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Article *in* Journal of Parasitology · September 2007

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THE FIRST CHONDRACANTHID (COPEPODA: CYCLOPOIDA) REPORTED FROM CULTURED FINFISH, WITH A REVISED KEY TO THE SPECIES OF *CHONDRACANTHUS*

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ABSTRACT: A new species of the Chondracanthidae (Copepoda: Cyclopoida), *Chondracanthus goldsmidi*, is described based on material collected from the nasobranchial region of striped trumpeter (*Latris lineata* [Forster]) cultured at the Tasmanian Aquaculture and Fisheries Institute, Marine Research Laboratories, Australia. This represents the first report of a chondracanthid copepod infecting cultured finfish and the first metazoan parasite from cultured striped trumpeter. *Chondracanthus goldsmidi* n. sp. can be distinguished from its female congeners by the absence of lateral processes on the head and the presence of 3 pairs of lateral trunk outgrowths, 3 middorsal body outgrowths (of which the first 2 are rounded), a small and subcylindrical antennule, and unornamented legs 1 and 2. A revised key to the 39 valid species of *Chondracanthus* is provided.

Latris lineata (Forster), known commonly in the southern hemisphere as striped trumpeter, is a demersal teleost species inhabiting the coasts of southeastern Australia, New Zealand, and South America (Kailola et al., 1993). This species, which grows to at least 1.2 m total length and 25 kg, has high-quality flesh and is amenable to culture conditions; it is currently being investigated as a candidate for commercial aquaculture at the Tasmanian Aquaculture and Fisheries Institute (TAFI), Marine Research Laboratories, Australia (Kailola et al., 1993; Trotter et al., 2001; Morehead and Hart, 2003; Bransden et al., 2005; Brown et al., 2005; Battaglene and Cobcroft, in press).

To date, only 1 parasite, namely the myxozoan *Kudoa neurophila* (Grossel, Dykovà, Handlinger and Munday, 2003), is known to cause disease in cultured striped trumpeter. This myxozoan species specifically targets the tissues of the central nervous system of postlarval striped trumpeter, resulting in behavioral abnormalities such as loss of spatial control (Grossel et al., 2003). Recent routine examination of healthy and moribund striped trumpeter reared at the Tasmanian Aquaculture and Fisheries Institute resulted in the discovery of a new parasite, a species of cyclopoid copepod, *Chondracanthus* Delaroche, 1811. The sessile parasites were commonly attached to tissue within the gill cavity, occasionally on the gills themselves, or in the nares. Host tissue appeared swollen at the attachment site and, in a severe infection of a population of 84 juveniles (250 g, 660 days old), holes developed in the operculum. Furthermore, 36 of these 84 fish died or were killed when close to death, over a 3-wk period. This new species, the first within the Chondracanthidae to be reported from cultured finfish, is herein described. Moreover, a revised key to the species of *Chondracanthus* is provided.

Received 14 November 2006; revised 29 January 2007; accepted 31 January 2007.

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MATERIALS AND METHODS

Parasites were collected from striped trumpeter *L. lineata* juveniles and adults that were either cultured or wild-caught animals held in captivity at the TAFI, Marine Research Laboratories in Tasmania. Fish were held in 25,000-L tanks supplied with unfiltered seawater at ambient temperature (annual range 9–19 C). Fish were routinely removed from the tanks, anaesthetized (0.02% 2-phenoxyethanol, Sigma-Aldrich, St. Louis, Missouri) and examined for chondracanthid copepods on 9 separate occasions (Table I). Twenty-four transformed adult female copepods (13 each with 1 attached male; 1 with 2 attached males; 2 without attached males) were removed from striped trumpeter, preserved in either 10% formalin or 70% ethanol, and later soaked in lactic acid for at least 24 hr prior to examination with an Olympus BX50 compound microscope. Three female and 4 male specimens were measured with the use of an ocular micrometer. Three specimens from each sex were dissected and examined according to the wooden slide procedure of Humes and Gooding (1964). All drawings were made with the aid of a camera lucida. Anatomical terminology follows Boxshall and Halsey (2004).

DESCRIPTION

Chondracanthus goldsmidi n. sp.

