NEW RECORDS AND DESCRIPTONS OF TRYPANORHYNCH CESTODES FROM AUSTRALIAN FISHES

I. BEVERIDGE & R. A. CAMPBELL

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Collections of trypanorhynch cestodes in the South Australian Museum, the Queensland Museum and the Australian Museum were examined. New host or geographical records as well as new morphological details are provided for the following species: Tentaculariidae: *Tentacularia coryphaenae* Bosc, 1797, *Nybelinia thyrsites* Korotaeva, 1971, *Nybelina sphyrnae* Yamaguti, 1952; Hepatoxylidae: *Hepatoxylon trichiuri* (Holten, 1802), *Hepatoxylon megacephalum* (Rudolphi, 1819); Sphyriocephalidae: *Sphyriocephalus tergestinus* Pinter, 1913; Otobothriidae: *Poecilancistrium caryophyllum* (Diesing, 1850); Lacistorhynchidae: *Callitetrarhynchus gracilis* (Rudolphi, 1819). *N. sphyrnae*, *H. megacephalum* and *S. tergestinus* are reported from Australia for the first time. The adult of *N. thyrsites* is described for the first time.

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Between 1985 and 1987, a survey of the cestode parasites in elasmobranch fishes in the Australian region was undertaken. The resulting collections, following the examination of 1 294 specimens belonging to some 98 species (Beveridge 1987, 1991) are now housed in the South Australian Museum. Prominent among the collections made were trypanorhynch cestodes including a number of new genera and species and other genera new to the Australian region (for summary, see Campbell & Beveridge 1994).

The purpose of this communication is to report additional species encountered during the survey, several reported for the first time from Australia, or from collections already housed in the South Australian Museum, the Australian Museum and the Queensland Museum. A substantial collection of larval trypanorhynchs from teleost fishes has also been made available for study by various colleagues, and the collation of data on the occurrence of both adult and larval forms provides ecological insight into the life-cycles of the parasites concerned. In addition, new observations are included on the morphology of several of the cosmopolitan species encountered.

Illustrations are provided for the species discussed. Particularly with trypanorhynch cestodes, adequate illustrations provide clear evidence of the accuracy of identifications made, without reliance on textual description. Written descriptions are provided only for species that have been poorly described or which have not been described as adults in the past.

Materials And Methods

Adult cestodes collected by the writers were washed in sea-water or tap-water and fixed in hot 70% ethanol or hot 10% formalin. In some instances, spiral valves were opened, cestodes were killed *in situ* by flooding the gut with near boiling water and formalin was added immediately to fix the cestodes. In the laboratory, cestodes were removed from spiral valves, cleaned in water and were stored in 70% ethanol. Plerocerci were dissected free of any enclosing membranes and placed in tap-water to induce eversion of tentacles, then fixed in 70% ethanol. Cestodes were examined either as temporary mounts in glycerol or were stained in Celestine blue, dehydrated in ethanol, cleared in clove oil and mounted permanently in Canada balsam. Tentacles were removed from some specimens and mounted in glycerine jelly. The taxonomic arrangement and terminology for anatomical features and for hook patterns follows Campbell and Beveridge (1994). Synonymies of well established species are not provided, as they are available in considerable detail in Dollfus (1942).

Synonymies are provided for species which are not treated in Dollfus (1942) or which are not obtainable from other readily available sources. Measurements are presented in millimetres as the range followed by the mean in parentheses. Unless otherwise stated, mean values are based upon ten individual measurements. Where fewer than ten measurements were available, the number made is indicated by n.

The following abbreviations are used for institutions:

AHC Australian Helminthological Collection, South Australian Museum, Adelaide

AM Australian Museum, Sydney

BMNH British Museum (National History), London (now The Natural History Museum)

MNHN Muséum national d' Historie naturelle, Paris

MPM Meguro Parasitological Museum, Tokyo, Japan

QM Queensland Museum, Brisbane

TINRO Tikhookeanskogo Nauchno – issledovatelskogo Institut Rybnogo Khozyaistva i Okeanaografii (Pacific Scientific Research Institute. Fisheries, Economics and Oceanography), Vladivostock, Russia.

The personal collection from which cestodes were borrowed was that of Dr. R .J. G. Lester (RJGL). Host nomenclature follows Last and Stevens (1994) for elasmobranchs and Gomon *et al.* (1994) and Paulin (1993) for teleosts in southern Australian waters.

Systematics

Order TRYPANORHYNCHA Diesing, 1863

Superfamily HOMEACANTHOIDEA Dollfus, 1942

Family TENTACULARIIDAE Poche, 1926

Genus ***Tentacularia*** Bosc, 1797

Tentacularia coryphaenae Bosc, 1797 (Figs 1–6, 54–55)

Synonymy — see Dollfus (1942)

Material examined

Adults. From *Carcharhinus melanopterus* (Quoy & Gaimard, 1824): 3 scoleces, strobilar fragments, 'Port-Western, Australie', collected 1829, (MNHN A_2R – 1142); 3 specimens, Bundaberg, Qld. (QM GL 10806–10821). From *Carcharhinus limbatus* (Valenciennes, 1839): 1 specimen, Darwin, N.T. (AHC 24935).

Metacestodes. From *Xiphias gladius* Linnaeus, 1758: 4 specimens, Cronulla, N.S.W. (AHC S711, S2528). From *Coryphaenae hippurus* Linnaeus, 1758: 8 specimens, Barwon Banks, 20 miles NE of Mooloolaba, Qld. (AHC 18497–8). From *Macruronus novaezelandiae* (Hector, 1871): 2 specimens, west coast of Tasmania (QM G212139).

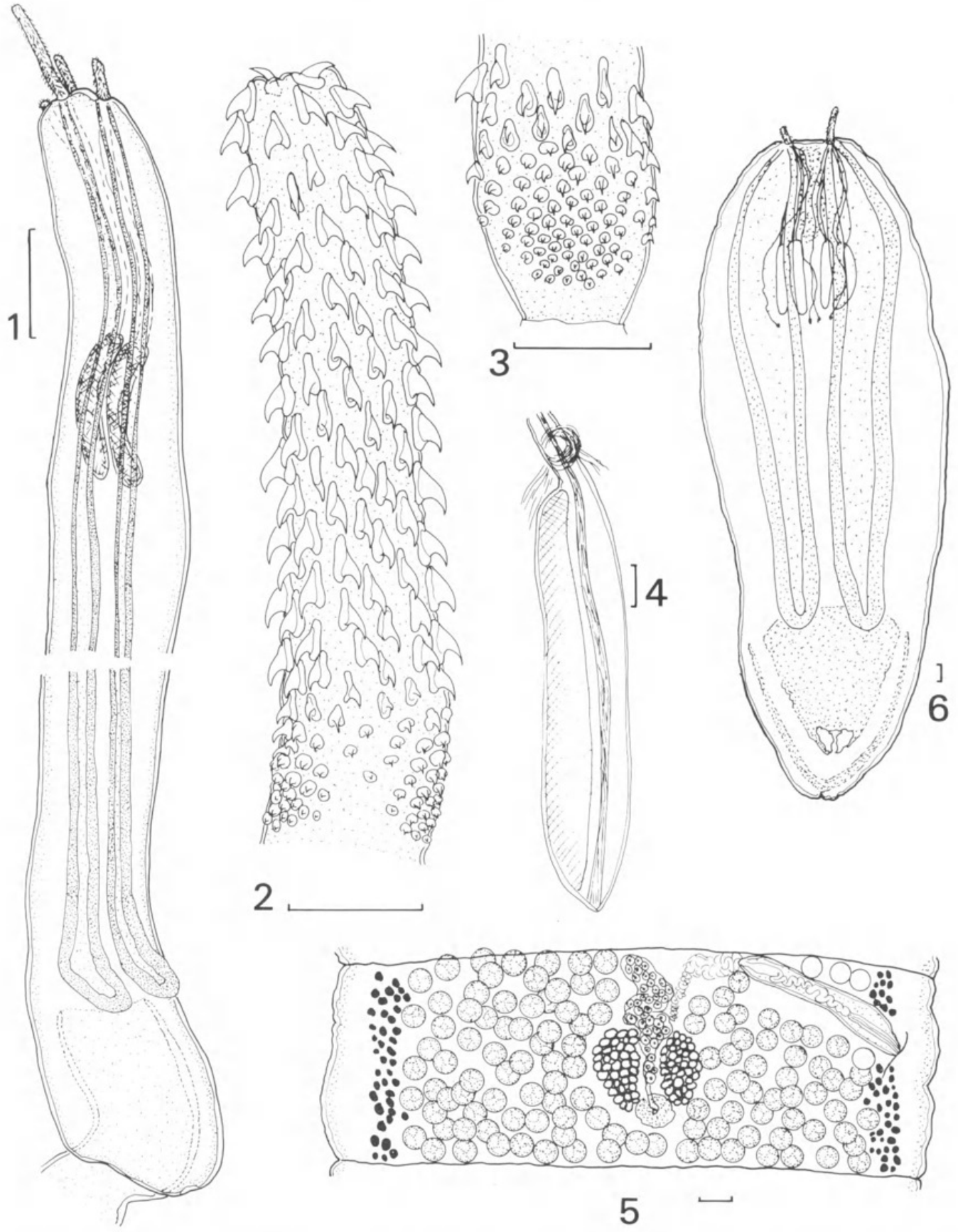
Remarks

This cosmopolitan species has been recorded only three times from Australian waters. The first record by Dollfus (1930, 1942), omitted in the checklist of Beumer *et al.* (1982), was based on specimens collected by Quoy and Gaimard in 1829 during the visit of the 'Astrolabe' to Australia under the command of Dumont D'Urville. The collection details associated with the specimen indicate that it was collected at 'Port-Western'. The 'Astrolabe' visited Westernport, Victoria, but *Carcharhinus melanopterus* is a tropical shark and does not occur in Victorian waters (Last & Stevens 1994). 'Port-Western', the locality associated with the labels, is unquestionably Westernport, Victoria as it occurs under this name in earlier maps such as Freycinet's General Chart of New Holland published in 1811 (Horner 1987 : 21). Hence, it is possible that the recorded locality is incorrect. As the voyage continued through the south-eastern Pacific, it is also possible that Quoy and Gaimard's specimens were in fact not from Australian waters, or that the host was not correctly identified.

T. coryphaenae has also been reported in *Katsuwonus pelamis* (Linnaeus, 1775) from New South Wales and Norfolk Island by Lester *et al.* (1985) and Korotaeva (1971) reported it from *Ruvettus pretiosus* Coco, 1829 (syn. *R. tidemani* Weber, 1913) from the Great Australian Bight.

The new collections confirm *C. melanopterus* as a host for the parasite in Australian waters and add the intermediate hosts *Xiphias gladius, Coryphaenae hippurus* and *Macruronus novaezelandiae,* all of which are new records for Australian waters.

