space 1.3 (1.1–1.8) times greater than dorsal spine length, profile between fins flat to elevated slightly towards soft dorsal origin; base of pectoral fin below a point either slightly anterior to or slightly posterior to rear margin of eye; caudal fin rather short, length 1.3 (1.1–1.9) in head length, with convex posterior margin, although second uppermost caudal ray elongate and filamentous in male (damaged in holotype); caudal peduncle slightly tapered (more so in slender males), length 2.5 (2.5–3.9) in head length, and 0.9 (1.0–1.3) in its depth; pelvic fin rudiment relatively small in size, length 2.0 (1.5–2.2) in eye diameter, consisting of five encasing scales with obvious barbs and spinules (Figure 5b), scales arranged as in *P.*

choirocephalus (Figure 4a); posterior encasing scale moveably articulated with rear of pelvis; pelvic fin rudiment projecting short distance rearward of posterior margin of ventral flap.

Anterior midbody scales small, imbricate, circular in small juvenile (12 mm SL), each with one simple central spinule, distal extremity becoming branched by 22 mm SL; scales of adult elliptical in shape, each with 1 short erect spinule, distal extremity with up to 7 radiating branches (Figure 6e), directed mostly posteriorly (slender males with smaller spinules and weaker branches, usually developing additional simple spinules on scale); no bristles or spines on caudal peduncle; scales on head larger, more rounded, usually with additional similarly sized spinules; skin velvety to slightly coarse; cutaneous tentacles small to

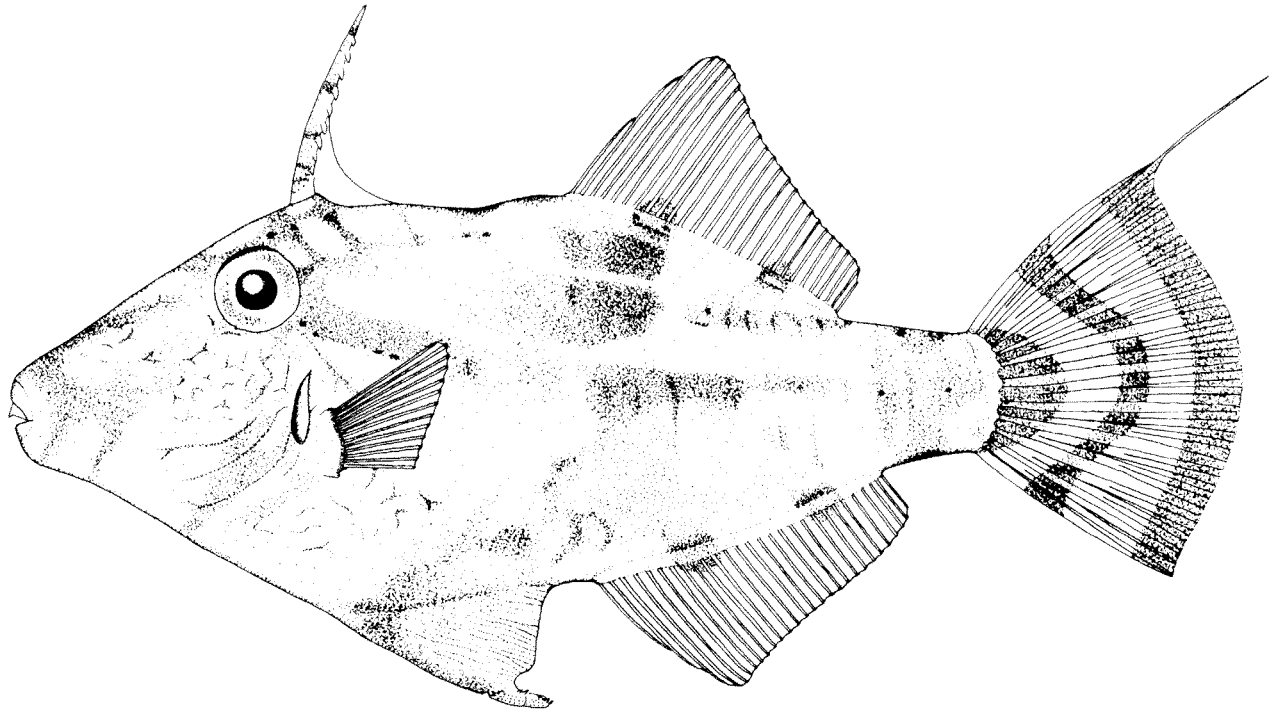


Figure 8 *Paramonacanthus arabicus*, paratype, WAM P.31179-001, 67 mm SL, male, Arabian Gulf (drawn by S. Morrison).

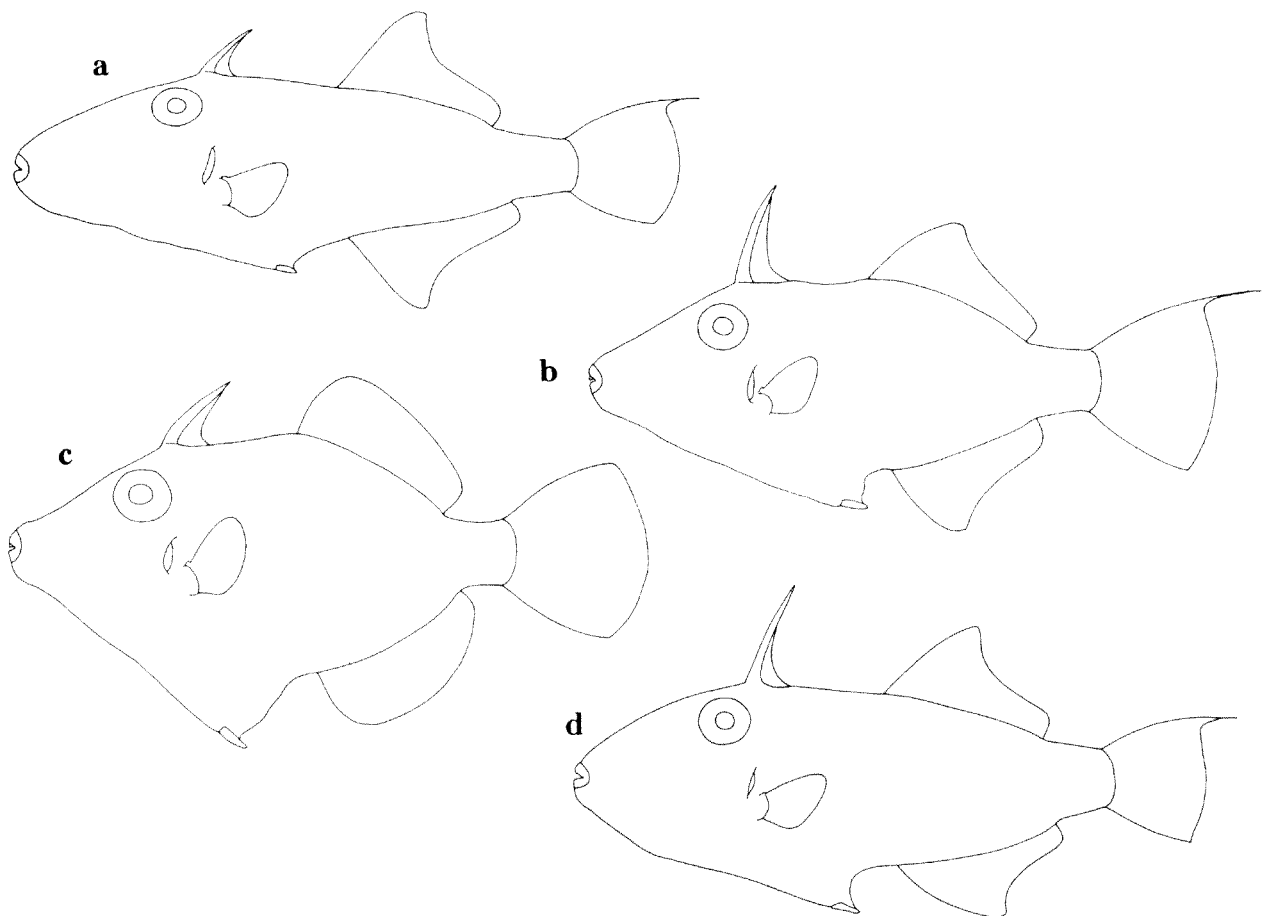


Figure 9 Variation in lateral profile of *Paramonacanthus arabicus*: a. BPBM 30911, 68 mm SL, male, Saudi Arabia; b. WAM P.31186-001, 60 mm SL, male, Saudi Arabia; c. WAM P.31179-001, 53 mm SL, female, Saudi Arabia; d. WAM P.25977-010, 63 mm SL, male, Bahrain.

moderate in size, noticeably smaller in slender males; no supra-abdominal branch in lateral line system.

Colour of holotype in alcohol: head and body pale brown with indications of dark brown markings, particularly a blotch below the anterior half of the soft dorsal fin which is bisected by a narrow pale longitudinal line, and another at junction of posterior abdominal and caudal branches of lateral line; indications of dark saddles on dorsal and ventral profiles, two across interorbital, one centrally on interdorsal space, one at origin and two on base of soft dorsal fin, one on upper surface of caudal peduncle and another on its lower surface, and two on base of anal fin; faint narrow elongate blotch extending ventro-posteriorly from rear margin of eye about two eye diameters; indications of scattered dark brown spots on body; soft dorsal and anal fins hyaline, with two dark basal blotches; caudal fin hyaline, with two curved slightly darker cross-bands, first widening towards upper and lower margins, second slightly wider, following contour of posterior border of fin, and dark basal blotch on middle rays. Colour of paratypes similar to holotype, but pattern of blotches and spots usually more distinct; some males with numerous curved brownish lines on ventral portion of head, lines often breaking up to spots dorsally.

Colour when fresh (based on colour transparencies of live fish underwater and freshly collected specimens): head and body pale brown to whitish, with mottled pattern of brownish to dusky

blotches; distinctive blotch below anterior half of soft dorsal fin, extending from base of fin anteroventrally to just cross posterior abdominal branch of lateral line, usually bisected longitudinally by white line; below this, another irregular-shaped blotch extending anteroventrally from junction of posterior abdominal and caudal branches of lateral line to ventral flap, and ventrally to anterior base of anal fin; diffuse irregular cross-band joining posterior portions of soft dorsal and anal fins, and another across caudal peduncle; small blotch at origin of soft dorsal fin and another on middle of interdorsal space; head with numerous bands radiating from eye, one extending ventroposteriorly to above pectoral fin, one anteroventrally to lower jaw, one anterodorsally to dorsal surface of snout, and two across interorbital space, posterior one joined to a blotch surrounding base of dorsal spine; ventral half of head usually with dark longitudinal lines, some curving up posteriorly toward pectoral base, lines breaking up to spots dorsally; dorsal spine pale with 2-3 darker cross-bands, other fins hyaline, soft dorsal and anal fins each with two dark basal blotches, caudal fin with two curved dark cross bars and a basal blotch centrally (in some male specimens, basal blotch and first cross-band separated by about five whitish spots, one on each of five central fin rays).

Distribution

Paramonacanthus arabicus is known only from the Arabian Gulf (Figure 10).

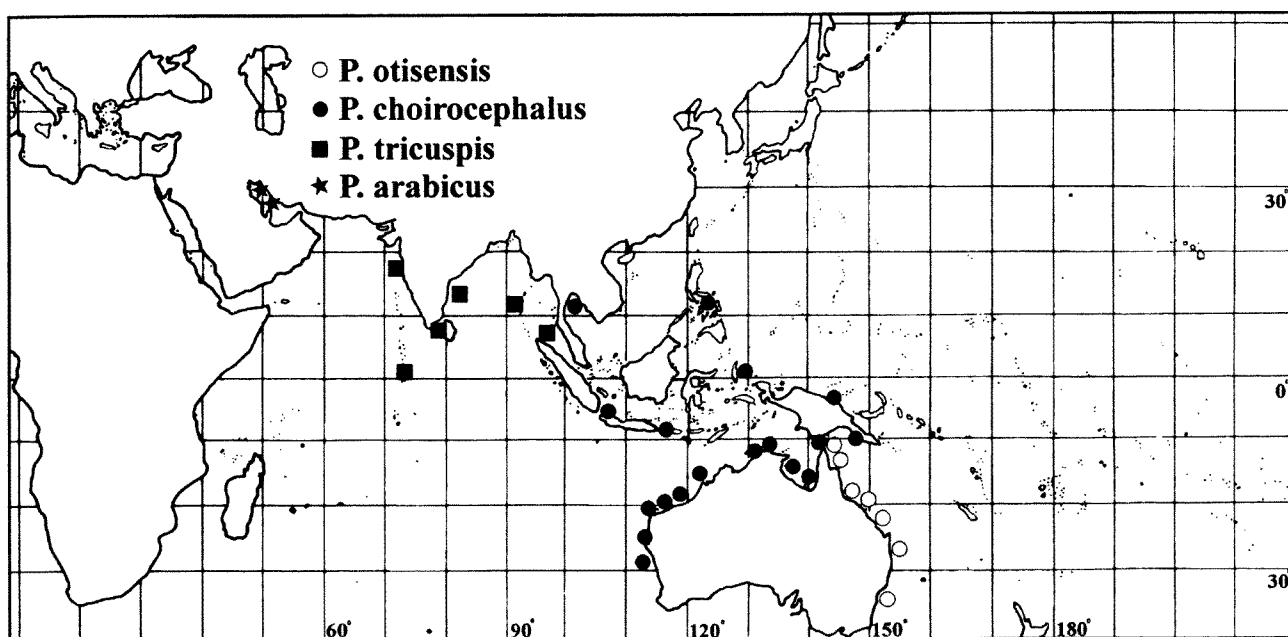


Figure 10 Distribution of *Paramonacanthus arabicus*, *P. choirocephalus*, *P. otisensis*, and *P. tricuspis* (based on material examined during the present investigation).

Remarks

Paramonacanthus arabicus is similar in general appearance to *P. tricuspis* from the Indian region, but the two are best separated by colour and scale differences. The distinctive dark blotch below the anterior half of the soft dorsal fin is present in both species, but is bisected by a narrow longitudinal white line in *P. arabicus* and by a wide wedge-like pale stripe that is directed more anteroventrally in *P. tricuspis*. The scales on the midside of the body of *P. arabicus* generally possess one large multibranched spinule per scale, whereas the midbody scales of *P. tricuspis* each have numerous small spinules arranged in 1–2 transverse series. This general arrangement, however, is subject to variation (see also Sexual Dimorphism in the Introduction above): in large slender males of *P. arabicus*, the scale spinules are much smaller, with additional simple spinules on each scale, whereas some large females of *P. tricuspis* possess large multibranched spinules. Nevertheless, this variation, in both cases, is rather rare.

Paramonacanthus arabicus has been taken by otter trawl to depths of 35 m; it has also been collected in waters as shallow as 1 m by beach seine and chemical ichthyocides.

This species is named *arabicus* in reference to the Arabian Gulf, the only area where it is known to occur.

Additional material examined.

WAM (unreg.), 10 specimens, 39–61 mm SL, Ar Ruays (24°10'N, 52°43'E), United Arab Emirates, Arabian Gulf, Dames and Moore Consultants, 1983; USNM (unreg.), 20 specimens, 22–43 mm SL, collected with AMS I.37401–001; USNM 147925, 2

specimens, 12 mm SL, Fasht Al Jarim, north of Bahrain, Arabian Gulf, 13 June 1948.

***Paramonacanthus choirocephalus* (Bleeker, 1852)**

Figures 1, 3a–b, 4a, 5a, 6b–d, 10, 11, 12; Tables 2, 3

Monacanthus choirocephalus Bleeker, 1852: 19, pl. 2, fig. 4 [type locality, Batavia (= Jakarta, Indonesia)].

Monacanthus nemurus Bleeker, 1852: 20, pl. 2, fig. 3 (type locality, Batavia).

Paramonacanthus whitleyi Fraser-Brunner, 1941: 194, fig. [type locality, between Cape Jaubert and Wallah (*sic*), Western Australia].

?*Stephanolepis retrospinis* Fowler, 1943: 90, fig. 25 (Cebu Island, Philippines).

Diagnostic description

Soft dorsal rays 27–31; anal rays 28–32; pectoral rays 11–13 (mostly 12, see Table 2); vertebrae 7+12=19; body width 2.1–2.7 in head length; body depth 1.7–3.0 in SL; head length 2.8–3.1 in SL; dorsal profile of snout straight to convex in male, small hump sometimes over or slightly in advance of nostrils (Figure 12e), straight to concave in female and juvenile, without hump, snout length 3.7–4.8 in SL; eye diameter 2.8–4.2 in head length, 0.8–1.1 in interorbital width; gill opening a short slit, length 3.7–5.2 in head length, centred below posterior quarter of eye to slightly behind eye; gill rakers on first gill arch 16–18; first dorsal spine originating over posterior half of eye, or slightly behind eye, length 1.1–2.1 in head length, circular

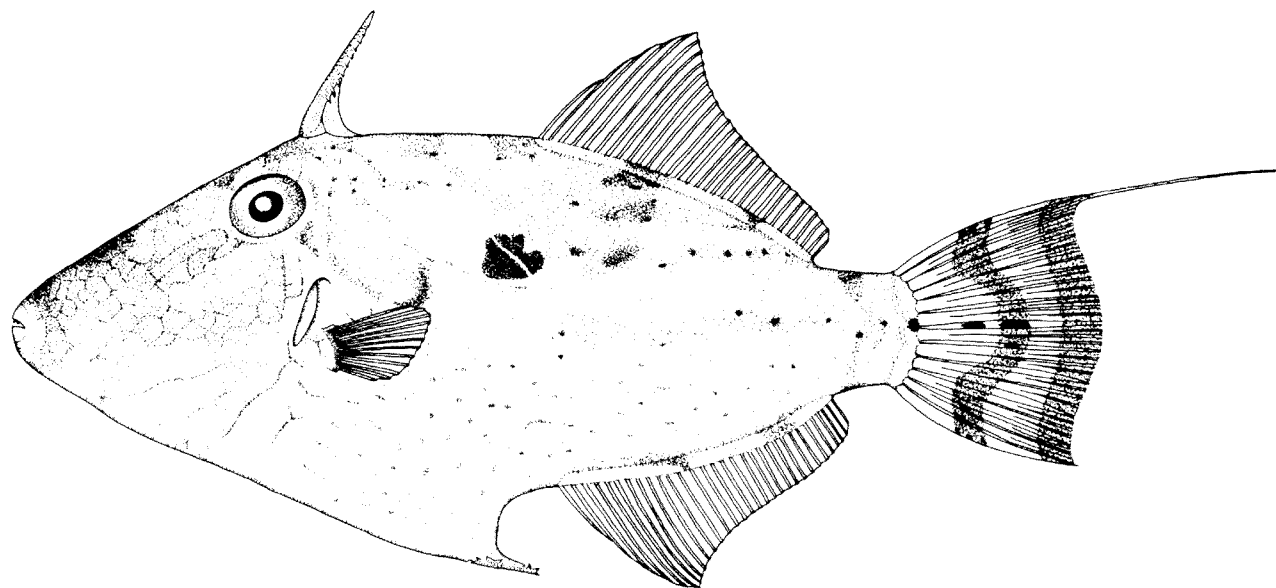


Figure 11 *Paramonacanthus choirocephalus*, WAM P.25508–024, 90 mm SL, male, Western Australia (drawn by S. Morrison).

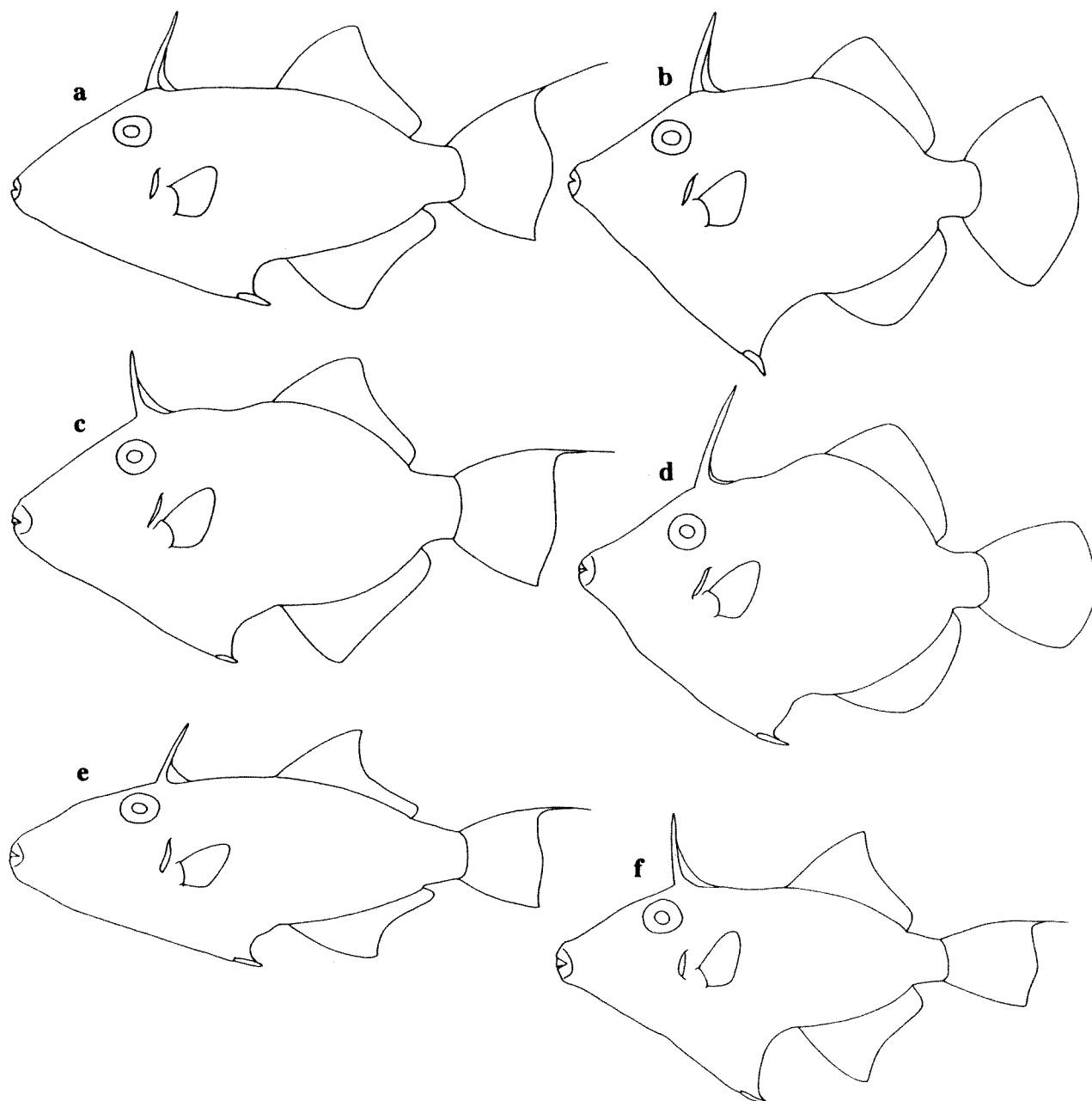


Figure 12 Variation in lateral profile of *Paramonacanthus choirocephalus*: **a.** WAM P.25508-024, 90 mm SL, male, Western Australia; **b.** WAM P.25508-024, 76 mm SL, female, Western Australia; **c.** WAM P.26273-007, 102 mm SL, male, Western Australia; **d.** WAM P. 28410-001, 77 mm SL, female, Western Australia; **e.** KFRS F.02094, 85 mm SL, male, Papua New Guinea; **f.** WAM P. 12091-001, 78 mm SL, male, Western Australia.

in cross-section; spine of juvenile with four rows of barbs, anterior two series with small double to triple-branched barbs, upward-directed branch strongest, and one row of posterolaterally projecting barbs on each posterolateral face; with increasing SL, barbs becoming more numerous and relatively smaller (Figure 1), anterior barbs approaching obsolescence, posterolateral barbs becoming multibranched proximally, especially in male; soft dorsal and anal fins elevated anteriorly, particularly in male [profile of outer margin of fin posterior to apex concave in male, straight to

convex in female and juvenile (Figure 12)], longest dorsal ray at apex of fin 1.5–2.8 in head length, equal to or slightly longer than longest anal ray; length of soft dorsal base 2.6–3.4 in SL, about equal to anal fin base (bases of fin membranes perforated); origin of soft dorsal fin slightly anterior to origin of anal fin; interdorsal space up to 1.8 times greater than length of first dorsal spine in adults, about equal in specimens smaller than 60 mm SL; caudal fin mostly convex, although second uppermost ray elongate and filamentous in male, fin length (not including filament) 1.0–1.9 in head

length; caudal peduncle moderate in length, 3.0–5.5 in head length and 1.2–1.8 in its depth, tapered in male but not in female and juvenile; pelvic fin rudiment relatively long and narrow, length 1.1–1.8 in eye diameter, rudiment projecting prominently rearwards of posterior margin of ventral flap; rudiment consisting of five encasing scales with small barbs and spinules (Figure 5a), scales arranged as in Figure 4a (no spaces between scales); midbody scales small, imbricate, circular in small juvenile (18 mm SL) with one central spinule, distal extremity multibranching; scales becoming more elliptical with increasing SL, usually developing 1–2 transverse rows of spinules; spinules in male generally multibranching (Figure 6b), those of female ranging from simple (Figure 6c) to multibranching with elongate branches (Figure 6d); female generally with larger spinules than male, occasionally with only one multibranching spinule per scale (Figure 6d), often tending to form longitudinal lines on body; small cutaneous tentacles on head and body, supported by slightly enlarged spinules; skin smooth in male to rather coarse in some female examples; lateral line sensory system usually with well developed supra-abdominal branch (specimens examined from Thailand generally with branch visible on one side of body only).

