

Article

Dactylogyrids (Platyhelminthes: Monogenoidea) Infecting the Gill Lamellae of Flatheads (Scorpaeniformes: Platycephalidae), with Proposal of *Platycephalotrema* n. gen. and Descriptions of New Species from Australia and Japan

Delane C. Kritsky ^{1,*} and Masato Nitta ² 

¹ Health Education Program, School of Health Professions, Campus Box 8090, Idaho State University, Pocatello, ID 83209, USA

² Graduate School of Science, Kobe University, 1-1 Rokkodai-chō, Nada, Kōbe 657-8501, Japan

* Correspondence: kritdela@isu.edu

<http://zoobank.org/urn:lsid:zoobank.org:pub:9A0381E7-7B58-4950-82C3-2714D44CF426>



Received: 9 July 2019; Accepted: 7 August 2019; Published: 12 August 2019

Abstract: *Platycephalotrema* n. gen. (Dactylogyridae) is proposed for four new species and 5 previously described species parasitizing the gills of flatheads (Scorpaeniformes: Platycephalidae) as follows: *Platycephalotrema ogawai* n. sp. (type species) from *Platycephalus* sp. 1 (type host) and *Platycephalus* sp. 2, both of Nakabo & Kai (2013) (locally known as “Yoshino-gochi” and “Ma-gochi,” respectively) (Japan); *Platycephalotrema austrinum* n. sp. from *Platycephalus endrachtensis* Quoy & Gaimard (type host) and *Platycephalus* sp. (Australia); *Platycephalotrema bassensis* (Hughes, 1928) n. comb. from *Platycephalus bassensis* Cuvier (Australia); *Platycephalotrema koppa* n. sp. from *Platycephalus fuscus* Cuvier (Australia); *Platycephalotrema macassarensis* (Yamaguti, 1963) n. comb. from *Platycephalus indicus* (Linnaeus) (China, Macassar); *Platycephalotrema mastix* n. sp. from *P. fuscus* and *P. endrachtensis* (Australia); *Platycephalotrema platycephali* (Yin & Sproston, 1948) n. comb. from *P. indicus* (China) and *P. fuscus* (Australia); *Platycephalotrema sinensis* (Yamaguti, 1963) n. comb. from *Cociella punctata* (Cuvier) (China); *Platycephalotrema thysanophrydis* (Yamaguti, 1937) n. comb. from *Inegocia japonica* (Cuvier), *Inegocia ochiaii* Imamura, and *Cociella crocodilus* (Cuvier) (Japan, China). Other species requiring further study but potentially members of *Platycephalotrema* include *Ancyrocephalus vesiculosus* Murray, 1931, *Haliotrema indicum* Tripathi, 1957, *Haliotrema swatowensis* Yao, Wang, Xia, & Chen, 1998, and *Haliotrema pterois* Paperna, 1972. The primary features differentiating *Platycephalotrema* include species having: (1) tandem gonads (testis postgermarial); (2) two prostatic reservoirs, each emptying independently into the base of the male copulatory organ; (3) a dextral vaginal pore and large vaginal vestibule; (4) dorsal and ventral pairs of morphologically similar anchors; (5) a ventral bar with spatulate ends; (6) a dorsal bar with bifurcated ends, and (7) absence of an accessory piece. The new species are described, and *P. thysanophrydis* is redescribed based on newly collected and museum specimens.

Keywords: parasites; Platyhelminthes; Monogenoidea; Dactylogyridae; *Platycephalotrema* n. gen.; flathead; *Platycephalus*; Scorpaeniformes; Platycephalidae

1. Introduction

The Platycephalidae (Scorpaeniformes) is currently comprised of 88 species commonly known as flatheads. All but one species occur in the brackish and marine waters of the Indo-Pacific Ocean; the Guinea flathead *Solitas gruvelli* (Pellegrin) occurs in the eastern Atlantic Ocean off Africa. The family

includes 18 genera: *Platycephalus* (with 21 species); *Thysanophrys* (11 species); *Onigocia* (9 species); *Rogadius* (8 species); *Cociella*, *Sorsogona* and *Sunagocia* (5 species each); *Cymbacephalus*, *Grammoplites* and *Ratabulus* (4 species each); *Inegocia* and *Suggrundus* (3 species each); and *Kumococius*, *Papilloculiceps*, *Solitas*, *Leviprora*, *Ambiserrula* and *Elates* (all monotypic) [1]. Although flatheads have a wide distribution within the Indo-Pacific Region and are economically important as recreational and commercial fishes in parts of the region [2], studies dealing with their dactylogyrid parasites are limited. To date, only seven dactylogyrid species have been described from five of the 88 species of flatheads listed in Eschmeyer's Catalog of Fishes [1].

The present paper, in part, represents the fourth installment recording the monogenoidean fauna of Moreton Bay, Queensland, Australia, and was supported by an Australian Biological Resources Study Grant to Drs. Thomas Cribb and Scott Cutmore at the University of Queensland, St. Lucia, Australia. Previous installments included the monogenoids infecting three species of beloniform fishes [3], two gerreid species [4] and two species of lutjanids and a monodactylid [5]. In addition to including the proposal of a new dactylogyrid genus and description of three new species occurring on flatheads from Moreton Bay, a description of a new species and a new geographic record for a previously described species from flatheads occurring in the Seto Inland Sea of Japan are provided.

2. Materials and Methods

Four dusky flatheads *Platycephalus fuscus* Cuvier and a single bar-tailed flathead *Platycephalus endrachtensis* Quoy & Gaimard were collected by various methods from Moreton Bay, Queensland, Australia, during January 2016 as part of a survey to determine the diversity of the parasite fauna infecting the fishes of the bay. Hosts were transported alive to the Moreton Bay Research Station located in Dunwich, North Stradbroke Island, Queensland, where they were euthanized and identified using Johnson [6]; gill baskets were immediately removed and placed in hot (60 °C) sea water to relax and kill the attached helminths; a volume of 10% formalin, equal to that of the sea water of each container, was then added for fixation in 5% formalin. When necessary, excess fluid was decanted, and the fixed gills and sediments from each fish were placed in separate vials, labeled, and shipped to Idaho State University for study.

Flatheads from Japan were commercially fished from the Seto Inland Sea, purchased from local fish markets, identified based on Nakabo & Kai [7], and frozen or placed on ice in plastic bags until examination for parasites. Monogenoids from the Japanese flatheads were fixed in AFA under coverslip pressure or in hot 5% formalin, stained in Heidenhain's iron hematoxylin, dehydrated through a graded ethanol series and mounted in Canada balsam from xylene. These specimens were subsequently deposited in the Meguro Parasitological Museum Collection (MPM), from which they were placed on loan to the authors for the present study.

Dactylogyrids collected in Australia were subsequently removed from the gills or sediment using a small probe and dissecting microscope. Some specimens were mounted unstained in Gray & Wess medium for study of sclerotized structures; other specimens were stained with Gomori's trichrome, VanCleave's hematoxylin, or Heidenhain's iron hematoxylin and mounted in Canada balsam for determination of internal anatomy.

Illustrations were prepared with the aid of a camera lucida or microprojector. Measurements, all in micrometers, represented straight-line distances between extreme points and were expressed as the range followed by the mean and number (n) of structures measured in parentheses. Body length included that of the haptor.

Except for *Platycephalus* sp. 1 and *Platycephalus* sp. 2, both of Nakabo & Kai [7] and locally known respectively as "Yochino-gochi" and "Ma-gochi" in Japan, scientific names of all fishes were verified in Fricke et al. [1].

Type and voucher specimens of helminths collected for the present study were deposited in the Queensland Museum (QM), Brisbane, Australia; the Meguro Parasitological Museum (MPM), Tokyo, Japan; and the University of Nebraska State Museum, Harold W. Manter Laboratory (HWML),

Lincoln, Nebraska as indicated in the species' accounts. The following museum specimens were also examined: 11 syntypes (2 in serial sections), *Ancyrocephalus vesiculosus* Murray, 1931, Museums Victoria, Melbourne, Australia (NMV) F 60389; 3 syntypes, *Ancyrocephalus platycephali* Yamaguti, 1953, MPM 23204 (SY6718); 4 syntypes, *Ancyrocephalus thysanophrydis* Yamaguti, 1937, MPM 23107 (SY0262); 21 voucher specimens, *Haliotrema thysanophrydis* (Yamaguti, 1937) Bychowsky & Nagibina, 1971, MPM 21470, 21471; 2 voucher specimens, *Pseudohaliotrema thysanophrydis* (Yamaguti, 1937) Young, 1968, National Museum of Natural History, National Invertebrate Zoology Collection, Washington D.C., USA, USNM 1356609; 3 voucher specimens, *Pseudohaliotrema platycephali* (Yin & Sproston, 1948) Young, 1968, USNM 1356610, 1356611; 3 voucher specimens, *Haliotrema platycephali* Yin & Sproston, 1948, The Natural History Museum, London (BMNH) 1984.7.19.69; 3 vouchers, unidentified Dactylogyridae (identified herein as *Platycephalotrema ogawai* n. sp.), MPM 31091 (F0293–0295); 5 voucher specimens, unidentified Dactylogyridae [identified herein as *Platycephalotrema thysanophrydis* (Yamaguti, 1937) n. comb.], MPM 31090 (F0287–0291).

In the ensuing sections of this paper, the following abbreviations for host and parasite genera beginning with the letter “P” are utilized: *Pl.* for *Platycephalus*; *Pt.* for *Platycephalotrema*; and *Ps.* for *Pseudohaliotrema*. In order to minimize confusion, these abbreviations were only used after the respective generic name was first used within a given passage.

3. Results

Subclass Polyonchoinea Bychowsky, 1937

Order Dactylogyridea Bychowsky, 1937

Dactylogyridae Bychowsky, 1933

3.1. *Platycephalotrema* n. gen.

3.1.1. Diagnosis

Body fusiform, slightly flattened dorsoventrally, comprising body proper (cephalic region, trunk, and peduncle) and haptor. Tegument smooth. Two terminal, two bilateral cephalic lobes; three pairs of bilateral head organs; bilateral groups of unicellular cephalic glands prepharyngeal, pharyngeal and/or postpharyngeal. Eyespots four, infrequently absent; granules small, ovate. Mouth subterminal, prepharyngeal; pharynx a muscular bulb; esophagus short to non-existent; intestinal ceca two, confluent posterior to gonads, lacking diverticula. Genital pore midventral, immediately posterior to intestinal bifurcation. Gonads intercecal, tandem (germarium pretesticular). Testis entire; vas deferens apparently looping dorsoventrally left intestinal cecum; seminal vesicle a simple dilation of distal vas deferens at level of male copulatory organ (MCO). Two generally large prostatic reservoirs; each having duct independently entering base of MCO; contents of anterior (or ventral) reservoir dense, usually comprising two zones of secretory material differing in density and stain preference; contents of posterior (or dorsal) reservoir nearly transparent, resisting stain. MCO a sclerotized tube, often with complex distal end; accessory piece absent. Germarium entire; oviduct, uterus not observed; Mehlis' gland present. Vaginal pore dextral, submarginal; vagina comprising large distal vestibule often with sclerotized components and from which the vaginal canal extends posteriorly toward ootype. Seminal receptacle not observed or indistinct. Vitellarium throughout trunk, except absent from regions of other reproductive organs. Globose haptor with bilateral lobes and armed with dorsal and ventral anchor/bar complexes, seven pairs of similar hooks having normal dactylogyrid distribution; vesicle filled with granular product usually associated with each of ventral and/or dorsal anchor. Dorsal and ventral anchors similar in size, shape; each with elongate superficial root, large base, short slightly arcing shaft, elongate point. Ventral bar simple, with spatulate ends; dorsal bar with bifurcated ends. Each hook with protruding blunt thumb, slender shank comprised of one subunit. Parasites of fishes assigned to the Platycephalidae.

3.1.2. Taxonomic Summary

Type species: Platycephalotrema ogawai n. sp. from *Platycephalus* sp. 1 & *Platycephalus* sp. 2, (both of Nakabo & Kai [7], two apparently undescribed or unidentified species locally known in Japan as “Yoshino-gochi” and “Ma-gochi”, respectively) (Scorpaeniformes: Platycephalidae) (Japan).