A detailed summary of the anatomy of *T.*



FIGURES 1–6. *Tentacularia coryphaenae* Bosc, 1797. **1.** Scolex. **2.** Tentacle, internal surface. **3.** Basal armature of tentacle, bothridial surface. **4.** Tentacular bulb. **5.** Mature proglottis. **6.** Post larva. Figures 1–5 based on material from *Carcharhinus melanopterus* Quoy & Gaimard, 1824 (in MNHN A_2R–1142). Scale bars: Figure 1, 1.0 mm; Figures 2–6, 0.1 mm.

coryphaenae was provided by Dollfus (1942), however, several significant features of the tentacular armature, illustrated in Figs 2 and 3, warrant comment. Some members of the Homeacanthoidea were considered by Campbell and Beveridge (1994) to display bilateral symmetry in the metabasal tentacular armature, in contrast to previous authors (e.g. Dollfus 1942) who considered the symmetry to be entirely rotational. The basal armature of *T. coryphaenae*, was illustrated by Dollfus (1942), Subhapradha (1955) and Campbell and Beveridge (1994), but none of these authors have commented on the fact that *T. coryphaenae* provide an example of rotational symmetry in the metabasal armature and bilateral symmetry in the basal armature. The internal and external surfaces of the tentacle are identical, unlike the situation in the heteroacanthous trypanorhynchs (Campbell & Beveridge 1994), in which the rows form a pattern of V-s on the internal surface and Λ-s on the external surface. The hooks on the base of the tentacle are arranged in ascending rows similar to the pattern found in heteroacanths, while in the metabasal region, the hooks are arranged in a quincunxial pattern, typical of homeoacanths.

Genus ***Nybelinia*** Poche, 1926

Some 42 species have been described in the genus *Nybelinia*, many very poorly, rendering its taxonomy difficult. Dollfus (1942) described or redescribed 14 species, regarding an additional three as *inquirendae*, and subsequently (1960) added 16 new species, mainly from fish from West Africa. Four new species were described by Yamaguti (1952) from Japanese fish, three more species from fish from the Indian Ocean were added by Reimer (1980) and single species were described by Heinz and Dailey (1974) from California, by Carvajal *et al.* (1976) from Hawaii, and by Shah and Bilqees (1979), Kurshid and Bilqees (1988) and Chandra (1988) from India and Pakistan.

Separation of species is based primarily on hook size, shape and uniformity, and secondarily on the proportions of the different regions of the scolex. The genus has been divided into two subgenera, *Nybelinia* and *Syngenes*, by Dollfus (1942), based on whether the proglottides are acraspedote or craspedote. However, as the adult is not known for most of the described species, few can be assigned to subgenus. Subgenera were not considered by Campbell and Beveridge (1994) for this reason.

Beumer *et al.* (1982) listed only one species, *N. thyrsites*, from the Australian region. Korotaeva (1971) named this species, previously known simply as '*Nybelinia sp.*' from larval stages only. The adult is described here for the first time.

Nybelinia thyrsites Korotaeva, 1971
(Figs 7–14)

Nybelinia thyrsites Korotaeva, 1971: 74–6, fig. 4.

Nybelinia thyrsites (Leiper & Atkinson, 1915) *in* Beumer *et al.*, 1982: 18.

Tetrarhynchus sp. of Leiper & Atkinson, 1915: 56–6, fig. 35.

Nybelinia (*Syngenes*) sp. of Dollfus, 1942: 195–7, figs 109–110.

Nybelinia (*?Syngenes*) sp. of Robinson, 1959: 146, figs 1–3.

Types

Metacestodes from abdominal cavity of *Thyrsites atun* (Euphrasen, 1791), Southern Australia in TINRO ANZ 4–35 (not examined).

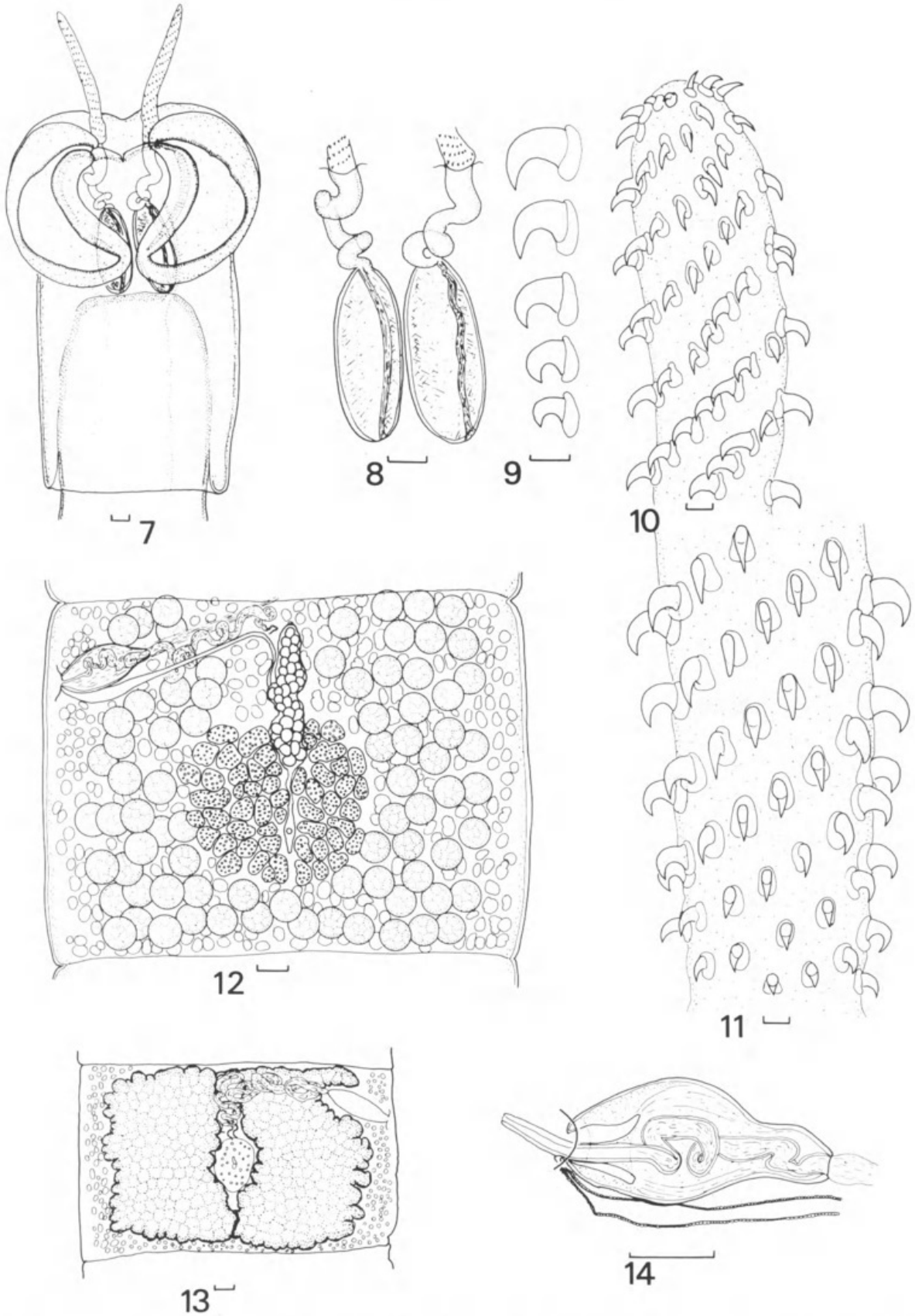
Material examined

Adults. From *Mustelus antarcticus* Guenther, 1870: 19 specimens, Goolwa, S.A. (AHC S17515–20). From *Carcharhinus brachyurus* (Guenther, 1870): 4 specimens, Goolwa, S.A. (AHC 17514). From *Galeorhinus galeus* (Linnaeus, 1758): 1 specimen, Pt Willunga, S.A. (AHC 312). From *Aptychotrema vincentiana* (Haake, 1885): 2 specimens, Goolwa, S.A. (AHC 17521).

Metacestodes. From *Arripis truttaceus* (Cuvier, 1829) (syn. *A. esper* Whitley, 1950): 2 specimens, Goolwa, S.A. (AHC 17522). From *Lepidopus caudatus* (Euphrasen, 1788): 1 specimen, Bay of Islands, New Zealand (BMNH 1914. 6.1 493–496B); 3 specimens, North Cape, New Zealand (BMNH 1914. 6.1 535–554). From unknown host: 2 specimens, locality unknown, coll. in 1829 by Quoy and Gaimard (MNHN A_2R. 1140)

Description

Cestodes of moderate size, up to 173 long, 1.9 maximum width, with up to 312 proglottides in gravid specimens. Scolex craspedote, subspherical anteriorly, truncated posteriorly;



FIGURES 7–14. *Nybelinia thyrsites* Korotaeva, 1971. **7.** Scolex. **8.** Bulbs and sheaths. **9.** Profiles of hooks along tentacle showing gradual increase in hook size. **10.** Distal region of tentacle, bothridial view. **11.** Basal region of tentacle, bothridial view. **12.** Mature proglottis. **13.** Gravid proglottis. **14.** Cirrus sac and vagina. Specimens from *Mustelus antarcticus* Guenther, 1870 (AHC S17515–20). Scale bars: Figures 7, 12–14, 0.1 mm; Figures 8–11, 0.01 mm.

maximum width 0.66–1.06 (0.83) in mid-region of bothridia; 4 bothridia, approximately reniform, external margin convex, internal margins concave; internal margin thicker than external, less variable in shape; area between dorsal and ventral pairs of bothridia distinctly cordiform. Surface of bothridium covered with elongate microtriches; pars bothridialis 0.43–0.72 (0.61); pars vaginalis 0.13–0.52 (0.32), always shorter than pars bothridialis; sheaths irregularly coiled; bulb ellipsoidal, approximately three times longer than wide, 0.31–0.40 (0.37) long by 0.10–0.16 (0.13) wide. Retractor muscle of tentacle originates at base of bulb. Pars post-bulbosa 0.010–0.024 (0.017; n=4); bulbs end either adjacent to pars proliferans of strobila or separated from it by space; velum 0.30–0.80 (0.55) long, posterior border sometimes straight, sometimes irregular in shape.

Tentacles 0.44–0.58 (0.52) long, tapering distally; width at base (without hooks) 0.040–0.096 (0.054), width at mid-region 0.028–0.064 (0.045); width occasionally variable with narrower section in middle, which may be processing artefact. Hooks arranged in 24–27 (26; n=8) oblique rows, with 7–8 (7.8) hooks per half-turn; hooks uncinate, relatively uniform in shape, with point gently curved posteriorly; hook length 0.016–0.020 (0.019), base 0.009–0.012 (0.010); hooks at base of tentacle slightly smaller, but of same shape.

Strobila acraspedote, apolytic; mature proglottides slightly wider than long 0.41–1.12 (0.76) by 0.77–1.70 (1.25). Genital pore submarginal, opening on ventral surface, in anterior third of proglottis 0.13–0.32 (0.23) from anterior margin, alternate irregularly. Cirrus sac small, ellipsodial to subspherical, muscular wall weak, 0.18–0.35 (0.28) by 0.06–0.16 (0.12); cirrus unarmed; internal and external seminal vesicles absent; vas deferens coils anteriorly towards midline; vasa efferentia not seen. Testes 84–111 (98) in number, variable in size, 0.048–0.104 (0.071) in diameter; smallest testes near periphery of proglottis, distributed in single layer, confluent posterior to female genitalia; frequently not confluent anterior to female genitalia; rarely overlying female genitalia. Vagina narrow, straight tube, sometimes slightly dilated at distal end; vagina passes antero-medially, then turns posteriorly to descend towards ovary, terminating in diminutive seminal receptacle approximately 0.16 by 0.06. Ovary just posterior to centre of proglottis, bilobed in whole mounts, 0.30–0.60 (0.45) by 0.40–0.80 (0.56). Mehlis' gland small, spherical, situated posterior to centre of ovary, approximately 0.24 in diameter. Vitelline follicles encircling medulla, 0.016–0.048 (0.032) in diameter. Uterine duct ascends to join uterus anterior to ovary. Uterus sacciform, in shape of inverted U anterior to ovary; arms of gravid uterus elongate, filling with eggs until dilated arms meet posteriorly; posterior part of uterine arms become filled with eggs while anterior part contains relatively few eggs, finally occupying entire medulla. Uterine pore absent. Eggs spherical, 0.024–0.040 (0.032) in diameter; unembryonated.