Colour when fresh (based on colour transparencies of live and freshly collected specimens from Western Australia and Indonesia): ground colour either whitish, pale yellowish or pale brownish, with dark brown to dusky blotches, blotches sometimes tending to form two curved, oblique stripes on body, first from rear of soft dorsal fin to pectoral fin, second from caudal fin base to ventral flap; three dark brown blotches nearly always present, first below anterior half of soft dorsal fin, extending onto base of fin rays, second on midside of body just anterior to imaginary line joining origins of soft dorsal and anal fins (always bisected by obliquely directed posterior abdominal branch of lateral line (Figure 11), third just behind gill opening near tip of pectoral fin; other less prominent dark blotches forming bands across dorsal and ventral surfaces of head and body, including 1–2 on snout, two on interorbital space, two on interdorsal space, one on rear half of soft dorsal base, one anteriorly on upper and lower surfaces of caudal peduncle, two above base of anal fin, 3–5 across throat and anterior surface of ventral flap (ventral flap sometimes mostly dusky); thin dark brown wavy lines and/or dark spotting often on head and body, former usually obvious only in male forming reticulate pattern on snout and cheek; one colour form with majority of dark brown blotches replaced by elongate, irregularly shaped pale yellowish brown blotches, tending to give

appearance of numerous somewhat longitudinally arranged pale yellowish stripes along side of body (bisected dark midside blotch always present); all fin rays pale yellowish to hyaline, soft dorsal and anal fins usually with two dusky basal blotches; caudal fin with dark basal blotch on middle rays, followed by two broad, curved, dusky cross bands, anterior one of male narrowing centrally, usually associated with several elongate blackish blotches on integument, posterior band following rear margin of fin (sometimes more yellowish than dusky); middle portion of caudal fin in male occasionally with white spots forming two narrow curved cross bars, one on either side of dark anterior band.

Colour in alcohol: head and body pale brown with darker markings as described above; some pale individuals lack most dark markings, but dark midside blotch bisected by lateral line always present.

Distribution

Paramonacanthus choirocephalus has been found in Thailand, Philippines, Indonesia, New Guinea, and northern Australia (east to Torres Strait) (Figure 10).

Remarks

Paramonacanthus choirocephalus is closely allied with *P. otisensis*, differing mainly in the number of caudal fin filaments (1 versus 2 respectively), scale structures (*P. choirocephalus* generally has smoother scale spinules) and colouration (*P. choirocephalus* has a prominent dark blotch bisected by the lateral line behind the pectoral fin and numerous small dark spots on the body, both features that are lacking in *P. otisensis*). The two species are mostly allopatric, their distributions overlapping only in the Cape York area of Queensland. Specimens from this region have proved difficult to identify as many have features of both *P. choirocephalus* and *P. otisensis*. For example most have a dark blotch on the midside of the body that is bisected by the anterior abdominal branch of the lateral line and dark body spotting indicating that they are examples of *P. choirocephalus*. However, some of these specimens also have two caudal fin filaments while others have reasonably coarse scale spinules suggesting that they are *P. otisensis*. The inference here is that this material consists of hybrids of the two species. Examples of true *P. choirocephalus* were examined from Torres Strait (east to 143°27'E), and the westernmost specimens of true *P. otisensis* were from the Gulf of Carpentaria near the Wellesley Islands (16°47'S, 139°34'E) (the latter are the only *P. otisensis* known from the western side of Cape York). All apparent hybrid specimens have been collected from off the tip of Cape York (latitude 9°30'S), south to Princess Charlotte Bay (14°05'S).

Paramonacanthus choirocephalus was described (Bleeker, 1852) on the basis of eight Indonesian specimens ranging in size from 50 to 92 mm TL. These are now apparently incorporated with other material in a single specimen lot totalling 47 specimens (RMNH 7301, 40–78 mm TL) and have no distinguishing tags (van Oijen, pers. comm.). However, the largest of the eight syntypes may have been sent to the BMNH in 1867 as Günther (1870) reported a single Bleeker specimen (BMNH 1867.11.28.204) of 3 1/2 inches (= approx. 89 mm TL) in the collection. A photograph of this specimen was examined and it clearly represents a large female of this species. Günther listed it as "Type" and as it is the only extant specimen from Bleeker's collection that is close to the maximum length of 92 mm TL, that also has the correct fin ray counts (see below), he may have been correct (neither of the two Bleeker specimens of this species at NMV [see Dixon and Huxley 1982] is close to this length). For the present study, two of the largest specimens from the above-mentioned specimen lot at RMNH were borrowed. They are 72 and 74 mm TL, both female, and agree well with the type description of *P. choirocephalus*, with the exception of the dorsal and anal fin ray counts. Although very close, neither specimen has the exact counts that were given by Bleeker (ie, D. 28; A. 30). Possibly Bleeker took counts only from the largest specimen (the BMNH specimen mentioned above has the correct counts) as it would be highly unlikely for all eight syntypes to have had the same count. Nevertheless there is little doubt that the species represented by the two individuals is the same as described and illustrated by Bleeker (1852, 1865).

Monacanthus nemurus was described by Bleeker (1852) from two specimens, 76–92 mm TL, taken in Indonesia. The only specimens at RMNH identified as *M. nemurus* are 91 and 103 mm TL, so the larger is unlikely to be one of the types (van Oijen, pers. comm.). Examination during the present study of the other specimen (RMNH 7302) showed that it closely agrees with the type description and illustration of *M. nemurus*, and was deduced to be a male example of *Paramonacanthus choirocephalus*. It was described in the same paper as the latter species (on the following page), and has the same type locality (ie, Batavia) (unfortunately Bleeker was unaware at the time that they represented different sexes of the one species). As first reviser, I select *P. choirocephalus* as the valid name for the species on the basis of page priority (Recommendation 24A of the International Code of Zoological Nomenclature, 1985), and include *M. nemurus* in its synonymy.

Fraser-Brunner (1941) described *Paramonacanthus whitleyi* from a 50 mm SL specimen collected in Western Australia that was sent to him on loan by

AMS. No specimen at AMS is currently listed as the type, but one 48 mm SL specimen (IA.4136) with correct locality data [between Jaubert and Wallah = (Wallal)] was examined for this study. It agrees reasonably well with the type description and illustration with the exception of the soft dorsal ray count (29 instead of 28). Nevertheless, this female specimen is provisionally recognised as the type.

Stephanolepis retrospinis (Fowler, 1943) was described from a 51 mm TL specimen collected from Cebu Island in the Philippines. Examination of the holotype showed that it is most similar to *Paramonacanthus choirocephalus*, allowing for the following differences: the blotch overlying the anterior abdominal branch of the lateral line, which is characteristic for the species, was not visible, nor could pores associated with the supra-abdominal branch of the lateral line be found. However, it matches none of the other known species of the genus. Therefore, this name is tentatively added to the synonymy of *P. choirocephalus*.

Paramonacanthus choirocephalus is a common component of bottom trawl catches in Western Australia and the Northern Territory. It is taken mostly by prawn and scallop trawlers at depths between 10 and 58 m, and is considered to be a nuisance because its dorsal spine often becomes entangled in the nets. It grows to a maximum size of 110 mm SL.

Material Examined (176 specimens, 9–110 mm SL).

Western Australia (all at WAM unless otherwise indicated): AMS IA.4136 (apparent holotype of *Paramonacanthus whitleyi*), 48 mm SL, between Cape Jaubert and Wallah (= Wallal), 1929; P.12091–94, 4 specimens, 56–93 mm SL, Shark Bay, 1960; P.23426–008, 3 specimens, 73–78 mm SL, Learmonth, June 1973; P.25508–024, 2 specimens, 70–92 mm SL, Exmouth Gulf, 6 December 1975; P.25631–003, 5 specimens, 67–91 mm SL, Bernier Island, August 1976; P.26149–001, 4 specimens, 75–110 mm SL, Mermaid Pass, Dampier Archipelago, 8 September 1977; P.26197–003, 3 specimens, 74–85 mm SL, North East of Legendre Island, Dampier Archipelago, 17 May 1978; P.26273–007, 102 mm SL, Broome, 29 June 1978; P.26284–001, 4 specimens, 84–99 mm SL, Broome, 29 June 1978; P.26997–001, 3 specimens, 86–96 mm SL, North of Shellborough, 7 June 1980; P.27219–024, 73 mm SL, Hummock Island, Abrolhos Islands, 22 November 1980; P.28410–001, 2 specimens, 77–91 mm SL, Peron Shoals, Shark Bay, 16 May 1976; P.28697–001, 15 specimens, 19–33 mm SL, North West Shelf, 26 April, 1983; P.28737–003, 2 specimens, 50–56 mm SL, North West Shelf, 25 October 1983; P.28739–002, 9 specimens, 9–47 mm SL, North West Shelf, 5 December 1982; P.29754–001, 2 specimens, 67–88 mm SL (cleared and stained),

Carnarvon, May 1976; P.29802-002, 83 mm SL (skeletal material), North West Shelf, 1985.

Northern Territory: NTM S.1094-001, 2 specimens, 92-94 mm SL, Groote Eylandt, 5 January 1983; NTM S.10031-083, 60 mm SL, North of Smith Point, Coburg Peninsula, 18-20 October 1981; NTM S.10051-006, 88 mm SL, Van Diemen Gulf, 26 October 1977; NTM S.10172-003, 4 specimens, 23-61 mm SL, Shoal Bay, 3 July 1973; NTM S.10938-011, 68 mm SL, Groote Eylandt, 6 January 1983; NTM S.10956-001, 2 specimens, 42-47 mm SL, Groote Eylandt, 8 December 1982; WAM P.26991-001, 75 mm SL, Timor Sea, North East of Melville Island, 10 July 1980; WAM P.14255, 102 mm SL, Darwin, 4 September 1965.

Queensland: AMS I.15557-272, 3 specimens, 65-71 mm SL, Gulf of Carpentaria, 18 June 1973; AMS I.17597, 3 specimens, 69-83 mm SL, Torres Strait, 24 March 1974; QM I.17601, 3 specimens, 46-75 mm SL, Torres Strait, 2 April 1974; NTM (unregistered), 3 specimens, 64-81 mm SL, off Bountiful Islands, Gulf of Carpentaria, 1 December 1975; QM I.17603, 3 specimens, 61-79 mm SL, Torres Strait, 23 April 1974; WAM P.13388-97, 10 specimens, 39-59 mm SL, Gulf of Carpentaria, November 1964.

Papua New Guinea: KFRS F.0263, 2 specimens, 61-67 mm SL, Marshall Lagoon, August 1960; KFRS F.0891, 4 specimens, 53-67 mm SL, Sepik Area, November 1965; KFRS F.02094, 56 mm SL, North West of Yule Island, 21 February 1971; KFRS F.4177-10, 56 mm SL, Sepik Coast, 31 May 1974.

Indonesia: ANSP 111890, 81 mm SL, Off Teluk Kau, Halmahera, 25 September 1963; BMNH 1867.11.28.204 (possible syntype of *Monacanthus choirocephalus*), 70 mm SL, East Indian Archipelago; BPBM 30171, 73 mm SL, Batu Bolong, Lombok Island, 23 February 1984; RMNH 7301 (possible syntypes of *Monacanthus choirocephalus*), 2 specimens, 72-74 mm SL, Jakarta; RMNH 7302 (syntype of *Monacanthus nemurus*), 72 mm SL, Jakarta.

Philippines: USNM 108467 (type of *Stephanolepis retrospinis*), 40 mm SL, Cebu Island; USNM 273251, 74 mm SL, south-east of Sicogon Island, 4 June 1978; USNM 273253, 12 specimens, 65-86 mm SL, east of Sicogon Island, 4 June 1978; WAM (unregistered), 2 specimens, 59-69 mm SL, Visayan Sea, October 1979.

Thailand: CAS 57548, 4 specimens, 52-64 mm SL, Gulf of Thailand, 24 October 1959; NSMT-P 44687, 56 mm SL, Gulf of Thailand; NSMT-P 44688, 3 specimens, 43-51 mm SL, Gulf of Thailand; NSMT-P 44689, 74 mm SL, Gulf of Thailand; NSMT-P 44690, 39 mm SL, Gulf of Thailand; NSMT-P 44691, 76 mm SL, Gulf of Thailand; NSMT-P 44692, 49 mm SL, Gulf of Thailand; NSMT-P 44693, 2 specimens, 42-53 mm SL, Gulf of Thailand.

Apparent hybrids of *Paramonacanthus choirocephalus* and *P. otisensis* from Queensland: AMS I.20771-078, 9 specimens, 57-96 mm SL, East of Captain Billy Creek, Cape York, 18 February 1979; AMS I.20771-095, 3 specimens, 56-77 mm SL, East of Captain Billy Creek, Cape York, 18 February 1983; AMS I.20827-013, 10 specimens, 59-78 mm SL, North East of Hannibal Island, Cape York, 15 February 1979; AMS I.20827-035, 63 mm SL, same data as for previous entry; AMS I. 20828-019, 64 mm SL, East of Turtle Island, Cape York, 15 February 1979; AMS I.20923-011, 7 specimens, 36-72 mm SL, Cape York, 15 February 1979; AMS I.20938-004, 86 mm SL, Eel Reef, Cape York, 20 February 1979; QM I.18161, not measured, Cape Weymouth, 24 September 1979; QM I.18250, 63 mm SL, North Queensland, 27 September 1979; QM I.18347, not measured, Princess Charlotte Bay, 30 September 1979.

***Paramonacanthus frenatus* (Peters, 1855)**

Figures 2c, 3e, 5f, 13, 14, 15; Tables 2, 3

Monacanthus frenatus Peters, 1855: 464 (type locality, Querimba Island, Mozambique).

Monacanthus bertolonii Bianconi, 1855: 148, pl. 3, fig. 2 (type locality, Mozambique).

Paramonacanthus barnardi: Fraser-Brunner, 1941: 193, fig. (type locality, Zanzibar) (in part).

Diagnostic description

Soft dorsal rays 24-26; anal rays 25-28; pectoral rays 10-12 (usually 11, see Table 2); vertebrae 7+12=19 in seven examples, 6+13=19 in one; body width 1.9-2.4 in head length; body depth 1.9-2.2 in SL; head length 2.9-3.2 in SL; dorsal profile of snout straight to slightly convex in male, without prominent angular hump above nostrils, concave in female and juvenile, snout length 3.8-4.2 in SL; eye diameter 2.9-4.2 in head length, 0.9-1.1 in interorbital width; gill opening a short slit, length 4.4-6.9 in head length, centred below posterior quarter of eye or slightly behind eye; gill rakers on first gill arch 16; first dorsal spine originating over posterior one-third of eye, length 1.3-1.8 in head length, circular to slightly depressed in cross-section; spine with four rows of barbs, anterior two series with upward- and downward-directed branches, former always stronger, and two rows of larger, posterolaterally projecting barbs (anterior barbs becoming obsolete with increasing SL); soft dorsal and anal fins prominently elevated anteriorly in male, only slightly elevated in female (profile of outer margin of fin posterior to apex concave in male, convex in female and juvenile [Figure 14]); second dorsal ray of male not elongate and filamentous, length 1.5-3.5 in head length, slightly longer or equal to longest anal ray; length

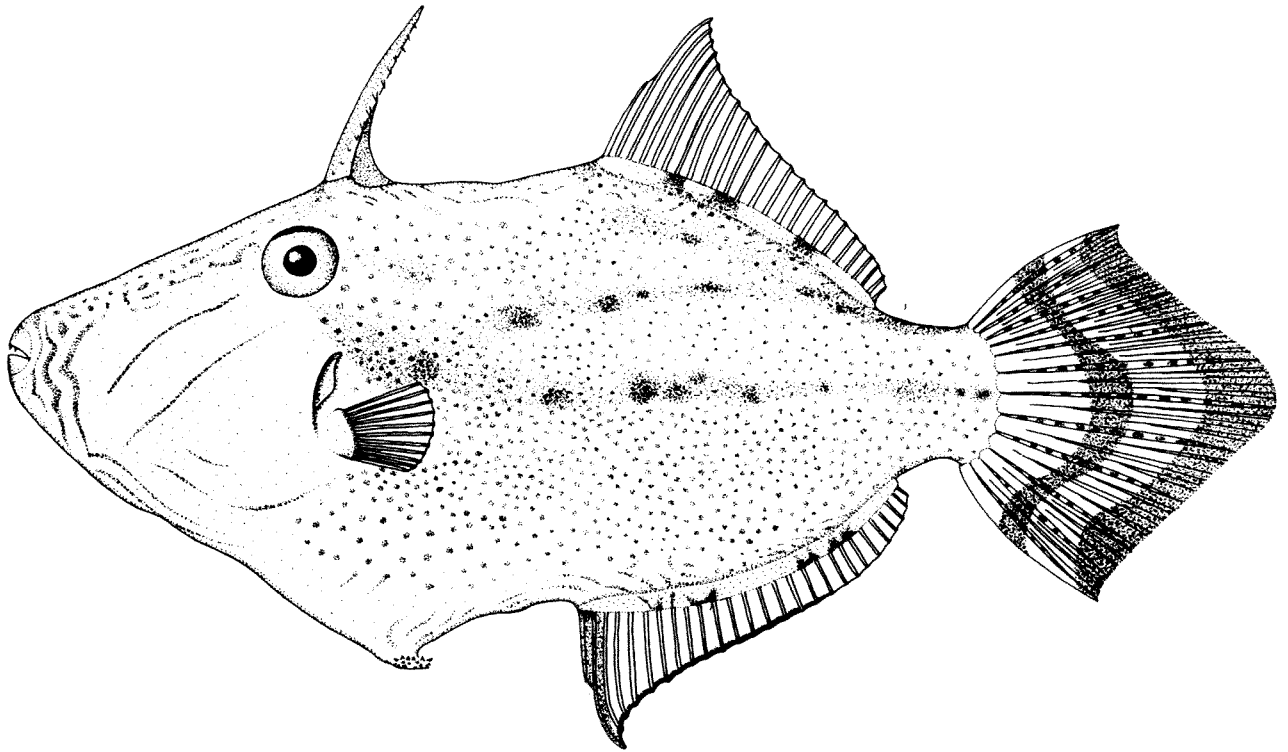


Figure 13 *Paramonacanthus frenatus*, RUSI 4079, 87 mm SL, male, Mozambique (drawn by S. Morrison).

of soft dorsal base 2.9–3.2 in SL, equal to or slightly shorter than base of anal fin (bases of fin membranes not perforated); origin of soft dorsal fin slightly anterior to or slightly posterior to anal fin origin; interdorsal space up to 1.3 times greater than length of first dorsal spine in adult, about equal in specimens smaller than 60 mm SL; caudal fin moderately long in male, posterior border arrowhead-shaped (Figure 14), but more convex in female, length 0.9–1.3 in head length; caudal peduncle tapered, especially in male, length 1.3–1.8 in its depth, and 3.5–4.7 in head length; pelvic fin rudiment projecting rearwards of posterior margin of pelvic flap; rudiment relatively short (Figure 3e), length 1.5–2.2 in eye diameter, consisting of five encasing scales with prominent central gap in segment 2 (Figure 5f), scales arranged as in *P. pusillus* (Figure 4b); midbody scales small, imbricate, elliptical, with transverse row of 3–5 slender simple spinules, second row with a single spinule developing in large individuals; no sexual dimorphism in scale structures; numerous prominent cutaneous tentacles on head and body of female, each supported by an enlarged scale with prominent central spinule (tentacles much smaller and less obvious in male); first dorsal spine and pelvic fin rudiment also with prominent tentacles in both sexes; skin velvety to the touch.

Colour when fresh: ground colour green, with many closely packed small brown spots on body, spotting not extending forwards of gill opening

onto cheek; several dark brown blotches on body, tending to form two oblique bars and longitudinal stripe along midside; most obvious blotch just above pectoral fin, continued to lower margin of eye, another on midside just behind line through origins of soft dorsal and anal fins; male with 2–3 thin dark lines from eye to throat, and several alternating blue and yellow lines from behind mouth, extending ventroposteriorly to pelvic fin rudiment (sometimes to anal fin origin), and dorsoposteriorly from mouth as series of blue spots to origin of spinous dorsal fin; soft dorsal and anal fins pale yellowish to hyaline, bases with 5–6 dark brown spots; anal fin in male with first two rays dusky and narrow black band along outer margin, extending from apex to about middle of fin (both absent in female); caudal fin hyaline to pale yellowish, membranes with numerous small blackish spots, forming two curved cross bars, second bar down rear edge of fin.

Colour in alcohol: head and body pale brown, markings as described above dark brown.

Distribution

Paramonacanthus frenatus is found along the east coast of Africa, from Mombassa to Durban (Figure 15), and possibly across to the Seychelles (see below).

Remarks

Paramonacanthus frenatus is closely related to *P.*

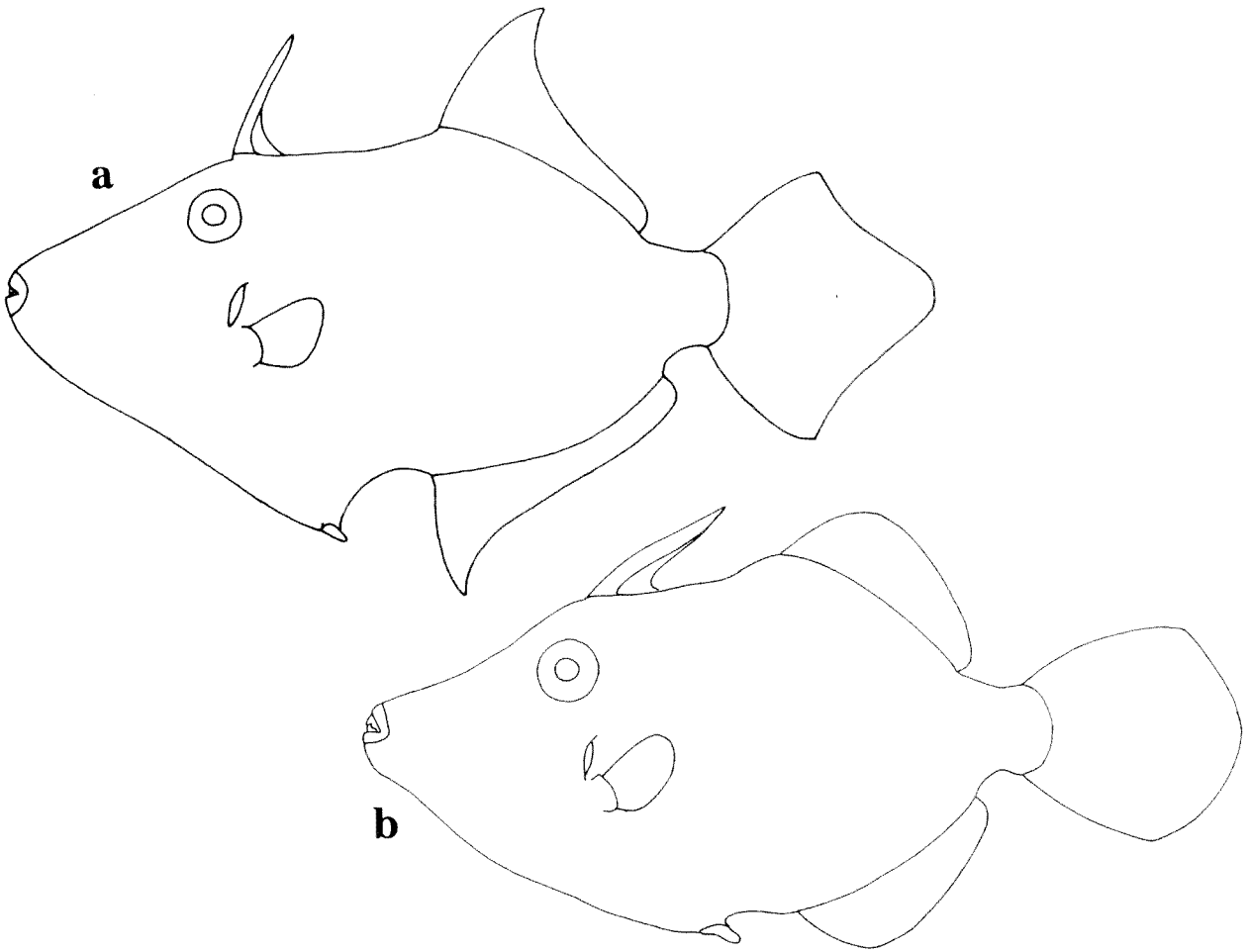


Figure 14 Variation in lateral profile of *Paramonacanthus frenatus*: a. RUSI 4079, 87 mm SL, male, Mozambique; b. RUSI 4624, 59 mm SL, female, Mozambique.

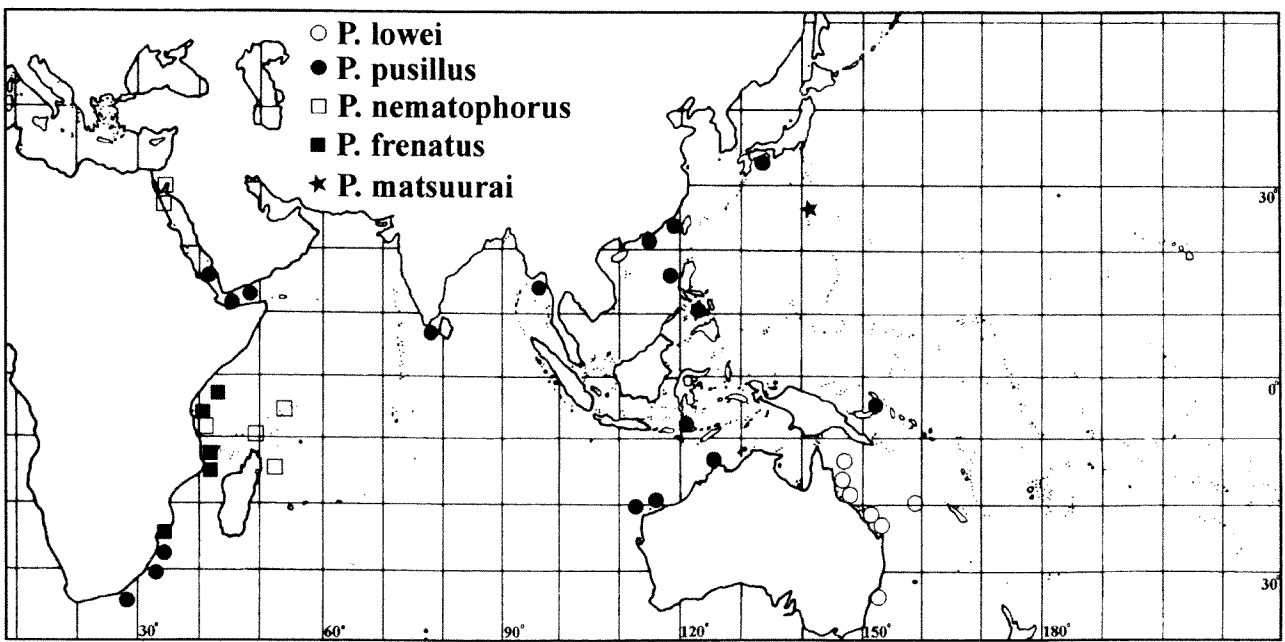


Figure 15 Distribution of *Paramonacanthus frenatus*, *P. lowei*, *P. matsuurai*, *P. nematophorus*, and *P. pusillus* (based on material examined during this study).

nematophorus (see Comments on Phylogeny at the rear of this paper); the differences between the two are discussed in the account of the latter species (see below). It inhabits weedy areas in sheltered bays where, according to Smith (1949), it is abundant.