Other species: Platycephalotrema austrinum n. sp. from *Pl. endrachtensis* Quoy & Gaimard and *Platycephalus* sp. (Australia); *Platycephalotrema bassensis* (Hughes, 1928) n. comb. from *Pl. bassensis* Cuvier (Australia); *Platycephalotrema koppa* n. sp. from *Pl. fuscus* Cuvier (Australia); *Platycephalotrema macassarensis* (Yamaguti, 1963) n. comb. from *Pl. indicus* (Linnaeus) (China, Macassar); *Platycephalotrema mastix* n. sp. from *Pl. fuscus* and *Pl. endrachtensis* (Australia); *Platycephalotrema platycephali* (Yin & Sproston, 1948) n. comb. from *Pl. indicus* (China); *Platycephalotrema sinensis* (Yamaguti, 1963) n. comb. from *Pl. punctatus* Cuvier [now *Cociella punctata* (Cuvier)] (China); *Platycephalotrema thysanophrydis* (Yamaguti, 1937) n. comb. from *Thysanophrys japonicus* (Tilesius) [an ambiguous synonym of *Pl. japonicus* Cuvier, now *Inegocia japonica* (Cuvier)], *Inegocia ochiaii* Imamura, and *Cociella crocodilus* (Cuvier) (Japan, China).

Likely congeners requiring further investigation: Ancyrocephalus vesiculosus Murray, 1931 from *Pl. bassensis* (Cuvier) (Australia); *Haliotrema indicum* Tripathi, 1957 from *Pl. insidiator* (Forsskål) (now *Pl. indicus*) (India); *Haliotrema pterosi* Paperna, 1972 from *Pterois volitans* (Linnaeus) (Red Sea); *Haliotrema swatowensis* Yao, Wang, Xia, & Chen, 1998 from *Pl. indicus* (China).

Etymology: The generic name (neuter) reflects the family of fishes, the Platycephalidae, species of which harbor members of the new genus.

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3.1.3. Remarks

Platycephalotrema n. gen. is characterized by dactylogyrids possessing a combination of the following features: (1) tandem gonads (testis postgermarial); (2) a copulatory complex lacking an accessory piece; (3) two prostatic reservoirs, each emptying independently into the base of the MCO; (4) the anterior prostatic reservoir usually containing two zones of secretion, each zone differing in density and stain affinity; (5) a dextral vaginal pore; (6) a large vaginal vestibule usually with sclerotized components; (7) dorsal and ventral pairs of morphologically similar anchors, each anchor with an elongate point, a short slightly arcing shaft, and a large base having a comparatively long superficial root and a short knob-like deep root; (8) a ventral bar with spatulate ends; (9) a dorsal bar with bifurcated ends; (10) seven pairs of hooks with a normal dactylogyrid distribution; (11) each hook having a protruding blunt thumb and a uniform slender shank comprised of a single subunit; and (12) haptoral reservoirs usually associated with each of the ventral and/or dorsal anchors. Currently, the genus is restricted to species parasitic on the gill lamellae of marine scorpaeniform fishes assigned to the Platycephalidae. Accordingly, all dactylogyrid species previously described and reported from marine scorpaeniform fishes and included in either *Ancyrocephalus* Creplin, 1839 or *Haliotrema* Johnston & Tiegs, 1922, are likely members of *Platycephalotrema*, although four of these species require further study before transfers can be made (see respective species accounts below).

With the exception of host preference, all of the above features can be found in members of other dactylogyrid genera. *Platycephalotrema* most closely resembles *Parancylo-discoides* Caballero y C. & Bravo-Hollis, 1961 as revised by Kritsky [8] and *Lethrinitrema* Lim & Justine, 2011, both with marine species parasitizing ehippid and serranid fishes (*Parancylo-discoides* spp.) and lethrinid fishes (*Lethrinitrema* spp.). Members of the three genera share the following features: (1) presence of haptoral reservoirs; (2) two elongate prostatic reservoirs, (3) a dextral vaginal pore; (4) a comparatively large vaginal vestibule; (5) hooks with protruding thumbs and shank of a single subunit; and (6) absence of an accessory piece in the copulatory complex. The accessory piece of *Lethrinitrema* spp. described by Lim & Justine [9] may or may not be present in respective *Lethrinitrema* spp., and when present, it appears to comprise a part of the distal end of the MCO rather than a free structure. *Platycephalotrema* differs from *Parancylo-discoides* by its species usually having sclerotized components associated with the

vaginal vestibule (absent in *Parancylo-discoides* spp.); a prostatic reservoir frequently containing two zones of secretory product, each varying in density and stain affinity (contents of individual prostatic reservoirs in *Parancylo-discoides* spp. uniform); and by having tandem gonads, testis postgermarial (gonads juxtaposed, germarium lying to right of testis in *Parancylo-discoides* spp.) (see [8]). The new genus differs from *Lethrinitrema* by its species having haptoral reservoirs associated with the dorsal anchors (reservoirs associated with the ventral anchors in *Lethrinitrema* spp.); morphologically similar dorsal and ventral anchors (dorsal and ventral anchors dissimilar in *Lethrinitrema* spp.); a dorsal bar with bifurcated ends (ends of the dorsal bar entire in *Lethrinitrema* spp.); and by lacking lateral grooves along the length of the ventral anchors (present in *Lethrinitrema* spp.) (see [9]).

3.2. *Platycephalotrema ogawai* n. sp.

3.2.1. Description (Figure 1)

Greatest width of body proper usually in posterior trunk at level of testis. Cephalic region with well-developed medial and bilateral cephalic lobes. Four eyespots apparently lacking lenses; posterior pair of eyespots larger, slightly farther apart than those of anterior pair; accessory chromatic granules few or usually absent in cephalic region. Pharynx subspherical to subovate. Peduncle slightly tapered posteriorly; haptor with two pairs of lateral lobes, each with subterminal hook. Ventral and dorsal anchors similar; each with elongate superficial root, short knob-like deep root, slightly arced short shaft, elongate point. Ventral bar dorsoventrally flattened, with prominent spatulate ends. Dorsal bar variable in width along its length, with bifurcated ends having unequal limbs. Hook with uniform shank, conspicuous protruding blunt thumb; filamentous hook (FH) loop nearly shank length. MCO with base shaped as inverted o-choko glass, broad tubular slightly undulating shaft, distal coiled end having weakly sclerotized flap. Testis subspherical; proximal vas deferens not observed; seminal vesicle a fusiform dilation of distal vas deferens, anterodextral to MCO. Prostates not observed; prostatic reservoirs large. Anterior (ventral) prostatic reservoir usually containing two zones of granules; proximal zone dense, distal zone nearly translucent. Germarium spherical; oviduct, ootype, uterus not observed; Mehlis' gland well developed, lying just anterior to germarium. Vaginal pore surrounded by sphincter-like muscle; vaginal vestibule complex, with sclerotized units, often showing serrated edge; vaginal canal delicate. Seminal receptacle apparently absent. Vitellarium dense, coextensive with intestinal ceca; transverse vitelline duct anterior to Mehlis' gland. Eggs not observed.

3.2.2. Measurements

Measurements are of specimens collected from the type host, *Platycephalus* sp. 1. Body 1247–1710 (1468; n = 14); greatest width of trunk 322–432 (371; n = 18). Haptor 212–272 (241; n = 15) wide. Ventral anchor 73–83 (79; n = 23) long; dorsal anchor 71–79 (75; n = 23) long. Ventral bar 70–91 (81; n = 24) long; dorsal bar 70–96 (86; n = 16) long. Hook 13–15 (14; n = 11) long. Pharynx 88–119 (98; n = 20) wide. MCO 116–133 (125; n = 27) long. Testis 83–155 (131; n = 18) long, 90–155 (126; n = 18) wide. Germarium 117–170 (139; n = 17) long, 120–178 (146; n = 17) wide.

3.2.3. Taxonomic Summary

Type host: *Platycephalus* sp. 1 of Nakabo & Kai [7] (locally known as “Yoshino-gochi” [(ヨシノゴチ)]) (*Platycephalidae*).

Type locality: Seto Inland Sea, Hiuchi-nada (34°06' N, 133°21' E), Japan (host purchased at the market of the Imabari Fishery Cooperative, Imabari City, Ehime Prefecture), 24 May 2018.

Other records: *Platycephalus* sp. 1: Seto Inland Sea, Utsumi-chō, off Yoko-shima Island, Fukuyama City, Hiroshima Prefecture, Japan (34°21.5' N, 133°16.5' E), 23 February 2019. *Platycephalus* sp. 2 of Nakabo & Kai (2013) [locally known as “Ma-gochi” (マゴチ)]: Seto Inland Sea, Utsumi-chō, off Yoko-shima Island, Fukuyama City, Hiroshima Prefecture, Japan (34°21.5' N, 133°16.5' E), 19 February 2017; North Pacific or Mikawa Bay off Tahara, Aichi Prefecture (coordinates not available), Japan,

14 May 1981. *Platycephalus* sp. (host identified as “Ma-gochi” in MPM records but probably not distinguished between *Platycephalus* sp. 1 and *Platycephalus* sp. 2 (collected by Dr. Kusuo Iwata, Fukuoka University), Sea of Japan, off Kyushu (coordinates not available), Japan, 7 July 1978.

Infection site: Gill lamellae.

Specimens studied: Holotype, MPM 21468 (A6679); 27 paratypes, MPM 21468 (A6678–A6680); 14 voucher specimens (from *Platycephalus* sp. 1), MPM 21522, QM G238134, G238135, HWML 216008; 62 voucher specimens (from *Platycephalus* sp. 2), MPM 21469 (A6681–A6683), 21051 (A6249–A6255).

Etymology: This species is named for our friend and colleague, Dr. Kazuo Ogawa, Director of the Meguro Parasitological Museum, in recognition of his extensive work on the Monogenoidea and in appreciation for allowing us to examine specimens of the species that he collected in 1981.

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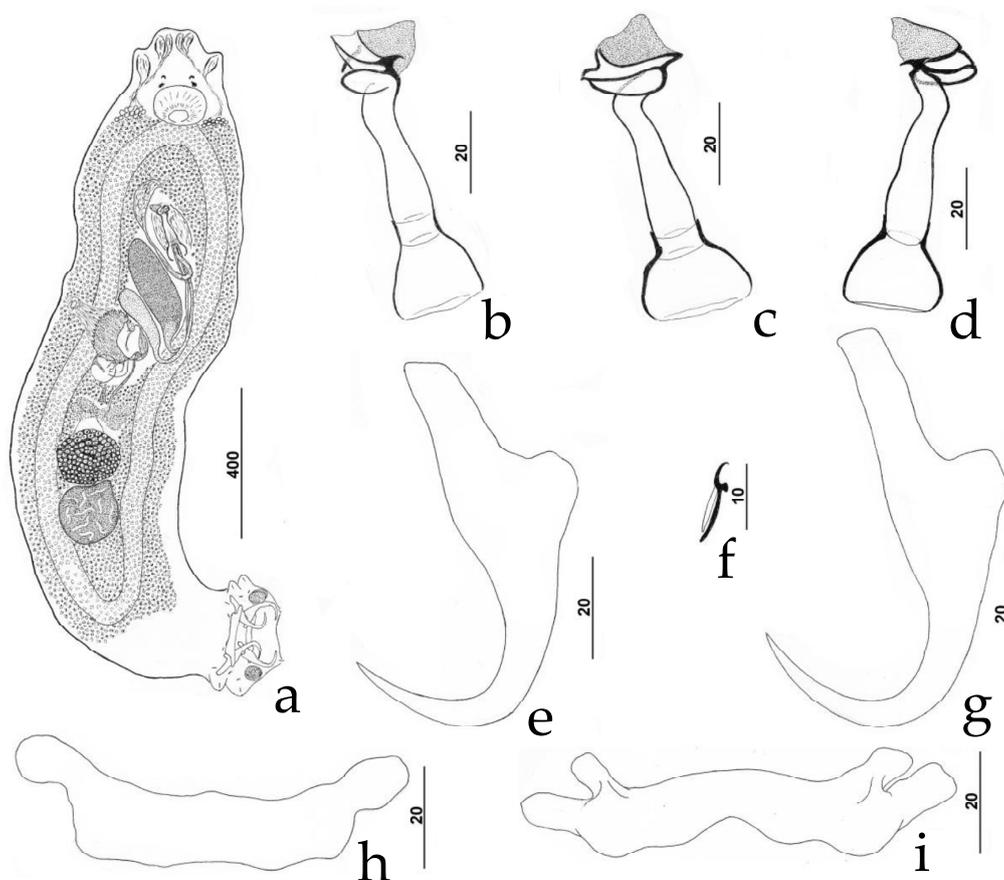


Figure 1. *Platycephalotrema ogawai* n. sp. (a) Whole mount (composite, ventral view); (b–c) male copulatory organs (ventral views); (d). male copulatory organ (dorsal view); (e). dorsal anchor; (f). hook; (g). ventral anchor; (h). ventral bar; (i). dorsal bar.