Remarks

The first description of this species was given by Leiper and Atkinson (1915) based on metacestodes collected from *Lepidopus caudatus* (Euphrasen, 1788) from the Bay of Islands, New Zealand, during the British Antarctic Expedition of 1912–1913. Deposited with material in the British Museum (National History) is a series of specimens from the same host species, collected at North Cape, New Zealand (BMNH 1914, 6.1, 535–54) on the same expedition but not mentioned in their publication. They named their material simply '*Tetrarhynchus* sp.' Dollfus (1942) described in some detail metacestodes from an unknown teleost collected by Quoy and Gaimard in 1829 during the voyage of the 'Astrolabe' to Australia and the Pacific region. These specimens (MNHN $A_2R.$ 1140) he identified as *Nybelinia* (? *Syngenes*) sp. and considered them to be identical with Leiper and Atkinson's (1915) specimens. Robinson (1959) subsequently described the same species from metacestodes collected from *Thyrsites atun* (Euphrasen, 1791), *Zeus faber* Linnaeus, 1758 and *Trachurus novaezealandiae* Richardson, 1843 from Cook Strait, New Zealand, employing the same nomenclature as Dollfus (1942). He noted that every specimen of *Thyrsites atun* examined was heavily infected, while specimens of *Lepidopus caudatus* were not infected. He suggested that Leiper and Atkinson (1915) had misidentified the host species.

Korotaeva (1971) proposed the name *N. thyrsites* for apparently the same metacestode collected from Australian waters from the abdominal cavity of *Thyrsites atun*. The types are held in TINRO and were not examined. However, the material described by Leiper and Atkinson (1915) as well as that described by Dollfus (1942) was examined and compared with a metacestode and numerous adult specimens from

South Australian waters. All were judged to be conspecific and the adult is described here for the first time. Dollfus (1942) speculated on the basis of hook morphology, that the species belonged to the sub-genus *Syngenes* which is characterised by craspedote proglottides. In fact, the proglottides of the adult are acraspedote and the species therefore belongs to the sub-genus *Nybelinia*.

The adult of this species was found commonly in the gravid state in the stomach of *Mustelus antarcticus*. In other definitive hosts, the specimens were small and immature. Two immature speciments of *N. thyrsites* were found in only one of 35 *Aptychotrema vincentinana* examined.

Beumer *et al.* (1982) cited the species as *N. thyrsites* (Leiper & Atkinson, 1915) and were probably misled by Korotaeva's (1971) use of *nom. nov.* rather than *sp. nov.* at the head of her description. She stated however that the type specimen had been deposited in the collections held in TINRO (p. 75, 'typov'e exeplyap' khranyatsya v laboratorii parazitologii morskikh zhivotni'kh TINRO preparat' no. ANZ 4–35), clearly indicating that they are the types of a new species.

N. thyrsites is characterised by homoeomorphous hooks 18–20 µm long, of comparable size on both sides of the tentacle. Species with similar morphological features are *N. strongyla* Dollfus, 1960, *N. edwinlintoni* Dollfus, 1960, *N. eureia* Dollfus, 1960, *N. palliata* (Linton, 1924), *N. anantaramanorum* Reimer, 1980 and *N. lingualis* (Cuvier, 1817). *N. strongyla*, *N. anantaramanorum* and *N. lingualis* have sharply recurved hooks whose shape differs significantly from those of *N. thyrsites*. *N. palliata* belongs to the sub-genus *Syngenes* as the strobila is craspedote, whereas *N. thyrsites* has acraspedote proglottides and belongs to the sub-genus *Nybelinia*. *N. eureia* differs from *N. thyrsites* in having longer hooks (24–25 µm), a much longer pars postbulbosa of 0.54 mm compared with a maximum of 0.024 mm in *N. thyrsites*, in having a pars bothridialis which extends to the posterior end of the bulbs and in lacking an expansive bothridial fossa.

Nybelinia sphyrnae Yamaguti, 1952
(Figs. 15–17)

Nybelinia sphyrnae Yamaguti, 1952: 56–58, figs. 83–84.

Types

Adult cestodes from *pars pylorica* of *Sphyrna zygaena* (Linnaeus, 1758), Nagasaki, Japan, in MPM (not examined).

Material examined

Adults. From *Sphyrna zygaena* (Linnaeus, 1758): 3 specimens, Goolwa, S.A. (AHC 24958).

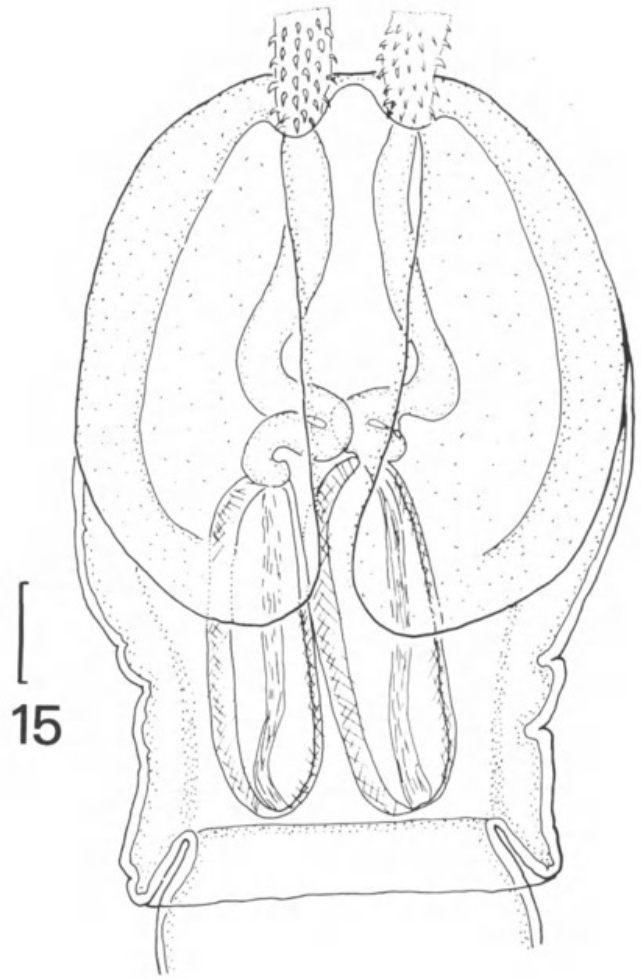
Remarks

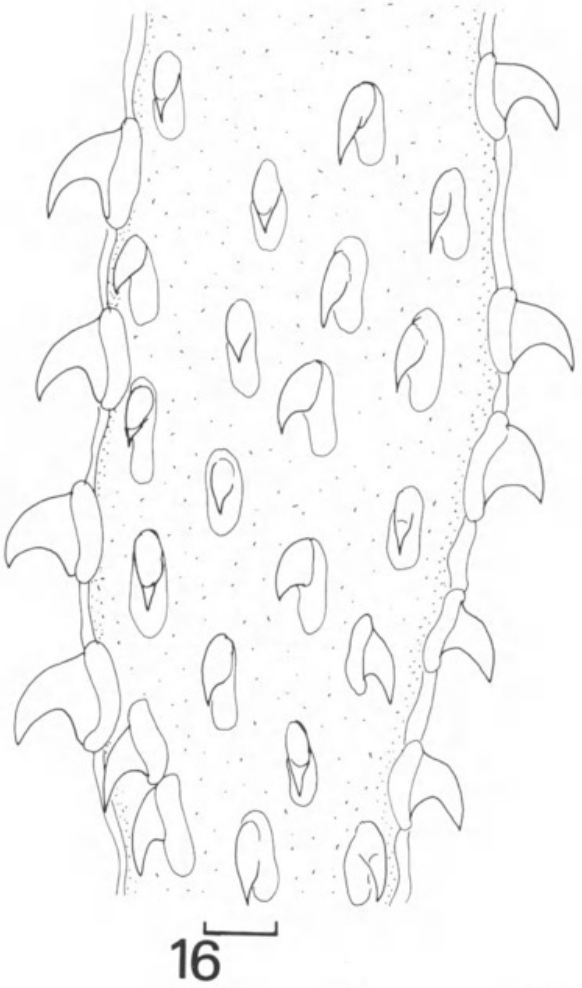
This species is readily recognisable from Yamaguti's (1952) description, and, as indicated by the illustrations, the Australian material is clearly referrable to this species. Yamaguti (1952) stated that an internal seminal vesicle was absent, however it is present in Australian specimens (Fig. 17), and Yamaguti's figure 84 shows a coiled proximal region of the cirrus which may form an internal seminal vesicle in fully mature proglottides. In addition, a small seminal receptacle was present in the Australian specimens, though not noted or illustrated by Yamaguti (1952).

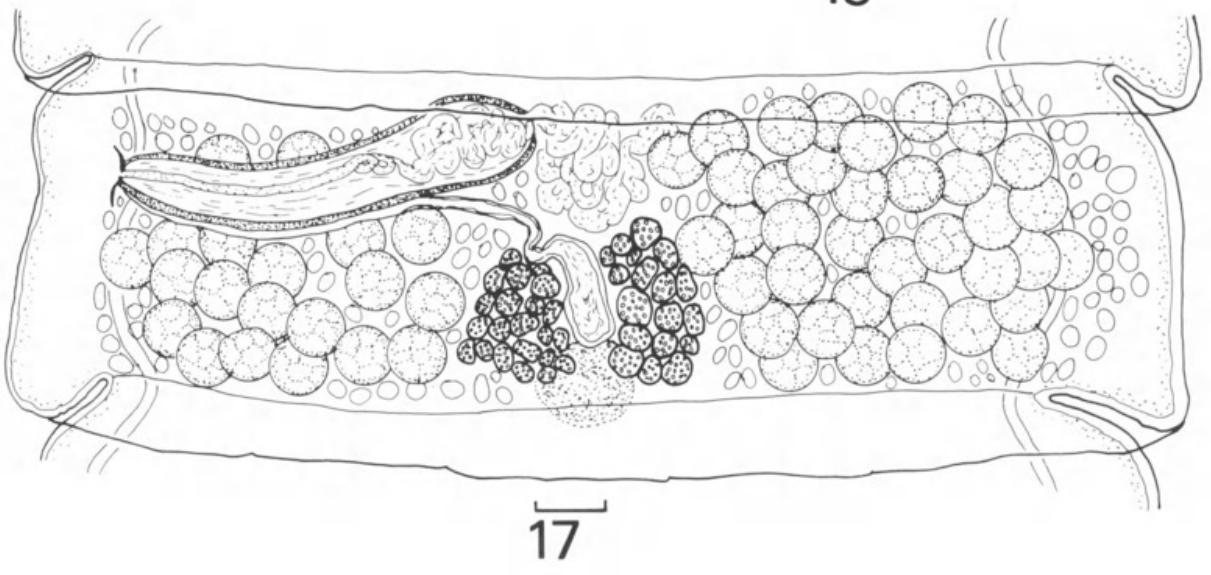
The species has not been reported subsequent to its original description (see Bates 1990), but would appear from the two records of the species to be restricted to *Sphyrna zygaena* in both northern and southern hemispheres.