The type descriptions of *Monacanthus frenatus* (Peters, 1855) and *M. bertolonii* (Bianconi, 1855) leave little doubt that they both represent the same species. Furthermore, both were published in the same year but there is little available evidence to indicate which one has priority. However, it seems reasonable to assume that the account of *M. frenatus* was published prior to that of *M. bertolonii* as, firstly, the date of May 10 was given as part of the running head for *M. frenatus*, which makes its date of publication reasonably early in the year, and secondly, Günther (1870), in a listing of synonyms of *Paramonacanthus oblongus*, cites the paper of Peters before that of Bianconi. Of course, if the publication date for *Monacanthus bertolonii* can be shown to have preceded May 10, 1855, then the correct name for this monacanthid will be *Paramonacanthus bertolonii*. It's also worth noting that Dean (1916) indicated that Bianconi published abstracts with diagnoses of new species from Mozambique in 1846 and 1853, but the evidence suggests that *Monacanthus bertolonii* was not included.

The description by Fraser-Brunner (1941) of *Paramonacanthus barnardi* was unfortunately based on individuals of two earlier described species, *P. nematophorus* and *P. frenatus* (see species account of *P. nematophorus*). This error was compounded by Smith (1949) who applied this name to the common *Paramonacanthus* of eastern Africa, shown above to be *P. frenatus*. Hutchins (1986b) also used *P. barnardi* for this species, but corrected this (Hutchins 1988) to *P. frenatus* after examining the types of *P. barnardi*.

BMNH 1868.5.30.121, one of nine non-type specimens mentioned in the original description of *Paramonacanthus barnardi* (see account of *P. nematophorus*) but here shown to represent *P. frenatus*, apparently was given the wrong registration number. According to the BMNH register, this number refers to an *Amphiprion*, whereas the previous number, BMNH 1868.5.30.120, is listed as '*Monacanthus*'. A. Gill (pers. comm.) considers that the latter number is the correct registration number for this specimen, a finding with which I concur.

Paramonacanthus barnardi has been reported for the Seychelles (Smith and Smith 1963; Landini and Sorbini 1988), but these records most likely refer to *P. nematophorus*, even though the illustration in the former work is of *P. frenatus*. Smith and Smith (1963) based their record on a paper by Regan (1908) who reported material (as *Monacanthus*

oblongus) from the nearby Amirante Islands, but the former used a photograph of an East African specimen to illustrate the species. Examination of Regan's specimens by the present author showed that they represent *P. nematophorus*. Furthermore, a specimen of this species was recently collected from the Seychelles by J.E. Randall (see the account of *P. nematophorus* below). Nevertheless, the presence of *P. frenatus* in the Seychelles cannot be ruled out entirely because Landini and Sorbini (1988) probably identified their material of "*P. barnardi*" from the above mentioned illustration, which does depict the true *P. frenatus*. Therefore, until more *Paramonacanthus* material becomes available from this area, it is best to include *P. frenatus* as possibly occurring there.

Material Examined (18 specimens, 31–87 mm SL).

Kenya: BMNH 1913.4.7.164 (paratype of *Paramonacanthus barnardi*), 87 mm SL, Mombassa.

Mozambique: ANSP 126524, 2 specimens, 40–71 mm SL, Delagoa Bay, 30 July 1954; RUSI 4079, 3 specimens, 54–87 mm SL, from Ibo fish depot, 2 October 1973; RUSI 4622–27, 5 specimens, 33–71 mm SL, Nacala, 26–27 August 1956; WAM P.30946–001, 64 mm SL (cleared and stained), same data as for RUSI 4079.

Zanzibar: BMNH 1868.5.30.72–76;120, 6 specimens, 31–78 mm SL (note: this registration number is the combination of six numbers, 1868.5.30.72 to 1868.5.30.76 inclusive and 1868.5.30.120, but as all the specimens were originally lumped together, it is not possible to now separate them with any confidence).

***Paramonacanthus japonicus* (Tilesius, 1810)**

Figures 2g, 3c, 6g–h, 16, 17, 29; Tables 2, 3

Balistes japonicus Tilesius, 1810: 211, pl. 13, figs. 1–6 (type locality, Japan).

Monacanthus oblongus Schlegel, 1850: 291, pl. 130, fig. 2 (type locality, Japan) (in part).

Monacanthus curtorhynchus (sic) Bleeker, 1855: 430 (Amboina = Ambon, Indonesia).

Monacanthus cryptodon Bleeker, 1855: 431 (Amboina = Ambon, Indonesia).

Monacanthus broekii Bleeker, 1858: 35 (Nagasaki, Japan).

Monacanthus trachyderma Bleeker, 1860: 70, pl. 1, fig. 4 (Nagasaki, Japan).

Diagnostic description

Soft dorsal rays 25–29; anal rays 25–29; pectoral rays 10–12 (mostly 11, see Table 2); vertebrae 7+12 = 19; body width 2.0–2.6 in head length; body depth 2.0–3.1 in SL; head length 2.7–3.2 in SL, dorsal profile of snout straight to convex in male,

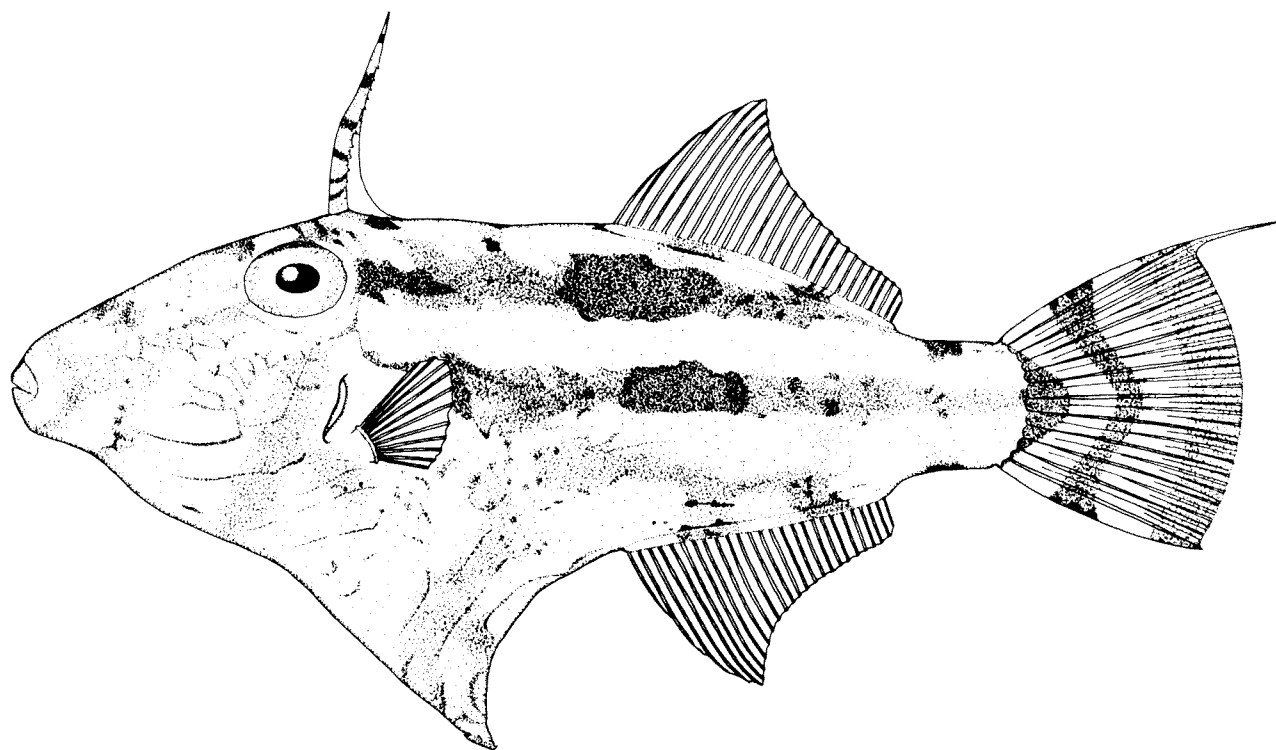


Figure 16 *Paramonacanthus japonicus*, QM I.16225, 71 mm SL, male, Queensland (drawn by S. Morrison).

slightly convex to concave in female and juvenile, without obvious hump over nostrils, snout length 3.7–4.1 in SL; eye diameter 2.7–3.7 in head length, 0.7–1.0 in interorbital width; gill opening a short slit, length 4.0–4.7 in head length, centred below posterior quarter of eye or slightly behind eye; gill rakers on first gill arch 15–17; first dorsal spine originating over posterior third of eye, circular in cross-section, length 1.3–1.7 in head length; spine with four rows of barbs in juvenile, anterior two series with small double to triple-branched barbs, upward-directed branch strongest, and one row of posterolaterally projecting barbs on each posterolateral face; with increasing SL, barbs becoming more numerous and relatively smaller (Figure 2g), anterior barbs approaching obsolescence, posterolateral barbs becoming more multibranched proximally, especially in male; soft dorsal and anal fins elevated anteriorly, particularly male (profile of outer margin of fin posterior to apex concave in male, straight to convex in female and juvenile [Figure 17]), longest dorsal ray at apex of fin 1.7–3.2 in head length, equal to or slightly longer than longest anal ray; length of soft dorsal base 2.8–3.3 in SL, about equal to anal fin base (bases of fin membranes perforated); origin of soft dorsal fin slightly anterior to origin of anal fin; interdorsal space up to 1.4 times greater than length of first dorsal spine in adults, about equal in specimens smaller than 55 mm SL; caudal fin mostly convex, although second uppermost ray—and, in Japanese specimens,

middle two rays—usually elongate and filamentous in male, fin length (not including filaments) 0.9–1.3 in head length; caudal peduncle moderate in length, 2.6–4.7 in head length and 1.1–1.8 in its depth, tapered in male but not in female and juvenile; pelvic fin rudiment relatively long and narrow (Figure 3c), length 1.5–2.0 in eye diameter, rudiment projecting rearwards of posterior margin of ventral flap; rudiment consisting of five encasing scales, arranged in similar pattern to that of *P. choirocephalus* (Figure 4a); midbody scales small, imbricate, circular in small juvenile, with one central, posteriorly curved, simple spinule, scale becoming more elliptical with increasing SL, usually developing 1–2 additional smaller spinules; adult male with 1–2 transverse rows of small spinules (Figure 6g), middle one somewhat bigger (spinules sometimes develop 1–2 smaller branches on anterior face); female scale spinules generally larger than in male (Figure 6h), sometimes multibranched at distal extremity, occasionally forming irregular longitudinal series on body; prominent cutaneous tentacles often on head and body (slightly smaller in male), each supported by enlarged spinule; skin smooth in male, slightly coarser in female; lateral line sensory system without supra-abdominal branch, although some scattered pores occasionally present in region.

Colour when fresh (based on colour transparencies of live and freshly collected specimens from Australia, Indonesia and Japan):

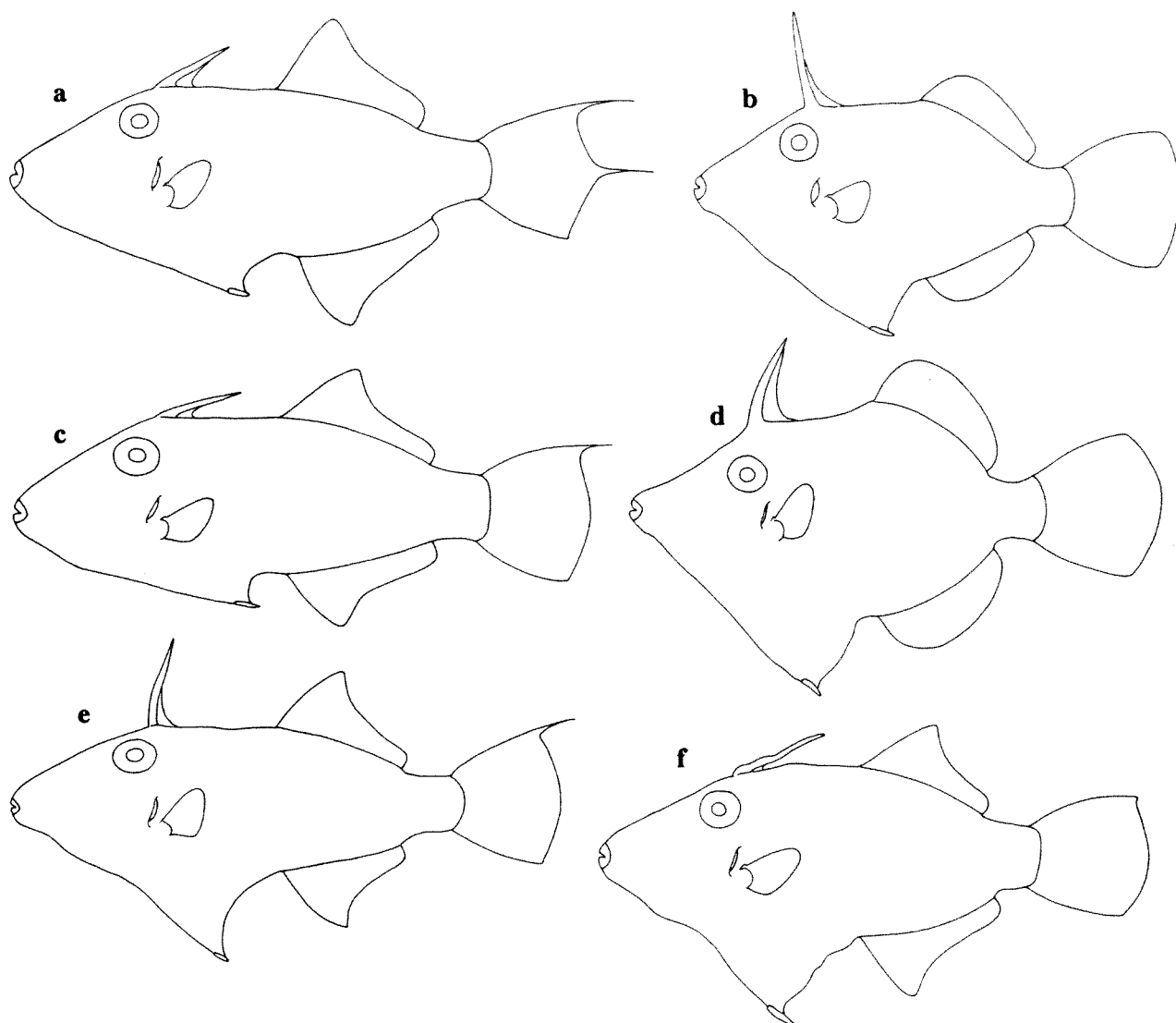


Figure 17 Variation in lateral profile of *Paramonacanthus japonicus*: a. HUMZ 52401, 88 mm SL, male, Japan; b. AMS I.20751-039, 56 mm SL, female, Australia; c. AMS IB.4457, 81 mm SL, male, New Caledonia; d. NSMT-P 22286, 63 mm SL, female, Japan; e. QM I.16225, 71 mm SL, male, Australia; f. WAM P.28198-002, 70 mm SL, male, Indonesia.

ground colour whitish, yellowish, or pale brownish, with dark brown to dusky blotches tending to form either two longitudinal stripes or several irregular-shaped cross bands on body, or a combination of both; both body stripes commence at rear border of eye, upper extending rearwards to upper caudal peduncle and lower extending ventrally to just above pectoral fin, then continuing along midside of body to middle of caudal peduncle (stripes sometimes break up to spots and blotches); principal body band (when present) extends from anterior third of soft dorsal base to anterior third of anal base (band mostly bifurcate on soft dorsal base), usually forming darker blotch at about eye level and another at junction of posterior abdominal branch and caudal branch of lateral line (band sometimes extends obliquely forward onto ventral flap); second body band

(when present) extends from posterior third of soft dorsal base to posterior third of anal base, usually not as well formed as anterior band; third band extends across caudal peduncle; most distinctive feature of body colour is single elongate dark brown blotch below anterior portion of soft dorsal base, forming part of both upper body stripe and principal body band; head with radiating dark bands, two across interorbital, one extending along snout to cross dorsal profile just behind upper lip, another extending forwards to region of mouth, usually forming two bars across lower jaw and throat, one from lower margin of eye extending anterior to gill slit on to breast; interdorsal space often with two dark cross bars; gill opening in Japanese specimens yellowish; dorsal spine pale, usually with four dark bands, and a dark brown blotch on integument; soft dorsal and anal fins

mostly hyaline with two dark brown basal blotches; caudal fin rays whitish to yellowish, with three darker cross bands, first a short bar across middle rays, second broader, narrowing towards middle and curving posteriorly, third broad, following contour of posterior margin of fin; one colour form completely devoid of stripes and bands except for faint upper stripe with prominent elongate dark blotch below anterior part of soft dorsal base.

Colour in alcohol: head and body pale brown with darker markings as described above, in particular two dark body stripes, upper with a prominent elongate darker blotch below anterior part of soft dorsal base.

Distribution

Paramonacanthus japonicus occurs throughout Indonesia, Philippines, southern Japan, and northern Australia across to New Caledonia and Fiji (Figure 29). A few specimens have been found in India, and two specimens has been collected in the Marshall Islands (see remarks below).

Remarks

Paramonacanthus japonicus is most similar to *P. tricuspis*, but differs in fin ray counts (*P. japonicus* usually has a pectoral ray count of 11 versus 12 in *P. tricuspis*) and colouration (the prominent twin longitudinal dark stripes on the upper body of the former are absent in the latter). The two species are apparently sympatric in the Bay of Bengal region (Figures 10, 29).

Japanese specimens of *Paramonacanthus japonicus* differ slightly from material examined from other localities throughout its range. Most notably, the second upper and middle two rays of the male's caudal fin are elongate and filamentous in the former, whereas only the second upper ray is elongate in the latter (Figure 17) [one published painting (Sainosuke 1958:64) also shows the second lowermost ray elongate, but this could not be verified]. Also the membranes of the gill opening are yellowish in Japanese specimens, but photographs examined during this study of live or freshly caught specimens from other localities do not show a similar colouration. Despite these inconsistencies, the two forms are difficult to separate, so are here recognised as representing only one species.

The Marshall Islands record is based on two small specimens (26 and 39 mm SL) from Rongelap and Bikini Atolls (reported as *Paramonacanthus cryptodon* by Woods in Schultz and collaborators, 1966). Both are females with well developed adult features, but possess most characters of *Paramonacanthus japonicus*, a species which at any size less than 40 mm SL would probably not be mature. This suggests that these specimens

represent either an allopatric pygmy form of *P. japonicus* (see also accounts of *P. nematophorus* and *P. pusillus*) or an undescribed species of small size. Another alternative is that they were transients from a breeding population to the west which grew at a slower rate during dispersal. However, until more material from the Marshall Islands becomes available, the problem cannot be resolved.

The nomenclatural history of *Paramonacanthus japonicus* is one of confusion. The species has been known under a variety of names, including *P. oblongus*, *P. curtorhynchus*, and *P. cryptodon*, and has also been confused with *P. choirocephalus*. Jordan and Fowler (1902) thought that it was a member of the genus *Stephanolepis*. However, Matsuura (1979) was the first to recognise the validity of *P. japonicus* when he used this name in his phylogenetic study of the balistoid fishes.

Balistes japonicus Tilesius, 1810 was described apparently on the basis of a single Japanese specimen, as only one set of counts was given. The description mentions that is common in the bays of Japan, and gives three localities, "Nangasaki", "Kibatsch" and "Megasaki" (none of these appears to be an accurate spelling). The type illustration shows a female typical of the species. Even though the fin ray counts presented are a little lower than expected (soft dorsal rays 24, anal rays 24, pectoral rays 10 and caudal rays 10, as against 25–29, 25–29, 10–12, and 12, respectively), there is no doubt that this species is the common *Paramonacanthus* of Japanese waters. The present whereabouts of the type is unknown.

The type description of *Monacanthus oblongus* Schlegel, 1850 was based on specimens of two species, *Paramonacanthus japonicus* and *Thamnaconus septentrionalis* (Günther, 1874) (the latter was undescribed at the time). Schlegel was unaware that the juvenile and adult stages of his new species were different taxa. His description presents details of both forms, but neither was indicated as being the type. However, the type illustration, which depicts the "juvenile" stage, is clearly a male individual of *P. japonicus*. Thus *Monacanthus oblongus* must be relegated to the synonymy of *P. japonicus*. According to Günther (1870), the British Museum purchased the skin of one of the types from Herr Frank in 1845 (BMNH 1845.6.22.309, photograph seen). It is a male specimen of *P. japonicus*.

Monacanthus curtorhynchus Bleeker, 1855 (inadvertently spelt *curtorhynchos* but corrected by Bleeker in subsequent publications) was described from two syntypes, 92–103 mm TL, collected at Ambon in Indonesia. The larger specimen was apparently sent by Bleeker to the British Museum in 1867 (BMNH 1867.11.28.147), whereas the smaller specimen is still in Leiden (RMNH 7292). Both were examined for this study, although only

a photograph of the former was available. Each specimen clearly represents the male form of *Paramonacanthus japonicus*.

The description of *Monacanthus cryptodon* Bleeker, 1855 was presented on the next page to that of *M. curtorhynchus* (see above). It was based on two specimens, 84–88 mm TL, also from Ambon. The largest is now at the Natural History Museum [BMNH 1867.11.28.147 (this specimen currently has the same registration number as the apparent syntype of *M. curtorhynchus*, but evidence suggests that the former was never registered, A. Gill, pers. comm.)], and the smallest is in Leiden (RMNH 7291). Both were examined during this investigation and were found to represent the female form of *Paramonacanthus japonicus*.

Monacanthus broekii was described by Bleeker (1858) on the basis of a single specimen, 103 mm TL, from Nagasaki in Japan. The holotype (RMNH 7300), which is a male specimen, was examined during this investigation; it is clearly an individual of *Paramonacanthus japonicus*.

Monacanthus trachyderma Bleeker, 1860 was described from a single specimen, 85 mm TL, from Nagasaki, Japan. The holotype (RMNH 7308), which is now in a poor condition, was examined and is without doubt a female individual of *Paramonacanthus japonicus*.

Material Examined (69 specimens: 26–91 mm SL).

Australia: AMS I.20751–039, 5 specimens, 45–60 mm SL, AMS I.20751–040, 2 specimens, 65–68 mm SL, AMS I.20752–014, 2 specimens, 57–59 mm SL, AMS I.20753–018, 14 specimens, 28–65 mm SL, AMS I.20754–024, 5 specimens, 37–51 mm SL, all from Lizard Island, Qld, 8 February 1979; QM I.11645, 2 specimens, 77–91 mm SL, North Palm Island, Qld, 15 August 1952; QM I.16225, 2 specimens, 67–71 mm SL, 8 February 1979, QM I.18217, 67 mm SL, 18 September 1979, both from Lizard Island, Qld; QM I.20515, 2 specimens (not measured), Cairns, Qld, 26 April 1982; WAM P.26197–011, 76 mm SL, Dampier Archipelago, WA, 17 May 1978; WAM P.26994–001, 43 mm SL, Timor Sea, WA, 16 July 1980; WAM P.27229–001, 69 mm SL, 10 March 1981, WAM P.28716–001, 4 specimens, 32–62 mm SL, all from North West Shelf, WA, 29 August 1983; WAM P.29755–001 (cleared and stained), 2 specimens, 49–62 mm SL, Lizard Island, Qld, 8 February 1979.

Fiji: BMNH 1936.10.21:30, 47 mm SL, no other data.

India: ANSP 100850, 29 mm SL, Bay of Bengal, 30 March 1963; ZSI (unreg.), 4 specimens, 26–70 mm SL, Madras, 24 May 1975.

Indonesia: BMNH 1867.11.28.147 (syntype of *Monacanthus cryptodon*, see remarks above), 68 mm SL, Ambon; RMNH 7291 (syntype of *Monacanthus cryptodon*), 64 mm SL, Ambon; RMNH 7292

(syntype of *Monacanthus curtorhynchus*), 74 mm SL, Ambon; USNM 266565, 3 specimens, 26–32 mm SL, Moluccas, 17 March 1974; USNM 278410, 34 mm SL, South China Sea, 14 June 1964; WAM P.28198–002, 70 mm SL, Bali, 1980; WAM P.30853–001, 68 mm SL, Bali.

Japan: HUMZ 52401, 88 mm SL, HUMZ 52408, 69 mm SL, both with no additional data; NSMT–P 21101, 90 mm SL, Kyushu, June 1975; NSMT–P 22286, 63 mm SL, Misaki, Miura Peninsula, 7 February 1978; RMNH 7300 (holotype of *Monacanthus broekii*), 63 mm SL, Nagasaki; RMNH 7308 (holotype of *Monacanthus trachyderma*), 63 mm SL, Nagasaki.

Marshall Islands: USNM 140641, 40 mm SL, Bikini Atoll, 26 April 1946; USNM 140674, 26 mm SL, Rongelap Atoll, 21 June 1946 (cleared and stained).

New Caledonia: AMS IB.4457–8, 2 specimens, 51–81 mm SL, Noumea; USNM 189934, 46 mm SL, Baide Pecheurs, Noumea, 28 January 1944.

Philippines: BPBM 26499, 41 mm SL, Negras, 6 August 1978; USNM 145421, 41 mm SL, Luzon, 11 March 1909.

Paramonacanthus lowei sp. nov.

Figures 2d, 2f, 15, 18, 19; Tables 2, 3, 5

Paramonacanthus oblongus (non Schlegel): Whitley, 1931: 331, pl. 27, fig. 1.

Laputa cingalensis (non Fraser-Brunner): Hutchins, 1977: 55.

Laputa species 1: Hutchins, 1988: 181.

Holotype

QM I.21319, 139 mm SL, male, Capricorn Group, Queensland, inter-reef trawl at 36–41 m, G. Lowe, 29 July 1980.