(Figs. 1–4)

Adult female: Body (Figs. 1A, B) divided into head, short neck, and stout trunk. Total length (from anterior margin of head to distal end of posterior processes on trunk) 4.92 ± 0.35 mm; trunk width 2.57 ± 0.43 mm; head length 1.23 ± 0.03 mm and head width 1.53 ± 0.20 mm. Head composed of cephalosome only, broader posteriorly, lacking processes. Neck region composed of first pediger only, with a rounded outgrowth on middorsal surface. Pedigerous somites 2, 3, and 4 fused to form a large trunk, bearing 3 pairs of lateral outgrowths (middle pair largest of three pairs), 1 pair of posterior processes, and 2 outgrowths along middorsal line; posterior middorsal outgrowth larger than anterior middorsal outgrowth, and protrudes either partially or completely over the genitoabdomen in dorsal view. Genitoabdomen (Fig. 1C) divisible as 2 tagmata by transverse constriction; anterior tagma bearing a minute seta near opening of each genital aperture and a sensilla on each posterolateral surface; posterior tagma suboval, narrower than genital somite, with a dorsal pair of sensillae and anteroventral pair of caudal rami. Caudal ramus (Fig. 1D) spiniform, armed with 2 ventral setae, 1 dorsal seta, and a medial knob.

Antennule (Fig. 1E) small, subcylindrical, with an armature of 1-1-1-3-2-8. Antenna (Fig. 2A) 2-segmented, composed of coxobasis and 1-segmented endopod; coxobasis short, unarmed; endopod forming uncinate claw, with transverse striations near apex. Labrum (Fig. 2B) with a small protrusion on each lateral margin and patches of minute spinules

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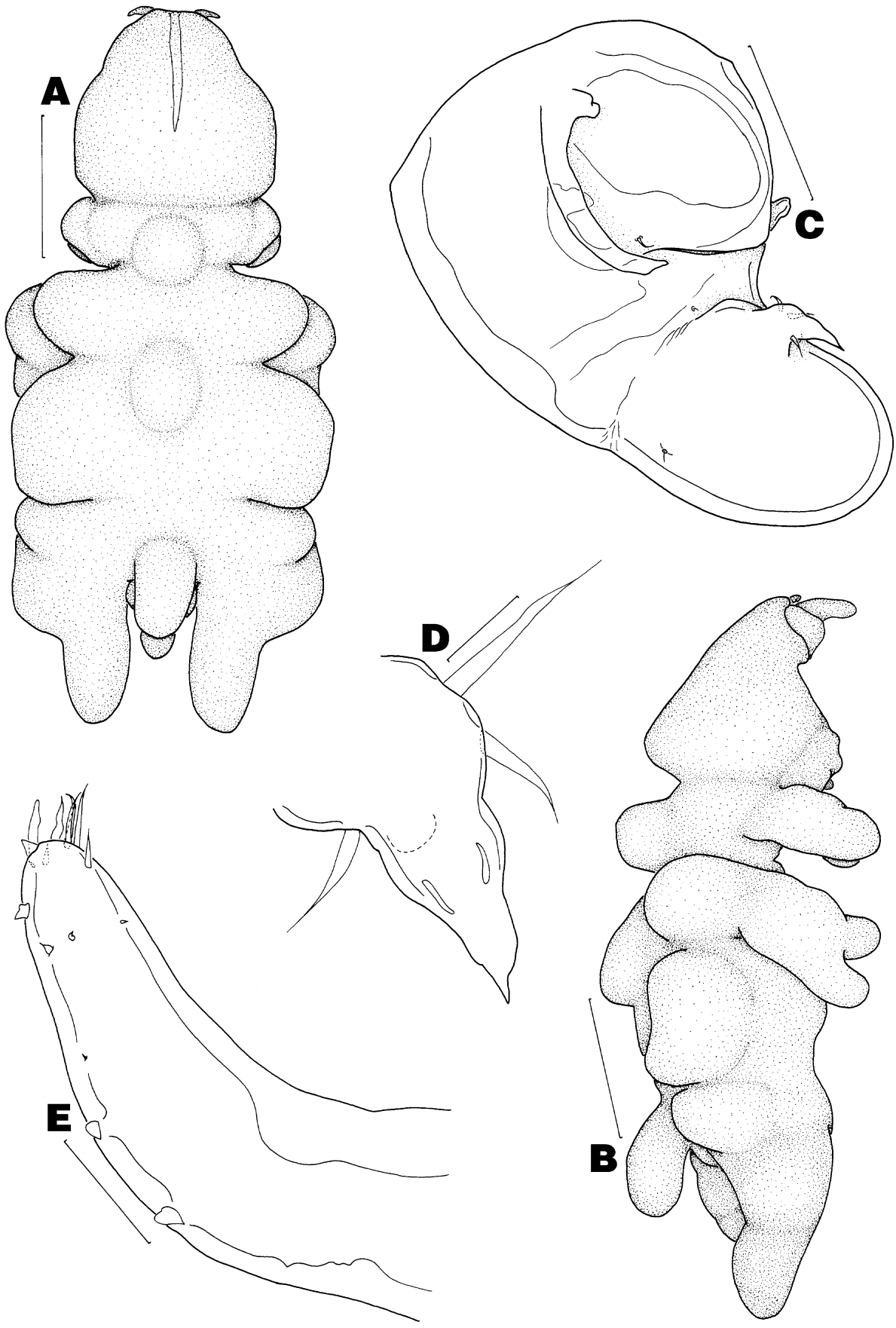
FIGURE 1. *Chondracanthus goldsmidi* n. sp., adult female. (**A**) Habitus, dorsal; (**B**) same, lateral; (**C**) genitoabdomen, lateral; (**D**) caudal ramus; (**E**) antennule. Scale bars: **A**, **B** = 1.00 mm; **C** = 200 μm; **D** = 25 μm; **E** = 50 μm.