N. sphyrnae differs from other species reported from hammer-head sharks, *N. edwinlintoni* Dollfus, 1960, *N. goreensis* Dollfus, 1960 from *Sphyrna lewini* (Griffith & Smith, 1834) (syn. *S. diplana* Springer, 1941) as well as *N. palliata* (Linton, 1924) and *N. syngenes* (Pinter, 1929) from *Sphyrna zygaena* in a number of features. Based on Pinter's (1929) description, it differs from *N. syngenes* in which the pars vaginalis exceeds the pars bothridialis and is differentiated from Linton's (1924) *N. palliata* in which the bothridia extend beyond the bulbs.

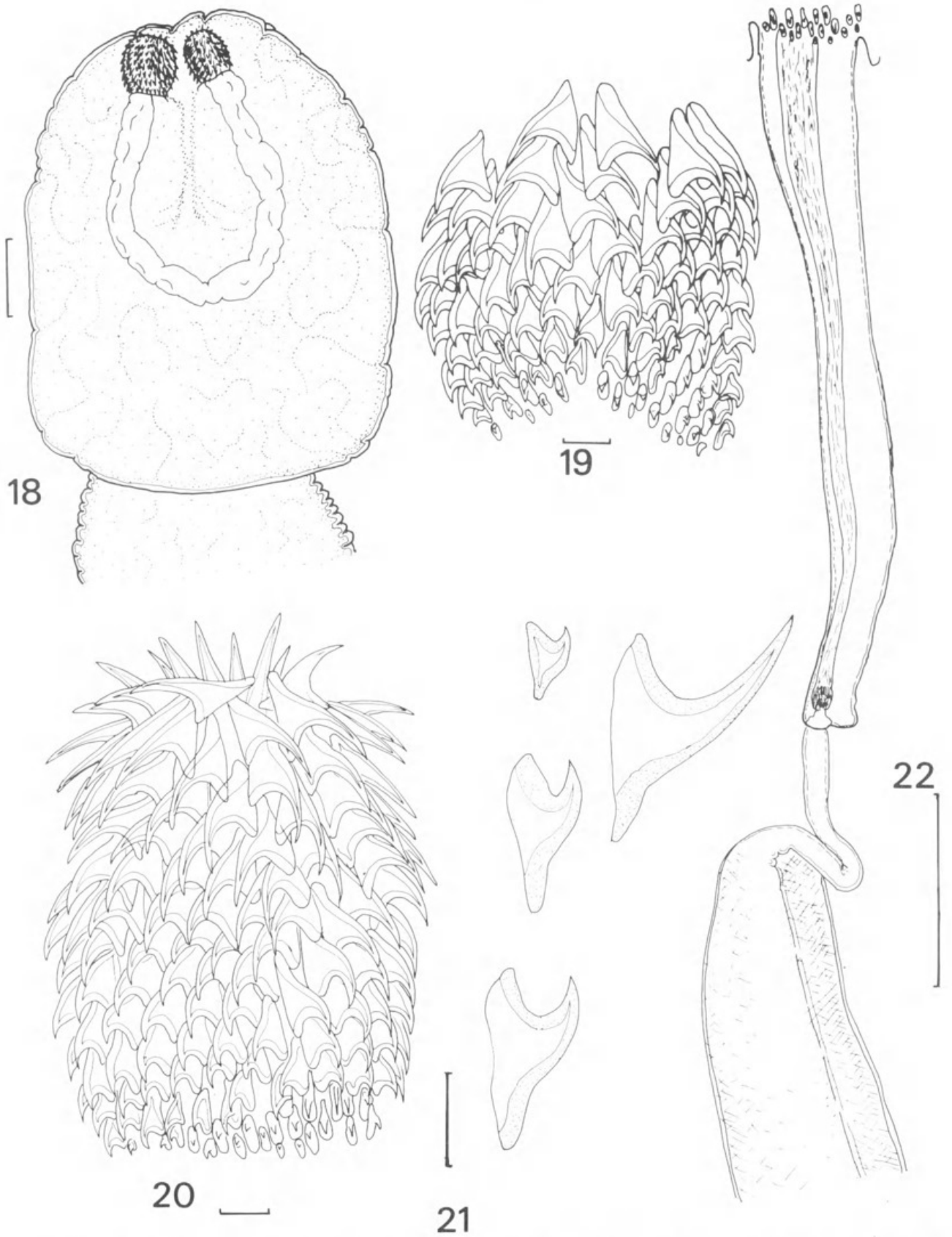
N. sphyrnae differs from *N. goreensis* as described by Dollfus (1960), in having smaller, more sharply recurved hooks (14–21 µm in *N. sphyrnae*, 27–30 um in *N. goreensis*) and a shorter velum (0.08–0.13 mm in *N. sphyrnae*, 0.18 –0.23 mm in *N. goreensis*). *N. sphyrnae* resembles *N. edwinlintoni* in hook size but differs in that *N. sphyrnae* has virtually no pars post-bulbosa, whereas in *N. edwinlintoni* it measures 0.29 mm. In spite of these apparent differences, the available descriptions of *N. palliata* are poor, while that of *N. edwinlintoni* is based on a single larval specimen. Therefore the identification is contingent upon *N. sphyrnae* being a valid species, recognizably distinct from those closely







FIGURES 15–17. *Nybelinia sphyrnae* Yamaguti, 1952. **15.** Scolex. **16.** Basal armature of scolex, bothridial view. **17.** Mature proglottis. Specimens from *Sphyrna zygaena* (Linnaeus, 1758) (AHC 24958). Scale bars: Figures 15, 17, 0.1 mm; Figure 16, 0.01 mm.



FIGURES 18–22. *Hepatoxylon trichiuri* (Holten, 1802). **18.** Scolex. **19.** Tentacle, basal region, internal surface, showing V-shaped area at base, free of hooks. **20.** Entire tentacle, bothridial surface. **21.** Series of alternate hooks of a single file in profile showing variation in size. **22.** Sheath and bulb showing origin of retractor muscle at junction of wide and narrow regions of sheath. Specimens from *Carchardon carcharias* (Linnaeus, 1758) (AHC 24933). Scale bars: Figures 18, 22, 1.0 mm; Figures 19–21, 0.1 mm.

related congeners on the basis of characteristics with which it is currently compared.

Family HEPATOXYLIDAE Dollfus, 1940

Genus ***Hepatoxylon*** Bosc, 1811

This genus contains two species which are cosmopolitan (Dollfus 1942), though Yamaguti (1959) and Schmidt (1986) considered them synonymous. Sin *et al* (1992) have recently provided electrophoretic as well as morphological evidence that the two species are valid.

Hepatoxylon trichiuri (Holten, 1802)
(Figs 18–21, 56–57)

Synonymy — see Dollfus (1942)

Material examined

Adults. From *Carcharodon carcharias* (Linnaeus, 1758): 2 specimens, Dangerous Reef, S.A. (AHC 24933); 4 specimens, Seal Rocks, Phillip Is., Vic. (AHC 24934). From *Isurus oxyrinchus* Rafinesque, 1810: 2 specimens, Southern Australia (coll. RJGL).

Metacestodes. From *Xiphias gladius* Linnaeus, 1758: 1 specimen, Cronulla, N.S.W. (AHC 71, 1407, S2561, S2531, 17593); 6 specimens, Port River, S.A. (AHC 6668). From *Cyttus traversi* (Hutton, 1872): 1 specimen, west coast, Tasmania (Coll. RJGL). From *Coryphaena hippurus* Linnaeus, 1758: 1 specimen, Barwon Banks, 20 miles NE of Mooloolaba, Qld. (AHC 18499). From *Hoplostethus atlanticus* Collet, 1889: 1 specimen, west coast of New Zealand (QM G212141). From *Rexea solandri* Cuvier, 1831: 2 specimens, Great Australian Bight (QM G211886), 1 specimen, south-eastern Tasmania (QM G211887). From *Macruronus novaezelandiae* (Hector, 1871): 2 specimens, west coast of Tasmania (QM G212137).

Remarks

Records of this species from the Australian region are few, being those of Korotaeva (1974) from *Oplegnathus woodwardi* (Waite, 1900) (Syn. *Ostorhinchus conwaii* (Richardson, 1840)), Korotaeva (1971) from *Lepidopus caudatus* (Euphrasen, 1788) (syn *Lepidopus lex* Phillips, 1932) and Lester *et al.* (1988) from *Hoplostethus atlanticus* Collett, 1889 from southern Australia as well as a record from a lamprey, *Geotria australis* Gray, 1851 by Lethbridge *et al.* (1983). The present data therefore greatly extend the known host range of this species in Australian waters.

The species occurs in a range of teleosts and elasmobranchs in New Zealand waters (Robinson 1959; Waterman & Sin 1991), but the definitive host in the Australasian region has not been reported previously. The parasite is reported here for the first time from *Carcharodon carcharias* and *Isurus oxyrinchus*. The adult has been described by Lönnberg (1899), Joyeux and Baer (1934, 1936) and Yamaguti (1934), the details of which were summarised by Dollfus (1942). The histological anatomy of the plerocercus has been described in considerable detail by Rees (1941) under the name *Dibothriorhynchus grossum* (Rudolphi, 1819). The arrangement of hooks in the metabasal region is quincunxial (see Figs 56, 57) and on the bothridial surface, this pattern extends to the base (Fig. 57). On both the internal and external tentacle surfaces (Fig. 56), the ascending rows of hooks leave an inverted V-shaped area at the base of the tentacle, analogous to the arrangement seen in *T. coryphaenae*. This area is only clearly visible in tentacles dissected free from the scolex, and when this is done, it is extremely difficult to determine orientation of surfaces. Orientation in this case has been determined by analogy with *T. coryphaenae* and from one flattened, stained whole mount in which all the hooks are visible (AHC S2351). It has been assumed that flattening has not altered the arrangement of the hook rows.