Paratypes

20 specimens, 13–187 mm SL (unless otherwise designated, all specimens from Queensland): AMS E.1424, 125 mm SL, trawled off Bustard Head at 20–30 m, 8 July 1910; AMS E.1963, 134 mm SL, 32 km off Bustard Head, trawled at 36 m, FIS Endeavour, 8 July 1910; AMS E.1964, 148 mm SL, same data as for previous entry; AMS E.2813, 2 specimens, 115–118 mm SL, southern Queensland, FIS Endeavour, no other data; AMS I.11127, 153 mm SL, Bustard Bay, FIS Endeavour, 8 July 1910; AMS I.22674–001, 2 specimens, 23–27 mm SL, Lizard Island, dip-netted, J. Leis, 2 February 1981; BPBM 33836, 2 specimens, 44–57 mm SL, Chesterfield Islands, Coral Sea, beam trawl at 74–78 m, R.V. "Alis", 22 August 1988; QM I.21837, 2 specimens, 68–77 mm SL, SSE of The Slashers Reefs (18°36'S, 147°16'E), trawled at 54 m, C. Jones, 16 April 1985; QM I.21838, 3 specimens, 95–103 mm

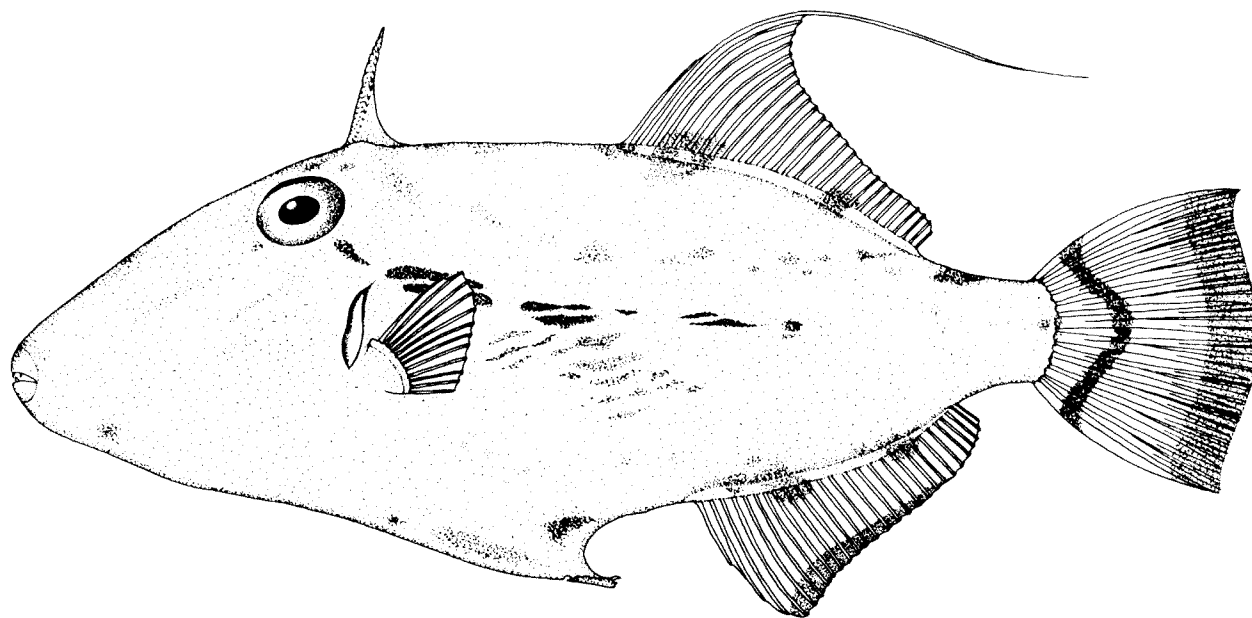


Figure 18 *Paramonacanthus lowei*, holotype, QM I.21319, 139 mm SL, male, Queensland (drawn by S. Morrison).

SL, same data as for previous entry; QM I.21839, 51 mm SL, NW of Rib Reef (18°27'S, 146°50'E), trawled at 50 m, C. Jones, 15 April 1985; QM I.21840, 75 mm SL, same data as for previous entry; QM I.21842, 34 mm SL, E of The Slashers Reefs (18°30'S, 147°16'E), trawled at 62 m, C. Jones, 8 May 1985; QM I.21843, 81 mm SL, same data as previous entry; WAM P.29775-001, 43 mm SL,

Manly Cove, Sydney Harbour, otter trawl at 5m, J. Paxton *et al.*, 22 April 1974.

Diagnosis

A species of *Paramonacanthus* with the following combination of characters: soft dorsal rays 27–30; anal rays 26–28; pectoral rays 11–13 (mostly 12, see Table 2); dorsal profile of snout moderately to

Table 5 Measurements of the holotype and selected paratypes of *Paramonacanthus lowei*.

	Holotype	Paratypes						
	QM I.21319	AMS I.11127	AMS E.2813	QM I.21838	QM I.21838	QM I.21840	BPBM 33836	QM I.21839
Standard length	139	153	118	103	95	75	57	51
Head length	48	55	44	35	34	27	22	19
Body depth	48	51	54	34	34	31	28	26
Body width	22	25	21	15	15	12	9.4	7.6
Snout length	39	43	36	27	26	21	16	14
Eye diameter	11	11	11	9.9	9.4	8.9	8.2	4.9
Interorbital width	10	11	11	7.8	7.8	7.8	6.8	5.7
Gill slit length	11	11	8.8	7.8	7.4	6.0	4.9	3.7
Snout to dorsal spine	52	56	47	39	31	31	25	21
Lower jaw to pelvic fin rudiment	80	91	78	60	57	50	40	36
Dorsal spine length	18	24	19	*	18	18	*	13
Interdorsal space	31	39	33	25	22	21	14	14
Longest dorsal ray	28	32	20	22	18	14	8.2	7.0
Longest anal ray	25	27	15	19	18	12	7.6	7.2
Longest pectoral ray	15	15	15	11	12	9.8	8.0	6.4
Length of caudal fin	30	34	29	29	23	21	18	15
Length of dorsal fin base	45	52	41	35	32	25	19	19
Length of anal fin base	39	45	34	30	28	21	15	17
Length of caudal peduncle	11	14	8.8	9.2	7.2	6.4	5.0	4.0
Depth of caudal peduncle	9.0	16	13	10	10	9.1	6.2	5.9
Length of pelvic fin rudiment	5.0	5.7	*	3.8	4.0	3.8	3.2	3.0

* Measurement not taken due to damage

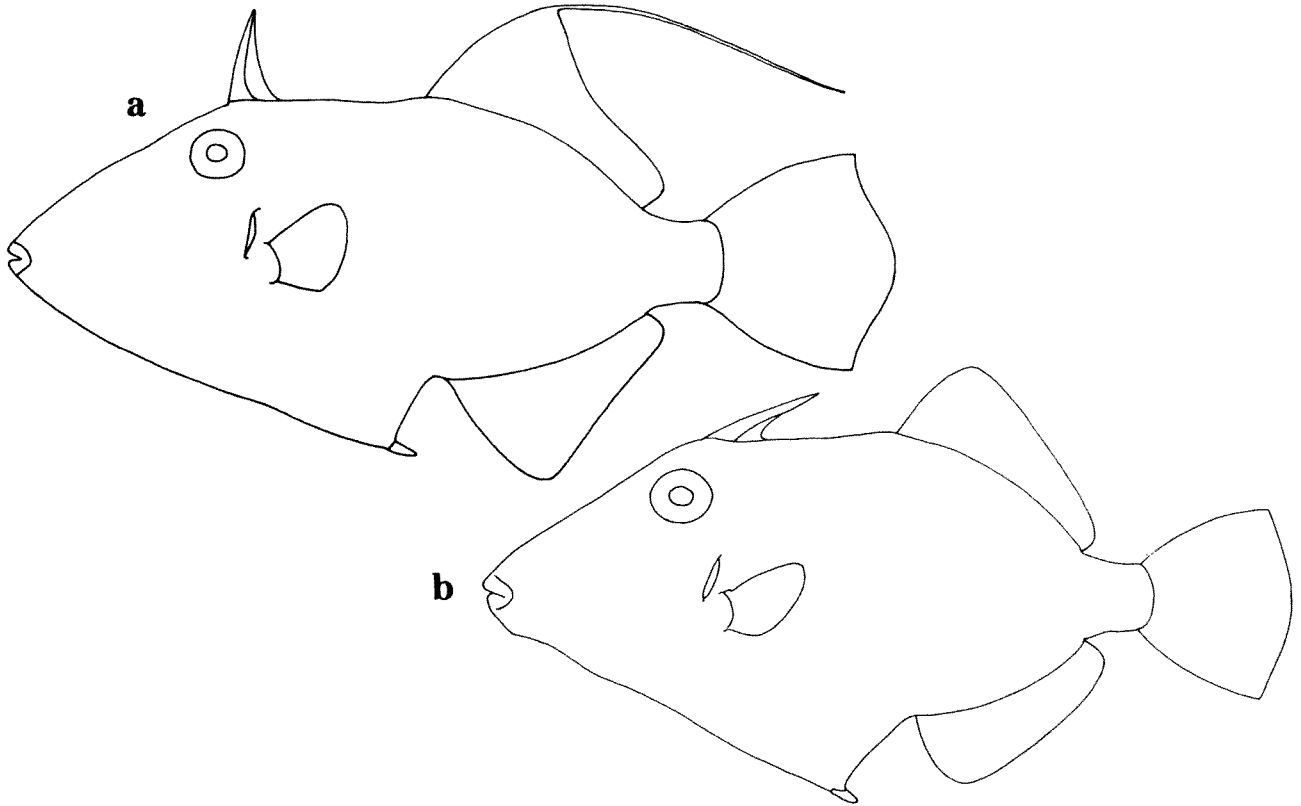


Figure 19 Variation in lateral profile of *Paramonacanthus loweri*. a. AMS E.1424, 125 mm SL, male, Queensland; b. AMS E.2813, 115 mm SL, female, Queensland.

slightly convex in male, usually straight in female, without prominent hump just before nostrils; soft dorsal fin of male with second ray elongate and filamentous; no elongate rays in caudal fin; narrow whitish lines often along side of body; dark stripe on outer margin of anal fin in male, width equal to or greater than width of pupil.

Description

Measurements of the holotype and selected paratypes are presented in Table 5. Counts and proportions in parentheses represent the ranges for the paratypes where different from those of the holotype.

Soft dorsal rays 28 (27–30); anal rays 27 (26–28, usually one fewer than soft dorsal count); pectoral rays 12 (11–13); vertebrae 7+12=19 (from radiographs and cleared and stained material); branchiostegals 1+4=5.

Body compressed and rather elongate, noticeably deeper in female and juvenile, width 2.2 (2.0–2.5) in head length and depth 2.9 (2.0–3.0) in SL; head rather long, length 2.9 (2.7–2.9) in SL; dorsal profile of snout when viewed laterally slightly convex, often straighter in female to slightly concave in small juvenile, length 3.6 (3.3–3.8) in SL; eye diameter 4.4 (3.0–5.0) in head length, 0.9 (0.8–1.2) in interorbital width; gill opening a short slit, length 4.4 (4.3–5.6) in head length, positioned in

advance of pectoral fin base, centred below posterior quarter of eye, or slightly behind; pelvic flap generally small in size.

Mouth small, terminal, lips not obviously fleshy; dentition consisting of three outer and two inner teeth on each side of upper jaw (exposed portion of first inner tooth small but obvious, with rounded extremity, second inner tooth mostly covered by outer teeth); three teeth on each side of lower jaw, posterior tooth small; anterior pair of teeth in both jaws with pointed extremities; gill rakers on first gill arch 25 (from 95 mm SL paratype).

First dorsal spine originating over posterior quarter of eye; spine rather short, length 2.7 (1.4–2.7) in head length, tapering from relatively wide base to acute tip; spine prominently depressed in cross-section in adult, more circular in juvenile, armed in latter with four rows of downward-directed barbs, comprising two adjacent series of moderate-sized barbs on anterior face, most with additional small upward-directed branch, merging with upward-directed spinules proximally, and one row of posterolaterally projecting barbs on each lateral face (Figure 2d); with increasing SL, barbs becoming more numerous, anterior series remaining prominently directed downwards, at least on distal half, eventually becoming worn down and indistinguishable from spinules, posterolateral series projecting more laterally, or

slightly anteriorly (Figure 2f); shallow groove in interdorsal space for receiving spine when folded rearwards; second dorsal spine small, hidden in skin at rear base of first spine; soft dorsal and anal fins elevated anteriorly, more prominently in male (profile of outer margin of fin posterior to apex concave in male, straight to convex in female and juvenile [Figure 19]), longest dorsal ray at apex of fin 1.7 (1.6–2.7) in head length, slightly longer than longest anal ray; second dorsal ray filamentous and very elongate in male, extending rearwards past origin of caudal fin; length of soft dorsal base 3.1 (2.7–3.2) in SL, slightly longer than anal base (bases of fin membranes perforated); origin of soft dorsal well in advance of anal fin origin; interdorsal space much greater than length of first dorsal spine in adult (up to twice as long), only slightly longer in juvenile, profile between fins flat in male, slightly elevated in female; base of pectoral fin below posterior quarter of eye to well behind eye; caudal fin rather short, length 1.6 (1.2–1.7) in head length, with convex to somewhat arrowhead-shaped posterior margin (several upper and lower rays slightly produced in male); caudal peduncle tapered, length 0.8 (0.8–1.5) in its depth; pelvic fin rudiment relatively small in size, length 2.2 (1.6–2.6) in eye diameter, consisting of five encasing scales with obvious barbs and spinules, scales arranged as in *P. pusillus* (Figure 4b), posterior scale movably articulated with rear end of pelvis; pelvic fin rudiment projecting rearwards of posterior margin of ventral flap.

Midbody scales small, imbricate, circular in small juvenile with one small central spinule, scale becoming more elliptical in shape with increasing SL, developing 1–4 transverse rows of spinules; each spinule erect, distal extremity slightly curved posteriorly, larger spinules usually with multibranching extremities; no bristles or spines on caudal peduncle; scales on forehead and breast enlarged with slightly more robust spinules than on midbody; skin velvety to the touch; no supra-abdominal branch in lateral line system.

Colour of holotype in alcohol: head and body pale greyish brown with indications of dark brown markings, particularly a curved stripe from rear margin of eye extending towards middle of caudal peduncle and a blotch below anterior fin rays of soft dorsal fin; numerous whitish, somewhat wavy longitudinal lines on lower half of body, extending from pectoral region to above middle of anal fin, those in region of dark midbody stripe more obvious; soft dorsal and anal fins pale brown, each with two dark basal blotches; margin of anal fin posterior to apex with prominent dusky band extending to about eighth last ray, band relatively wide, about equal to or wider than pupil width; caudal fin pale brown, with two curved darker cross-bands, first rather narrow, widening towards

upper and lower margins, second paler and broader, following contour of posterior border of fin; indication of three darker rings on first dorsal spine.

Paratypes similar to holotype, except some specimens more whitish on ventral half of head and body (but not including anterior part of throat and lower jaw); others possess second dark stripe running parallel to but above midbody stripe; white lines and dark stripe on anal fin of female tend to be less distinct than in the male; juvenile pale brown with indications of 4–5 darker lines on side of body, middle one curving from rear of eye towards middle of caudal peduncle; a prominent dark blotch below anterior part of soft dorsal fin and two curved cross-bands on caudal fin.

Colour when fresh (based on colour transparency of freshly collected specimen): head and body purplish brown, ventral half somewhat paler; scattered darker markings tending to form two dark stripes along side of body as described above; numerous wavy whitish lines along midside of body, those located in midbody stripe more obvious, curving downwards in region of gill slit towards breast, breaking into spots; fin rays yellowish brown, membranes hyaline, with darker markings as described above.

Distribution

Paramonacanthus lowei is found only on the east coast of Australia, from Lizard Island in north Queensland to Sydney Harbour in New South Wales (Figure 15). In addition, two specimens have been collected at the Chesterfield Reefs, about 900 km off the eastern Australian coastline. A transparency of a specimen from off Jervis Bay in southern New South Wales was seen, but the fish was not available for examination.

Remarks

Paramonacanthus lowei has mostly been taken by bottom trawl at depths between 20 and 78 m. Juveniles have been found in floating *Sargassum* weed.

Paramonacanthus lowei is similar in general morphology to *P. pusillus*, differing mainly in colouration (latter lacks narrow white lines on the body, and has a narrower dusky stripe along the margin of the anal fin), head shape (*P. lowei* lacks the prominent ridge on the dorsal surface of the snout which produces the characteristic hump just anterior to the eyes in the male of *P. pusillus*) and fin structure (male of *P. lowei* has an elongate ray in the soft dorsal fin but lacks elongate rays in the caudal fin, whereas the male of *pusillus* has the reverse condition). The differences between *P. lowei* and *P. matsuurai* sp. nov. (described herein) are described in the account of the latter species.

Whitley (1931) was the first to describe and

illustrate this species (based on AMS E.1424, now a paratype of *P. lowei*), using the name *Paramonacanthus oblongus* (Schlegel) (= *P. japonicus*, see Table 3). Hutchins (1977) reidentified it as *Laputa cingalensis* Fraser-Brunner (= *Paramonacanthus pusillus*) in a listing of Australian monacanthids. However, after a comparison of all material referable to the invalid genus *Laputa* (see generic account above), Hutchins (1988) concluded that the eastern Australian form represented an undescribed species closely related to *P. pusillus*.

This species is named in honour of Mr Graham Lowe who not only collected the holotype, but also provided additional monacanthid material and information for this study.

Other material examined

Unless otherwise designated, all from Qld: AMS I.20735-003, 38 specimens, 12-23 mm SL, One Tree Island, 3 December 1979; AMS I.17874-018, 2 specimens, 14-16 mm SL, Sydney, NSW, 16 April 1973; QM I.17994, 94 mm SL, off Port Douglas, 9 September 1979; QM I.19658, 80 mm SL, off Hinchinbrook Island, 16 October 1978; QM I.19680 (not measured), off Innisfail, 18 October 1989; QM I.19986 (not measured), off Point Cartwright; QM I.23513 (not measured), N of Cape Bowling Green, 19 February 1985.

Paramonacanthus matsuurai sp. nov.

Figures 15, 20; Tables 2, 3, 6

Paramonacanthus japonicus (non Tilesius): Matsuura and Tachikawa, 1994: 138, fig. 3.

Holotype

NSMT-P 35285, 106 mm SL, male, washed up on Miyanoama Beach, Chichi-jima, Ogasawara Islands, 5 February 1992.

Paratypes

NSMT-P 35094, 67 mm SL, female?, 5 December 1991, rest of data as for holotype; NSMT-P 35148, 64 mm SL, male, washed up on west coast of Tatsumi Bay, Chichi-jima, Ogasawara Islands, 4 January 1992.

Diagnosis

A species of *Paramonacanthus* with the following combination of characters: soft dorsal rays 29; anal rays 28-29; pectoral rays 12-13; dorsal profile of snout straight to slightly concave, without prominent hump just anterior to nostrils; soft dorsal fin of male with second ray slightly elongate and filamentous; caudal fin long, length equal to head length; broad dark stripe on outer margin of anal fin in male, width greater than width of pupil.

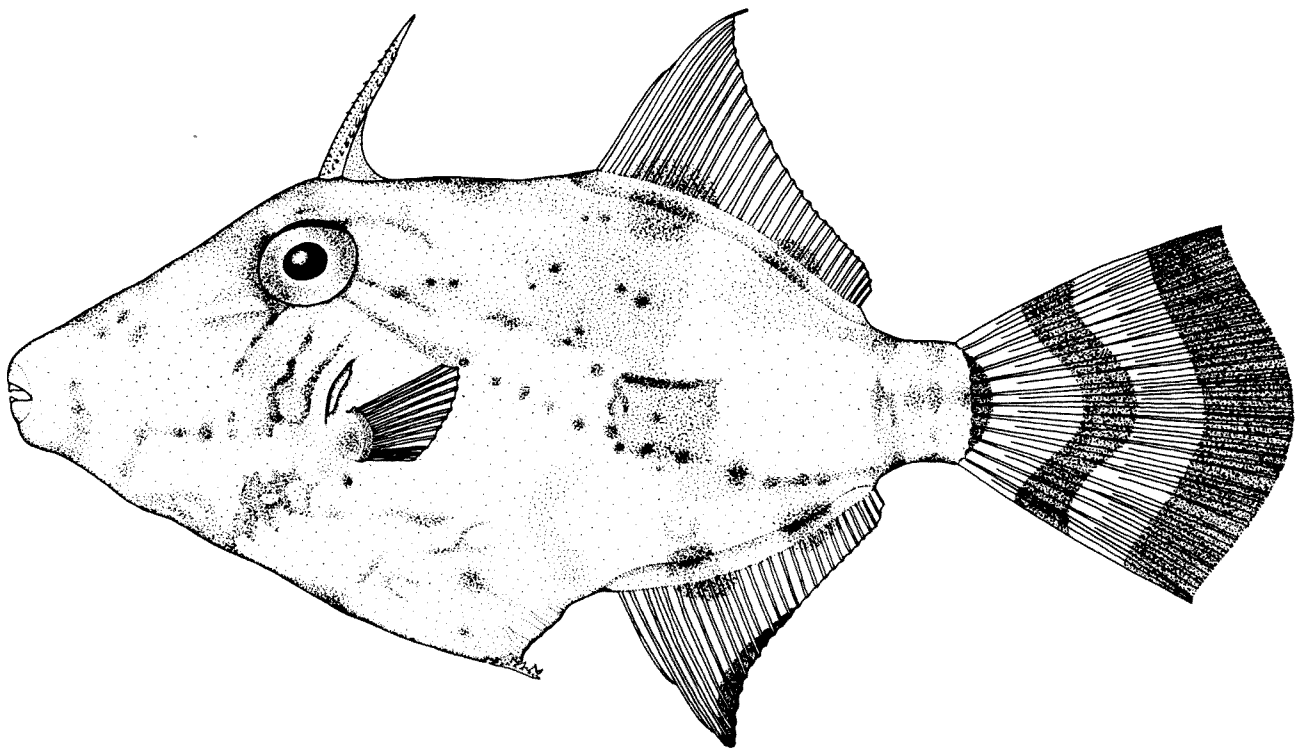


Figure 20 *Paramonacanthus matsuurai*, holotype, NSMT-P 35285, 106 mm SL, male, Ogasawara Islands (drawn by S. Morrison).

Description

Measurements of the holotype and paratypes are presented in Table 6. Counts and proportions in parentheses represent the ranges for the paratypes where different from those of the holotype.

Soft dorsal rays 29; anal rays 28 (29); pectoral rays 12 (12–13); vertebrae 7+12=19 (from radiographs); branchiostegals 1+4=5.

Body compressed and rather deep, width 2.3 (2.4–2.6) in head length and depth 2.2 (1.9) in SL; head rather long, length 2.7 (2.6–2.7) in SL; dorsal profile of snout when viewed laterally straight to slightly concave, length 3.7 (3.5–3.6) in SL; eye moderately large, diameter 3.5 (3.0–3.1) in head length, 0.9 (0.8) in interorbital width; gill opening a short slit, length 4.4 (4.9–5.4) in head length, positioned in advance of pectoral fin base, centred below posterior quarter of eye; pelvic flap generally small in size.

Mouth small, terminal, lips not obviously fleshy; dentition consisting of three outer and two inner teeth on each side of upper jaw (exposed portion of first inner tooth small but obvious, with rounded extremity, second inner tooth mostly covered by outer teeth); three teeth on each side of lower jaw, posterior tooth small; anterior pair of teeth in both jaws with pointed extremities; gill rakers on first gill arch 24 (from 67 mm SL paratype).

First dorsal spine originating over posterior third of eye; spine moderately long, length 1.7 (1.4–1.5) in head length, tapering from relatively wide base to acute tip; spine prominently depressed in cross-section, particularly proximally, becoming more

circular near distal tip (smaller paratype with more circular cross-section for whole length), armed with four rows of downward-directed barbs, comprising two adjacent series of moderately sized barbs on anterior face, those proximally with additional small upward-directed branches, merging with upward-directed spinules, and one row of laterally projecting barbs along each lateral edge; shallow groove in interdorsal space for partly receiving spine when folded rearwards; second dorsal spine small, hidden in skin at rear base of first spine; soft dorsal and anal fins elevated anteriorly, more prominently in male [profile of outer margin of fin posterior to apex concave in male (Figure 20), straight to convex in female], longest dorsal ray at apex of fin (not including filament) 1.6 (1.8–2.4) in head length, slightly longer than longest anal ray; second dorsal ray elongate and filamentous in male (damaged in holotype); length of soft dorsal base 2.9 in SL, relatively longer than anal base (3.2 in SL)(bases of fin membranes perforated); origin of soft dorsal well in advance of anal fin origin; interdorsal space slightly greater than length of first dorsal spine (equal to length of first dorsal spine in both paratypes), profile between fins elevated slightly towards soft dorsal; base of pectoral fin below a point slightly posterior to eye; caudal fin rather long, length 1.0 in head length, with convex to somewhat arrowhead-shaped posterior margin (central rays noticeably produced in holotype); caudal peduncle slightly tapered, length 4.4 (3.9–4.3) in head length, and 1.6 (1.3–1.5) in its depth;

Table 6 Measurements of the holotype and paratypes of *Paramonacanthus matsuurai*.

	Holotype NSMT P35285	Paratype NSMT P35094	Paratype NSMT P35148
Standard length	106	67	64
Head length	39	26	24
Body depth	48	35	33
Body width	17	10	10
Snout length	29	19	18
Eye diameter	11	8.4	8.0
Interorbital width	9.6	7.0	6.2
Gill slit length	8.9	4.8	4.9
Snout to dorsal spine	40	28	26
Lower jaw to pelvic fin rudiment	68	45	43
Dorsal spine length	23	17	17
Interdorsal space	27	17	17
Longest dorsal ray	25	11	13
Longest anal ray	21	9.5	11
Longest pectoral ray	14	9.1	8.6
Length of caudal fin	39	26	20
Length of dorsal fin base	36	23	22
Length of anal fin base	33	21	20
Length of caudal peduncle	8.9	6.1	6.2
Depth of caudal peduncle	14	9.2	8.2
Length of pelvic fin rudiment	4.8	3.0	3.3

pelvic fin rudiment relatively small in size, length 2.3 (2.4–2.8) in eye diameter, consisting of five encasing scales with obvious barbs and spinules, scales arranged as in *P. pusillus* (Figure 4b), posterior scale moveably articulated with rear end of pelvis; pelvic fin rudiment projecting rearwards of posterior margin of ventral flap.

Anterior midbody scales small, imbricate, elliptical in shape, with 1–2 transverse rows of simple spinules; each spinule erect, distal extremity slightly curved posteriorly; no bristles or spines on caudal peduncle; scales on head larger, more rounded in shape, with numerous rows of spinules, those on forehead and ventral surface of pelvis with more robust spinules; skin velvety to slightly coarse; no visible cutaneous tentacles; no supra-abdominal branch in lateral line system.