A
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D
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TABLE I. Infection parameters of *Chondracanthus goldsmidi** parasitizing *Latris lineata* cultured at the Tasmanian Aquaculture and Fisheries Institute, Marine Research Laboratories, Australia.

Date	No. hosts examined	Mean† host length (cm)	Mean† host weight (kg)	Host age (days)	Prevalence (%)	Parasite counts (range)
4 June 2003	38	41.6 ± 4.5	1.08 ± 0.27	1,453	92	0 to >25
11 March 2005	48	24.3 ± 2.1	0.21 ± 0.05	675	54	0 to >8
21 April 2005	22	47.5 ± 2.8	1.76 ± 0.34	2,120	100	1 to >10
15 December 2005	5	28.9 ± 3.1	0.36 ± 0.35	954	80	0 to 8
20 December 2005	6	63.5 ± 5.2	4.03 ± 0.95	9–17 years‡	33	0 to 13
22 March 2006	154	28.0 ± 4.5	0.36 ± 0.25	683	42	0 to 4
30 March 2006	19	49.6 ± 5.1	2.08 ± 0.89	3,285	100	1 to 25
9 May 2006	58	41.2 ± 4.8	0.95 ± 0.54	1,385	100	5 to >60
23 May 2006	18	49.6 ± 4.5	2.26 ± 0.68	3,338	94	0 to 15

* Parasites were removed manually and fish treated with Neguvon® following each date given.
† Data are mean ± SD.
‡ Estimated age of wild-caught fish held in captivity for several years as brood stock.

along posterior margin. Mandible (Fig. 2C) 1-segmented, bearing apical falcate blade armed with 40–51 teeth on convex margin and 29–38 teeth on concave margin (counts based on each pair of mandibles from 3 specimens). Paragnath (Fig. 2D) trilobate, with spinules on small, outer lobe and large, medial lobe. Maxillule (Fig. 2E) lobate, bearing a large basal protrusion, a subapical patch of spinules, and 2 terminal, unequal elements. Maxilla (Fig. 2F) 2-segmented, comprised of syncoxa and basis; syncoxa robust, unarmed; basis forming a claw-like process, armed with 2 unequal basal setae and 11–13 marginal teeth (counts based on each pair of maxillae from 3 specimens). Maxilliped (Fig. 2G) 3-segmented, composed of syncoxa, basis, and terminal claw (formed from fused endopod and claw); syncoxa naked, longer than last 2 segments combined; basis stout, with 2 large patches of minute spinules along inner margin; claw short and robust, bearing 1 accessory tooth. Leg 1 (Fig. 2H) fleshy and bilobate, armed with an outer protopodal seta; both rami subequal and naked. Leg 2 (Fig. 3A) similar to leg 1, except larger in size.