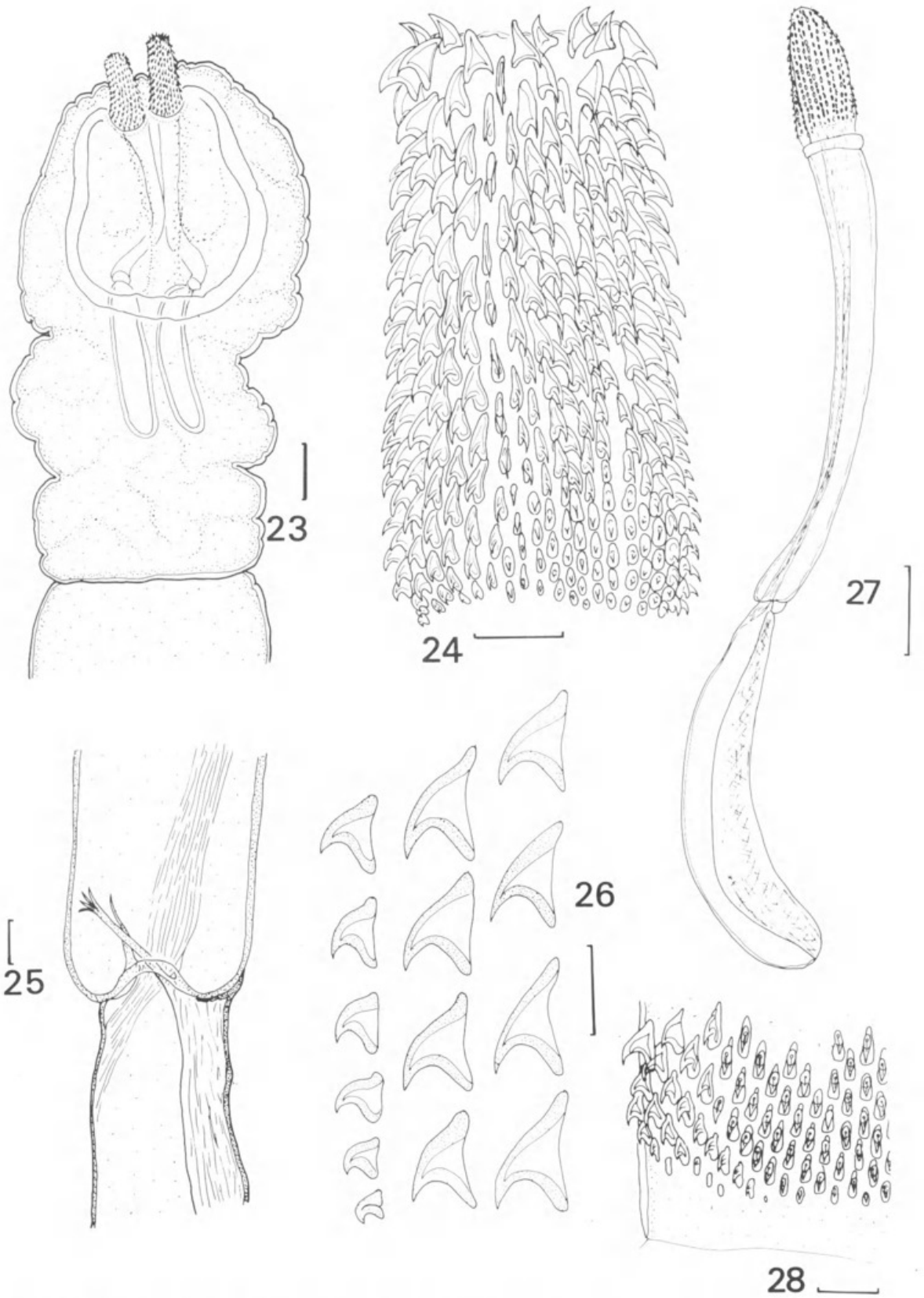
Hepatoxylon megacephalum (Rudolphi, 1819)
(Figs 23–28, 58–59)

Synonymy — see Dollfus (1942)

Material examined

Adults. From *Carcharodon carcharias* (Linnaeus, 1758): 3 specimens, Kangaroo Island, S.A. (AHC 24932).

Metacestodes. From *Galeorhinus galeus* (Linnaeus, 1758): 1 specimen, Kangaroo Island, S.A. (AHC 17591); 1 specimen, Pt. Willunga, S.A. (AHC 593, S2564); 1 specimen, coast of N.S.W. (AM W 3452). From *Carcharhinus obscurus* (LeSueur, 1818) (Syn. *C. macrurus* (Ramsay & Ogilby, 1887): 2 specimens, Glenelg, S.A. (AHC 585, S2565). From *Squalus megalops* (Macleay, 1881): 2 specimens, south coast of N.S.W. (AM W 3359, W 3453). From *Squatina*



FIGURES 23–28. *Hepatoxylon megacephalum* (Rudolphi, 1819). **23.** Scolex. **24.** Entire tentacle, internal surface, showing V-shaped area at base, free of hooks. **25.** Junction of sheath and bulb, showing origin of retractor muscle. **26.** Series of single file of hooks in profile showing size variation. **27.** Rhyncheal system. **28.** Base of tentacle, bothridial view, internal surface to left, showing ascending rows of hooks around unarmed region at base. Specimens from *Carcharodon carcharias* (Linnaeus, 1758) (AHC 24932); Fig. 28 from *Galeorhinus galeus* (Linnaeus, 1758) (AHC 17591). Scale bars: Figures 23, 27, 1.0 mm; Figure 24, 0.2 mm; Figures 25, 26, 28, 0.1 mm.

australis Regan, 1906: 2 specimens, N.S.W. (AM W 3358)

Remarks

This species has not apparently been reported previously from Australia (see Beumer *et al* 1982) though it is well represented in museum collections. Plerocerci were found in several species of elasmobranchs, while the only adults seen were from *Carcharodon carcharias*.

The morphology of the plerocerus has been summarised by Dollfus (1942), with scanning electron microscopical observations by added Sin *et al* (1992), while the adult has been described from *C. carcharias* from New Zealand by Robinson (1959).

The rhyncheal system of this species has apparently not been described in detail. It appears to differ from that of *H. trichiuri* in that the sheaths are not divided into a distal region of greater diameter than the proximal section and in that the retractor muscle originates from the sheath close to the bulbs, rather than at the junctions of the two distinct regions of the sheath noted in *H. trichiuri* (see Rees, 1941).

As with *H. trichiuri, H. megacephalum* has an armature arranged in quincunxial fashion in the metabasal region, but with ascending hook rows leaving hook-free triangular areas at the base of the tentacle on the internal and external surfaces. The hook patterns in the metabasal region are not totally regular and if hook files are traced; several files from the base disappear in the metabasal region. The disappearance of files has been noted previously in the armature of *Sphyriocephalus dollfusi* by Bussieras and Aldrin (1968), though in that species, the arrangement of abbreviated files is symmetrical about the plane drawn through the mid-region of the external surface of the tentacle. In *H. megacephalum*, no symmetry in the reduction of hook files was noted.

Family SPHYRIOCEPHALIDAE Pintner, 1913

Genus ***Sphyriocephalus*** Pintner, 1913

Sphyriocephalus tergestinus Pintner, 1913
(Figs. 29 – 32, 60)

Synonymy — see Dollfus (1942)

Material examined

Metacestodes. From *Macruronus novaezelandiae* (Hector, 1871): 2 specimens, Tasmania (QM G212133–5).

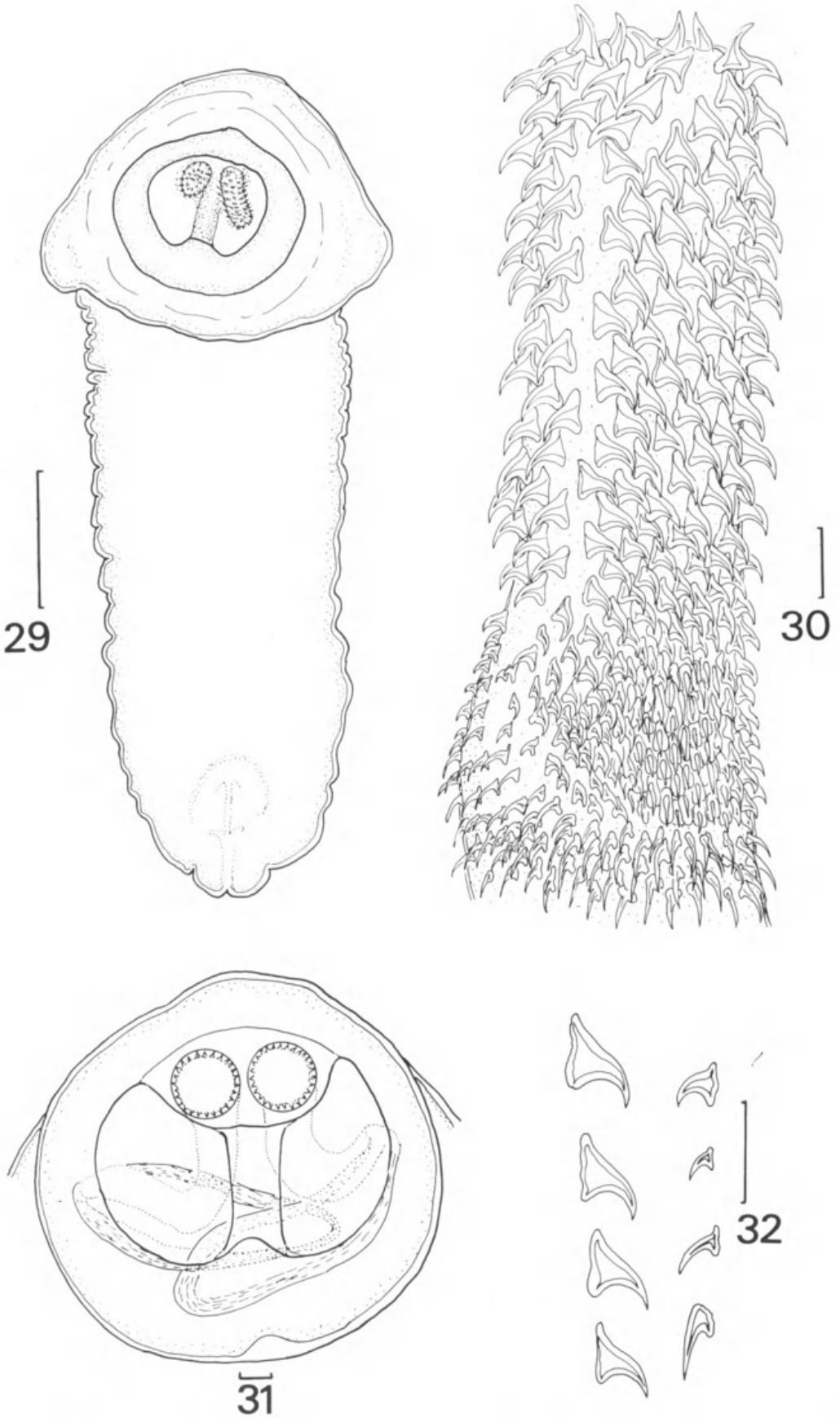
Remarks

The family Sphyriocephalidae has not previously been reported from Australian waters. The specimens illustrated here are tentatively referred to *S. tergestinus*, contingent upon subsequent clarification of the validity of species within the genus. Dollfus (1942) recognised two valid species, *S. viridis* and *S. tergestinus*, and listed (p. 116) a series of criteria by which the two could be distinguished. His synonymies assumed *S. alberti* to be a synonym of *S. viridis*, a situation subsequently confirmed by Bussieras (1970) who re-examined the types of *S. alberti*. The detailed descriptions of the armature of *S. alberti* given by Bussieras (1970) are the most detailed and informative descriptions of armature within the genus. Heinz and Dailey (1974) gave a very brief description of *S. pelorosoma* from *Alopias superciliosus* (Lowe, 1839) from California, based on a single specimen. The principal features they used for distinguishing their new species were the greater widths of the tentacles and relatively longer bulbs (Heinz & Dailey 1974). The latter character must remain questionable until measurements for *S. viridis* and *S. tergestinus* are available. Dollfus (1942) cited Pintner (1913) in reporting that the bulbs of *S. tergestinus* were twice as long as wide, yet illustrated them (Fig. 72) as being four times as long as wide. The value of this character in distinguishing species therefore remains uncertain until the extent of variation is established for *S. viridis* and *S. tergestinus*.