Colour of holotype in alcohol: head and body greyish brown with indications of dark brown markings, particularly a square-shaped blotch on middle of side of body above anal fin origin (upper and lower margins of square darker than remainder); large indistinct blotch extending from base of anterior third of soft dorsal fin ventrally to just above square-shaped blotch and anteriorly to about middle of interdorsal space; two faint narrow elongate blotches extend posteriorly from rear margin of eye toward upper and lower sides respectively of dark square-shaped blotch on midside; caudal peduncle with small blotch on upper and lower surfaces anteriorly; indications of scattered dark brown spots on body; head with faint dark brown band extending vertically from lower margin of eye to ventral surface; soft dorsal and anal fins hyaline, with two dark basal blotches; margin of anal fin posterior to apex with indications of broad dusky stripe extending rearwards (much of integument damaged); caudal fin hyaline, with two curved dusky cross-bands, first widening towards upper and lower margins, second slightly wider, following contour of posterior border of fin; integument of dorsal spine mostly dusky. Colour of paratypes similar to holotype, but blotch on midside of body not obviously square-shaped, and no dark stripe on margin of anal fin (see Matsuura and Tachikawa, 1994: fig. 3)

Colour when fresh: not known.

Distribution

Paramonacanthus matsuurai is known only from the type locality, Ogasawara Islands, to the south of Japan.

Remarks

Paramonacanthus matsuurai is similar in general morphology to both *P. lowei* sp. nov. (described herein) and *P. pusillus*, particularly in respect to the structure of the dorsal spine (spine mostly elliptical

in cross-section, anterior and lateral series of barbs downward directed, latter projecting laterally from side of spine) and colour of the anal fin (dusky stripe along outer margin posterior to apex of fin). Of the two it is more similar to *P. lowei*, differing mainly in the shape of its snout (dorsal profile of the male, when viewed laterally, is straight to slightly concave versus straight to convex in *P. lowei*), depth of the body (1.9–2.2 versus 2.2–3.0 in SL for similarly sized specimens of *P. lowei*) and colouration (lacks the distinctive narrow white lines on the body of *P. lowei*). In addition, the caudal fin is noticeably longer (1.0 in head length versus 1.2–1.7 for *P. lowei*). *Paramonacanthus matsuurai* is distinguishable from *P. pusillus* by its snout shape (the male lacks the prominent convex dorsal profile and distinctive hump before the eye of *P. pusillus*) and fin shapes (the male of *P. matsuurai* lacks elongate fin rays in the upper and lower portions of the caudal fin, a feature characterising *P. pusillus*).

Little is known about this species as the three type specimens were all found washed ashore on the same island in the Ogasawara Islands. Like its two close relatives, *Paramonacanthus pusillus* and *P. lowei*, this species probably inhabits waters of moderate depth, preferring areas with soft bottoms.

The smallest paratype appears to have been on the beach the longest before it was collected. Both eyes are missing, and the muscle tissue has deteriorated considerably due to desiccation.

This species is named in honour of Dr Keiichi Matsuura who has helped the author on many occasions with information and specimens of monacanthids.

Paramonacanthus nematophorus (Günther, 1870)

Figures 2a–b, 3f, 5d, 15, 21, 22; Tables 2, 3

Monacanthus nematophorus Günther, 1870: 241 (type locality, ?China or Borneo, probably an error).

Monacanthus cirrosus Kossmann and Räuber, 1877: 30, pl. 2, fig. 10 (type locality, Red Sea).

Paramonacanthus barnardi Fraser-Brunner, 1941: 193, fig. (type locality, Zanzibar)(in part).

Diagnostic description

Soft dorsal rays 24–27; anal rays 24–28; pectoral rays 10–12 (mostly 11, see Table 2); vertebrae 6+13 = 19 (30 specimens); body width 2.0–2.7 in head length; body depth 2.0–3.0 in SL; head length 2.6–3.2 in SL; dorsal profile of snout straight to slightly convex in male, without prominent angular hump above nostrils, straight to concave in female and juvenile, snout length 3.4–4.4 in SL; eye diameter 2.8–4.3 in head length, 0.7–1.0 in interorbital width; gill opening a short slit, length 4.7–6.7 in head

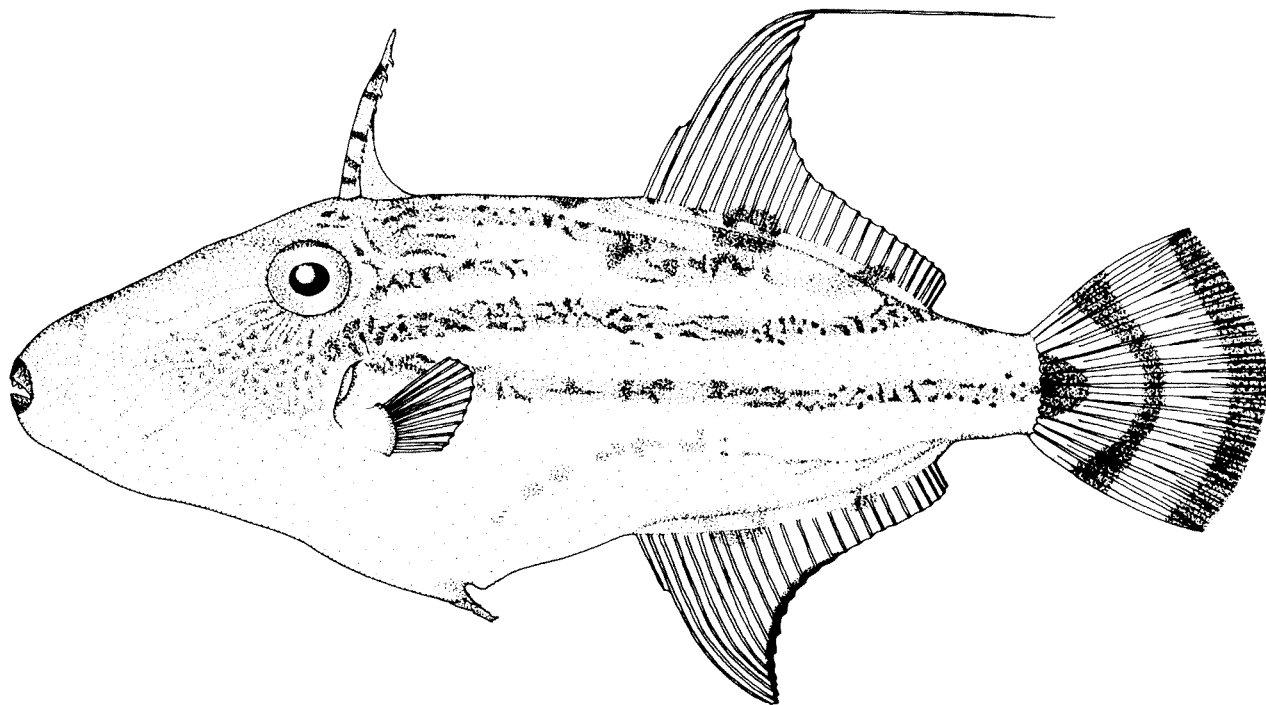


Figure 21 *Paramonacanthus nematophorus*, BPBM 13862, 64 mm SL, male, Gulf of Aqaba (drawn by S. Morrison).

length, centred below posterior quarter of eye or slightly behind eye; gill rakers on first gill arch 17 (2 specimens); first dorsal spine originating over posterior third of eye, length 1.3–2.3 in head length, circular to slightly depressed in cross-section; spine with four rows of barbs in juvenile, barbs in anterior two series with upward- and downward-directed branches, former usually stronger, and two rows of larger, posterolaterally projecting barbs along each posterolateral edge; with increasing SL, barbs becoming more numerous, relatively smaller, anterior series approaching obsolescence, posterolateral barbs projecting more laterally (Figures 2a–b); soft dorsal and anal fins prominently elevated anteriorly in male, only slightly elevated in female (profile of outer margin of fin posterior to apex concave in male, convex in female and juvenile [Figure 22]); second dorsal ray elongate and filamentous in male, often extending rearwards past origin of caudal fin; longest dorsal ray at apex of fin (not including filamentous ray) 1.3–3.5 in head length, slightly longer than longest anal ray; length of soft dorsal base 2.8–3.4 in SL, equal to or slightly shorter than base of anal fin (bases of fin membranes not perforated); origin of soft dorsal fin slightly anterior to or slightly posterior to anal fin origin; interdorsal space up to 1.5 times greater than length of first dorsal spine in adult, about equal in specimens smaller than 42 mm SL; caudal fin without elongate rays, posterior margin convex, length 1.0–1.9 in head length; caudal peduncle somewhat tapered, length 0.9–1.6 in its depth and 3.1–5.7 in head length; pelvic fin

rudiment projecting rearwards of posterior margin of pelvic flap; rudiment relatively small in size (Figure 3f), length 1.5–2.4 in eye diameter, consisting of five encasing scales (Figure 5d), arranged as in *P. pusillus* (Figure 4b); midbody scales small, imbricate, circular in small individual (25 mm SL) with 1–3 slender simple spinules; scales becoming more elliptical with increasing SL, developing 2–4 transverse rows of simple spinules (no sexual dimorphism); numerous prominent cutaneous tentacles on head and body of female, each supported by enlarged scale with prominent central spinule (tentacles smaller and less obvious in male); tentacles also on first dorsal spine and pelvic fin rudiment of both sexes; skin velvety to the touch.

Colour when fresh (based on colour transparencies of live fish underwater and freshly dead specimens from the Red Sea, as well as a freshly dead specimen from the Seychelles)(see also Remarks below): ground colour whitish, pale yellowish, to pale brown, upper half of head and body usually more olive green to brown; head and body with slightly darker close-packed spots, dashes and small blotches, tending to form 4–6 pale to dark olive green or brown stripes along side of body, first from basal area of spinous dorsal fin to anterior portion of soft dorsal base, second from posterior margin of eye to below anterior half of soft dorsal base, third extending rearwards from lower margin of eye to rear base of soft dorsal fin, fourth curving down above pectoral fin, continuing to base of caudal fin, fifth curving up from ventral

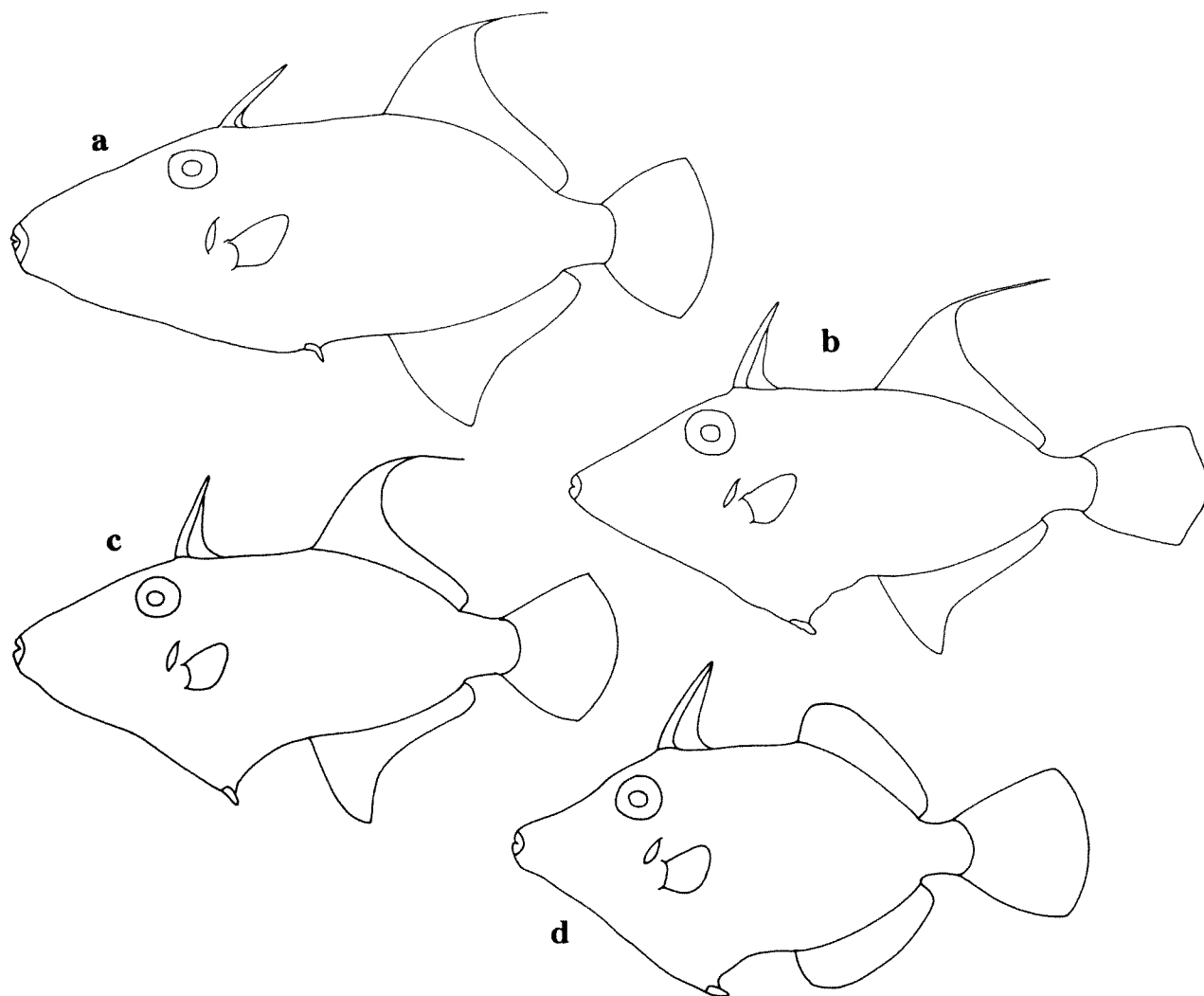


Figure 22 Variation in lateral profile of *Paramonacanthus nematophorus*. a. BMNH 1864.11.15.86, 85 mm SL, male, Zanzibar; b. BPBM 35483, 62 mm SL, male, Seychelles; c. BPBM 19818, 56 mm SL, male, Red Sea; d. BPBM 19818, 45 mm SL, female, Red Sea.

flap to rear base of anal fin, sixth running below and parallel to fifth (first and second often joined as one, sixth not always distinct); triangular area bounded by anterior portions of fourth and fifth stripes sometimes noticeably paler than surrounding area; large olive green to brown blotch usually below anterior half of soft dorsal base, often merging with first three stripes; head with several dark stripes from eye to ventral surface of head; 2-3 narrow dark lines occasionally extending from eye to throat in male, with another 2-3 across cheek to below pectoral fin; interorbital sometimes with two darker cross-bands; small white and/or brown spots scattered on head and body; lips of male dusky; cutaneous tenacule on head and body white; spinous dorsal whitish with narrow dusky irregular bands; soft dorsal and anal fins hyaline to pale brownish orange, each usually with two dark basal blotches; elongate ray of soft dorsal fin and first 2-3 rays of anal fin yellowish in male, hyaline in female; male with narrow black

stripe on outer margin of anal fin, extending from apex posteriorly to about rear third of fin, absent in female; caudal fin hyaline to pale brownish, with dark basal blotch on middle rays, followed by two curved dark cross-bands; caudal fin of some individuals also criss-crossed by numerous narrow pale lines.

Colour in alcohol: head and body pale brown to dark brown with indications of darker markings as described above, except small dark blotch present on dorsal surface of caudal peduncle; coloration occasionally an overall darker brown with scattered pale blotches, particularly a large triangular-shaped one behind pectoral fin, several across ventral surface of head, and pale stripe down dorsal surface of snout.

Distribution

Paramonacanthus nematophorus is known to occur in the Red Sea, at Zanzibar off the African east coast, and at the Seychelles and surrounding

islands to as far south as Cargados Carajos (Figure 15) (also see below).

Remarks

Paramonacanthus nematophorus is closely related to *P. frenatus* from eastern Africa (see comments on phylogeny at the rear of this paper). The two differ mainly in the form of the body and fins (*P. nematophorus* is a more slender species [body depth 2.0–3.0 in SL versus 1.9–2.4 respectively], and the male has an elongate second soft dorsal ray which *P. frenatus* lacks), in the number of precaudal versus caudal vertebrae (6+13 in *P. nematophorus*, normally 7+12 in *P. frenatus*), as well as in colouration (the body spotting of *P. nematophorus* is continued anteriorly on to the cheek, but only as far as the gill slit in *P. frenatus*).

Clark and Gohar (1953) examined several hundred specimens of *Paramonacanthus nematophorus* (as *P. oblongus*) that were taken from *Halophila* beds in the Red Sea. Differences between their account and the description presented above are worthy of note. Clark and Gohar give a pectoral fin ray count of 9–12, noting that 11 was the most common count. Red Sea specimens examined for the present study had pectoral ray counts of 10–12, with most possessing 11 rays, whereas specimens from other areas were more likely to have 12 than 11 rays. Clark and Gohar's colour description, which was based on aquarium maintained individuals, states that the colour "varies from pale green to dark brown with irregular dark mottling sometimes suggestive of broken vertical bands...". None of the specimens examined by the present author showed any broken vertical bands, but as this variation occurs in other members of the genus, it must also be included for this species.

Since the original description of *Monacanthus nematophorus* (Günther, 1870), it has largely been ignored by workers (Bleeker [1873] listed it as occurring in China, Regan [1908] recorded it for the Maldives [misidentification = *P. tricuspis*], Seychelles [misidentification = new taxon, see Hutchins, 1988], Amirante, and Cargados Carajos, but gave no additional details, and Fraser-Brunner [1941] listed it as a member of *Paramonacanthus*). The species was described from a single 44 mm SL specimen (BMNH 1848.3.16.163) collected by Captain Sir Edward Belcher, a naval surveyor and collector of biological material, questionably from either China or Borneo. However, the type compares very well with specimens of a species of *Paramonacanthus* from the Red Sea and East Africa. In particular, the rare vertebral count of 6+13 is common to both (this character is only found consistently in two additional species, both of which belong to the Atlantic Ocean genus *Leprogaster*). Both Winterbottom (1976: 178) and

Springer and Williams (1994: 148) reported on the problem of Belcher specimens supposedly from China. Winterbottom (1976) showed that Belcher probably collected in South Africa either on his way to South-East Asia (1843) or during the return voyage (1846), and this material may have become mixed in with his other collections. Therefore, it is here considered that the type locality given in the original description of *M. nematophorus* was probably erroneous; it is more likely to have been somewhere along the east coast of Africa.

The type description and figure of *Monacanthus cirrosus* (Kossmann and Rauber, 1877) were based on a 50 mm female individual from the Red Sea, and leave little doubt that this species is synonymous with *Paramonacanthus nematophorus* (the authors mentioned the similarity with the latter species in this description).

Fraser-Brunner's (1941) description of *Paramonacanthus barnardi* was based on individuals representing two species which he mistakenly believed were the male and female forms of the same species. The specimen selected as holotype – Fraser-Brunner's "male" – was originally reported as *Monacanthus oblongus* by Günther (1870). It was one of 10 specimens collected in the 1860's by Playfair from Zanzibar (see also below). The "female" paratype was collected about 1913 by Cunninghame from Mombassa, just to the north of Zanzibar. Examination of this material revealed the holotype to be a male specimen of *Paramonacanthus nematophorus*, although somewhat larger at 85 mm SL than any of the numerous specimens available from the Red Sea (largest 71 mm SL); the paratype is a male of *P. frenatus*. Playfair's Zanzibar collection also contained two additional specimens (76 and 61 mm SL) of *P. nematophorus*, the remaining six specimens being referable to *P. frenatus* (see below). Smith (1949) subsequently applied *P. barnardi* to the common east African member of the genus, but this move was incorrect as an earlier name was already available, namely *P. frenatus* (see Remarks in the account of the latter species).

The holotype of *Paramonacanthus barnardi* was never actually labelled as a type by Fraser-Brunner (Wheeler, pers. comm.). It remained lumped together at BMNH with the other nine specimens referred to by Fraser-Brunner (1941: 194). The numbers on the original labels for these specimens were BMNH 1864.11.15.13;86, BMNH 1868.2.29.41–42, and BMNH 1868.5.30.72–76;121. The type has now been removed and is registered as BMNH 1864.11.15.86 (the other half of the original number, namely BMNH 1864.11.15.13, was earlier made into a skin – Wheeler, pers. comm.). The two additional non-type specimens of *P. nematophorus* from Zanzibar (referred to in the above paragraph) are probably BMNH 1868.2.29.41–42, and BMNH

1868.5.30.72–76;121 comprises six specimens of *P. frenatus* (see species account of latter species for more details).

Two forms of *Paramonacanthus nematophorus* were identified during the present study, one from the Red Sea and one from the region between Zanzibar and the Seychelles. Besides a slight difference in pectoral fin ray counts (see above), the main discrepancy involves their maximum lengths. The Red Sea form reaches a known maximum size of only 71 mm SL— including the measurements of several hundred specimens examined by Clark and Gohar (1953)—whereas the other form reaches 85 mm SL (four of 12 specimens examined measured greater than 71 mm SL). Red Sea specimens as small as 40 mm SL possess adult features, while similarly sized specimens from the Zanzibar/Seychelles region still have numerous juvenile characteristics. Notwithstanding these discrepancies, there is little to separate the two forms; they are therefore recognised as representing the same species. Perhaps the Red Sea population represents a pygmy form of the species, a phenomenon that has been reported (Hutchins, 1988) in other monacanthid genera, as well as in other species in the present paper (see *P. japonicus* and *P. pusillus*).

Material examined (53 specimens, 34–85 mm SL).

Amirantes: BMNH 1908.3.23.288–9, 2 specimens, 41–64 mm SL, no other data.

Cargados Carajos: BMNH 1908.3.23:283–7, 5 specimens, 37–71 mm SL, no other data; BMNH 1908.3.23:290, 81 mm SL, no other data.

Red Sea: BMNH 1848.3.16.163 (holotype of *Monacanthus nematophorus*), 44 mm SL, ?China or Borneo, but probably East Africa (see Remarks above); BPBM 18132, 26 mm SL, Gulf of Aqaba, 12 September 1974; BPBM 13862, 64 mm SL, Gulf of Aqaba, June 1972; BPBM 13863, 3 specimens, 47–51 mm SL, Gulf of Aqaba, 14 June 1972; BPBM 19818, 21 specimens, 29–58 mm SL, Gulf of Aqaba, 29 October 1975; USNM 166904, 11 specimens, 41–50 mm SL, Al Ghardaqa, 1951; WAM P.30945–001, 2 specimens, 35–57 mm SL (cleared and stained), same data as for BPBM 19818.

Seychelles: BPBM 35483, 62 mm SL, Bird Island, 20 December 1992.

Zanzibar: BMNH 1864.11.15.86 (holotype of *Paramonacanthus barnardi*), 85 mm SL; BMNH 1868.2.29.41–2, 2 specimens, 61–76 mm SL.

***Paramonacanthus otisensis* Whitley, 1931**

Figures 5h, 6a, 7a, 10, 23, 24; Tables 2, 3

Paramonacanthus oblongus otisensis Whitley, 1931: 332, pl. 27, fig. 2 (type locality, Queensland).

Arotrolepis (Scurrilichthys) barbarae Fraser-Brunner, 1941: 187, fig. (type locality, Australia).

Diagnostic description

Soft dorsal rays 28–31 ; anal rays 29–33 ; pectoral rays 12–13 (Table 2); vertebrae 7+12=19; body width 2.0–2.5 in head length; body depth 1.9–3.1 in SL; head length 2.8–3.3 in SL; dorsal profile of snout convex in male, normally without prominent hump above nostrils, although small one occasionally present (Figure 24b), slightly convex

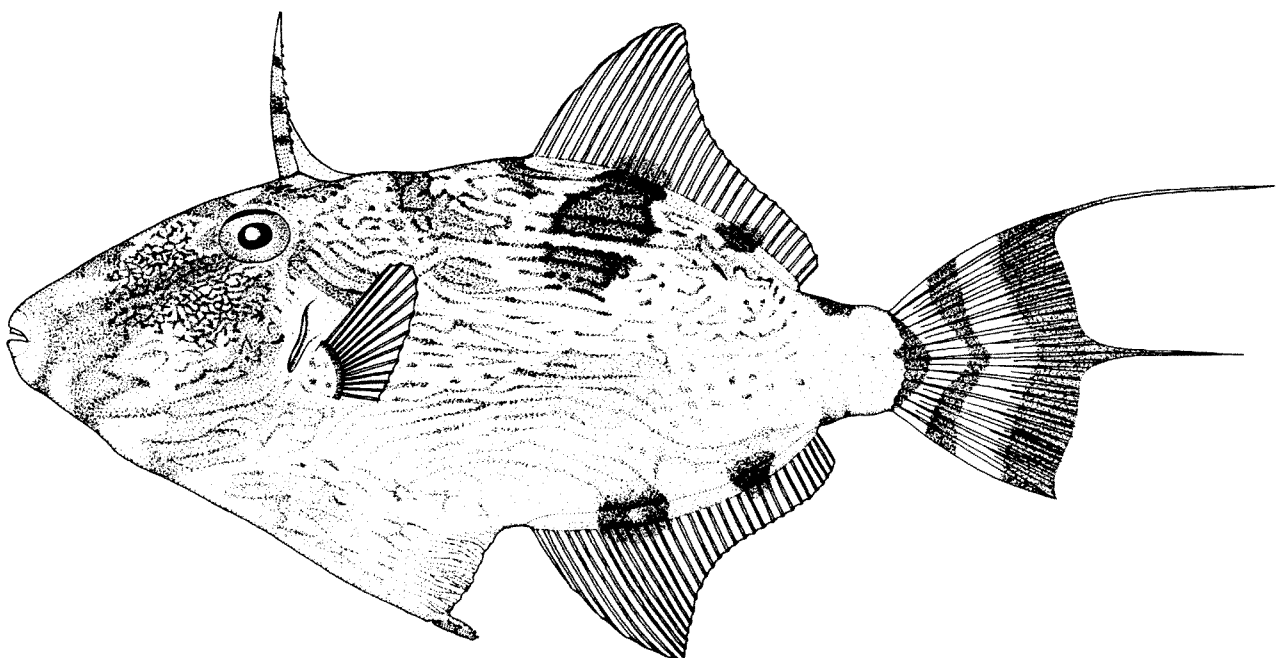


Figure 23 *Paramonacanthus otisensis*, AMS I.17760–004, 93 mm SL, male, New South Wales (drawn by S. Morrison).