3.2.4. Remarks

Platycephalotrema ogawai n. sp. is the type species of the genus.

3.3. *Platycephalotrema koppa* n. sp.

3.3.1. Description (Figure 2)

Greatest width of body proper usually near midlength of trunk. Cephalic region with well-developed medial and bilateral cephalic lobes. Eyespots four, apparently lacking lenses; members of posterior pair larger, closer together than those of anterior pair; accessory chromatic granules absent or very few in cephalic region. Pharynx ovate; esophagus short or absent. Peduncle moderately long,

slightly tapered posteriorly; haptor with two pairs of lateral lobes, each with subterminal hook. Ventral and dorsal anchors similar; each with elongate superficial root, short knob-like deep root, slightly arced to straight short shaft, elongate point. Ventral bar with long spatulate ends. Dorsal bar variable in width along its length, with unequal terminal limbs. Hook with uniform shank, conspicuous protruding blunt thumb; FH loop nearly shank length. MCO with inverted-cup-shaped base, slightly tapering tubular shaft, distal end having two unequal projections and weakly sclerotized flap. Testis ovate; proximal vas deferens not observed; seminal vesicle a fusiform dilation of distal vas deferens, lying to right of MCO; proximal portion of ejaculatory duct narrow, giving rise to wide distal portion before entering base of MCO. Prostates not observed; prostatic reservoirs large; anterior (ventral) reservoir usually containing two zones of granules with proximal zone dense, distal zone nearly translucent; posterior (dorsal) reservoir smaller than and often obscured by anterior reservoir, with fine reticulate to granular contents. Germarium spherical; oviduct, ootype, Mehlis' gland not observed; uterus delicate diverted to left of large vaginal vestibule. Vaginal pore surrounded by delicate sphincter-like muscle; vaginal vestibule with anterior sclerotized rod-like unit; vaginal canal not observed. Seminal receptacle apparently absent. Vitellarium dense, coextensive with intestinal ceca; transverse vitelline duct anterior to germarium. Eggs not observed.

3.3.2. Measurements

Body 701–912 (801; n = 5); greatest width of trunk 130–177 (147; n = 6). Haptor 136–151 (144; n = 5) wide. Ventral anchor 68–79 (73; n = 9) long; dorsal anchor 66–77 (71; n = 9) long. Ventral bar 66–78 (72; n = 7) long; dorsal bar 74–81 (77; n = 6) long. Hook 13–15 (14; n = 20) long. Pharynx 44–54 (48; n = 7) wide. MCO 87–107 (96; n = 11) long. Testis 59–81 (70; n = 6) long, 36–52 (45; n = 6) wide. Germarium 44–57 (51; n = 7) long, 39–54 (47; n = 7) wide.

3.3.3. Taxonomic Summary

Type host: Dusky flathead, *Platycephalus fuscus* Cuvier (Platycephalidae).

Type locality: Moreton Bay off Green Island, Queensland, Australia (27°26' S, 153°20' E), 12 January 2016.

Other records: *Pl. fuscus*: Moreton Bay off Dunwich, North Stradbroke Island, Queensland, Australia (27°50' S, 153°40' E), 18 January 2016; Moreton Bay near Port of Brisbane, Queensland, Australia (27°23' S, 153°11' E), 19 January 2016.

Infection site: Gill lamellae.

Specimens studied: Holotype, QM G238120; 21 paratypes, QM G238121–G238129, HWML 216001, 216002, 216003, MPM 21520.

Etymology: The specific name (*koppa*), a noun, is derived from an archaic letter-like-numeral character (Ѐ) of Cyrillic script known as koppa and here refers to the basic shape of the MCO.

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3.3.4. Remarks

Platycephalotrema koppa n. sp. is easily differentiated from all congeners by possessing two large projections and a conspicuous delicate flap at the distal end of the MCO. It is closest morphologically to *Pt. platycephali* (Yin & Sproston, 1948) n. comb., from which it differs by having elongate spatulate ends of the ventral bar (ends of ventral bar comparatively short in *Pt. platycephali*; see [10,11]).

Four specimens of the dusky flathead were collected and examined for monogenoids during the survey of the parasites infecting the fishes of Moreton Bay, Australia. Prevalence of *Pt. koppa* n. sp. in the four fishes was 100%.

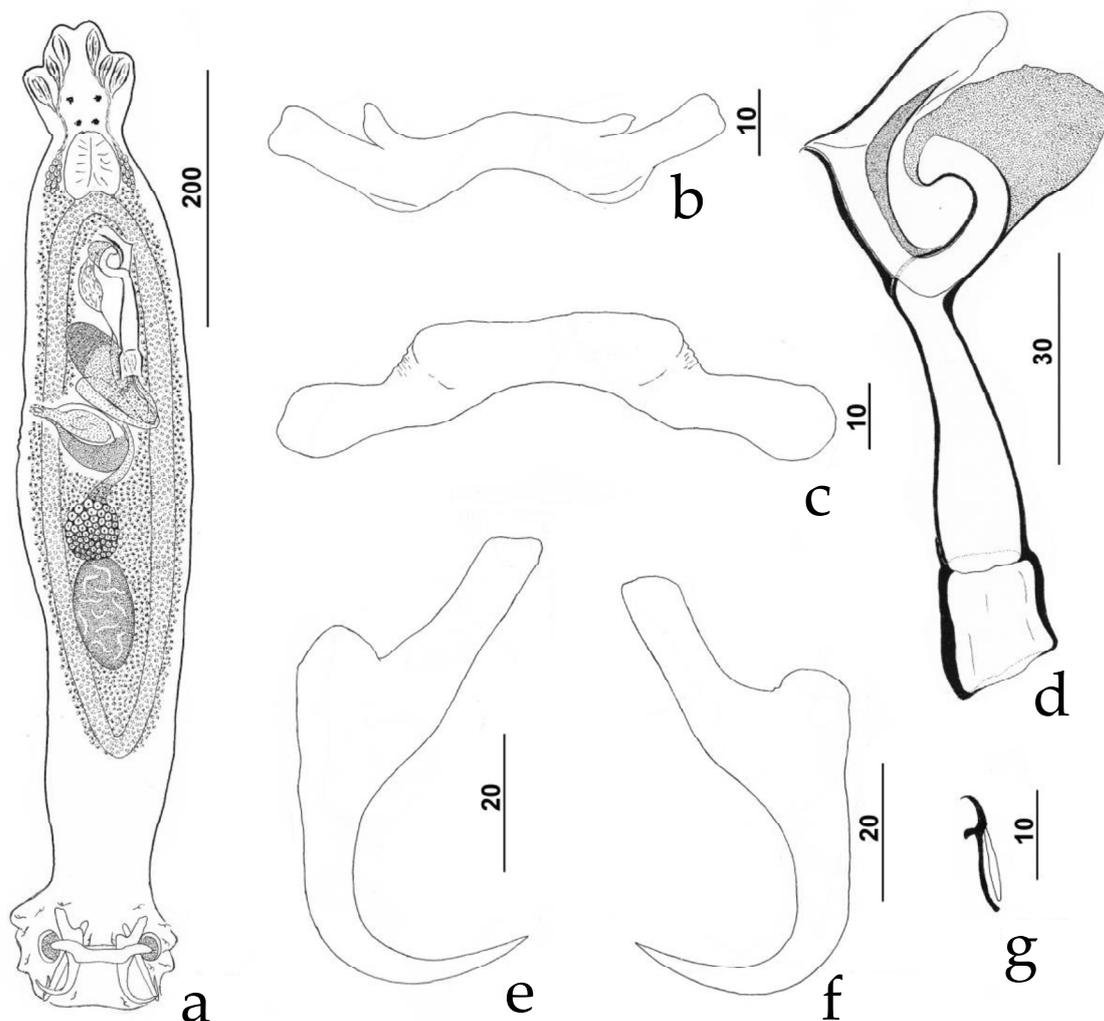


Figure 2. *Platycephalotrema koppa* n. sp. (a). Whole mount (composite, ventral view); (b). dorsal bar; (c). ventral bar; (d). male copulatory organ (dorsal view); (e). ventral anchor; (f). dorsal anchor; (g). hook.

3.4. *Platycephalotrema mastix* n. sp.

Syn. *Pseudohaliotrema thysanophrydis* of Young [12].

3.4.1. Description (Figure 3)

Greatest width of body proper usually near midlength of trunk. Cephalic region with well-developed pairs of bilateral and terminal cephalic lobes. Eyespots four, apparently lacking lenses; members of posterior pair larger, equidistant or slightly closer together than those of anterior pair; accessory chromatic granules usually absent in cephalic region. Pharynx subspherical; esophagus short to absent. Peduncle moderately long, slightly tapered posteriorly; haptor subtrapezoidal, tapering posteriorly. Ventral anchor with elongate broad superficial root, short knob-like deep root, slightly arcing short shaft, elongate point. Dorsal anchor with elongate depressed superficial root, short deep root, straight or slightly arcing shaft, elongate point. Ventral bar with long spatulate ends. Dorsal bar variable in width along its length, with two posterior subterminal humps, bifurcated ends having short ventral limbs and flattened truncate dorsal limbs. Hook with uniform shank and conspicuous protruding thumb; FH loop nearly shank length. MCO with base shaped as an inverted wine glass, slightly tapered and loosely coiled shaft having a short delicate keel along its midlength; coil comprising about $1\frac{1}{2}$ counterclockwise rings. Testis ovate; proximal vas deferens not observed; seminal vesicle

a small fusiform dilation of distal vas deferens lying just posterior and dextral to genital pore; proximal portion of ejaculatory duct narrow, giving rise to inflated distal portion before entering base of MCO. Prostates lying lateral and dorsal to vitelline field from about level of genital pore posteriorly to that of vaginal pore, extending lateral to or obscured by vitellarium; prostatic reservoirs large; anterior (ventral) reservoir usually containing two zones of granules with proximal zone dense, distal zone nearly translucent; posterior (dorsal) reservoir smaller than and often obscured by anterior reservoir, with fine reticulate to granular contents. Germarium spherical; oviduct, ootype, Mehlis' gland, uterus not observed. Small vesicle apparently serving as seminal receptacle lying to left of anterior end of germarium. Vaginal pore located at proximal end of lateral tegumental depression; vaginal vestibule with two anterior sclerotized units; vaginal canal not observed. Vitellarium dense, coextensive with intestinal ceca; transverse vitelline duct anterior to germarium. Eggs not observed.