Bussieras and Aldrin (1968) described *S. dollfusi* based on plerocerci from tuna, *Thunnus obesus* (Lowe, 1839), distinguished from *S. tergestinus* and *S. viridis* in lacking a unique basal armature and having broad tentacles, similar in width to those of *S. pelorosoma*.

The specimens described here differ from *S. viridis* and *S. dollfusi* in that the sheaths are confined within the pars bothridialis. The specimens described conform with the description given by Dollfus (1942) of *S. tergestinus* and are therefore attributed to that species.

Bussieras (1970) noted that the armature of the metabasal region of the tentacle of *S. viridis* (= *alberti*) was arranged in an heteroacanthous pattern rather than an homeoacanthous pattern and questioned whether or not this was a specific characteristic. Although the current material of *S. tergestinus* is limited, it appears that it also has



FIGURES 29–32. *Sphyriocephalus tergestinus* Pintner, 1913. **29.** Plerocercus. **30.** Oblique view of tentacle with bothridial surface to lefthand side. **31.** Scolex of plerocercus, showing bulbs in transverse position, overlapped by the pars bothridialis. **32.** Tentacular hooks showing variation in shape between those of metabasal region (left file) and basal region (right file). Specimens from *Macruronus novaezelandiae* (Hector, 1871) (QM G212133–5).

glide reflection symmetry (Campbell & Beveridge 1994) in the arrangement of its armature in the metabasal region.

Superfamily OTOBOTHRIOIDEA Dollfus, 1942

Family OTOBOTHRIIDAE Dollfus, 1942

Genus ***Poecilancistrium*** Dollfus, 1929

Poecilancistrium caryophyllum (Diesing, 1850) (Figs 33 – 47)

Synonymy — see Dollfus (1942)

Material examined

Adults. From *Carcharhinus brachyurus* (Guenther, 1870): 8 specimens, Tathra, N.S.W. (AHC 24957);

Metacestodes. From *Pomatomus saltatrix* (Linnaeus, 1766): 3 specimens, Pt Jackson, N.S.W. (AHC 1410, S2563). From *Sillago robusta* Stead, 1908: 3 specimens, Qld. (QM G212164).

Description

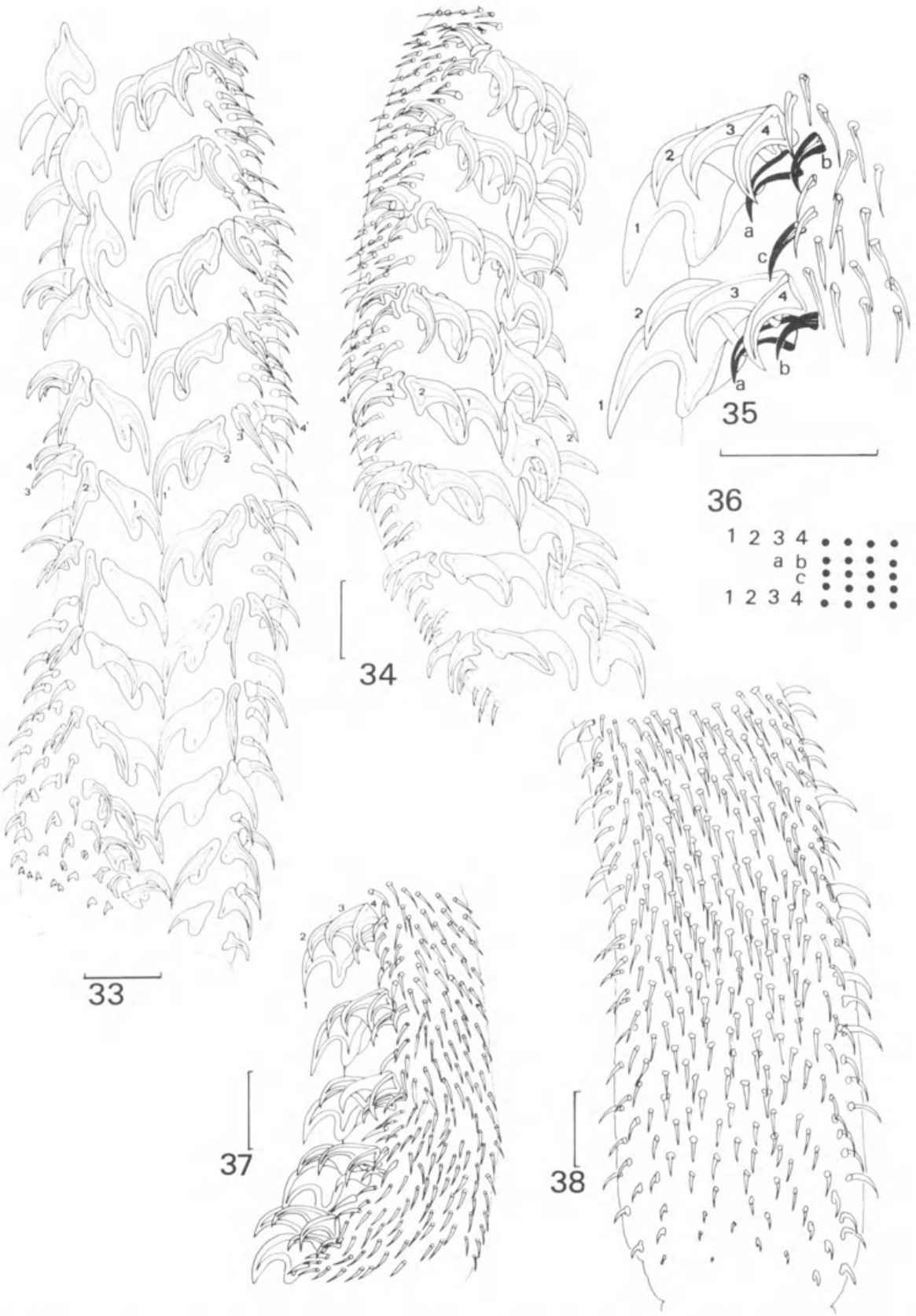
Cestodes of moderate size, up to 170 long, with up to 280 proglottides in gravid strobilae. Scolex 3.9–4.6 (3.3) (n=8) long, maximum width 1.1–1.4 (1.3) (n=8) in region of pars vaginalis; 2 bothridia, 2.0 (n=1) in diameter; almost circular, with indistinct, fleshy margins; pairs of sensory fossettes present in margin of each bothridium. Pars bothridialis 1.55–2.00 (1.77) (n=8). Pars vaginalis 1.65–2.48 (2.22) (n=8), sheaths not coiled, straight anteriorly, characteristically S-shaped posteriorly; pre-bulbar organ absent, but prominent muscle band encircling junction of sheath with bulb. Bulbs stout, 1.35–1.76 (1.59) (n=8) long by 0.32–0.42 (0.38) (n=8) wide; origin of retractor muscle at anterior end of bulb. Pars post-bulbosa approx. 0.22; velum absent. Tentacles stout, 0.08–0.13 (0.11) (n=7) in diameter in metabasal region, without basal swelling or distinctive basal armature. Armature heteroacanthous, atypical; principal hooks arranged in ascending rows; 4 hooks per row decreasing in size anteriorly; hooks 1(1') largest, 0.114–0.126 (0.120) long, strongly recurved, base prominent, 0.084–0.100 (0.087) long; hooks 2(2') smaller, 0.092–0.098 (0.095) long, base 0.048–0.052 (0.050); hooks 3(3') 0.068–0.082 (0.075) long, base 0.034–0.040 (0.036); hooks 4(4') smallest, 0.054–0.064 (0.061) long, base 0.022–0.032 (0.029).

Single intercalary row of hooks present between each major row; 2, sometimes 3, intercalary hooks per row, situated proximal to hooks 3(3') and 4(4') respectively; intercalary hooks a(a') 0.046–0.054 (0.049) long, hooks b(b') 0.036–0.046 (0.041) long; single hook, c(c´) possibly representing second intercalary row, present posterior to other hooks. Internal surface of tentacle uniformly covered with numerous ascending rows of small hooks, 0.030–0.036 (0.034) long. Rows ascending with approximately 14 hooks per row; 4 rows per principal hook row.

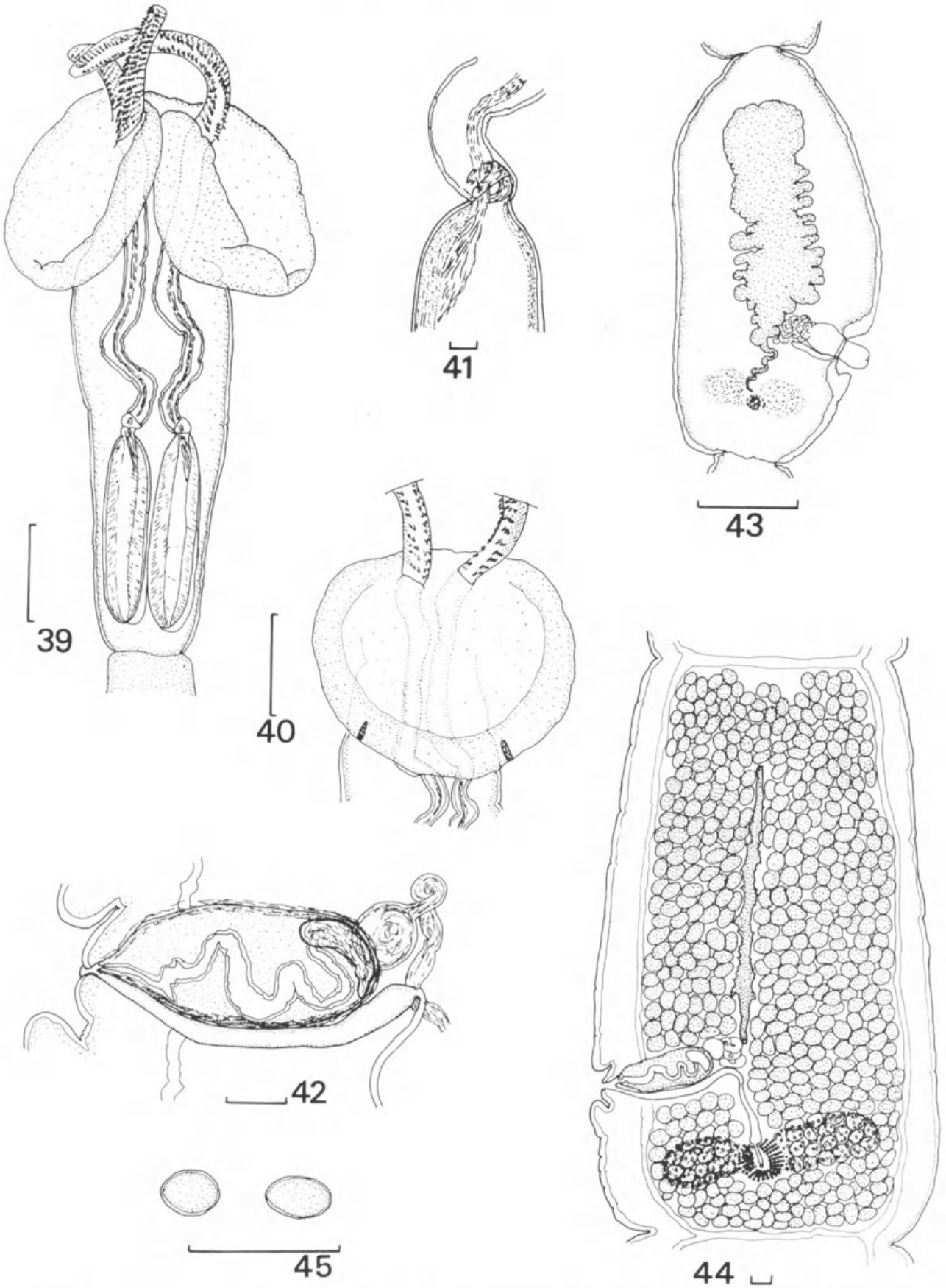
Mature proglottis 1.43–2.02 (1.78) (n=9) by 1.25–1.40 (1.30) (n=9); genital pore in posterior third of proglottis, 1.07–1.50 (1.28) (n=9) from anterior end of proglottis. Cirrus sac pyriform, thin-walled, 0.21–0.28 (0.25) by 0.14–0.19 (0.16); cirrus unarmed, slightly coiled, entering crescentic internal seminal vesicle; external seminal vesicle spherical, adnate to cirrus sac. Vas deferens coils posteriorly to region of ovary. Testes numerous, 550 (n=1) per proglottis, occupying entire medulla in single dorso–ventral layer; testis diameter 0.045–0.065 (0.053). Vagina opens to genital atrium posterior to cirrus sac; narrow, turning posteriorly at midline and descending towards ovary, dilating slightly at posterior end, but not forming distinct seminal receptacle. Ovary bilobed, each lobe 0.30–0.50 (0.45) by 0.20–0.28 (0.25); Mehlis' gland 0.15–0.19 (0.17) in diameter, posterior to ovarian isthmus. Uterine duct, without glandular investment, ascends to just anterior to cirrus sac; uterus with glandular wall extends anteriorly, not reaching anterior end of proglottis. Gravid proglottis 3.0 to 3.2 by 1.0 to 1.5; uterus initially linear, becoming sacciform with numerous small lateral branches; eggs ellipsoidal approx. 0.036 by 0.026; uterine pore absent. Vitelline follicles forming sleeve encircling reproductive organs.