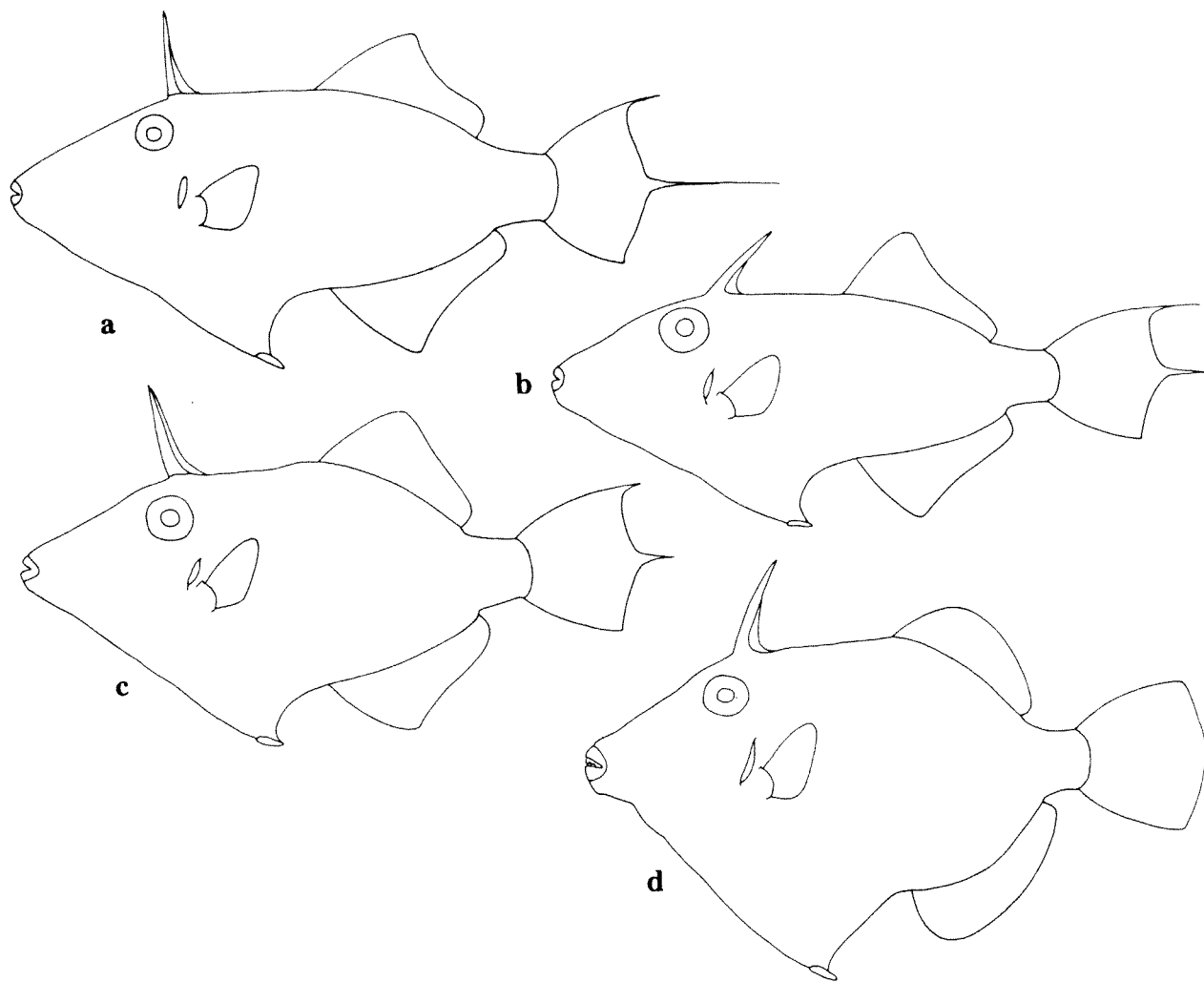


Figure 24 Variation in lateral profile of *Paramonacanthus otisensis*: **a.** AMS I.17322-005, 107 mm SL, male, New South Wales; **b.** QM I.13061, 79 mm SL, male, Queensland; **c.** QM I.13061, 81 mm SL, male, Queensland; **d.** AMS I.20532-002, 95 mm SL, female, Queensland.

to straight in female and juvenile, without obvious hump, snout length 3.6–4.9 in SL; eye diameter 2.7–4.5 in head length, 0.8–1.1 in interorbital width; gill opening a short slit, length 3.7–5.5 in head length, centred below posterior quarter of eye or slightly behind eye; gill rakers on first gill arch 16–20; first dorsal spine originating over posterior half of eye, length 1.2–2.1 in head length, circular in cross-section; spine with four rows of barbs in juvenile, anterior two series with small double to triple-branched barbs, upward-directed branch strongest, and one row of posterolaterally projecting barbs on each posterolateral face; with increasing SL, barbs becoming more numerous and relatively smaller, anterior barbs approaching obsolescence, posterolateral barbs becoming multibranched proximally, especially in male; soft dorsal and anal fins elevated anteriorly, particularly in male (profile of outer margin of fin posterior to apex concave in male, straight to convex in female and juvenile [Figure 24]), longest dorsal ray at apex of

fin 1.6–2.8 in head length, equal to or slightly longer than longest anal ray; length of soft dorsal base 2.8–3.2 in SL, about equal to anal fin base (bases of fin membranes perforated); origin of soft dorsal fin slightly anterior to origin of anal fin; interdorsal space up to 1.7 times length of first dorsal spine in adults, about equal in specimens smaller than 60 mm SL; caudal fin mostly convex in shape, although second uppermost and several middle rays elongate and filamentous in male (Figure 24), fin length (not including filaments) 0.9–1.6 in head length; caudal peduncle moderate in length, 2.8–4.3 in head length and 1.0–1.7 in its depth, more tapered in male than in female and juvenile; pelvic fin rudiment relatively long and narrow (Figure 5h), length 1.3–1.9 in eye diameter, rudiment projecting prominently rearwards of posterior margin of ventral flap; rudiment consisting of five encasing scales arranged as in *P. choirocephalus* (Figure 4a); midbody scales small, imbricate, circular in small juvenile (30 mm SL)

with one central spinule, distal extremity multibranched, scales becoming more elliptical with increasing SL, usually developing additional simple spinules surrounding central one (Figure 6a); some females with one large central multibranched spinule per scale, forming roughly longitudinal rows of spinules along side of body; male generally with smaller and more closely packed spinules than female, producing a smoother feel; small cutaneous tentacles occasionally on head and body, supported by slightly enlarged spinules; lateral line sensory system with supra-abdominal branch usually well developed (Figure 7a).

Colour when fresh (based on live and freshly collected specimens): ground colour pale brown, yellowish brown, or dusky brown, with dark brown blotches on side of body occasionally tending to form two oblique cross bars on body as described for *P. choirocephalus*; prominent blotch usually below anterior portion of soft dorsal base, split into two halves by pale bar (sometimes only margins of blotch dusky as in Figure 23); indications of two dark blotches behind eye; narrow alternating pale and dark longitudinal lines often on body, those on head in more reticulate pattern (Figure 23) (one colour form with pale wavy lines completely covering head and body); head with two broad oblique stripes from eye to ventral surface, first to rear of mouth, usually spitting in two on throat, second to breast; dorsal and ventral profiles often with darkish blotches as described for *P. choirocephalus*; spinous dorsal pale brown with indications of 2–3 darker cross bands; all fin rays pale yellowish brown to hyaline, soft dorsal and anal fins usually with two dusky basal blotches; caudal fin with dusky basal blotch, followed by two broad curved dusky cross bars, anterior one narrower and darker than posterior one; filamentous caudal rays whitish.

Colour in alcohol: head and body pale brown with darker markings as described above; most prominent feature is usually bisected blotch below anterior half of soft dorsal base.

Distribution

Paramonacanthus otisensis is known only from eastern Australia, from Cape York in Queensland south to Sydney in New South Wales (Figure 10) (two apparently extralimital specimens have been collected from the Wellesly Islands in the Gulf of Carpentaria).

Remarks

The similarity between *Paramonacanthus otisensis* and *P. choirocephalus* has been discussed in the account of the latter species.

Paramonacanthus otisensis was originally described (Whitley, 1931) as a new subspecies of

Paramonacanthus oblongus (= *P. japonicus*). However, Whitley was unaware that his comparative material of *P. oblongus* was incorrectly identified and represented another undescribed species (described herein as *P. lowei*). Hutchins (1988) showed that *P. otisensis* was in fact more closely related to *P. choirocephalus* than to *P. japonicus*, and recognised it as a full species. Furthermore, the misidentified "*P. oblongus*" was shown to be a close relative of *P. pusillus* (see account of *P. lowei*).

The description of *Arotrolepis (Scurrilichthys) barbarae* (Fraser-brunner, 1941) was based on three BMNH specimens collected from Australia (at least one was thought to have come from Queensland). Hutchins (1977) examined one of these, a paratype AMS IB.5387, which had been transferred to AMS by Fraser-brunner in 1961. Although in a poor condition, it agreed reasonably well with the description of *Paramonacanthus sulcatus* (Hollard, 1854), particularly with regard to scalation and fin ray counts, and therefore was assigned to the synonymy of this species. On this basis, *P. sulcatus* was included in the fish fauna of Australia. However, for the present study, the holotype and second paratype of *A. (S.) barbarae* were examined (BMNH 1851.2.20.15). This showed that the fin ray counts for the holotype (D. 29, A. 31) were just outside the range for *P. sulcatus* (see Table 2). The AMS paratype, on the other hand, has slightly higher counts (D. 31, A. 32) which do fall within the range for *P. sulcatus*. Furthermore the counts for all three types also fall within the range for *P. otisensis* (Table 2). Like *P. sulcatus*, the three types of *A. (S.) barbarae* possess longitudinal series of scale spinules along the side of the body. However, in the former species, each spinule is either simple (Figure 6f), or with a small branch on its anterior face, whereas in the latter species each midbody scale carries a single coarsely branched spinule which do not completely form longitudinal series. The latter condition best fits one of the varieties of scale spinules found in *Paramonacanthus otisensis* (see Diagnostic description above). Therefore, on the basis of these differences in fin ray counts and scale structures, it is clear that the type series of *Arotrolepis (S.) barbarae* better represent individuals of *P. otisensis* than *P. sulcatus*. Thus the latter species has yet to be recorded from Australia.

Paramonacanthus otisensis is mostly taken by bottom trawl at depths between 10 and 36 m. It is considered a trash fish in the shallow water prawn fishery of Queensland. This species grows to a maximum size of 110 mm SL.

Material Examined (81 specimens, 32–109 mm SL).

New South Wales: AMS E.1412 (holotype of *P. oblongus otisensis*), 102 mm SL, Qld (no other data); AMS I.17217–001, 103 mm SL, Sydney Harbour, 18 June 1973; AMS I.17322–005, 3 specimens, 87–106

mm SL, Manly Cove, 18 September 1973; AMS I.17760-004, 9 specimens, 54-93 mm SL, Manly Cove, Sydney Harbour, 22 April 1974; AMS I.19170-001, 87 mm SL, Rose Bay, Sydney Harbour, 6 July 1976; ; AMS I.23883.001, 5 specimens, 67-107 mm SL, Sydney Harbour, 12 September 1963. AMS (uncat.), 2 specimens, 78-106 mm SL, 16 January 1976.

Queensland: AMS E.1925 to E.1935, 22 specimens, 63-92 mm SL, NW of Bustard Head, 9 July 1910; AMS IB.5387, 62 mm SL, Queensland? (paratype of *Arotrolepis [Scurrilichthys] barbarae*); AMS I.20532-002, 2 specimens, 95-109 mm SL, no other data; BMNH 1851.2.20:15, 2 specimens, 66-70 mm SL (holotype [largest specimen] and paratype of *Arotrolepis [Scurrilichthys] barbarae*), collection data refers only to "Australia"; QM I.11608 (not measured), North Palm Island, 15 August 1952; QM I.11069, 2 specimens (not measured), Wellesley Islands, Gulf of Carpentaria, 23 November 1965; QM I.11646, 2 specimens, 69-73 mm SL, North Palm Island; QM I.12952, 21 specimens, 33-78 mm SL, Moreton Bay, 5 February 1975; QM I.13061, 8 specimens, 39-90 mm SL, Moreton Bay, 22 April 1975; QM I.15601 (not measured), E. side of Cape York, 20 February 1979; QM I.15984, 4 specimens (not measured), Princess Charlotte Bay, 23 February 1979; QM I.23512 (not measured), N of Cape Bowling Green, 19 February 1963; QM (unreg.), 11 specimens, 32-77 mm SL, Moreton Bay, 5 February 1975; WAM P.29766-001, 3 specimens (cleared and stained), 32-80 mm SL, Moreton Bay, 5 February 1975.

***Paramonacanthus pusillus* (Rüppell, 1828)**

Figures 2e, 3d, 4b, 5e, 5g, 7b, 15, 25, 26;
Tables 2, 3, 7

Monacanthus pusillus Rüppell, 1828: 34 [type locality, harbour at Massaua (= Mits'iwa), Eritrea, Red Sea].

Monacanthus (Stephanolepis) nipponensis Kamohara, 1939: 624, fig. 1 (type locality, off Mimase, near Kochi, Japan).

Laputa cingalensis Fraser-Brunner, 1941: 191, fig. [type locality, Ceylon (= Sri Lanka)].

Laputa umgazi Smith, 1949: 402, fig. 1138 (type locality, mouth of Umgazi River, South Africa).

Rudarius virgulatus Nalbant and Mayer, 1975: 240, figs 10-13 (type locality, Kunduchi, near Mbundya Island, Tanzania).

Paramonacanthus falcatus Kotthaus, 1979: 31, fig. 481 (type locality, Red Sea).

Paramonacanthus spec.: Kotthaus, 1979: 32, fig. 482.

Diagnostic description

Soft dorsal rays 25-30; anal rays 24-29; pectoral rays 11-13 (Tables 2-3); vertebrae 7+12 = 19; body width 2.0-2.8 in head length; body depth 1.9-3.0 in SL; head length 2.6-3.0 in SL; dorsal profile of snout (in lateral view) convex in male, normally with prominent hump just in front of nostrils, slightly convex to straight in female and juvenile, without obvious hump, snout length 3.5-4.1 in SL; eye diameter 2.8-4.8 in head length, 0.8-1.1 in

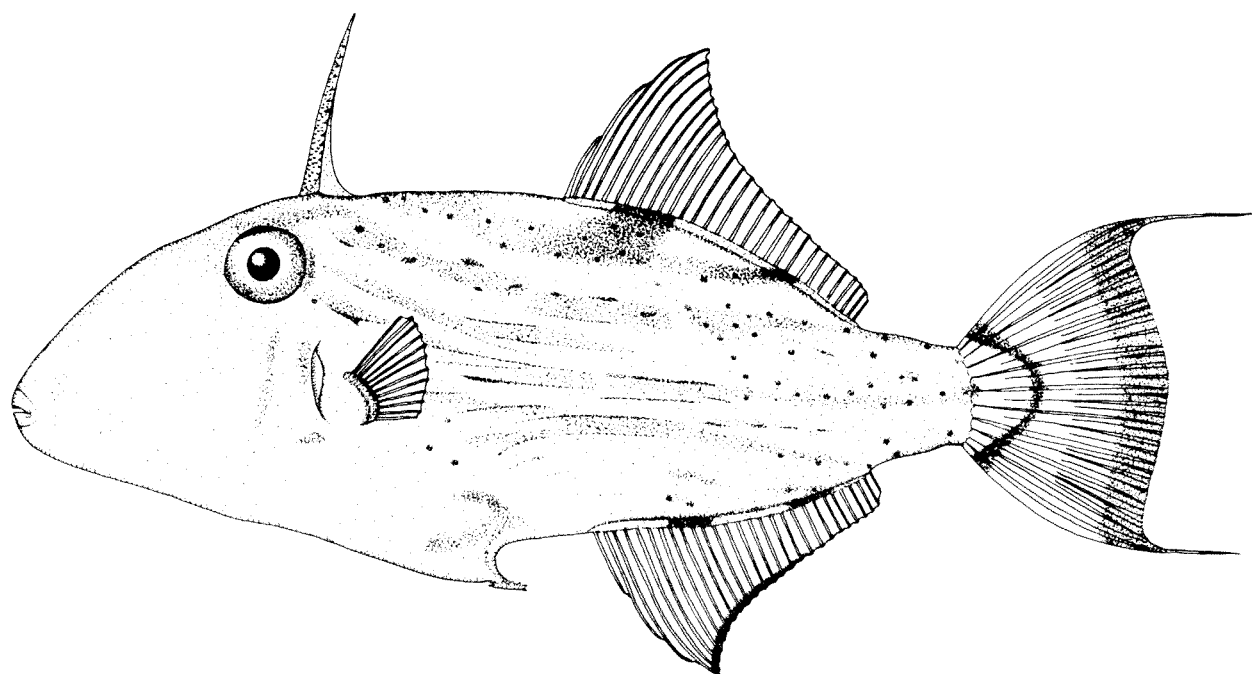


Figure 25 *Paramonacanthus pusillus*, USNM 273252, 111 mm SL, male, Philippines (drawn by S. Morrison).

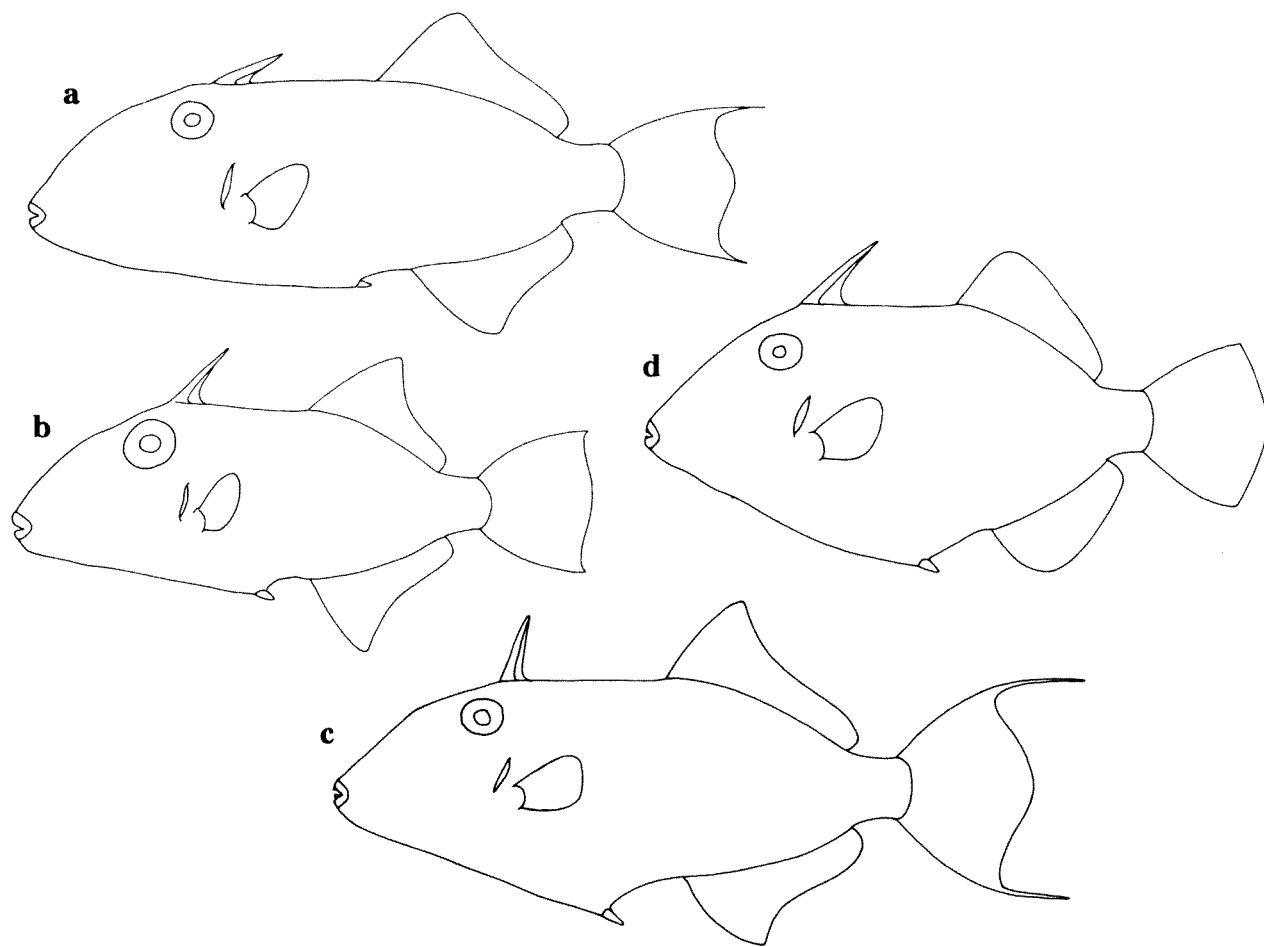


Figure 26 Variation in lateral profile of *Paramonacanthus pusillus*. a. USNM 192536, 146 mm SL, male, Taiwan; b. USNM 278412, 66 mm SL, male, Red Sea; c. CA4033, 96 mm SL, male, Western Australia; d. USNM 192537, 112 mm SL, female, Taiwan.

interorbital width; gill opening a short slit, length 3.8–6.0 in head length, centred below posterior quarter of eye or slightly behind eye; gill rakers on first gill arch 20–24; first dorsal spine originating over posterior half of eye, or slightly behind eye, length 1.4–2.7 in head length, depressed in cross-section, armed with four rows of downward-directed barbs (Figure 2e) (similar to condition described for *P. lowei*); soft dorsal and anal fins elevated anteriorly, particularly in male (profile of outer margin of fin posterior to apex concave in male, straight to convex in female and juvenile [Figure 26]), longest dorsal ray at apex of fin 1.5–3.3 in head length, equal to or slightly longer than longest anal ray; length of soft dorsal base 2.7–3.3 in SL, somewhat longer than length of anal base (2.9–3.6 in SL) (bases of fin membranes perforated); origin of dorsal fin well in advance of origin of anal fin; interdorsal space up to twice as long as length of first dorsal spine in adults, only slightly longer in specimens shorter than 60 mm SL; caudal fin mostly convex, although several upper and lower caudal rays elongate and filamentous in male (Figure 25), fin length (not including filaments) 1.0–

1.7 in head length; caudal peduncle tapered, length 3.3–4.8 in head length and 1.0–1.6 in its depth; pelvic fin rudiment relatively small in size (Figures 3d), length 1.8–2.8 in eye diameter, rudiment projecting rearwards of posterior margin of ventral flap; rudiment with five encasing scales (Figures 5e, 5g), scales arranged as in Figure 4b (small space between scales of segment 2 occasionally present), posteriormost scale movable articulated with rear end of pelvis; midbody scales small, imbricate, circular in small juvenile with one small central spinule, scale becoming more elliptical in shape with increasing SL, developing 1–4 transverse rows of spinules; each spinule erect, distal extremity slightly curved posteriorly, larger spinules usually with multibranching extremities; no bristles or spines on caudal peduncle; small cutaneous tentacles occasionally on body; skin velvety; lateral line sensory system without prominent supra-abdominal branch (some scattered pores may be present) (Figure 7b).

Colour when fresh (based on colour transparencies of live and freshly collected specimens from north-western Australia, Indonesia

and Japan, see Figure 25): head and body pale greyish brown to whitish, with numerous yellowish to dark brown markings tending to form 3-4 irregular curved stripes on body, most prominent stripe curving down from rear margin of eye and extending to middle of caudal base; lower side sometimes with dark lines breaking up to spots anteriorly and posteriorly; dark markings in life occasionally more blotchy than linear, forming several irregular cross bands on body, bands covered with many small whitish spots; head sometimes with 2-3 indistinct purplish lines from lower margin of eye to region of throat, interspaces brownish; soft dorsal and anal fin rays hyaline, each fin with indications of two dark blotches basally; anal fin with narrow blackish band along margin posterior to apex of fin, extending posteriorly to about 10th last ray; caudal fin rays hyaline, with two curved dark cross-bands, first narrow and often rather indistinct centrally, becoming wider and darker towards dorsal and ventral margins of fin, second wide, following profile of posterior margin of fin (additional indistinct dark spotting between bands sometimes present); caudal fin filaments whitish.

Colour in alcohol: head and body pale brown with darker markings as described above; dusky band along edge of anal fin in male narrow, much narrower than width of pupil, often faint in long-preserved material.

Distribution

Paramonacanthus pusillus ranges across the Indo-West Pacific, from South Africa northwards to the southern end of the Red Sea, then eastwards to northern Australia (but not north-eastern Australia), and northwards to southern Japan (Figure 15) (see also Remarks below).

Remarks

The similarities between this species and *P. lowei* sp. nov. were discussed in the account of the latter species.

Paramonacanthus pusillus is the most widespread member of the genus. It is mostly taken by bottom trawl at depths between 28 and 79 m, but has been photographed underwater in Indonesia (Flores) on a shallow weedy bottom.

Paramonacanthus pusillus in the past has been referred to under various names, including *Laputa cingalensis* Fraser-Brunner, 1941 (e.g., Munro 1955; Hutchins 1977), *Paramonacanthus cingalensis* (e.g., Hutchins 1984, 1986b; Sainsbury *et al.* 1985), and *P. nipponensis* (Kamohara, 1939) (e.g., Matsuura 1984). Hutchins (1988) was the first to recognise the wide distribution of the species, placing *P. cingalensis* from the Indian Ocean in the synonymy of *P. nipponensis* from Japan (as *Laputa nipponensis*). Hutchins also included names based on African

material in this synonymy, namely *Laputa umgazi* Smith, 1949, *Rudarius virgulatus* Nalbant and Mayer, 1975, and *Paramonacanthus falcatus* Kotthaus, 1979, although *Monacanthus pusillus* Rüppell, 1828 from the Red Sea was omitted. Rüppell's description was based on a 32 mm TL monacanthid which showed some similarities to a juvenile *Paramonacanthus*, but was too brief to allow an accurate identification. Klunzinger's (1871) redescription of the same specimen provided some additional information, although his soft dorsal and anal fin ray counts each of 22 were unusually low for a *Paramonacanthus* (see Table 2). During the present study, Rüppell's type (SMF 3488, 25 mm SL) was examined, and although in poor condition, agrees well with juvenile material from other localities across the range of *P. pusillus*. Notably it possesses prominent downward-directed barbs on the anterior face of the first dorsal spine and a movable pelvic fin rudiment, a character combination which is unique amongst Red Sea monacanthids. This examination also showed that Klunzinger's fin ray counts were wrong, and are in fact within the usual range for the species. This leaves little doubt that *P. pusillus* is the oldest name for this wide-ranging species (but also see below).