Adult male: Body (Fig. 3B) 465 ± 30 μm long and 337 ± 12 μm wide; body segmentation indistinct; cephalothorax globose, comprising more than half total body length; urosome flexed ventrally. Genital somite completely fused with abdomen (Fig. 3C), bearing paired apertures ventrally; opercula unarmed. Caudal rami (Fig. 3C) spiniform, each bearing three basal setae, a small medial knob, and minute spinules apically.

Antennule (Fig. 3D) filiform, with an armature of 1-1-2-3-8. Antenna (Fig. 3E) short and stout, with 1 seta on the coxobasis and a medial seta on the claw. Labrum (Fig. 3F) as in female, except with median knob. Mandibular blade (Fig. 4A) bearing 13–23 teeth on convex side and 9–14 teeth on concave side (counts based on each pair of mandibles from 3 specimens). Maxillule (Fig. 4B) with 2 subequal, terminal elements, a small patch of spinules, and a medial lobe bearing an acuminate tip. Maxillary basis (Fig. 4C) lacking teeth; large basal seta unilaterally spinulated. Maxilliped (Fig. 4D) as in female, except with smaller patches of spinules on basis. Leg 1 (Fig. 4E) with inner basal protrusion, a long subapical seta (representing the protopodal seta), 2–3 apical setae (representing the exopodal elements), and an inner subtriangular process (representing the endopod). Leg 2 (Fig. 4F) similar to leg 1, except smaller in size and bearing 1–2 apical setae. One dissected specimen lacking endopod on leg 2 (Fig. 4G).

Taxonomic summary

Type host: Latris lineata (Forster, 1801) (Perciformes: Latridae).
Infection site: Branchial cavity wall, operculum, gills, nares.
Type locality: Crayfish Point, Taroona, Tasmania, Australia (43°35′S, 147°35′E).
Prevalence and parasite counts: See Table I.
Type material: The holotype female (AM P.73329), allotype (AM P.73330), and paratypes (3 females, each with attached male; AM P.73328) are deposited in the Australian Museum, Sydney, Australia.
Etymology: The specific name is in honor of Ross Goldsmid for his continuing work and commitment to brood-stock husbandry and the culturing of striped trumpeter juveniles, including parasite monitoring and management.

Remarks

With the absence of an atrophied tip on the antenna and possession of a cephalosomic head region, outgrowths on the trunk region, and 2 pairs of modified legs in the transformed adult female, the new species is unequivocally a member of *Chondracanthus* Delaroche, 1811. *Chondracanthus goldsmidi* n. sp. closely resembles *Chondracanthus irregularis* Fraser, 1920, in lacking lateral processes on the head and having 3 pairs of lateral outgrowths on the trunk and 3 middorsal outgrowths on the body. However, *Ch. goldsmidi* can be distinguished from *Ch. irregularis* by differences in the shape of the first two middorsal body outgrowths (rounded in *Ch. goldsmidi*; digitiform in *Ch. irregularis*), complexity of the mid-lateral trunk outgrowth (lacks a ventrolateral, digitiform outgrowth in *Ch. goldsmidi*; with ventrolateral, digitiform outgrowth in *Ch. irregularis*), antennular structure (small and subcylindrical in *Ch. goldsmidi*; large and fleshy in *Ch. irregularis*), and leg ornamentation (naked in *Ch. goldsmidi*; covered with fine denticles in *Ch. irregularis*) of the female, as well as in the shape of the antennule (slender in *Ch. goldsmidi*; inflated in *Ch. irregularis*) and structural details of the legs (with an inner basal protrusion in *Ch. goldsmidi*; lacking inner basal protrusion in *Ch. irregularis*) of the male.