Remarks

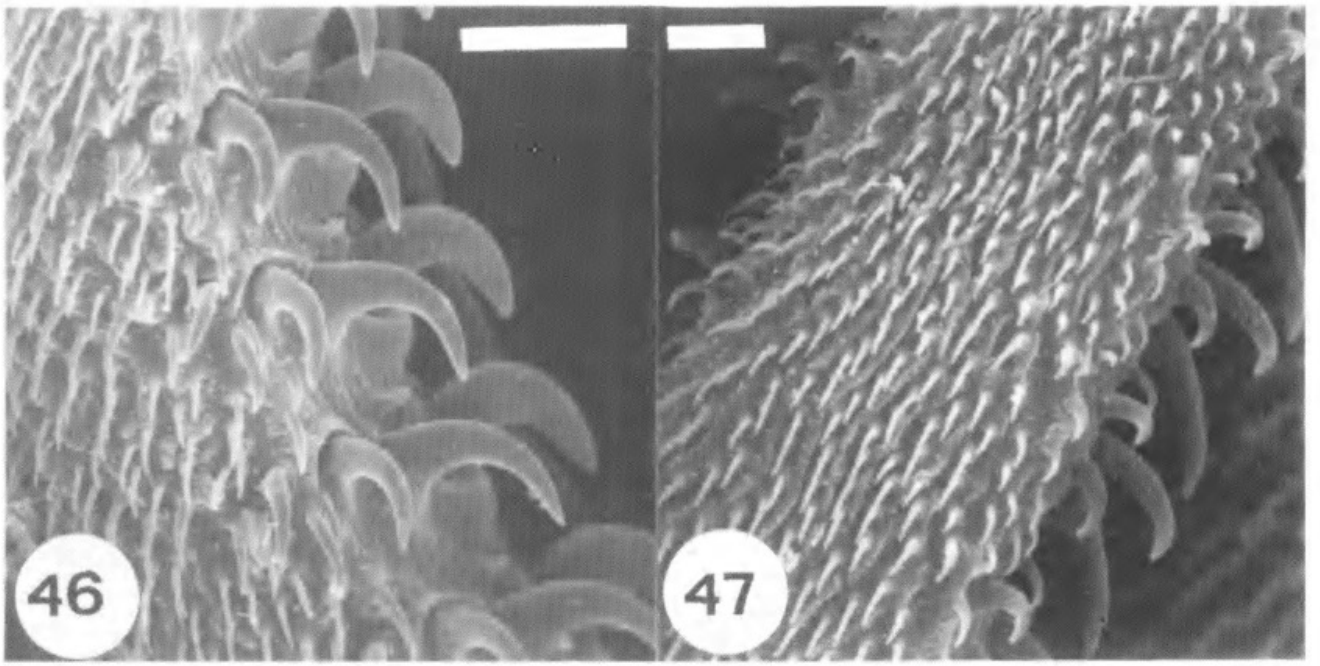
In spite of its cosmopolitan distribution, the anatomy of this species is relatively poorly known. The first report from Australia was that of Robinson (1965), who described plerocerci from *Argyrosomus hololepidotus* (Lacépède, 1802) (syn. *Sciaena antarctica* Castlenau, 1872) from New South Wales. The adult stage had been described earlier by Goldstein (1962, 1963) from American sharks. Robinson (1965) compared his specimens with those of Goldstein (1963). The armature of this species has recently been



FIGURES 33–38. *Poecilancistrium caryophyllum* (Diesing, 1850). Tentacular armature. **33.** Basal and metabasal region, internal surface. **34.** Metabasal region, bothridial surface. **35.** Two principal hook rows showing relationships between intercalary hooks and band of hooklets. **36.** Schematic representation of hook arrangements. Numerals indicate hooks of principal rows, letters are intercalary hooks; circles represent hooklets of external surface. **37.** Basal region, bothridial surface. **38.** Basal and metabasal regions, external surface. Specimens from *Carcharhinus brachyurus* (Guenther, 1870) (AHC 24957). Scale bars: 0.1 mm.



FIGURES 39–45. *Poecilancistrium caryophyllum* (Diesing, 1850). **39.** Scolex. **40.** Bothridium. **41.** Junction of sheath and bulb showing origin of retractor muscle. **42.** Cirrus sac. **43.** Gravid proglottis. **44.** Mature proglottis. **45**. Eggs. Specimens from *Carcharhinus brachyurus* (Guenther, 1870) (AHC 24957). Scale bars: Figures 39, 40, 43, 1.0 mm; Figures 41, 42, 44, 45, 0.1 mm.



FIGURES 46–47. *Poecilancistrium caryophyllum* (Diesing, 1850). Scanning electron micrographs of armature. **46.** Bothridial surface, metabasal region, showing junction of principal rows of hooks with band of hooklets on external surface. **47.** External surface, metabasal region showing band of hooklets. Specimens from *Carcharhinus brachyurus* (Guenther, 1870). Scale bars: 0.1 mm.

redescribed by Palm (1995) based on specimens from Atlantic teleosts.

The present description of the adult provides additional information, in demonstrating the presence of a crescentic internal seminal vesicle, a circular external seminal vesicle adnate to the cirrus sac and in describing the morphology of the gravid uterus.

The most significant aspect of the current redescription is the oncotaxy. Although adequately described by Robinson (1965), the only attempt to interpret the pattern of hooks is that of Campbell and Beveridge (1994) and Palm (1995). The external surface of the tentacle of *P. caryophyllum* is covered by a band of small hooks. The features not noted in previous descriptions are associated with the regularity of arrangement of the small hooks comprising the band. They are arranged in ascending rows, with four between each principal row, and with the ascending rows terminating in the midline of the external surface. Some minor departures from the regular pattern are detectable, with the presence of an occasional hook which does not fit within a row. However, these irregularities are rare, and at the base of the tentacle the hook files form a convergence as seen in typical heteroacanthous armature patterns.

Superfamily POECILACANTHOIDEA Dollfus, 1942

Family LACISTORHYNCHIDAE Guiart, 1927

Genus ***Callitetrarhynchus*** Pinter, 1931

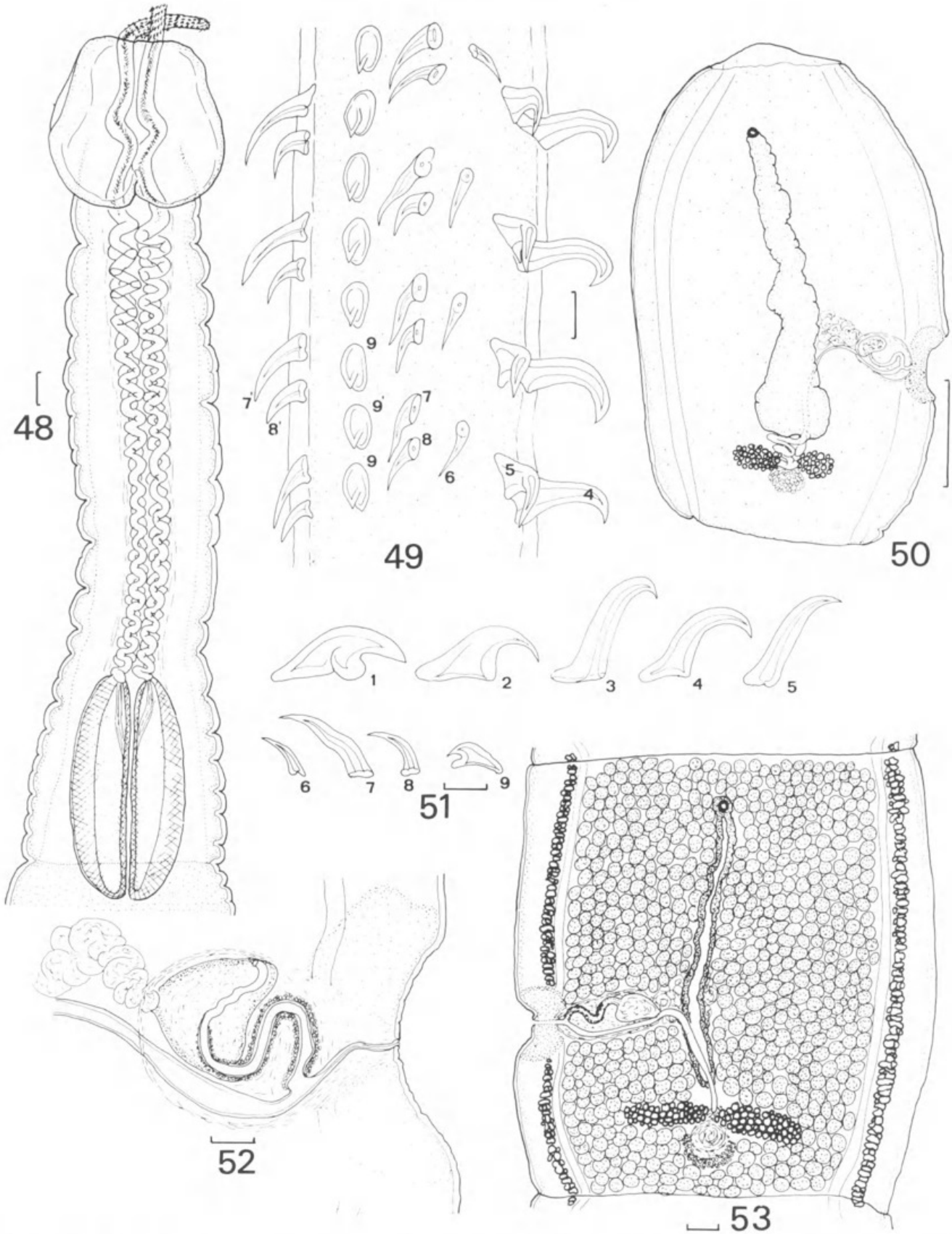
The genus was considered monotypic by Dollfus (1942). However, Carvajal and Rego (1985) have shown that Dollfus' description is a composite of *C. gracilis* and *C. speciosus*. Only *C. gracilis* has been found in Australian fishes to date.