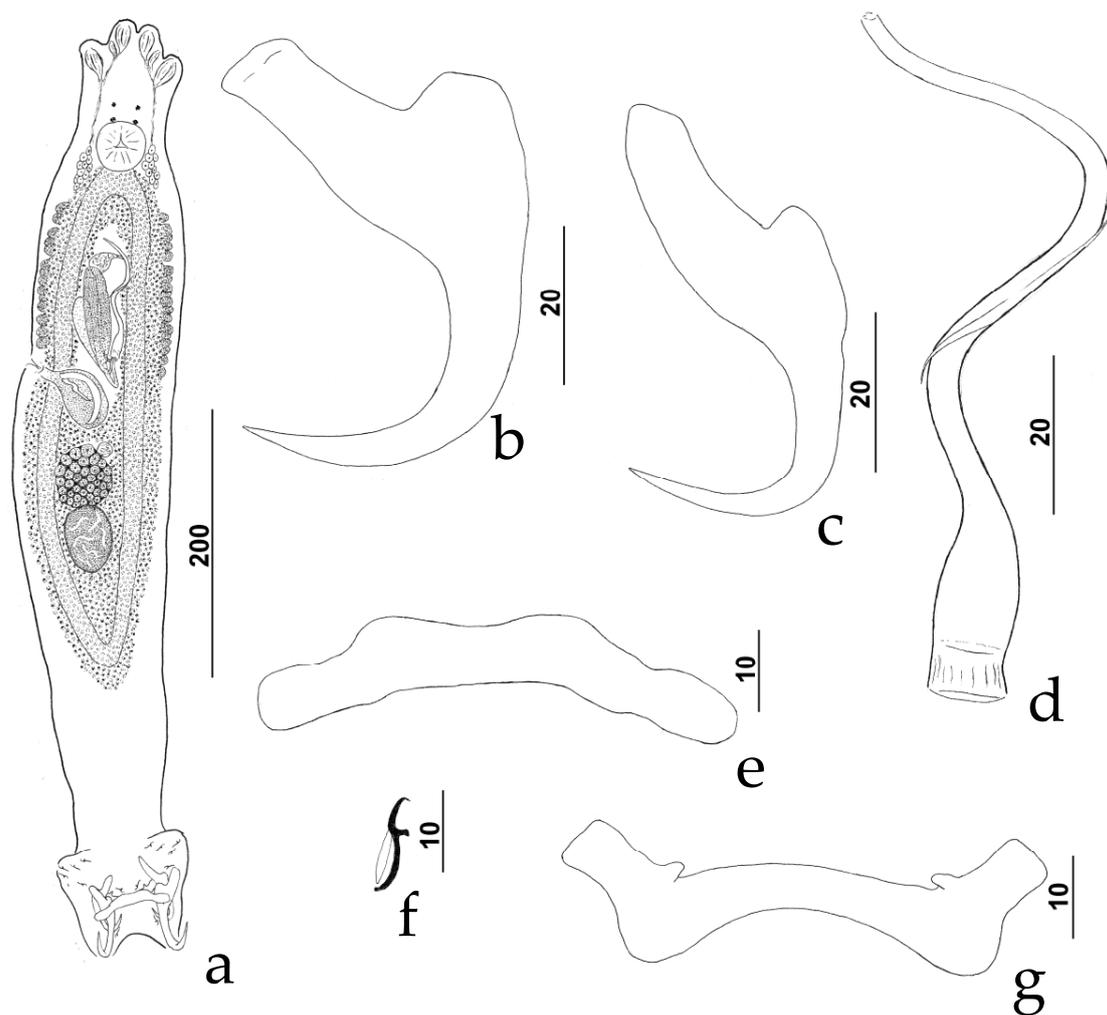


Figure 3. *Platycephalotrema mastix* n. sp. (a). Whole mount (composite, ventral view); (b). ventral anchor; (c). dorsal anchor; (d). male copulatory organ (ventral view); (e). ventral bar; (f). hook; (g). dorsal bar.

3.4.2. Measurements

Respective measurements of the specimen collected from *Pl. endrachtensis* in Moreton Bay follow in brackets those from the type host. Body 684–733 (711; n = 3) [906–907 (n = 1)] long; greatest width of trunk 125–129 (127; n = 3) [177–178 (n = 1)]. Haptor 106–121 (115; n = 3) [141–142 (n = 1)] wide. Ventral anchor 54–55 (n = 1) [56–57 (n = 1)] long; dorsal anchor 53–54 (n = 1) [53–54 (n = 1)] long. Ventral bar 54–70 (63; n = 4) [65–66 (n = 1)] long; dorsal bar 55–60 (57; n = 3) long. Hook 13–15 (14;

n = 4) [12–14 (13; n = 3)] long. Pharynx 39–41 (40; n = 3) [56–57 (n = 1)] wide. MCO 85–109 (97; n = 2) [105–106 (n = 1)] long. Testis 51–63 (59; n = 3) [73–74 (n = 1)] long, 27–42 (35; n = 3) [48–49 (n = 1)] wide. Germarium 53–56 (54; n = 3) [60–61 (n = 1)] long, 45–53 (49; n = 3) [50–51 (n = 1)] wide.

3.4.3. Taxonomic Summary

Type host: Dusky flathead, *Platycephalus fuscus* Cuvier (Platycephalidae).

Type locality: Moreton Bay off Green Island, Queensland, Australia (27°26' S, 153°20' E), 12 January 2016.

Other records: *Pl. fuscus*: Moreton Bay near Port of Brisbane, Queensland, Australia (27°23' S, 153°11' E), 19 January 2016. *Pl. endrachtensis*: Moreton Bay off Peel Island, Queensland, Australia (27°24' S, 153°20' E), 14 January 2016.

Previous record: *Pl. fuscus*: Moreton Bay, Queensland, Australia as *Pseudohaliotrema thysanophrydis* (Yamaguti, 1937) Young, 1968 [12].

Infection site: Gill lamellae.

Specimens studied: Holotype, QM G238130; 3 paratypes, QM G238131, HWML 216004, 216005; voucher specimen (from *Pl. endrachtensis*), HWML 216006; 2 voucher specimens identified as *Ps. thysanophrydis* by Young [12] from *Pl. fuscus*, USNM 1356609.

Etymology: The specific name, a noun, is derived from Greek (*mastix* = a whip) and refers to the shape of the MCO.

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3.4.4. Remarks

Platycephalotrema mastix n. sp. most closely resembles *Pt. thysanophrydis* (Yamaguti, 1937) n. comb. In both species, the MCO is an elongate tube comprising a minimally to loosely coiled shaft and a slightly expanded base. *Platycephalotrema mastix* n. sp. differs from *Pt. thysanophrydis* by having an MCO with a larger diameter throughout its length, shorter anchor roots, a ventral bar with slender flattened ends (ends of ventral bar broadly spatulate in *Pt. thysanophrydis*), and a dorsal bar with rudimentary ventral limbs of the bifurcated ends (ventral limbs of the dorsal bar of *Pt. thysanophrydis* massive and bilobed).

Young [12] transferred *Ancyrocephalus thysanophrydis* Yamaguti, 1937 to *Pseudohaliotrema* based on five specimens of a dactylogyrid he collected from *Pl. fuscus* in Moreton Bay, Australia. Young [12] clearly did not have access to Yamaguti's type specimens when he made the species determination as indicated in the list of specimens examined during his study. However, examination of two voucher specimens that Young [12] deposited in the USNM (1356609) revealed that they belonged to *Pt. mastix* n. sp. Therefore, the present accounts of *Pt. mastix* n. sp. on *Pl. fuscus* in Moreton Bay are not new host or geographic records for the species but represent the first accurate identification of the species from this host and locality.

During the present study, *Pt. mastix* n. sp. occurred concurrently with *Pt. koppa* n. sp. on two of the four specimens of *Pl. fuscus* (prevalence = 50%) and with *Pt. austrinum* n. sp. on the single specimen of *Pl. endrachtensis* examined during the survey of the parasites found in the fishes of Moreton Bay, Australia.

3.5. *Platycephalotrema austrinum* n. sp.

Syns *Pseudohaliotrema platycephali* of Young [12]; *Pseudohaliotrema platicephali* of Young [12] (lapsus).

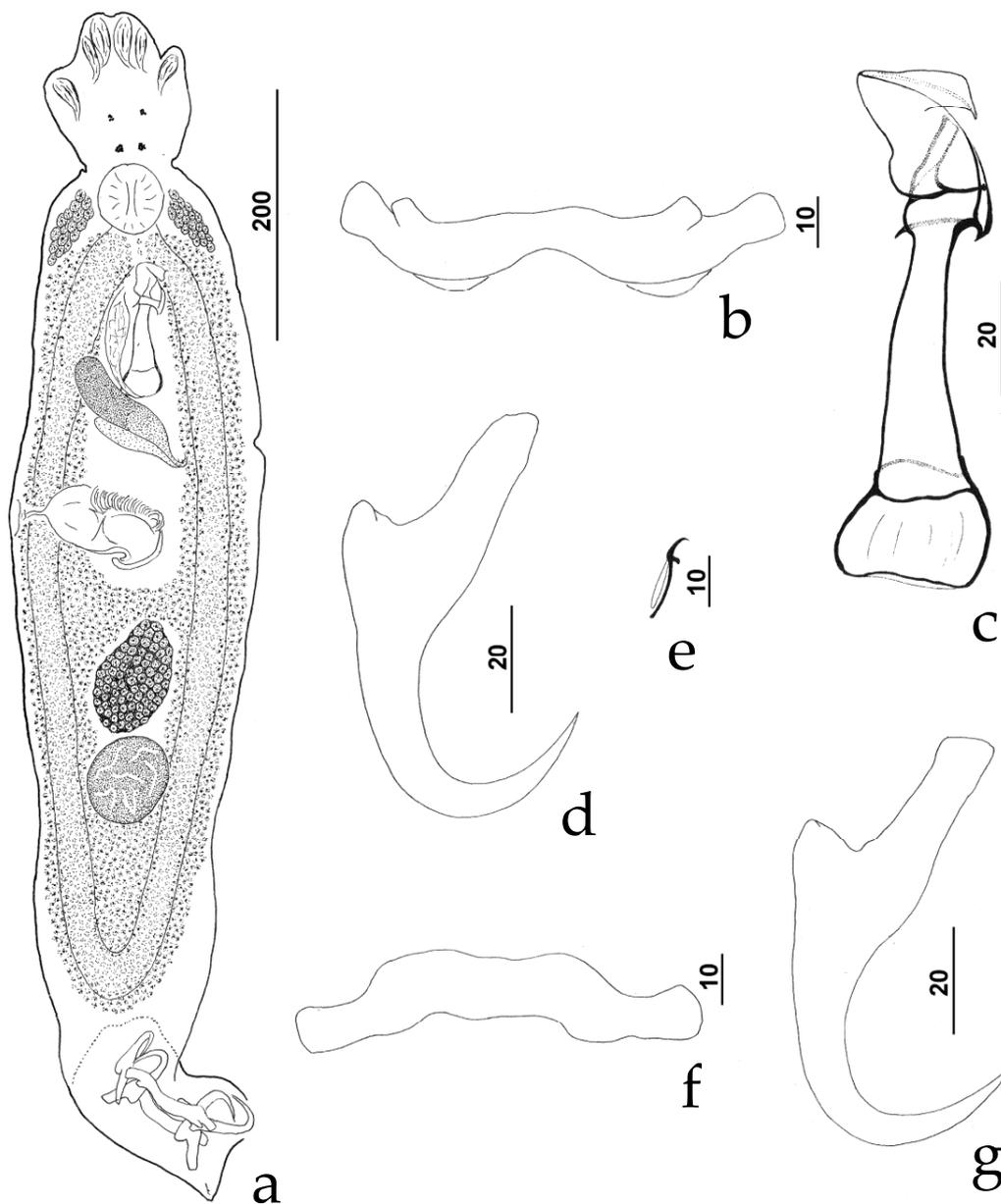


Figure 4. *Platycephalotrema austrinum* n. sp. (a). Whole mount (composite; body, ventral view; haptor, dorsal view); (b). dorsal bar; (c). male copulatory organ (ventral view); (d). dorsal anchor; (e). hook; (f). ventral bar. (g). ventral anchor.

3.5.1. Description (Figure 4)

Greatest width of body proper near midlength of trunk at level of vaginal pore. Cephalic region with well-developed pairs of bilateral and medial cephalic lobes. Eyespots four, apparently lacking lenses; members of posterior pair slightly larger, closer together than those of anterior pair; accessory chromatic granules absent. Pharynx subspherical; esophagus short to absent. Peduncle slightly tapered posteriorly; haptor subtrapezoidal to subrectangular. Anchors similar; each with elongate superficial root, short knob-like deep root, slightly arcing short shaft, elongate point. Ventral bar with slightly expanded spatulate ends. Dorsal bar variable in width along its length, with two posterior humps, bifurcated ends having truncate ventral and dorsal limbs; ventral limb shorter than dorsal limb. Hook with uniform shank and conspicuous protruding thumb; FH loop nearly shank length. MCO with base shaped as an inverted o-choko glass, slightly tapered shaft having complex termination, delicate

distal flap. Testis subspherical; proximal vas deferens not observed; seminal vesicle a small fusiform dilation of distal vas deferens lying to right of MCO; ejaculatory duct entering base of MCO. Prostates not observed; prostatic reservoirs large; anterior (ventral) reservoir containing two zones of granules with proximal zone dense, distal zone nearly translucent; posterior (dorsal) reservoir smaller than and partially obscured by anterior reservoir, with comparatively clear contents. Germarium pyriform; oviduct, ootype, Mehlis' gland, uterus not observed. Vaginal pore located at proximal end of lateral tegumental depression; vaginal vestibule with two posterior sclerotized units, numerous anterior ridges often not visible in individual specimens; vaginal canal not observed. Seminal receptacle apparently absent. Vitellarium dense, coextensive with intestinal ceca; transverse vitelline duct anterior to germarium. Eggs not observed.