Monacanthus (Stephanolepis) nipponensis was described by Kamohara, 1939 from two specimens collected near Mimase, Japan. The type description and illustration present enough evidence to indicate that this species is conspecific with *Paramonacanthus pusillus*. The whereabouts of the types are unknown.

The description of *Laputa cingalensis* Fraser-Brunner, 1941 was based on a 68 mm SL specimen (BMNH 1902.8.23.4) from Ceylon (= Sri Lanka). Fraser-Brunner was in error when he placed his new species in *Laputa* (see Introduction). He was also mistaken concerning its undescribed status, as it is clearly a synonym of *Paramonacanthus pusillus*.

Like the type of *Monacanthus pusillus*, both *Laputa umgazi* Smith, 1949 and *Rudarius virgulatus* Nalbant and Mayer, 1975 were described from juvenile material. All possess four rows of prominent downward-directed barbs on the first dorsal spine and a movable pelvic fin rudiment. Although neither type was examined [that of *L. umgazi* (at RUSI) was unavailable for loan because of its poor condition], the type descriptions and illustrations show that they are clearly conspecific with *P. pusillus*. Furthermore, *Rudarius virgulatus* was placed originally in a genus characterised by small overall size and non-movable pelvic fin rudiment, but obviously does not belong here because neither of these two features identify this form.

Paramonacanthus falcatus was described (Kotthaus, 1979) from material collected in the southern portion of the Red Sea and the Gulf of

Table 7 Fin ray counts for *Paramonacanthus pusillus*.

	Dorsal rays						Anal rays						Pectoral rays		
	25	26	27	28	29	30	24	25	26	27	28	29	11	12	13
Red Sea and Gulf of Aden	2	14	9				1	16	7	1			8	15	2
South Africa	1		5				1		4		1			5	
Indo-Australian Archipelago		1	5	8	11	6		1	3	6	12	10		19	13
Total	3	15	19	8	11	6	2	17	14	7	13	10	8	39	15

Aden. The description and illustration show that it is clearly conspecific with *P. pusillus*. Kotthaus also reported in the same publication a species he referred to as "*Paramonacanthus spec.*" He noted that it was close to *P. falcatus* but differed in the shape of the body and fins and in its colouration. Obviously Kotthaus was unaware that these differences were due to sexual dimorphism; the illustrations of *P. falcatus* and *P. spec.* clearly show that they are the male and female forms of the same species.

The Red Sea/Gulf of Aden form of *Paramonacanthus pusillus* has slightly lower fin ray counts (Table 7, incorporating additional data from the type descriptions of *P. falcatus* and *Laputa umgazi*) and a smaller maximum size (91 mm SL versus 146 mm SL) than the form inhabiting the rest of its range. Furthermore, all male specimens from the former area that were examined for this study had damaged caudal fins, so it was not possible to determine the presence or absence of caudal fin filaments (see Figure 26b). In all other respects, the two are identical. In the absence of additional evidence, the two forms are treated here as conspecific.

One small specimen (16 mm SL) from Rabaul in New Britain represents the easternmost limit in the range of the species. However, because of its small size, it is not possible to say that it is definitely this species and not the closely related *Paramonacanthus lowei* (described herein) from north-eastern Australia.

Material examined (64 specimens, 14–146 mm SL).

Australia (all from Western Australia): WAM P.26186–001, 61 mm SL, North West Shelf, 10 May 1978; WAM P.26565–001, 56 mm SL (cleared and stained), north of Montebello Islands, 2 December 1979; WAM P.27224–003, 3 specimens, 82–105 mm SL, north of Montebello Islands, 9 March 1981; WAM P.27233–006, 3 specimens, 30–34 mm SL, North West Shelf, 11 March 1981; WAM P.28684–004, 52 mm SL, North West Shelf, 20 February 1983; WAM P.28687–004, 37 mm SL, North West Shelf, 22 February 1983; WAM P.28690–006, 2 specimens, 18–24 mm SL, North West Shelf, 22 January 1982; WAM P.28721–002, 5 specimens, 27–

32 mm SL, North West Shelf, 4 September 1983; WAM P.30943–001, 68 mm SL, Long Reef, off Admiralty Gulf.

Burma: ANSP 100850, 7 specimens, 28–58 mm SL, Bay of Bengal; ANSP 102135, 42 mm SL, Bay of Bengal, 24 March 1963.

Gulf of Aden/Red Sea: BMNH unregistered, 7 specimens, 33–50 mm SL, off Mukalla, Gulf of Aden, South Yemen; HUI 11500, 3 specimens, 14–25 mm SL, Entedabir, Eritrea, Red Sea, 13 March 1962; SMF 3488 (holotype of *Monacanthus pusillus*), 25 mm SL, Massaua, Eritrea, Red Sea, no other data; USNM 278412, 66 mm SL, Massawa, Ethiopia, Red Sea, 20 September 1971; WAM P.29771–001, 2 specimens, 42–48 mm SL (smaller cleared and stained), off Aden, Yemen, 18 September 1975; WAM P.29776–001, 2 specimens, 66–70 mm SL (cleared and stained), Maskali Island, Gulf of Tadjoura, Djibouti, 12 February 1978.

Hong Kong: BPBM 18735, 117 mm SL, Aberdeen Fish Market, 20 June 1975.

Japan: NSMT P21104, 137 mm SL, off Kochi, Japan.

Papua New Guinea: KFRS unregistered, 16 mm SL, Rabaul, New Britain, 22 June 1973 (see Remarks above).

Philippines: AMS I.22023–001, 113 mm SL, and 3 unregistered AMS specimens, 63–99 mm SL, Samar Sea; USNM 169046, 75 mm SL, Luzon Island, 11 April 1909; USNM 242195, 99 mm SL, Samar Sea, 14 April 1980; USNM 273252, 111 mm SL, Visayan Sea, 6 June 1978; WAM P.29758–001, 2 specimens, 50–70 mm SL (cleared and stained), Visayan Sea, October 1979.

South Africa: RUSI 1463, 31 mm SL, Illovo, Natal, 16 June 1969; RUSI 4618, 32 mm SL, Port Shepstone, 6 January 1958; RUSI 4620, 2 specimens, 29–30 mm SL, Xora River mouth, 4 June 1955; RUSI 8043, 30 mm SL, off East London, 20 June 1968; RUSI 9664, 15 mm SL, Sodwana, Zululand, 18 April 1979.

Sri Lanka: BMNH 1902.8.23:4 (holotype of *Laputa cingalensis*), 68 mm SL, no other data.

Taiwan: USNM 192536, 146 mm SL, Pescadores, Taiwan, 17 October 1961; USNM 192537, 2 specimens, 101–112 mm SL, Pescadores, Taiwan, 17 October 1961.

***Paramonacanthus sulcatus* (Hollard, 1854)**

Figures 2h, 3g, 4c, 5c, 6f, 27, 28, 29; Tables 2, 3

Monacanthus sulcatus Hollard, 1854: 363, pl. 14, fig. 3 (type locality, Macao [= Macau, China]).

Monacanthus isogramma Bleeker, 1857: 367 (type locality, Batavia [= Jakarta, Indonesia]).

Diagnosis description

Soft dorsal rays 30–33; anal rays 31–34; pectoral rays 12–14 (all specimens examined for this study have 13 [Table 2]); vertebrae 7+12 = 19; body width 2.1–2.5 in head length; body depth 1.9–2.5 in SL; head length 2.8–3.1 in SL; dorsal profile of snout straight to slightly convex in male, straight to slightly concave in female and juvenile, without obvious hump above nostrils in either sex, snout length 4.1–4.5 in SL; eye diameter 2.7–3.9 in head length, 0.8–1.0 in interorbital width; gill opening a short slit, length 3.1–4.4 in head length, centred below posterior quarter of eye or slightly behind eye; gill rakers on first gill arch 18–19; first dorsal spine originating over posterior half of eye, length 1.3–1.6 in head length, circular in cross-section; spine of juvenile (Figure 2h) with four rows of downward-directed barbs, two adjacent rows of rather small barbs on anterior face, some with smaller upward-directed branch, and one row of larger, posterolaterally projecting barbs along each posterolateral face; with increasing SL, barbs becoming more numerous, relatively smaller, anterior series tending to obsolescence distally, posterolateral series becoming more laterally

projecting; soft dorsal and anal fins elevated anteriorly, profile of outer margin posterior to apex concave in male, convex in female and juvenile (Figure 28), longest dorsal ray at apex of fin 1.9–2.3 in head length, somewhat longer than longest anal ray (2.2–2.7 in head length); length of soft dorsal base 2.8–3.1 in SL, about equal to anal base (bases of fin membranes perforated); origin of soft dorsal fin above or slightly posterior to origin of anal fin; interdorsal space up to 1.4 times greater than length of first dorsal spine in adults, about equal in specimens smaller than 50 mm SL; caudal fin mostly convex, although upper 1–2 and middle caudal rays usually elongate and filamentous in male (Figure 28), fin length (not including filaments) 1.0–1.4 in head length; caudal peduncle moderate in length 3.2–4.6 in head length and 1.3–1.9 in its depth, somewhat more tapered in male than in female and juvenile; pelvic fin rudiment moderate in size (Figure 3g), length 1.3–1.8 in eye diameter, rudiment projecting rearwards of posterior margin of ventral flap; rudiment consisting of five encasing scales (Figure 5c), arranged as in Figure 4c (no space between scales); midbody scales small, imbricate, circular in smallest specimen examined (42 mm SL), each with one central spinule supported by a v-shaped lateral ridge, spinules forming obvious longitudinal rows along side of body; spinule simple or with additional small branch on anterior face, spinule curving posteriorly; midbody scales in adult as above, except more elliptical in shape (Figure 6f), those just behind head multibranching; scale

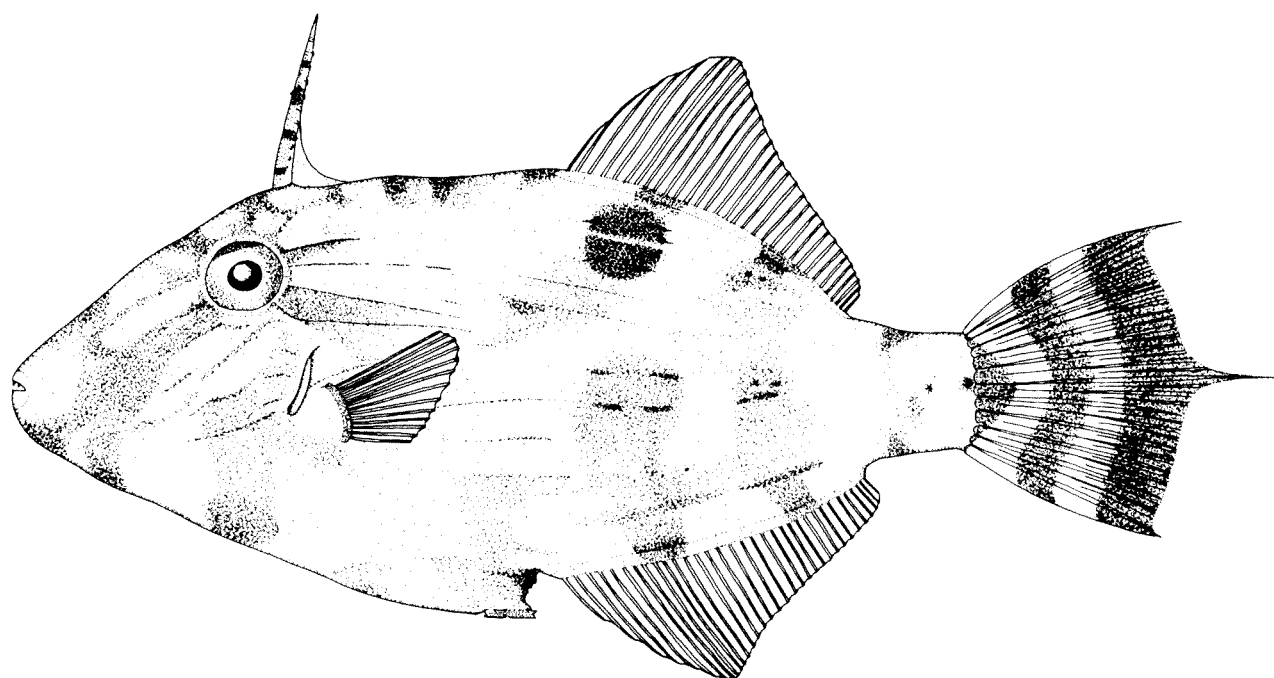


Figure 27 *Paramonacanthus sulcatus*, WAM P.30748-001, 90 mm SL, male, Hong Kong (drawn by S. Morrison).

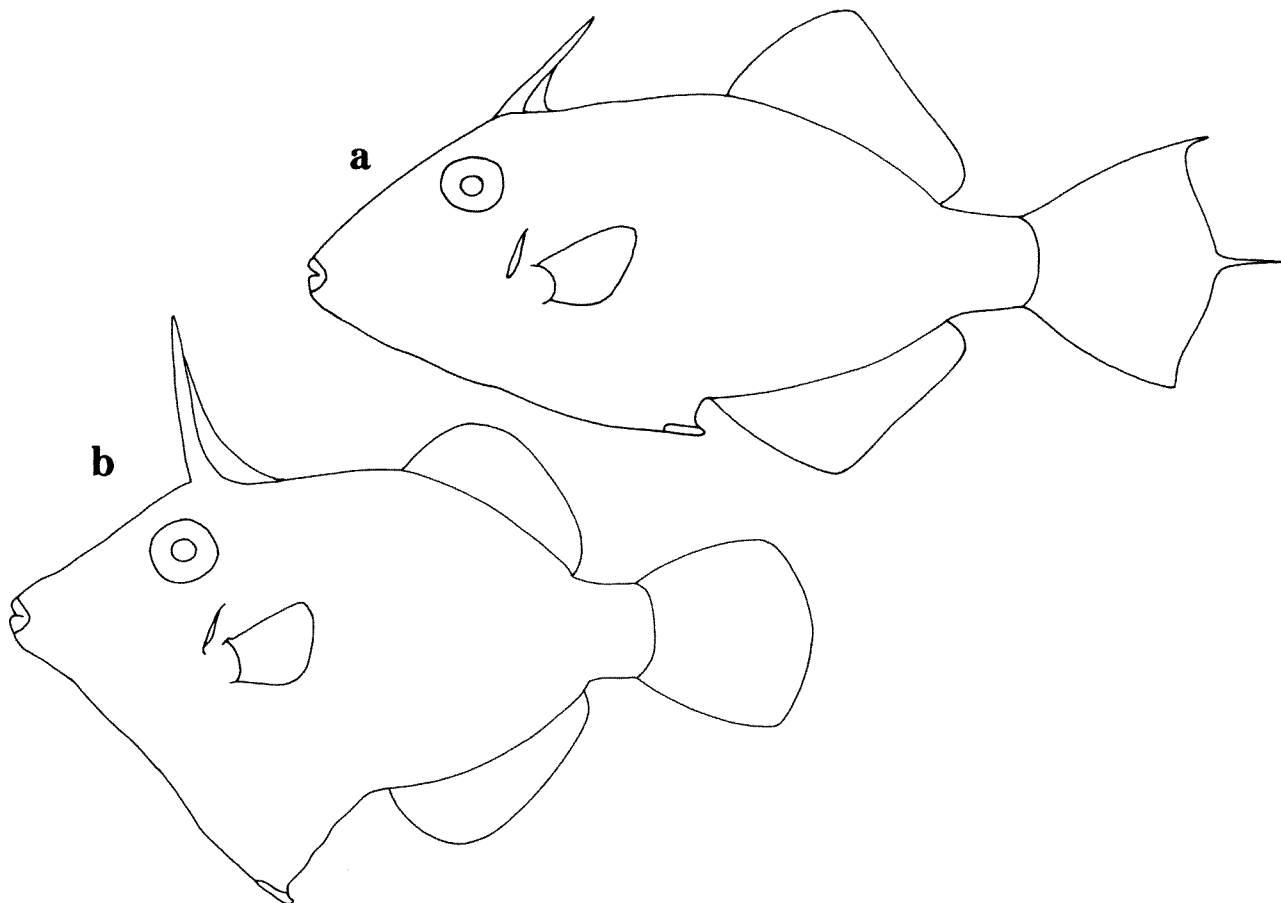


Figure 28 Variation in lateral profile of *Paramonacanthus sulcatus*: a. WAM P.30748-001, 90 mm SL, Hong Kong; b. CAS 57548, 64 mm SL, female, Thailand.

spinules on rear half of body slightly longer than more anterior spinules; no sexual dimorphism; small cutaneous tentacles sometimes visible; skin velvety to slightly coarse; lateral line sensory system without supra-abdominal branch, although several scattered pores present in one individual.

Colour when fresh (based on photographs of live fish underwater in Indonesia and a freshly collected specimen from Taiwan [see Shen 1993, pl. 202, fig. 2]): ground colour white to pale brown with mottled pattern of brownish to dusky blotches; most prominent blotch usually below anterior half of soft dorsal fin, mostly circular in shape, often split longitudinally in two by a pale line, but sometimes more irregular in shape (extending from base of soft dorsal fin to middle of posterior abdominal branch of lateral line); below, another blotch often at junction of posterior abdominal and caudal branches of lateral line, extending to base of anterior half of anal fin; diffuse cross band joining posterior portions of soft dorsal and anal fins, and another across caudal peduncle; small blotch at origin of soft dorsal fin and another on middle of interdorsal space; ventral flap with dusky band posteriorly, extending dorsally to about level of pectoral fin; head with

numerous dark bands radiating from eye, one extending ventroposteriorly to above pectoral fin, one ventrally to breast, one anteroventrally to throat (sometimes split in two ventrally) and 3-4 across dorsal profile; adults often with numerous thin dark lines along body, most running parallel from rear of head toward caudal fin but 2-3 extending more obliquely from posteroventral margin of eye toward posterior base of anal fin; dorsal spine with about 4 dark cross bands; soft dorsal and anal fins hyaline, although body bands extending basally onto rays; caudal fin with two curved brownish to dusky cross bands, anterior one usually darker, and dark semicircular blotch at base of rays.

Colour in alcohol: head and body brown to pale brown with darker blotches as described above, although in some individuals these have faded; narrow dark lines on body of adult poorly defined; ventral flap mostly dusky, especially along posterior margin; fins as described above.

Distribution

Paramonacanthus sulcatus has been recorded from Malaysia, Indonesia, Thailand, Taiwan and China.

Remarks

Paramonacanthus sulcatus is a poorly known species because of the shortage of specimens in collections. It is often confused with other members of the genus, but is best separated by the combination of generally higher fin ray counts and scales structures (see Key to Species). An underwater photograph of this species taken at Pulau Putri, off Jakarta, Indonesia, shows four small individuals feeding on algae growing on a coral reef. The linear arrangement of scale spinules is clearly visible.

Hollard's (1854) type description and illustration of *Monacanthus sulcatus* was based on a 72 mm TL specimen from China. The type (MNHN B.1418) was examined for this study, and clearly shows the diagnostic features of the description.

Monacanthus isogramma (Bleeker, 1857) was described from two specimens, 92–95 mm TL, collected from Batavia (= Jakarta). A third specimen (67 mm TL) from the same locality was reported by Bleeker (1865). However, only two specimens are currently housed at RMNH (65 and 92 mm TL), the larger of which is probably one of the types. The other one was probably sent to BMNH as Günther (1870) reported a type of this species in his collection, with a length of three and a half inches (= approx. 90 mm TL). This female specimen [BMNH 1867.11.28.205, although incorrectly labelled as 1867.11.28.206 (A. gill, pers. comm.)] was examined and agrees with Bleeker's description except for the soft dorsal count (30 instead of 31 rays). There seems to be little doubt

that this is the smaller of Bleeker's syntypes. The two RMNH specimens (both with the same registration number, RMNH 7296) were also examined and are typical of *P. sulcatus*.

Hutchins (1977) erroneously recorded *Paramonacanthus sulcatus* for Australia based on his examination of a paratype of *Arotrolepis (Scurrilichthys) barbarae* (AMS IB.5387). At the time, he believed that *Paramonacanthus sulcatus* and *A. (S.) barbarae* were conspecific, but the present study has shown this to be wrong (see account of *Paramonacanthus otisensis* above).

Material Examined (13 specimens, 42–90 mm SL).

China: MNHN B.1418 (holotype of *Monacanthus sulcatus*), 56 mm SL, Macau; USNM 278408, 80 mm SL, Tolo Harbour, Hong Kong, 24 July 1970; WAM P.30748-001, 2 specimens, 83–90 mm SL, Hong Kong.

Indonesia: BMNH 1867.11.28.205, 70 mm SL, syntype of *Monacanthus isogramma*, Jakarta, Java; BPBM 18608, 42 mm SL (cleared and stained), Jakarta Fish Market, Java, 18 February 1975; RMNH 7296, 2 specimens, 49–70 mm SL (larger is syntype of *Monacanthus isogramma*), Jakarta, Java.

Malaysia: AMS I.34725-001, 46 mm SL, "British Malaya", 1920 (no other data).

Singapore: SU 32760, 2 specimens, 87–88 mm SL, 5 May 1937.

Thailand: CAS 57548, 2 of 6 specimens (remainder is *P. choirocephalus*), 64–65 mm SL, Gulf of Thailand, 24 October 1959.

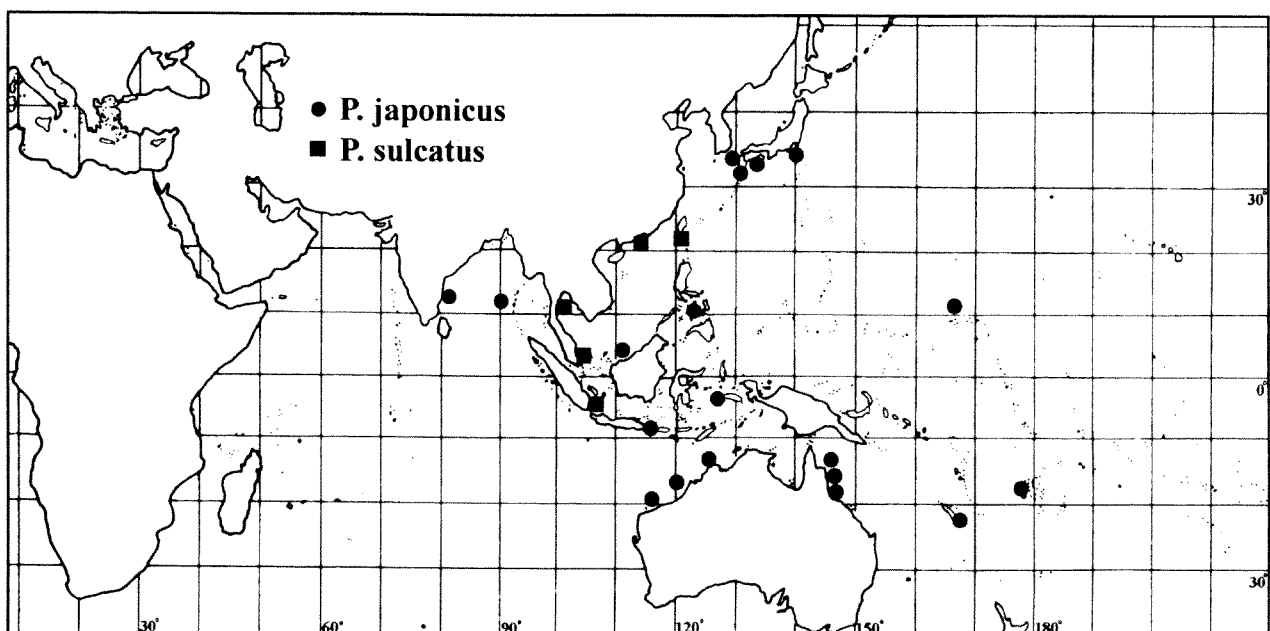


Figure 29 Distribution of *Paramonacanthus japonicus* and *P. sulcatus* (based on material examined during this study).

Paramonacanthus tricuspis (Hollard, 1854)

Figures 10, 30, 31; Tables 2, 3

Monacanthus (sic) *tricuspis* Hollard, 1854: 351, pl. 13, fig. 3 (type locality, "la mer des Indes" = Bombay?, see Remarks below).

Paramonacanthus horae Fraser-Brunner, 1941: 196, fig. (type locality, Madras Presidency, India).