Callitetrarhynchus gracilis (Rudolphi, 1819) (Figs 48 – 53)

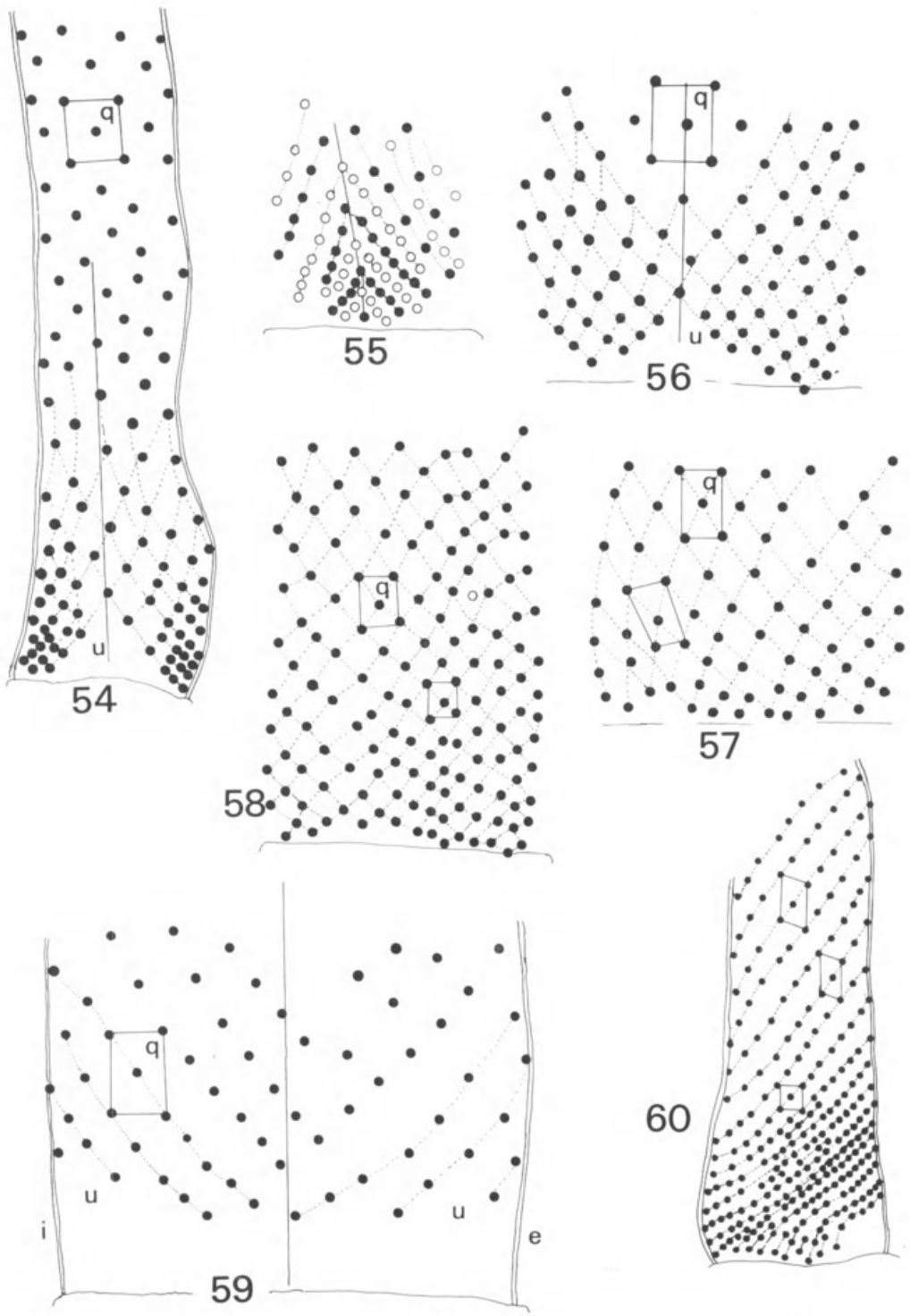
Synonymy — see Dollfus (1942)

Material examined

Adults. From *Carcharhinus amblyrhynchoides* (Whitley, 1934): 1 specimen, Snapper Island, Qld. (AHC 24941). From *Carcharhinus melanopterus* (Quoy & Gaimard, 1824): 3 specimens, Flat Top Island, Qld. (AHC 24940); 1 specimen, Darwin, N.T. (AHC 24939). From *Carcharhinus amboinensis* (Mueller & Henle, 1839): 1 specimen, Mary River, N.T. (AHC



FIGURES 48–53. *Callitetrarhynchus gracilis* (Rudolphi, 1819). **48.** Scolex. **49.** Tentacular armature, metabasal region, external surface. **50.** Gravid proglottis. **51.** Profiles of hooks 1–9. **52.** Terminal genital ducts showing cirrus and vagina uniting within 'cirrus sac' to form a short hermaphroditic duct. **53.** Mature proglottis. Specimens from *Carcharhinus fitzroyensis* (Whitley, 1943) (AHC 24937). Scale bars: Figures 48, 52, 53, 0.1 mm; Figures 49, 51, 0.01 mm; Figure 50, 1.0 mm.



FIGURES 54–60. Schematic arrangements of hook patterns. **54.** *Tentacularia coryphaenae*. Basal and metabasal regions, internal surface, showing ascending hook rows and V-shaped unarmed area (u) at base of tentacle. Hooks of metabasal region are arranged in quincunxes (q). Derived from Fig. 2. **55.** *Tentacularia coryphaenae*. Basal region bothridial surface (from Fig. 3), showing ascending rows of hooks. **56.** *Hepatoxylon trichiuri*. Basal and metabasal regions, internal surface (from Fig. 19), showing V-shaped unarmed area at base of tentacle (u) and quincunxial arrangement of hooks (q) in metabasal region. **57.** *Hepatoxylon trichiuri*. Basal and metabasal region, bothridial surface, showing quincunxial hook arrangement (q) (from Fig. 20). **58.** *Hepatoxylon megacephalum*. Basal and metabasal region, internal surface (from Fig. 24) showing quincunxial hook arrangement (q). **59.** *Hepatoxylon megacephalum*. Basal region, bothridial surface, showing ascending hook rows which form V-shaped unarmed areas (u) on internal (i) and external (e) surfaces and quincunxial hook arrangement (q). **60.** *Sphyriocephalus tergestinus*. Oblique view with bothridial surface to left (from Fig. 30) showing hooks arranged in ascending spiral rows in typical heteroacanthous pattern.

24938). From *Carcharhinus fitzroyensis* (Whitley, 1943): 6 specimens, Darwin N.T., (AHC 24937); 5 specimens, Mary River, N.T (AHC 24936). From *Dasyatis fluviorum* Ogilby, 1908: 1 specimen, Moreton Bay, Qld. (AHC 24942).

Metacestodes. From *Sphyraena novaehollandiae* Günther, 1860: Brighton, S.A. (AHC S539); Outer Harbour, S.A. (BMNH 1986. 10.1.2). From *Pristipomoides multidens* (Day, 1870): 1 specimen, Bathurst Island. N.T. (AHC 24943). From *Makaira indica* (Cuvier, 1832): 1 specimen, Cape Bowling Green, Qld. (AHC 17410); 5 specimens, Pixie Reef, Cairns, Qld. (AHC 17417). From *Makaira mazara* (Jordon & Snyder, 1901): 1 specimen, Cape Moreton, Qld. (QM G212785). From *Istiophorus platypterus* (Shaw & Nodder, 1791): 3 specimens, Cape Moreton, Qld. (AHC 18496); 2 specimens, Beaver Cay, Qld. (AHC 18495). From *Euthynnus affinis* (Cantor, 1849): 1 specimen, Cape Moreton, Qld. (AHC 18493). From *Saurida tumbil* (Bloch, 1795): 1 specimen, Moreton Bay, Qld. (Coll. RJGL). From *Scomberomorus commerson* (Lacépède, 1800): 1 specimen, Pt Lookout, Qld. (Coll. RJGL). From *Scomberomorus munroi* Collette & Russo, 1980: 3 specimens, Amity Pt, Qld. (Coll. RJGL). From *Platycephalus fuscus* Cuvier, 1829: 1 specimen, Moreton Bay, Qld. (QM G212172). From *Arripis trutta* (Bloch & Schneider, 1801): 3 specimens, Phillip Island, Vic. (AHC 24944). From *Arripis truttaceus* (Cuvier, 1829): 1 specimen, Phillip Island, Vic. (AHC 24945).

Remarks

This cosmopolitan species has previously been reported from Australia only by Prudhoe (1969) from *Platycephalus bassensis* Cuvier, 1829 from Tasmania and by Adjei *et al* (1986) from *Saurida tumbil* (Bloch, 1795) and *S. undosquamis* (Richardson, 1848) from Queensland. The identification of the Queensland specimens was confirmed, however, the Tasmanian specimens (SAM V604) on re-examination proved to be *Floriceps minacanthus* Campbell & Beveridge, 1986, and have not therefore been included in the list of material examined. The scolex and armature of *C. gracilis* were well described by Dollfus (1942) but unfortunately, the description was a composite of *C. gracilis* and *C. speciosus*. The scolex and armature of both species were illustrated and described by Carvajal and Rego (1985). The adult was described very briefly under the name *Tentacularia pseudodera* by Shuler (1938). A more complete description was provided by Subhapradha (1955). It is clear from Subhapradha's figures of the armature that the specimens described are indeed *C. gracilis* rather than *C. speciosus*, since hooks 7(7') are much longer than hooks 8(8'). However, Subhapradha's (1955) description needs to be amended at three points. Firstly, a muscular pad surrounds the genital atrium (Fig. 53). This very prominent feature was not mentioned or illustrated by Subhapradha (1955). Secondly, an hermaphroditic duct is present (Fig. 52). The vagina enters the cirrus sac (actually an hermaphroditic sac) on its medio–ventral aspect then runs within the sac the join with the cirrus leaving a short hermaphroditic duct to enter the genital atrium. The presence of a hermaphroditic duct was first reported by Beveridge and Campbell (1989) and was illustrated by them subsequently (Campbell & Beveridge 1994). All known genera with chainettes and two bothridia have hermaphroditic ducts (Beveridge & Campbell 1989). Thirdly, a uterine pore is present. This feature was not included in the generic diagnosis given by Campbell and Beveridge (1994).

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