3.5.2. Measurements

Body 922–1,203 (1062; n = 2) long; greatest width of trunk 194–251 (222; n = 2). Haptor 150–161 (156; n = 2) wide. Ventral anchor 72–73 (n = 2) long; dorsal anchor 64–72 (68; n = 2) long. Ventral bar 70–71 (n = 2) long; dorsal bar 73–76 (74; n = 2) long. Hook 13–15 (14; n = 2) long. Pharynx 49–57 (53; n = 2) wide. MCO 103–107 (105; n = 2) long. Testis 65–66 (n = 1) long, 54–55 (n = 1) wide. Germarium 71–72 (n = 1) long, 66–67 (n = 1) wide.

3.5.3. Taxonomic Summary

Type host: Bar-tailed flathead, *Platycephalus endrachtensis* Quoy & Gaimard (Platycephalidae).

Type locality: Swan River Estuary near Perth, Western Australia.

Other record: *Pl. endrachtensis*: Moreton Bay off Peel Island, Queensland, Australia (27°24' S, 153°20' E), 14 January 2016.

Previous records: *Platycephalus* sp.: Moreton Bay, Queensland, Australia as *Pseudohaliotrema platycephali* (Yin & Sproston, 1948) Young, 1968 (sic) [12].

Infection site: Gill lamellae.

Specimens studied: Holotype, paratype, BMNH 1984.7.19.69; voucher specimen (from *Pl. endrachtensis* in Moreton Bay), QM G238132; voucher specimen [collected by P. C. Young from *Pl. indicus* (now *Pl. australis*) from Moreton Bay, Queensland, Australia], USNM 1356610; 2 voucher specimens (collected by P. C. Young from *Platycephalus* sp. from Moreton Bay, Queensland, Australia), USNM 1356611.

Etymology: The specific name (an adjective) is from Latin (*austrinus* = southern or Australian) and refers to the locations from which the parasite specimens were collected.

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3.5.4. Remarks

The description of *Platycephalotrema austrinum* n. sp. is based on two of three dactylogyrid specimens collected by Dr. Alan Williams (Western Australian Fisheries, Perth) from *Platycephalus endrachtensis* in 1984, identified by Dr. Rod Bray (The Natural History Museum, London) as *Haliotrema platycephali* Yin & Sproston, 1948, and deposited in the BMNH (1984.7.19.69). The third specimen present on the BMNH slide lacks a haptor, possesses a morphologically different MCO, and remains unidentified. A published account of these specimens was not found during the literature search.

Young [12] reported *Pseudohaliotrema platycephali* (Yin & Sproston) Young, 1968 from *Pl. fuscus*, *Pl. indicus*, and an unidentified species of *Platycephalus* from Moreton Bay, Queensland, Australia. Dactylogyrids deposited by Young [12] in the USNM included one voucher specimen from *Pl. indicus* (USNM 1356610) and two voucher specimens from *Platycephalus* sp. (USNM 1356611); none of his specimens from *Pl. fuscus* were apparently submitted to the USNM for deposition. Examination of the available voucher specimens revealed that those from *Platycephalus* sp. were conspecific with *Pt. austrinum* n. sp. and that Young's specimen from *Pl. indicus* could not be identified but may represent an undescribed species. Finally, it should be mentioned that the platycephalid fishes of Australia

recently have undergone significant taxonomic revision [13] and that those previously identified as *Pl. indicus* from the Moreton Bay area are now *Pl. australis* Imamura.

During the present study, a single specimen of *Pt. austrinum* n. sp. was collected from the gills of *Pl. endrachtensis* from Moreton Bay. Although this finding represents the first recorded occurrence of the nominal species in the bay, it technically does not represent a new geographic record for the parasite. Young's [12] report of *Ps. platycephali* (now *Pt. austrinum* n. sp.) serves as the first recorded occurrence of the species in the bay.

3.6. *Platycephalotrema macassarensis* (Yamaguti, 1963) n. comb.

Syns *Ancyrocephalus platycephali* Yamaguti, 1953; *Ancyrocephalus macassarensis* Yamaguti, 1963; *Haliotrema macassarensis* (Yamaguti, 1963) Bychowsky & Nagibina, 1971; *Haliotrema macassariensis* of Bychowsky & Nagibina [11] (lapsus).

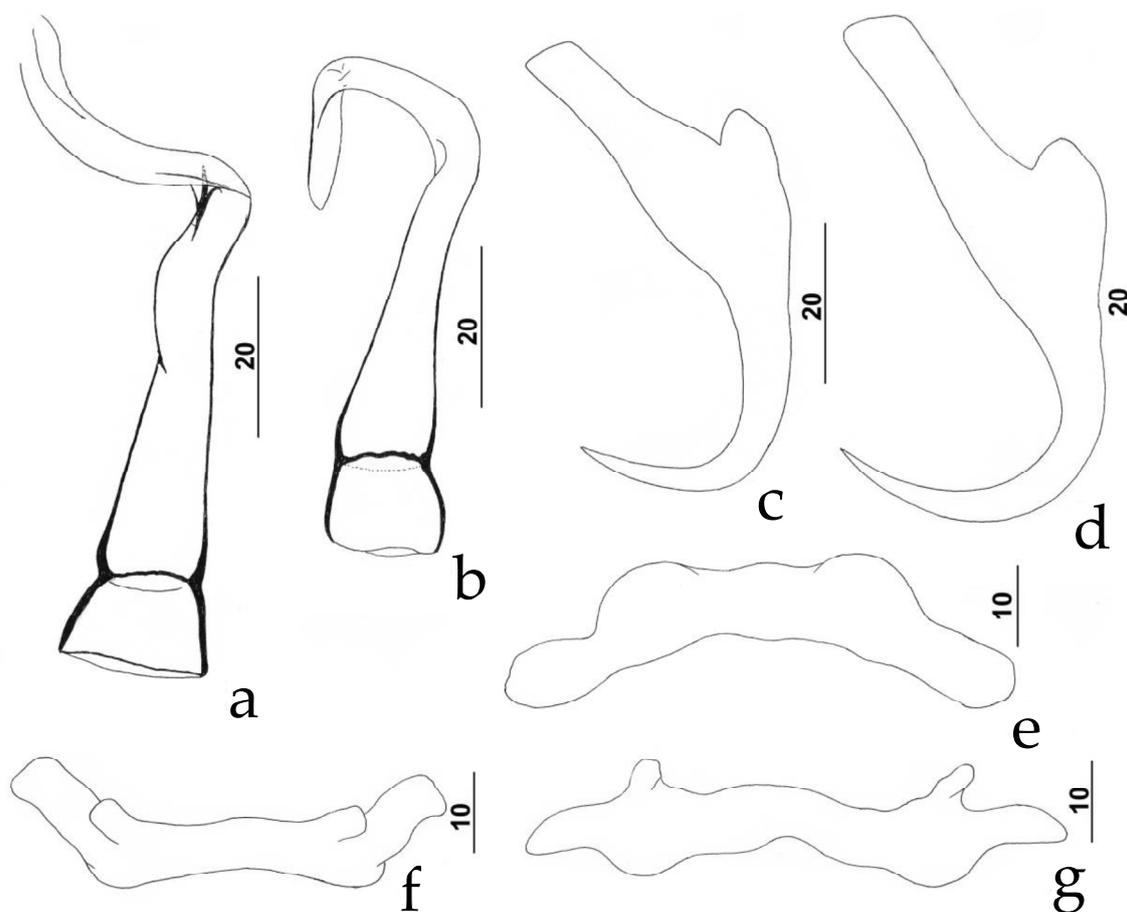


Figure 5. *Platycephalotrema macassarensis* (Yamaguti, 1963) n. comb. (a–b). male copulatory organs (ventral views); (c). dorsal anchor; (d). ventral anchor; (e). ventral bar; (f–g). dorsal bars.

3.6.1. Measurements

Body 663–838 (750; n = 2); greatest width of body proper (anterior trunk) 127–142 (135; n = 2). Haptor 125–155 (140; n = 3) wide. Ventral anchor 61–66 (64; n = 3) long; dorsal anchor 56–59 (58; n = 3) long. Ventral bar 60–63 (61; n = 3) long; dorsal bar 60–68 (65; n = 3) long. Hook 12–13 (n = 4) long. Pharynx 36–43 (40; n = 3) wide. MCO 62–64 (63; n = 3) long. Testis 81–82 (n = 1) long, 42–43 (n = 1) wide. Germarium 49–50 (n = 1) long, 50–51 (n = 1) wide.

3.6.2. Taxonomic Summary

Type host: Bartail flathead, *Platycephalus indicus* (Linnaeus) (Platycephalidae).

Type locality: Macassar, Celebes.

Previous records: *Pl. indicus*: Macassar, Celebes as *Ancyrocephalus platycephali* Yamaguti, 1953 [14]; South China Sea off Hainan, China as *Haliotrema macassariensis* Yamaguti, 1963 (lapsus) [11]; Guangdong Province, China as *Haliotrema macassarensis* [15].

Infection site: Gill lamellae.

Specimens studied: 3 syntypes, *Ancyrocephalus platycephali* Yamaguti, 1953, MPM 23204 (SY6718; labeled paratypes: Notes on the slide containing the three specimens indicate that paratypes of *Ancyrocephalus platycephali* Yamaguti, 1953 were present. However, Yamaguti [14] did not specifically identify a holotype or paratypes for this species. According to Dr. K. Ogawa (personal communication), personnel at the MPM designated the specimen drawn as the whole mount by Dr. Yamaguti as the holotype and the remaining specimens were considered the paratypes, which is against the rules presented in the International Code of Zoological Nomenclature (ICZN) [16]. The specimens on which the original description was based are all syntypes according to Article 73 of the ICZN).

3.6.3. Remarks

This species was originally described as *Ancyrocephalus platycephali* by Yamaguti [14]. In order to remove secondary homonymy, Yamaguti [17] renamed the species *A. macassarensis* when he transferred the senior *Haliotrema platycephali* Yin & Sproston, 1948 to *Ancyrocephalus*. Later, Bychowsky & Nagibina [11] transferred *A. macassarensis* and returned *A. platycephali* of Yin & Sproston [10] to *Haliotrema*. Retention of “*macassarensis*” for the specific name of Yamaguti’s species was required after Bychowsky & Nagibina’s [11] taxonomic acts, because the two helminth species remained congeners.

Haliotrema macassarensis is now transferred to *Platycephalotrema* as *Pt. macassarensis* (Yamaguti, 1963) n. comb. based on the presence of two large prostatic reservoirs, tandem gonads, a dextral vaginal pore, a large vaginal vestibule, a copulatory complex lacking an accessory piece, and a haptor armament morphologically similar to that of other species currently assigned to the genus (Figure 5). Neither Yamaguti [14] nor Bychowsky & Nagibina [11] reported the presence of haptor reservoirs associated with the ventral or dorsal anchors, and examination of the three syntypes did not clearly reveal their presence. Yamaguti [14] mentioned two “muscle bundles” lying near the “end of the dorsal (superficial) root of the dorsal hook (anchor)” in the original description, but no such structures were depicted by Bychowsky & Nagibina [11]. In the available syntypes of *A. platycephali* Yamaguti, 1953, the structures referenced by Yamaguti [14] were visible and appeared to contain comparatively coarse fibers that differed from the muscle fibers of muscles entering the haptor from the peduncle. Nonetheless, it was unclear in the syntypes if the structures mentioned by Yamaguti [14] are muscle bundles or vesicles containing fibrous secretions.

Bychowsky & Nagibina [11] recorded *H. macassarensis* from *Pl. indicus* in the South China Sea off Hainan, while the type locality of the species (Macassar, Celebes) lies approximately 5,700 km distant. Within the Indo-Pacific Region, Puckridge et al. [2], looking at cryptic diversity between populations of flatheads, recognized that eight lineages of *Pl. indicus* existed using COI barcoding and that specimens of *Pl. indicus* from the northwest Pacific (including the waters off Korea, Japan, and China) showed major genetic differences from those collected from Indonesia. These findings suggested that the platycephalid hosts of the dactylogyrids from off Hainan, China and off Macassar may represent different, albeit cryptic, flathead species. Concordantly, the helminths reported by Yamaguti [14] and Bychowsky & Nagibina [11] may also represent different but morphologically similar species, an idea probably requiring molecular analyses of the helminths from the two locations for confirmation.

Comparison of Bychowsky & Nagibina’s [11] drawings with the available syntypes of *A. platycephali* Yamaguti, 1953 showed minimal morphological differences between the Russian account and the syntypes. However, Bychowsky & Nagibina [11] depicted a series of fine lines associated with the terminal half of the MCO in their figure 2B, whereas similar lines were not mentioned or shown in the

original description by Yamaguti [14]. However, our examination of the syntypes of *A. platycephali* Yamaguti, 1953 revealed that the lines shown by Bychowsky & Nagibina [11] likely represented thin apparently sclerotized ridges occurring along or within the wall of the genital atrium rather than being directly associated with the MCO.