Diagnostic description

Soft dorsal rays 26–29; anal rays 27–30; pectoral rays 11–12 (mostly 12, see Table 2); vertebrae 7+12 = 19; body width 1.9–2.5 in head length; body depth 2.0–2.8 in SL; head length 2.6–3.0 in SL; dorsal profile of snout (viewed laterally) straight to somewhat convex in male, rarely with obvious hump just anterior to nostrils, straight to slightly concave in female and juvenile, without hump, snout length 3.7–4.3 in SL; eye diameter 2.7–3.8 in head length, 0.7–1.1 in interorbital width; gill opening a short slit, length 3.4–4.5 in head length, centred below posterior quarter of eye or slightly behind eye; gill rakers on first gill arch 16–18 (four specimens); first dorsal spine originating over posterior third of eye, or slightly behind eye, length 1.1–1.7 in head length; structure of spine similar to that described for *P. choirocephalus* but spine often smaller and shorter in slender males, with very small barbs; soft dorsal and anal fins elevated anteriorly, particularly in male (profile of outer margin of fin posterior to apex concave in male, straight to convex in female and juvenile [Figure

31), longest dorsal ray at apex of fin 1.7–3.3 in head length, equal to or slightly longer than longest anal ray; length of soft dorsal base 2.8–3.2 in SL, about equal to anal fin base (bases of fin membranes perforated); origin of soft dorsal base mostly directly above origin of anal base; interdorsal space up to 1.3 times length of first dorsal spine in adults, about equal in specimens smaller than 60 mm SL; caudal fin mostly convex in shape, although second uppermost ray elongate and filamentous in male (Figure 30), fin length (not including filaments) 0.9–1.5 in head length; caudal peduncle moderately long, length 3.3–4.9 in head length and 1.2–1.6 in its depth, tapered in male but not in female and juvenile; pelvic fin rudiment relatively long and narrow, length 1.3–1.9 in eye diameter, rudiment projecting prominently rearwards of posterior margin of ventral flap; rudiment consisting of five encasing scales arranged as in *P. choirocephalus* (see Figure 4a); midbody scales small, imbricate, circular in small juvenile (30 mm SL) with one simple spinule, scale becoming more elliptical with increasing SL, developing 1–2 transverse rows of simple spinules (central one sometimes slightly more robust), those on caudal peduncle often slightly more elongate than on midside of body; male usually with smaller, more closely packed spinules than female, producing a smoother skin; female rarely with one large central multibranching spinule per midbody scale, with or without additional simple spinules, those on caudal peduncle weakly branched or simple; prominent

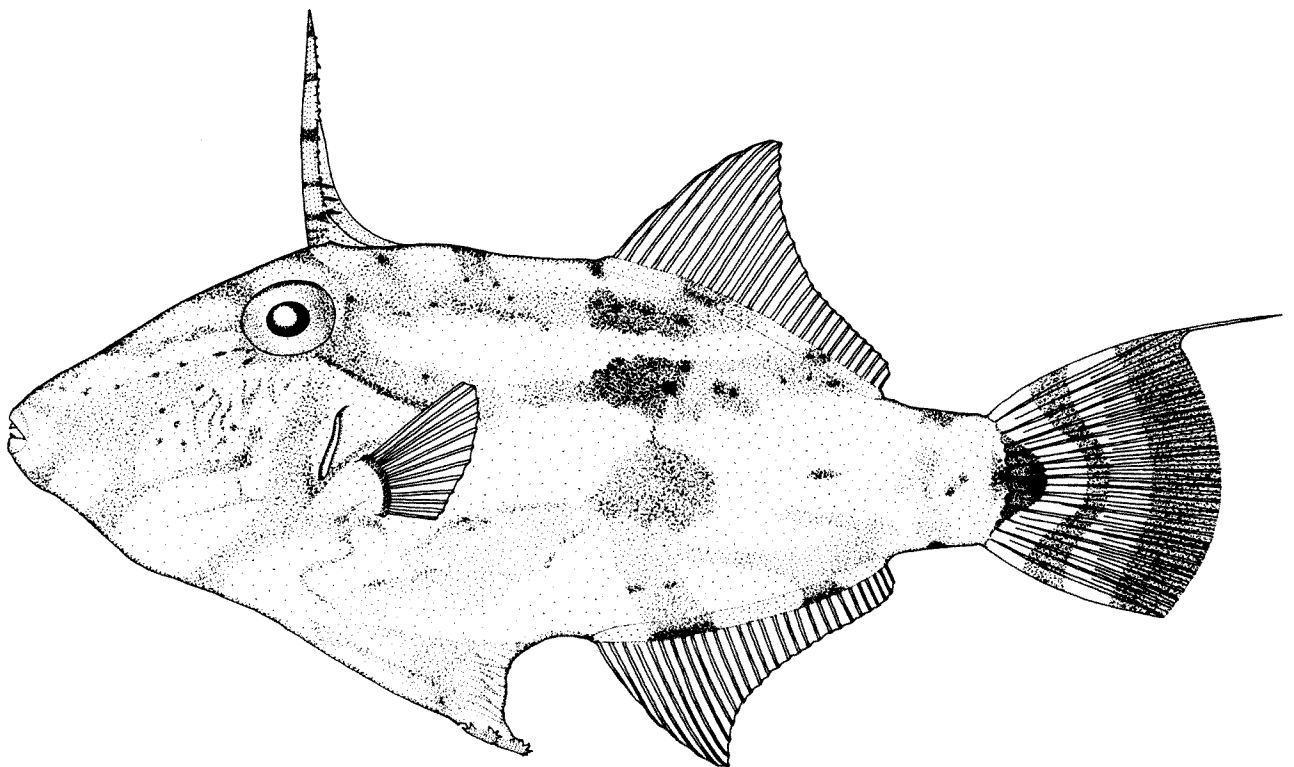


Figure 30 *Paramonacanthus tricuspis*, ZSI (unreg.), 77 mm SL, male, India (drawn by S. Morrison).

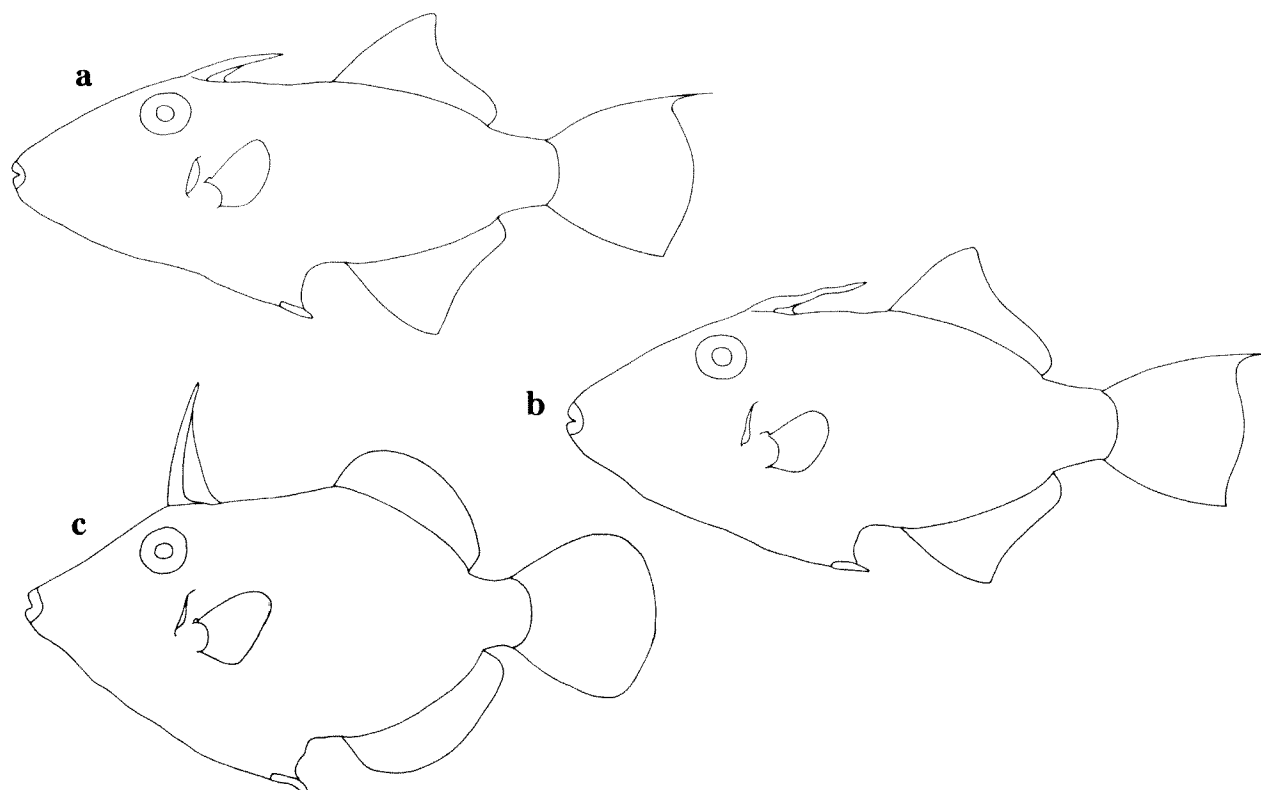


Figure 31 Variation in lateral profile of *Paramonacanthus tricuspis*: a. ZSI (unreg.), 77 mm SL, male, India; b. ZSI (unreg.), 67 mm SL, male, India; c. BPBM 20628, 70 mm SL, female, India.

cutaneous tentacles on head and body, supported by enlarged spinules (tentacles somewhat smaller in male); lateral line sensory system without supra-abdominal branch.

Colour when fresh: not known, although a black and white photograph of a recently caught specimen from Mandapam Camp, Gulf of Mannar, indicates the following pattern of colouration. Head and body pale, with three wide, darker but rather indistinct stripes on body, first from eye to anterior half of soft dorsal base, second from above gill opening, continuing posteriorly to rear half of soft dorsal base, and third curving up from ventral flap, extending along midside of body to caudal peduncle; two prominent dark blotches separated by a pale wedge-shaped bar below anterior portion of soft dorsal fin (Figure 30); indications of narrow dark reticulations on lower half of head and body; caudal fin with dusky basal blotch, followed by two dark curved cross bands.

Colour in alcohol (Figure 30): head and body pale brown to brown with indications of darker markings as described above, the most distinctive one being the blotch bisected by a wide pale bar below the anterior portion of the soft dorsal fin; junction of posterior abdominal and caudal branches of lateral line often with dark blotch extending ventrally onto base of anal fin; other

blotches along dorsal and ventral profiles of head and body as described for *P. choirocephalus* (blotches tend to be less defined when compared with other members of the genus); caudal fin with dark semicircular blotch basally, followed by two curved dark cross-bands.

Distribution

Paramonacanthus tricuspis has been recorded from both sides of India, and across to the western coast of Thailand (Figure 10). A small post-pelagic juvenile has been collected from the Maldives..

Remarks

Paramonacanthus tricuspis can be distinguished from other allied members of the genus (see Comments on Phylogeny at the rear of this paper) by a combination of colouration, fin ray counts and scale structures. It differs from *P. arabicus* and *P. otisensis* by having mostly simple scale spinules (see also below), from *P. choirocephalus* in lacking both a supra-abdominal branch of the lateral line and a dark blotch bisected by the anterior abdominal branch of the lateral line, and from *P. japonicus* by possessing mostly 12 pectoral fin rays (versus 11) and lacking two prominent dark stripes along the upper side of the body.

Hollard's (1854) description of *Monocanthus* (sic)

tricuspis was based on a 65 mm TL specimen collected by Dussumier from "la mer de Indes". Le Danois subsequently (1961) gave the type locality as Bombay without comment in a list of monacanthid types held at MNHN. There seems little doubt that the holotype did come from India as it has much in common with the types of *Paramonacanthus horae* (see below) which were collected from the Madras region of India. However, like the latter type specimens, the holotype of *M. tricuspis* has quite different scale structures when compared with most other Indian individuals of the genus *Paramonacanthus*. The latter generally have simple scale spinules in 1–2 transverse rows per midbody scale whereas the type has only 1–2 spinules per scale, the extremities of each spinule possessing 2–3 small branches (many of the spinules on the caudal peduncle, however, are simple). This variety appears to be rare in Indian seas, but nevertheless it is also shared by both types of *P. horae*, as well as several female specimens (see also the remarks in the account of *P. choirocephalus*). Other than this difference, the holotype agrees well with other Indian specimens.

Le Danois (1961) listed a paratype of *Monacanthus tricuspis* at MNHN (A.4134) but no mention of this specimen can be found in the type description. Examination proved it to be a specimen of *Acanthaluteres spilomelanurus* (Quoy and Gaimard, 1824) from southern Australia, so the designation by Le Danois is obviously incorrect.

Paramonacanthus horae was described by Fraser-Brunner (1941) on the basis of two specimens (64–65 mm SL) from the east coast of India. An examination of these specimens (BMNH 1888.11.6.85–86) left no doubt that *P. horae* is synonymous with *P. tricuspis*. The characteristic dark bisected blotch below the anterior half of the soft dorsal fin is evident in both specimens.

An Indian specimen examined at AMS (B.7612) is registered as "Co-type of *Monacanthus choirocephalus*, purchased from Mr F. Day, 1885". This is obviously one of the specimens on which Day (1876) based his description of *Monacanthus choirocephalus* (*non* Bleeker), and thus has no type status. Day's description and illustration clearly indicate that the species in question was *Paramonacanthus tricuspis*.

Material Examined (seventy specimens, 23–83 mm SL).

India: AMS B.7612, 60 mm SL, Madras; ANSP 100850, 19 specimens, 23–62 mm SL, W of Andaman Islands, Bay of Bengal, 30 March 1963; ANSP 111524, 79 mm SL, Bombay, 10 September 1966; BMNH 1888.11.6.85 (holotype of *Paramonacanthus horae*), 64 mm SL, Madras; BMNH

1888.11.6.86 (paratype of *P. horae*), 65 mm SL, Madras; BPBM 20628, 5 specimens, 58–70 mm SL, Gulf of Manner, India, 5 March 1975; BPBM 20629, 75 mm SL, Gulf of Manner, India, 5 March 1975; MNHN A.4135 (type of *Monacanthus tricuspis*), 50 mm SL, Bombay?, 1830; ZSI (unreg.), 5 specimens, 43–63 mm SL, Madras, 5 September 1975; ZSI (unreg.), 4 specimens, 55–60 mm SL, off harbour, Madras, 24 May 1975; ZSI (unreg.), 8 specimens, 54–77 mm SL, Madras, 25 June 1975; ZSI (unreg.), 12 specimens, 48–70 mm SL, Madras, 9 July 1975.

Maldives: BMNH 1901.12.31:150, 20 mm SL, no other data.

Thailand: AMS I.21035–001, 7 specimens, 41–53 mm SL, near Phuket, 23 March 1974; ANSP. 111891, 4 specimens, 67–83 mm SL, S of Phuket, Strait of Malacca, 10–15 February 1966.

Comments on the Phylogeny of *Paramonacanthus*

Hutchins (1988) investigated the phylogeny of monacanthid fishes, examining 112 characters which had potential to indicate phylogenetic change. As little of this study has been published (Hutchins 1992; 1994), it would be difficult to defend the phylogenetic considerations described below without detailed osteological descriptions of many taxa. For this reason, the following account is presented without full justification for decisions made concerning apparent derived character states versus apparent plesiomorphies. It is meant only as a guide to the relationships of *Paramonacanthus* until a more detailed phylogenetic account of the family is published.

As mentioned earlier, *Paramonacanthus* was placed in Group A (Table 1) by Hutchins (1988), and was linked together with two undescribed genera referred to for convenience as "*Arotrolepis*" and "*Laputa*" (both names are junior synonyms and were therefore considered invalid, see Remarks in the generic account above). This association was made on the basis of one synapomorphy (Character 1, see Character Analysis below). "*Arotrolepis*", which in its present form consists of two species, *filicauda* Günther, 1880 and an undescribed species from the Philippines, was considered to be the sister taxon of the other two on the basis of the apomorphic condition of four characters (Characters 2, 3, 4, and 5). Furthermore, Hutchins (1988) differentiated *Paramonacanthus* from "*Laputa*" on the basis of the apomorphic state of four characters (Characters 6–9). Three of the latter four derived states are present in other monacanthid taxa and were interpreted by Hutchins as being of little use for resolving phylogeny. The only unequivocal apomorphy for separating "*Laputa*" from *Paramonacanthus* was a feature involving anal fin colouration (Character

6). However, the present study does not consider this sufficient evidence to warrant maintaining the two as separate taxa, and only *Paramonacanthus* is recognised here.

Hutchins (1988) found few additional apomorphies to elucidate intrageneric relationships, although several homoplasies (Characters 10–13) and autapomorphies for individual species suggest species groupings as indicated in Figure 32 (specific autapomorphies not included).

Character Analysis

Character 1. Ethmoid with a dorsal ridge, sometimes resulting in a prominent hump on the dorsal surface of the snout: This apomorphic character state occurs in all males of "*Arotrolepis*"

and *Paramonacanthus*, although it is not prominent in *P. sulcatus*, *P. nematophorus* and *P. frenatus*. A similar condition occurs in *Oxymonacanthus* and *Pseudaluteres* from Group C, but is considered to have arisen independently.

Character 2. Basioccipital with prominent ventral projection for attachment to the swim-bladder: This derived condition is found only in the two species of "*Arotrolepis*" and is interpreted as an autapomorphy.

Character 3. Anterior portion of the soft dorsal and anal fins prominently elevated in the male, the margin of the fins posterior to the apex conspicuously concave: This apomorphy occurs in all members of *Paramonacanthus*, as well as in some balistids (an outgroup), and in *Thamnaconus*, *Nelusetta*, and *Eubalichthys* from Group B. It is

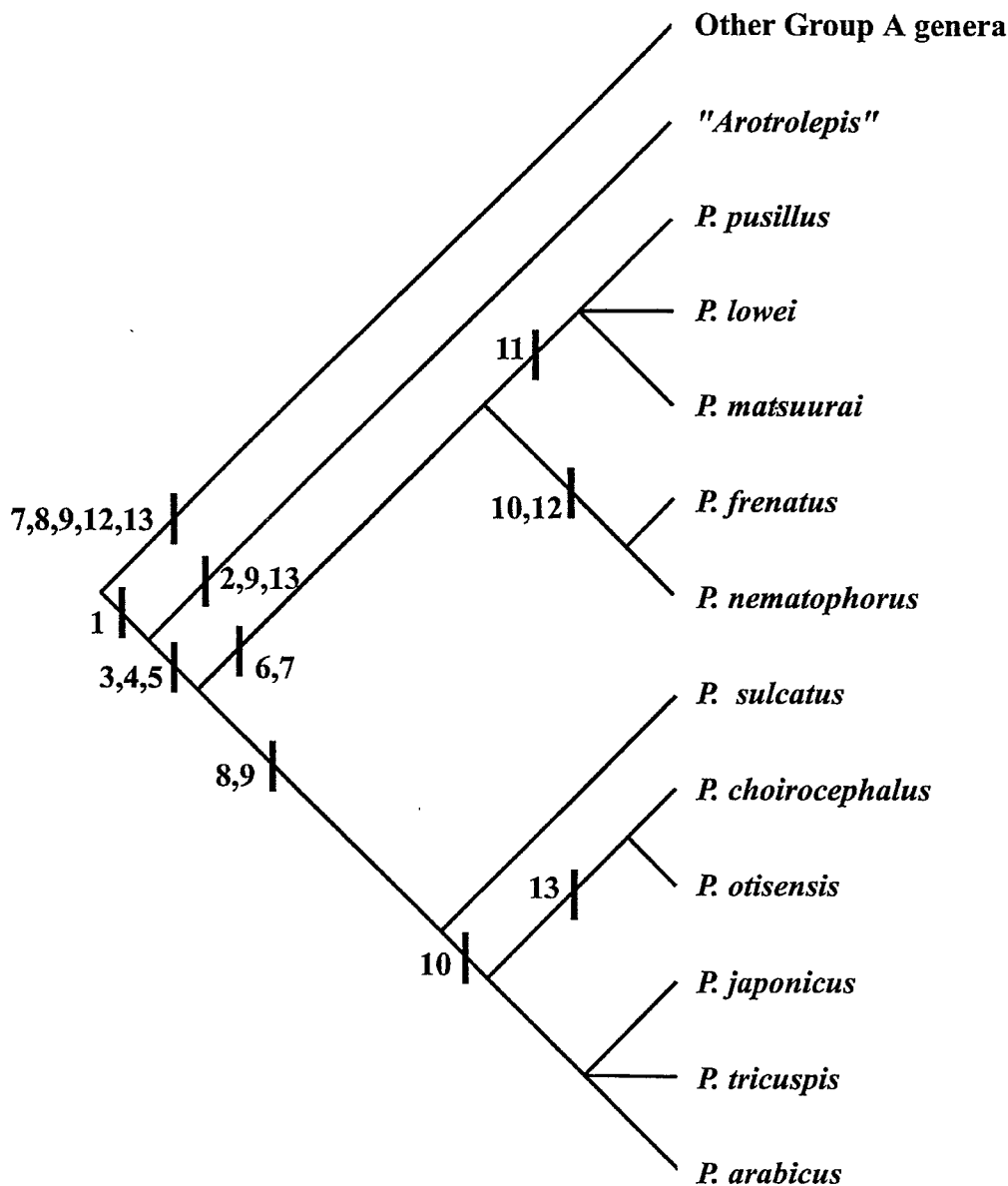


Figure 32 Cladogram of the genus *Paramonacanthus*. Numbers identify derived character states which are described in the text.

thought to have arisen independently in the two monacanthid lineages concerned.

Character 4. Osteology and myology of the basal region of the soft dorsal and anal fins are affected by sexual dimorphism: The basal pterygiophores, predorsal neural spines, basal flanges of the dorsal and anal rays, and the muscles controlling these rays develop differently in males than in females of *Paramonacanthus* (described in Sexual Dimorphism in the Introduction above). There is no similar sexual dimorphism of these structures in balistids, "*Arotrolepis*" or in any other Group A genus, but it does occur in two Group B genera, *Eubalichthys* and *Thamnaconus*. Hutchins (1988) treated this sexual dimorphism as the derived condition, believing that the apomorphy arose separately in the main lineages concerned.

Character 5. Anterior keel-like projection to the first basal pterygiophore of the anal fin: This apomorphic condition occurs in the males of all members of the genus, although it is not well developed in *P. sulcatus*. It is also found in *Nelusetta* and two species of *Eubalichthys* from Group B.

Character 6. Black stripe along the margin of the anal fin: Males of *P. pusillus*, *P. lowei*, *P. matsuurai*, *P. nematophorus*, and *P. frenatus* possess a black to dusky stripe along the margin of the fin, extending from the apex posteriorly to about the middle of the fin. This stripe is absent from all other monacanthid species, and is therefore considered synapomorphic for these five species.

Character 7. Increased number of foramina in the ventral surface of the exoccipital: The exoccipital has three foramina in *P. pusillus*, *P. lowei*, *P. nematophorus*, and *P. frenatus* (condition for *P. matsuurai* not known), whereas there are only two foramina in the remaining species of *Paramonacanthus*. The former condition is interpreted as the derived one, but as it also occurs in numerous other genera in Groups A, B, and C, the phylogenetic implications are unclear.

Character 8. Reduced number of foramina in the basal pterygiophore of the spinous dorsal fin: The basal pterygiophore possesses two foramina in *P. pusillus*, *P. lowei*, *P. nematophorus*, and *P. frenatus* (the condition in *P. matsuurai* is unknown), but only one in the remaining species of the genus. The latter condition is considered to be apomorphic, but also occurs in *Colurodontis* and one species of *Pervagor*, both belonging to Group A, and is treated as a homoplasy.

Character 9. Number of predorsal neural spines articulating with the first basal pterygiophore of the second dorsal fin: There are two predorsal neural spines in contact with the basal pterygiophore in *P. pusillus*, *P. lowei*, *P. matsuurai*, *P. nematophorus*, and *P. frenatus*, and three spines in contact in the remaining species. The latter condition is interpreted as apomorphic, but also

occurs in "*Arotrolepis*", *Monacanthus*, *Chaetoderma*, and one species of *Pervagor* from Group A. This character, therefore, appears to be of little use in determining phylogeny.

Character 10. Upward-directed barbs on the anterior face of first dorsal spine. This derived character is found in *P. choirocephalus*, *P. otisensis*, *P. japonicus*, *P. tricuspis*, *P. arabicus*, *P. nematophorus*, and *P. frenatus*, as well as in most other Group A genera. The remaining members of *Paramonacanthus* possess the plesiomorphic condition of downward-directed barbs. However, the widespread nature of this apomorphy in Group A precludes any reliance on the above association.

Character 11. Dorsal spine depressed in cross-section, with a row of laterally projecting barbs along each lateral edge. This apomorphic character occurs in *P. pusillus*, *P. lowei*, and *P. matsuurai*, as well as in *Thamnaconus* and *Nelusetta* from Group B. The plesiomorphic condition of a circular to compressed dorsal spine with posterolaterally projecting barbs is found in the remaining members of *Paramonacanthus*.

Character 12. Epineural ribs commence on the third abdominal vertebra. This derived condition is found only in *P. nematophorus* and *P. frenatus*, but also occurs in *Colurodontis* and the undescribed genus from Group A and *Brachaluteres*, *Rudarius*, and the undescribed genus from Group C). The plesiomorphic condition of epineural ribs commencing on the second abdominal vertebra occurs in all other members of *Paramonacanthus*.

Character 13. Lateral line sensory system with a supra-abdominal branch. This derived character state is found in *P. choirocephalus* and *P. otisensis*, but also occurs in "*Arotrolepis*", *Monacanthus*, *Lalmohania*, and *Colurodontis* from Group A and *Aluterus* from Group B, whereas all other members of *Paramonacanthus* lack this feature. Due to the widespread nature of this condition, it is difficult to determine its phylogenetic importance.

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Guide to Authors

Subject Matter:

Reviews, observations and results of research into all branches of natural science and human studies will be considered for publication. However, emphasis is placed on studies pertaining to Western Australia. Longer papers will be considered for publication as a Supplement to the *Records of the Western Australian Museum*. Short communications should not normally exceed three typed pages and this category of paper is intended to accommodate observations, results or new records of *significance*, that otherwise might not get into the literature, or for which there is a particular urgency for publication. All material must be original and not have been published elsewhere.

Presentation:

Authors are advised to follow the layout and style in the most recent issue of the *Records of the Western Australian Museum* including headings, tables, illustrations and references.

The title should be concise, informative and contain key words necessary for retrieval by modern searching techniques. An abridged title (not exceeding 50 letter spaces) should be included for use as a running head.

An abstract must be given in full length papers but not short communications, summarizing the scope of the work and principal findings. It should normally not exceed 2% of the paper and should be suitable for reprinting in reference periodicals.

The International System of units should be used.

Numbers should be spelled out from one to nine in descriptive text; figures used for 10 or more. For associated groups, figures should be used consistently, e.g. 5 to 10, not five to 10.

Spelling should follow the *Concise Oxford Dictionary*.

Systematic papers must conform with the International Codes of Botanical and Zoological Nomenclature and, as far as possible, with their recommendations.

Synonymies should be given in the short form (taxon, author, date, page) and the full reference cited at the end of the paper. All citations, including those associated with scientific names, must be included in the references.

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The original and two copies of manuscripts and figures should be submitted to the Editors, c/- Publications Department, Western Australian Museum, Francis Street, Perth, Western Australia 6000. They must be in double-spaced typescript on A4 sheets. All margins should be at least 30 mm wide. Tables plus heading and legends to illustrations should be typed on separate pages. The desired position for insertion of tables and illustrations in the text should be indicated in pencil. Tables should be numbered consecutively, have headings which make them understandable without reference to the text, and be referred to in the text.

High quality illustrations are required to size (16.8 cm x 25.2 cm) or no larger than 32 cm x 40 cm with sans serif lettering suitable for reduction to size. Photographs must be good quality black and white prints, not exceeding 16.8 cm x 25.2 cm. Scale must be indicated on illustrations. All maps, line drawings, photographs and graphs, should be numbered in sequence and referred to as Figure/s in the text and captions. Each must have a brief, fully explanatory caption. On acceptance an IBM compatible disk containing all corrections should be sent with amended manuscript. The disk should be marked with program (e.g. WordPerfect, Wordstar, etc).

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