3.7. *Platycephalotrema thysanophrydis* (Yamaguti, 1937) n. comb.

Syns *Ancyrocephalus thysanophrydis* Yamaguti, 1937; *Haliotrema thysanophrydis* (Yamaguti, 1937) Bychowsky & Nagibina, 1971; *Haliotrema thysanophrydis* (Yamaguti, 1937) Bychowsky & Nagibina, 1971 (lapsus).

3.7.1. Redescription (Figure 6)

Greatest width of body proper in posterior trunk or near midlength of trunk. Cephalic region with well-developed pairs of terminal and bilateral cephalic lobes. Eyespots usually absent; numerous free chromatic granules in cephalic region. Pharynx subspherical; esophagus short to absent. Peduncle short, slightly tapered posteriorly; haptor subhexagonal, with three bilateral pairs of lobes each containing haptor hook near tip. Ventral and dorsal anchors similar; each with elongate superficial root, short deep root, slightly arcing short shaft, elongate point. Ventral bar bowed, with broad spatulate ends. Dorsal bar with globose bilobed subterminal ventral limbs, flattened dorsal terminal limbs. Hook with uniform shank and protruding depressed thumb; FH loop nearly shank length. MCO with small fusiform base having proximal collar, delicate slightly coiled shaft recurved distally. Testis ovate to subspherical; proximal vas deferens not observed; seminal vesicle a small fusiform dilation of distal vas deferens lying to left of distal portion of MCO; ejaculatory duct directed posteriorly from seminal vesicle to base of MCO dorsal to prostatic reservoirs. Prostates not observed. Prostatic reservoirs large, overlying each lying each other to right of MCO; ventral reservoir containing dense staining secretory product; dorsal reservoir often obscured by ventral prostatic reservoir, containing nearly translucent contents. Germarium variable in shape, displaced to right side of body immediately anterior to testis. Oviduct, ootype, Mehlis' gland, uterus, seminal receptacle not observed. Vaginal pore dextral; vaginal vestibule large, often extending to left intestinal cecum, lacking sclerotized components; vaginal canal not observed. Vitellarium dense, coextensive with intestinal caeca; transverse vitelline duct anterior to germarium. Eggs not observed.

3.7.2. Measurements

Body 697–1,088 (918; n = 25); greatest width of body proper 155–272 (220; n = 25). Haptor 158–216 (181; n = 25) wide. Ventral anchor 79–89 (85; n = 24) long; dorsal anchor 84–100 (92; n = 22) long. Ventral bar 64–78 (72; n = 13) long; dorsal bar 71–98 (83; n = 14) long. Hook 12–13 (n = 14) long. Pharynx 40–56 (47; n = 23) wide. MCO 120–164 (148; n = 17) long. Testis 100–207 (159; n = 23) long, 102–194 (139; n = 24) wide. Germarium 48–118 (82; n = 24) long, 51–107 (80; n = 24) wide.

3.7.3. Taxonomic Summary

Type host: Japanese flathead, *Thysanophrys japonicus* (Tilesius) [now *Inegocia japonica* (Cuvier), a possible mis-identification of *Cociella crocodilus* (Cuvier) (see Remarks)] (Platycephalidae).

Type locality: Tarumi, Hyogo Prefecture, Japan.

Previous records: *T. japonicus* (= *Inegocia japonica*): Inland Sea near Tarumi, Hyogo Prefecture, Japan, 3 August 1936 [18]. *Cocius crocodilus* (Tilesius) [as *Coccius crocodilus* (Tilesius) (lapsus); now *Cociella crocodilus*]: Yellow Sea as *Haliotrema thysanophrydis* (Yamaguti, 1937) Bychowsky & Nagibina, 1971 (sic) [11].

Current records: *Cociella crocodilus* [standard Japanese name is “Ine-gochi” (イネゴチ) and known within the local region as “Me-kochi” (メコチ)]: Seto Inland Sea, Hiuchi-nada, Imabari City, Ehime Prefecture (purchased at the market of the Imabari Fishery Cooperative), Japan (34°06' N, 133°21' E), 23 June 2015; Seto Inland Sea, Utsumi-chō, off Yoko-shima Island, Fukuyama City, Hiroshima

Prefecture, Japan (34°21.5' N, 133°16.5' E), 19 February 2017, 26 February 2019. *Inegocia ochiaii* Imamura [host identified as “Wani-gochi” (ワニゴチ) in MPM records and collected by Dr. Kusuo Iwata (Fukuoka University)]: Sea of Japan, off Kyushu (coordinates not available), Japan, 10 May 1978.

Infection site: Gill lamellae.

Specimens studied: 4 syntypes, MPM 23107 (SY0262); 47 voucher specimens, MPM 21470, 21471, 21521, QM G238133, HWML 216007; 5 voucher specimens (collected by Dr. K. Iwata), MPM 31090 (F0287–0291).

3.7.4. Remarks

Platycephalotrema thysanophrydis is currently known to parasitize three species of platycephalid fishes. Yamaguti [18] described the species from the gills of the Japanese flathead *Thysanophrys japonicus* (Tilesius) (now *Inegocia japonica*) from the Seto Inland Sea off Tarumi, Hyogo Prefecture, Japan. However, the name of the host was written, presumably by Dr. Yamaguti, as メコチ (= “Me-kochi”) on the slide label of the syntypes (MPM 23107). While the Japanese flathead and the crocodile flathead *Cociella crocodilus* are sympatric in the Seto Inland Sea, the local Japanese name “Me-kochi” currently refers to the latter species and not to *I. japonica* within the region from which Yamaguti [18] collected the fish host (see [19]). The helminth was subsequently reported from the crocodile flathead from the Yellow Sea off China by Bychowsky and Nagibina [11], and during the course of the present study, it was found on the gill lamellae of this flathead from the Seto Inland Sea of Japan.

The search for other published or unpublished records of dactylogyrids infesting flatheads resulted in the finding of five specimens of a dactylogyrid deposited by Dr. K. Iwata (Fukuoka University) in the collection of the Meguro Parasitological Museum (MPM 31090); these specimens also were identified herein as *Pt. thysanophrydis*. Museum records indicate that Dr. Iwata collected his specimens from a fish locally known as “Wani-gochi” (ワニゴチ), which recently was described as *Inegocia ochiaii* Imamura by Imamura [20]. Whereas the three species of flatheads currently recorded as hosts for *Pt. thysanophrydis* have overlapping geographic ranges (see [21]) and assuming all previous host identifications were correctly determined, *Pt. thysanophrydis* is the only species of *Platycephalotrema* known to infect fishes assigned to more than one platycephalid genus, and its occurrence on *I. ochiaii* represents a new host record for the species. It should be mentioned, however, that the taxonomy of some flathead fishes has recently undergone significant revision and that identification of many platycephalid species is often difficult, suggesting that a re-examination of the dactylogyrids infecting the two previously mentioned species of *Inegocia* should be conducted in order to confirm the comparatively low host specificity exhibited by *Pt. thysanophrydis*.

Young [12] identified a dactylogyrid from the gills of *Pl. fuscus* from Moreton Bay, Queensland, Australia, as *Pseudohaliotrema thysanophrydis* (Yamaguti, 1937) Young, 1968. Examination of two of Young’s voucher specimens deposited in the USNM (1356609) revealed that the identification of the parasite as *Ps. thysanophrydis* was erroneous, and that the specimens instead represented *Pt. mastix* n. sp. *Platycephalotrema thysanophrydis* is differentiated from *Pt. mastix* sp. n. by having an elongate uniform shaft of the MCO, while that of *Pt. mastix* sp. n. has a comparatively larger diameter and a short keel along the outer surface near its midlength (compare Figures 3d and 6d).

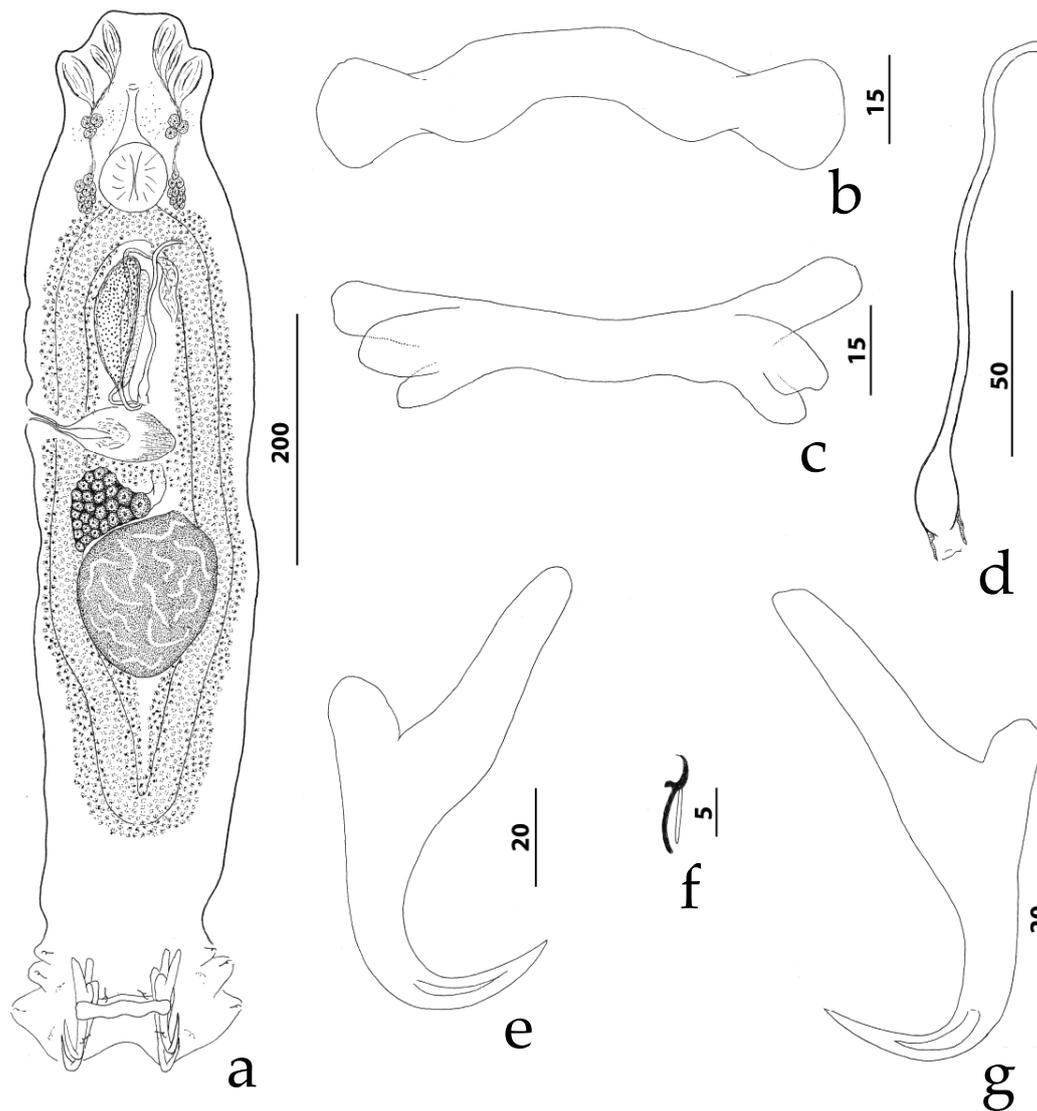


Figure 6. *Platycephalotrema thysanophrydis* (Yamaguti, 1937) n. comb. (a). Whole mount (composite, ventral view); (b). ventral bar; (c). dorsal bar (ventral view); (d). male copulatory organ (ventral view); (e). dorsal anchor; (f). hook; (g). ventral anchor.

3.8. *Platycephalotrema platycephali* (Yin & Sproston, 1948) n. comb.

Syns *Haliotrema platycephali* Yin & Sproston, 1948; *Ancyrocephalus platycephali* (Yin & Sproston, 1948) Yamaguti, 1963; *Pseudohaliotrema platycephali* (Yin & Sproston, 1948) Young, 1968; *Pseudohaliotrema platicephali* and *Haliotrema platicephali* both of Young [12] (both lapsus).

3.8.1. Taxonomic Summary

Type host: Bartail flathead, *Platycephalus indicus* (Linnaeus) (Platycephalidae).

Type locality: Chusan Region of the East China Sea, China.

Previous records: *Pl. indicus*: Chusan Region of the East China Sea, China [10]; South China Sea off Shanghai, China [11]; Fujian, Guangdong, Guangxi, China [15]; Weihai, Shandong Province, China [22]. *Pl. fuscus*: Moreton Bay, Queensland, Australia [12,23].

Infection site: Gill lamellae.

3.8.2. Remarks

This species was described as *Haliotrema platycephali* by Yin & Sproston [10] from the gills of *Platycephalus indicus* collected from the Chusan Region of the South China Sea. Bychowsky & Nagibina [11] subsequently reported the species from the same host in the South China Sea off Shanghai. *Haliotrema platycephali* was herein transferred to *Platycephalotrema* based on it having two large prostatic reservoirs each emptying separately into the base of the MCO, tandem gonads, a dextral vaginal pore, a large vaginal vesicle, a copulatory complex lacking an accessory piece, paired haptoral vesicles associated with the dorsal anchors, and the common features of the haptoral armament. It differs from all of its congeners by the complex distal end of the MCO (see figure 28 in [10]; figure 1B in [11]).

The report of *Pt. platycephali* by Bychowsky & Nagibina [11] in China appears to be the only valid account of the species since its original description by Yin & Sproston [10]. Young's [12] report of the species (as *Pseudohaliotrema plalticephali*) on *Pl. fuscus* from Moreton Bay, Australia, is likely erroneous. During the present study, the species was not found parasitizing the four specimens of *Pl. fuscus* examined for dactylogyrids from Moreton Bay.

3.9. *Platycephalotrema sinensis* (Yamaguti, 1963) n. comb.

Syns *Ancyrocephalus thysanophrydis* of Yin & Sproston [10] (nec Yamaguti [18]); *Ancyrocephalus sinensis* Yamaguti, 1963.

3.9.1. Taxonomic summary

Type host: Spotted flathead, *Platycephalus punctatus* Cuvier [now *Cociella punctata* (Cuvier)] (Platycephalidae).

Type locality: Sen-Chia-Men, Chusan Region, East China Sea, China.

Previous record: There have been no other records except that of Yin & Sproston [10].

Infection site: Gill lamellae.

3.9.2. Remarks

Yin & Sproston [10] reported *Ancyrocephalus thysanophrydis* from the spotted flathead collected from the Chusan Region of the East China Sea. Yamaguti [17] believed that Yin & Sproston's specimens were not conspecific with those he described in 1937 as *A. thysanophrydis* and, as a result, renamed the former specimens *A. sinensis*. Yamaguti [17] listed the following reasons for the renaming of Yin & Sproston's specimens: 1) differences in the structure of the dorsal bar (differences not specified); 2) the presence of two prostatic reservoirs (one reported by Yamaguti [18], but see the description and remarks herein for *Platycephalotrema thysanophrydis*); and 3) the presence of a genitointestinal canal (genitointestinal canal not mentioned, presumed absent in *A. thysanophrydis* by Yamaguti [18]). Yamaguti [17] apparently had in mind additional differences as indicated by his use of "etc." at the end of his list, but these were not provided in his justification for the renaming.

Although the features used to differentiate *A. sinensis* from *A. thysanophrydis* on the surface appear to justify Yamaguti's [17] actions, the two nominal species nonetheless may be synonyms. Yin & Sproston [10] did not examine the type specimens of *A. thysanophrydis* for comparison. As a result, they had some doubt that their specimens were conspecific with this species when they stated that "the dorsal bar has its ends deeply tri-fid . . . ; the upper ramus is bent slightly forwards, and the two lower point obliquely backwards in different planes," whereas Yamaguti [18] simply described the dorsal bar as being straight. However, examination of the two available syntypes of *A. thysanophrydis* revealed that the dorsal bars are straight with tri-fid ends (ventral limb actually bilobed) similar to that described by Yin & Sproston [10]. The shape of the dorsal bar in the available voucher specimens of *Pt. thysanophrydis* from Japan conforms to that shown by Yin & Sproston [10] (compare Figure 6c with figure 25 in Yin & Sproston [10]). While two prostatic reservoirs were not visible in the two syntypes, both were observed in the voucher specimens collected from *Cociella crocodilus* from Japan during the

present study. In the latter specimens, the posterior (dorsal) reservoir contained a nearly transparent material that often precluded observation of the vesicle, further suggesting that this vesicle was missed by Yamaguti [18]. Finally, the presence of a genitointestinal canal as reported by Yin & Sproston [10] for their specimens is clearly erroneous. A genitointestinal canal is an apparent synapomorphy for the Infraclass Oligonchoinea (see [24,25]), whereas it does not occur in members of the Subclass Polyonchoinea, to which dactylogyrid species belong [26,27]. Thus, there is a high probability that *Pt. sinensis* is a synonym of *Pt. thysanophrydis*. In order to minimize potential synonyms, however, formal proposal of synonymy is not made pending new collections of dactylogyrids infecting the spotted flathead.

3.10. *Platycephalotrema bassensis* (Hughes, 1928) n. comb.

Syn. *Ancyrocephalus bassensis* Hughes, 1928.

3.10.1. Taxonomic Summary

Type host: Southern sand flathead, *Platycephalus bassensis* Cuvier (Platycephalidae).

Type locality: Port Phillip Bay, Australia.

Previous records: *Pl. bassensis*: Port Phillip Bay, Australia [28]. Murray [29] reported this species from *Pl. bassensis* but did not provide a specific locality from which the host and its parasite were collected other than indicating in the introduction to the paper that most of the fishes were from "Southern Australian waters." However, Murray [29] described two other parasites from *Pl. bassensis* which she clearly indicates were from Port Phillip Bay, Victoria, Australia. It seems likely, therefore, that her specimens of *A. bassensis* also originated from this locality.

Infection site: Gill lamellae.

3.10.2. Remarks

Specimens of this species were not available for study. Attempts to locate the type specimens used by Hughes [28] for the description of the species and the voucher specimens reported by Murray [29], included inquiries to the Queensland Museum (Brisbane), Museums Victoria (Melbourne), South Australian Museum (Adelaide), Australian Museum (Sydney), and The Natural History Museum (London). All attempts were unsuccessful.

Inconsistencies regarding the dorsoventral axis of the body in the respective descriptions and figures exist in both accounts of the species by Hughes [28] and Murray [29]. For example, in her figure 3 (labeled a ventral view), Hughes [28] shows the so-called prostate (apparently a prostatic reservoir) lying to the right of the MCO, while in the description she states that the structure lies to the left of the penis. In her figure 3, the vas deferens and seminal vesicle are shown to be within the left side of the body (as occurs in other dactylogyrids), but the germarium is suggested to dorsally overlap the anterior end of the testis (germarium usually ventral to testis in other dactylogyrids with overlapping gonads). Similar inconsistencies occur in the account of the species provided by Murray [29]. Here, she states that the vas deferens is "slightly to the right" and joins the seminal vesicle on the right side of the body (opposite that reported by Hughes [28] and what usually occurs in other dactylogyrids); she describes two ducts arising from the seminal vesicle, one of which extends directly to the base of the MCO, while the other duct passes to the right side of the MCO where it joins a small rounded body (labeled an accessory vesicular seminalis). However, in her figures 2 and 10, the accessory vesicular seminalis lies to the left of the MCO, assuming the figures are in ventral views. In the description, Murray [29] reports two prostatic glands (= prostatic reservoirs) (position not provided), but shows them to be to the left of the MCO in her figures 2 and 10. Similar to the report of Hughes [28], her figures 2 and 10 suggest that the germarium dorsally overlaps the testis and that the uterus lies dorsal to the vas deferens (uterus ventral to the ducts of the male reproductive system in other dactylogyrids).

These inconsistencies clearly demonstrate the need for a redescription of the species. Nonetheless, *Ancyrocephalus bassensis* is transferred to *Platycephalotrema* as *Pt. bassensis* (Hughes, 1928) n. comb., based

on the presence of two prostatic reservoirs [29]; tandem, slightly overlapping gonads; and a dextral vaginal pore (assuming the dorsoventral axes reported by Hughes [28] and Murray [29] are erroneously depicted), a large vaginal vestibule, and absence of an accessory piece in the copulatory complex.

3.11. *Dactylogyrids from Scorpaeniform Fishes that Are Potential Members of *Platycephalotrema* n. gen.*

3.12. *Ancyrocephalus vesiculosus* Murray, 1931

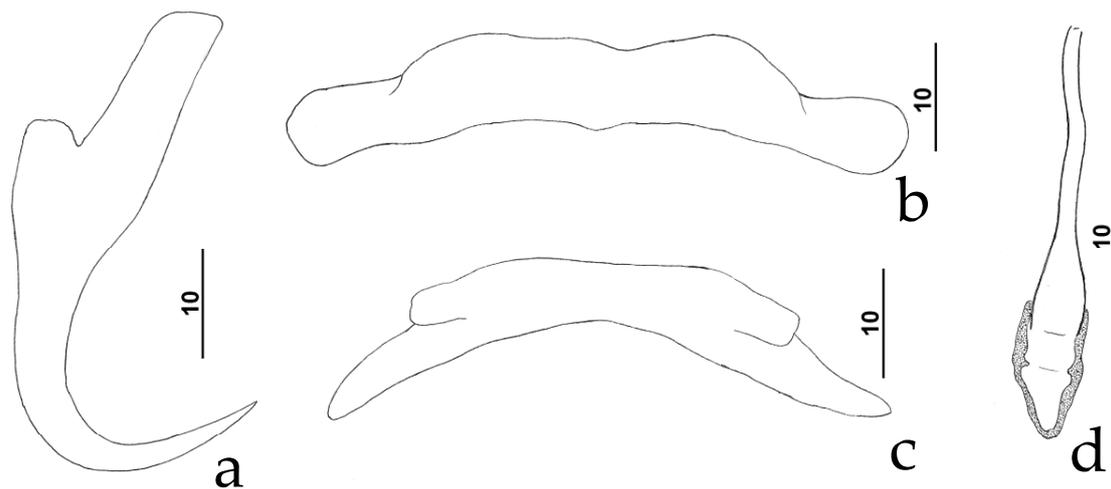


Figure 7. *Ancyrocephalus vesiculosus* Murray, 1931. (a). ventral anchor; (b). ventral bar; (c). dorsal bar; (d). male copulatory organ (ventral view).

3.12.1. Measurements

Body 716–946 (808; n = 5); greatest width of trunk 160–231 (190; n = 7). Haptor 139–161 (150; n = 5) wide. Ventral anchor 46–49 (47; n = 4) long; dorsal anchor 43–47 (45; n = 3) long. Ventral bar 49–52 (51; n = 3) long; dorsal bar 49–51 (50; n = 4) long. Hook 12–14 (13; n = 6) long. Pharynx 39–52 (46; n = 7) wide. MCO 36–49 (42; n = 7) long. Testis 57–99 (85; n = 6) long, 75–119 (98; n = 6) wide. Germarium 49–73 (65; n = 4) long, 35–56 (43; n = 4) wide.

3.12.2. Taxonomic Summary

Type host: Southern sand flathead, *Platycephalus bassensis* Cuvier (Platycephalidae).

Type locality: Port Phillip Bay, Victoria, Australia.

Previous record: There have been no previous records other than that of the original description by Murray [29]. Hooper [30] lists *Pl. arenarias* Ramsay & Ogilby (now *Pl. endrachtensis*, see [31]) as a host for *A. vesiculosus* in his Appendix 1 (Checklist of parasites from Australian flathead fishes), where he erroneously credits Murray [29] and Yamaguti [17] for the record. However, no published accounts of *Pl. arenarias* or *Pl. endrachtensis* serving as hosts for this parasite were found during an exhaustive literature search.

Infection site: Gill lamellae.

Specimens studied: 9 syntypes (7 whole-mounts and 2 transversely sectioned syntypes), Museums Victoria, Melbourne, Victoria, Australia (MV) F60389.

3.12.3. Remarks

Ancyrocephalus vesiculosus could not be assigned to *Platycephalotrema* with certainty. Murray [29] collected this species from two of “about” 50 *Platycephalus bassensis* she examined from Port Phillip Bay in southern Australia. The species was described as having the usual number and distribution of haptor sclerites found in dactylogyrids, four haptor vesicles lying in relation to the anchors,

tandem gonads (testis post-germarial), a trilobed prostate (prostatic reservoirs were not mentioned), a chitinous tube lying in connection with the MCO, and a vaginal pore on the left side of the body just anterior to the germarium.

Examination of the available syntypes of *A. vesiculosus* confirmed the presence of four haptoral vesicles, the number and position of the hooks and anchor/bar complexes in the haptor (Figure 7), and presence of tandem gonads, but the presence of the trilobed prostate could not be confirmed. It appears that the dorsoventral axis of the helminth was reversed in the original description. Although the vaginal pore and vestibule were difficult to see in the syntypes, an indication of the former on the right side of the body was present. That the dorsoventral axis of the body was reversed in the original description was further supported by Murray's drawing of the whole mount showing the vas deferens along the right side of the body (vas deferens usually extending along the left side of the body in dactylogyrids) and the germarium ventrally overlain by the testis (testis usually dorsal to the germarium in dactylogyrids).

Murray [29] described a "chitinous tube" ventral to the MCO as indicated in her figure 1A of the copulatory complex. The nature and function of the tube was not determined in the available syntypes, although it did not appear to be "chitinous" (or sclerotized) as stated by Murray [29]. It may represent a descending portion of the ejaculatory duct, but this requires confirmation.

The original description of this species was apparently based on more specimens than the seven whole mounts and two transversely sectioned syntypes that were available for study. None of the available syntypes represented the specimen on which Murray's whole-mount drawing was based, and Murray [29] did not indicate the total number of specimens available to her. Based on the above observations, this species clearly requires redescription in order to determine its taxonomic position within the Dactylogyridae.

3.13. *Haliotrema indicum* Tripathi, 1957

Syn. *Ancyrocephalus indicum* (Tripathi, 1957) Yamaguti, 1963.

3.13.1. Taxonomic Summary

Type host: Bartail flathead, *Platycephalus insidiator* (Forsskål) [now *Pl. indicus* (Linnaeus)] (Platycephalidae).

Type locality: Estuary of Matla River at Canning and Hooghly River, India.

Previous record: There have been no other records except that of the original description [32].

Infection site: Not indicated (probably gill lamellae).

3.13.2. Remarks

Specimens of this species were not available, and the type specimens apparently have not survived (see [33,34]). The original description of *Haliotrema indicum* is inadequate, and if valid, the species requires redescription. Tripathi [32] indicated in his remarks that *H. indicum* most closely resembled *H. platycephali* of Yin & Sproston [10], differing from it in the morphology of the vagina and in the size of the MCO. Tripathi [32] described the vagina of *H. indicum* as a "bowl-shaped structure, whose outer margin is frayed." Although Yin & Sproston [10] mention the presence of a vagina, they did not provide a detailed description of it, while stating that the female ducts were obscured by the cells of the vitelline field. Yin & Sproston's [10] whole-mount drawing also showed no details of the vagina or vaginal vestibule, suggesting that Tripathi's use of it for differentiating *H. indicum* from Yin & Sproston's species lacks merit.

That both *H. indicus* and *H. platycephali* were described from the same host, that Tripathi's descriptive account lacks specificity, and that the drawing of the MCO provided by Tripathi [32] in his whole-mount figure of *H. indicus* superficially resembles that provided by Yin & Sproston [10] for *H. platycephali*, suggests that the two species are synonyms. Formal proposal of synonymy, however, must await new collections of the dactylogyrids parasitizing *Pl. indicus* in both China and India.

3.14. *Haliotrema swatowensis* Yao, Wang, Xia, & Chen, 1998

3.14.1. Taxonomic Summary

Type host: Bartail flathead, *Platycephalus indicus* (Linnaeus) (Platycephalidae).

Type locality: South China Sea, off Nanao Island, Guangdong Province, China.

Previous record: There has been no other record except that of the original description [35].

Infection site: Gill lamellae.

3.14.2. Remarks

The type specimens of this species were not available for study. *Haliotrema swatowensis* represents the fourth dactylogyrid species recorded from the bartail flathead and the second from this host in the South China Sea. Other species include *H. platycephali* (now *Platycephalotrema platycephali*), *Ancyrocephalus macassarensis* (now *Pt. macassarensis*), and *H. indicum*. The original description of *H. swatowensis* is comprised solely of measurements of the body, pharynx, and haptor and copulatory structures and drawings of the haptor sclerites, MCO, and vagina. Yao et al. [35] differentiated *H. swatowensis* from *H. platycephali* by stating that the two species differed “in the structure and size of the copulatory organ.” However, the MCO of *H. swatowensis* depicted by Yao et al. [35] resembles that of *H. platycephali* as depicted by Yin & Sproston [10] and Bychowsky & Nagibina [11]. Finally, Yao et al. [35] showed jagged (or frayed) margins in their drawing of the vagina, which resembled the frayed vaginal margin mentioned by Tripathi [32] for *H. indicum*. These observations suggested that *Pt. platycephali*, *H. indicum*, and *H. swatowensis* were possible synonyms (see also the Remarks for *H. indicum* above). However, determination of synonymy among these nominal species would require a more extensive collection of the dactylogyrid parasites infecting *Pl. indicus* from throughout its geographic range. *Platycephalotrema macassarensis* is excluded from this group of species by having a simple tubular termination of the MCO.

3.15. *Haliotrema pterois* Paperna, 1972

3.15.1. Taxonomic Summary

Type host: Red lionfish, *Pterois volitans* (Linnaeus) [a probable mis-identification of the devil firefish, *Pterois miles* (Bennett)] (Scorpaenidae).

Type locality: Southwest Gulf of Eilat (Gulf of Aqaba).

Previous record: There have been no other records except that of the original description [36].

Infection site: Gill lamellae.

3.15.2. Remarks

Although its host is not a member of the Platycephalidae, this species was included among the potential members of *Platycephalotrema* because of its similar haptor sclerites to those of species presently assigned to the genus, presence of a dextral vaginal pore, and absence of an accessory piece in the copulatory complex. Paperna [36] did not mention the presence of prostatic reservoirs in this species, which at this time prevented transfer of the species to *Platycephalotrema*.

Colorni & Diamant [37] reported an unidentified species of *Haliotrema* on the gills of the devil firefish, *Pterois miles* (Bennett), collected from “Eilat’s North Beach,” and Tuttle et al. [38] found *Haliotrema* sp. on the gills of red lionfish, *Pterois volitans*, from the Philippines. No mention was made in either of these papers that voucher specimens of the respective helminths were deposited in a museum collection, and a direct attempt to obtain specimens from Dr. Tuttle failed. Thus, new collections of the dactylogyrids infecting *P. miles* and *P. volitans* will be necessary to determine the generic placement of *H. pterois* within the Dactylogyridae.

As far as we know, *H. pterois* is the only other identified dactylogyrid species known to parasitize a marine scorpaeniform fish.

Finally, it should be mentioned that the type host of *H. pterois* was likely mis-identified by Paperna [36] as *P. volitans*. *Pterois volitans* is apparently restricted to the waters of the western Pacific and eastern Indian Ocean. In the waters of the western Indian Ocean including that of the Gulf of Eilat, *P. volitans* is replaced by *P. miles* [21].

4. Discussion

The Dactylogyridae includes several genera that have become known as “taxonomic wastebaskets,” each containing generally nondescript species lacking unique features that would allow their reassignment within the family. Among these genera are *Ancyrocephalus* and *Haliotrema*, both of which have long been known or suspected to be unnatural. In 1955, Gussev [39] recommended that *Ancyrocephalus* be referred to as “*sensu lato*” because of its wide range of species infecting both marine and freshwater fishes (50+ species according to Bychowsky & Nagibina [40]). Bychowsky and Nagibina [40] provided a diagnosis for *Ancyrocephalus (sensu stricto)*, to which they assigned only two of the 50+ species to the genus: *Ancyrocephalus paradoxus* Creplin, 1839 and *Ancyrocephalus percae* Ergens, 1966, both infecting freshwater percid fishes of the Palearctic. Similarly, *Haliotrema*, with approximately 150 nominal species infecting marine fishes assigned to 33 teleost families representing six orders: the Perciformes, Tetraodontiformes, Ophidiiformes, Scorpaeniformes, Siluriformes, and Beryciformes [41], was characterized as a taxonomic wastebasket by Klassen [42]. Unlike *Ancyrocephalus*, however, determination of the taxonomic boundaries of *Haliotrema (sensu stricto)* has not been accomplished.

Recent proposals of new dactylogyrid genera have narrowed *Haliotrema* and reduced the number of species assigned to *Ancyrocephalus (sensu lato)*. The proposal herein of *Platycephalotrema* n. gen. and transfer of five species previously assigned to *Ancyrocephalus* and/or *Haliotrema* has further reduced the diversity of species in the two genera. These actions followed the proposals of *Ligophorus* Euzet & Suriano, 1977 for two previously described species of *Haliotrema* [43]; *Euryhaliotrema* Kritsky & Boeger, 2002 for nine previously described species of *Haliotrema* [44]; *Euryhaliotrematoides* Plaisance & Kritsky, 2004 (now *Euryhaliotrema*) for three previously described species of *Haliotrema* [45]; *Haliotrematoides* Kritsky, Yang, & Sun, 2009 for 15 previously described species of *Haliotrema* [46]; and *Lethrinitrema* for three previously described species of *Haliotrema* [9]. Three additional species of *Haliotrema* and one species previously assigned by various authors to *Haliotrema* and *Ancyrocephalus* were transferred to *Euryhaliotrema*, and a species of *Haliotrema* was transferred to *Haliotrematoides* by Kritsky [47], further reducing the number of species assigned to the genus. The proposals of *Volsellituba* Řehulková, Justine, & Gelnar, 2010 and *Pennulituba* Řehulková, Justine, & Gelnar, 2010 by Řehulková et al. [48] have further limited the taxonomic borders of *Haliotrema (sensu lato)* and *Ancyrocephalus (sensu lato)* by preventing the assignments of these and other unrelated species to these genera.

Ancyrocephalus (sensu stricto) as proposed by Bychowsky & Nagibina [40] appears to represent a natural taxon, although further investigation is needed to determine if additional nominal species should be included within it. On the other hand, the absence of a clear definition of *Haliotrema (sensu stricto)* continues to hinder the understanding of the relationships among the remaining species assigned to it. While proposal of new genera, such as *Platycephalotrema* n. gen., might continue to reduce the unnatural composition of *Haliotrema*, investigations to define the genus in its strict sense are required. Until this is achieved, new species lacking well-defined or unique characteristics will likely continue to be added to the genus, further complicating the taxonomy of the taxon.

Author Contributions: Conceptualization, D.C.K. and M.N.; data curation, D.C.K. and M.N.; formal analysis, D.C.K. and M.N.; investigation, D.C.K. and M.N.; methodology, D.C.K. and M.N.; writing—original draft, D.C.K. and M.N.; writing—review & editing, D.C.K.

Funding: The research for this paper had no direct external funding to the authors.

Acknowledgments: This study was indirectly supported in part by an Australian Biological Resources Grant No. RF215-40 to Thomas Cribb and Scott Cutmore (University of Queensland) for the exploration of the diversity of parasites infecting the fishes in Moreton Bay, Queensland, Australia; and JSPS KAKENHI Grant Number JP18J00466 to M. Nitta for the sampling of fishes in Japan. John Page, David Thompson and the many students are gratefully acknowledged for assistance during the collection of the fishes in Australia. The support provided by the

staff of the Moreton Bay Research Station was instrumental during field operations. We thank Kazuya Nagasawa and Susumu Ohtsuka (Hiroshima University) and Takuya Sato (Kobe University) for providing laboratory facilities for the examinations of Japanese fishes. The authors gratefully acknowledge the following museum personnel for their assistance in locating type and voucher specimens: Kazuo Ogawa (Meguro Parasitological Museum, Tokyo, Japan), Lillian Tuttle (University of Hawai'i at Mānoa, Honolulu, Hawaii, U.S.A.), Mal Bryant (Queensland Museum, South Brisbane, Queensland, Australia), Leslie Chisholm (South Australian Museum, Adelaide, South Australia, Australia), Steve Keable (Australian Museum, Sydney, New South Wales, Australia), and Chris Rowley (Museum Victoria, Melbourne, Victoria, Australia). We thank Kazuo Ogawa, Katie Ahlfeld (Smithsonian Institution, Suitland, Maryland, U.S.A), Eileen Harris (The Natural History Museum, London, U.K.), and Melanie Mackenzie (Museum Victoria, Melbourne, Victoria, Australia) for loans of type and voucher specimens that were essential for completion of this study.

Conflicts of Interest: The authors declare no conflict of interest.

Ethical Approvals: All applicable institutional, national, and international guidelines for the care and use of animals were followed.

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