All specimens identified to date have been from fish held in land-based tank systems at 1 site, and the effects of the parasite in sea cages and at alternative sites are unknown. However, this parasite has the potential to affect striped trumpeter in a sea-cage industry via mortality in the event of heavy infection, as has occurred in land-based systems, or possibly through reduced growth rates of infected fish, treatment costs, or reduced quality of harvested fish. Research to culture and describe the developmental stages of the parasite, examine the histopathology of infection, and test potential control and treatment methods for *Ch. goldsmidi* are currently underway and will be dealt with in detail elsewhere. Furthermore, wild striped trumpeter populations from Tas-

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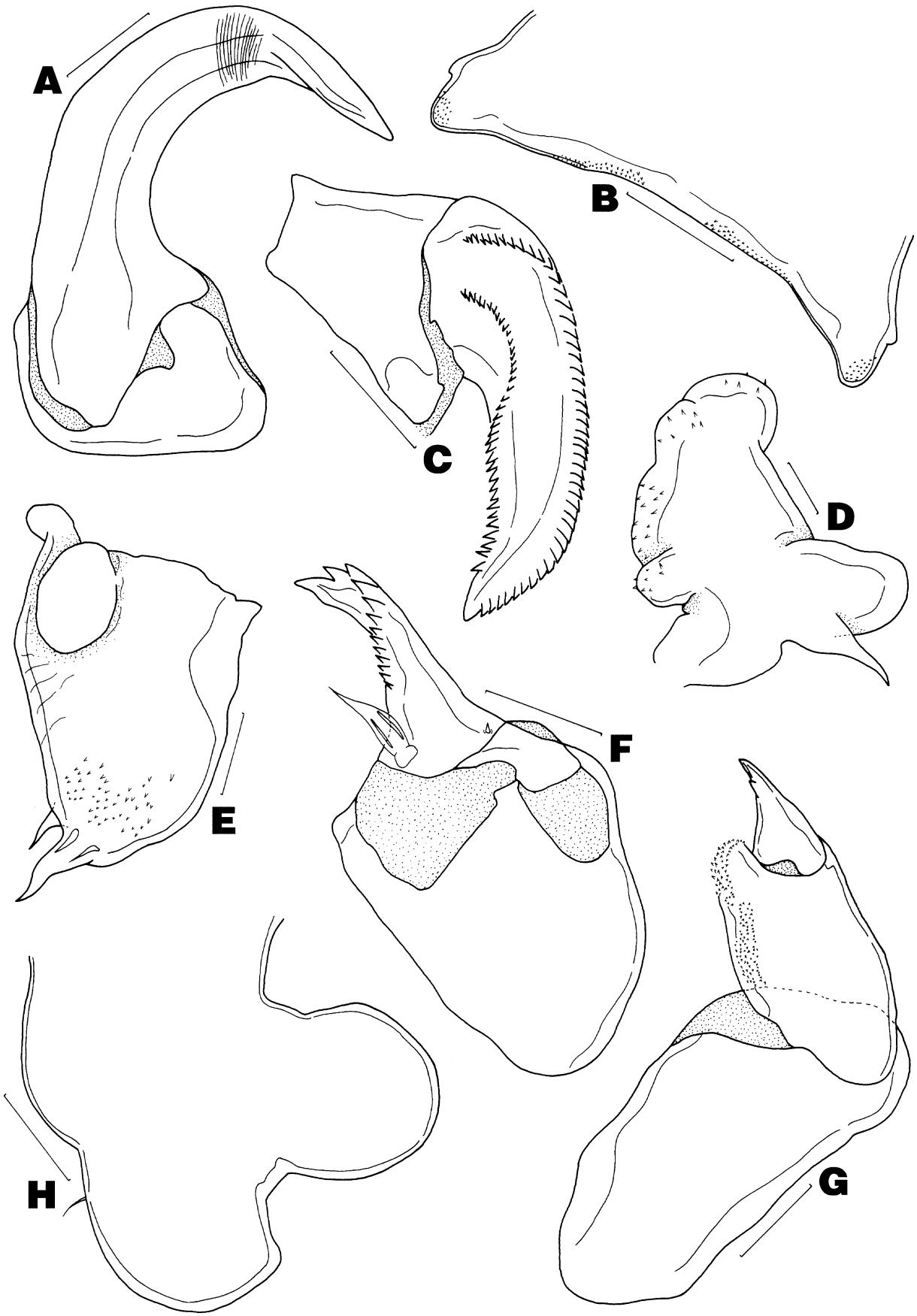
FIGURE 2. *Chondracanthus goldsmidi* n. sp., adult female. (**A**) Antenna, (**B**) labrum, (**C**) mandible, (**D**) paragnath, (**E**) maxillule, (**F**) maxilla, (**G**) maxilliped, (**H**) leg 1. Scale bars: **A**, **B** = 100 μm; **C**, **F**, **G** = 50 μm; **D** = 12.5 μm; **E** = 25 μm; **H** = 200 μm.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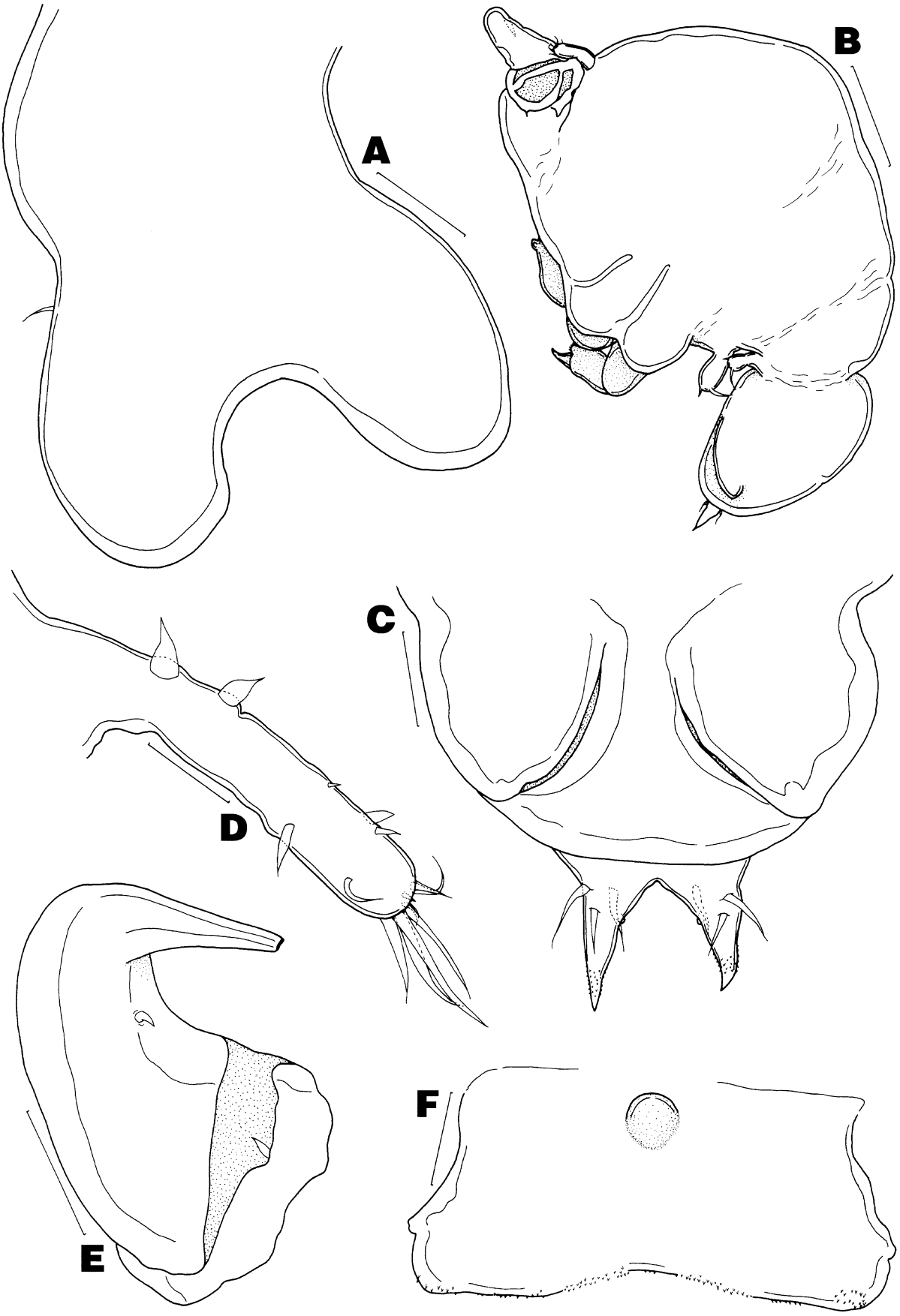
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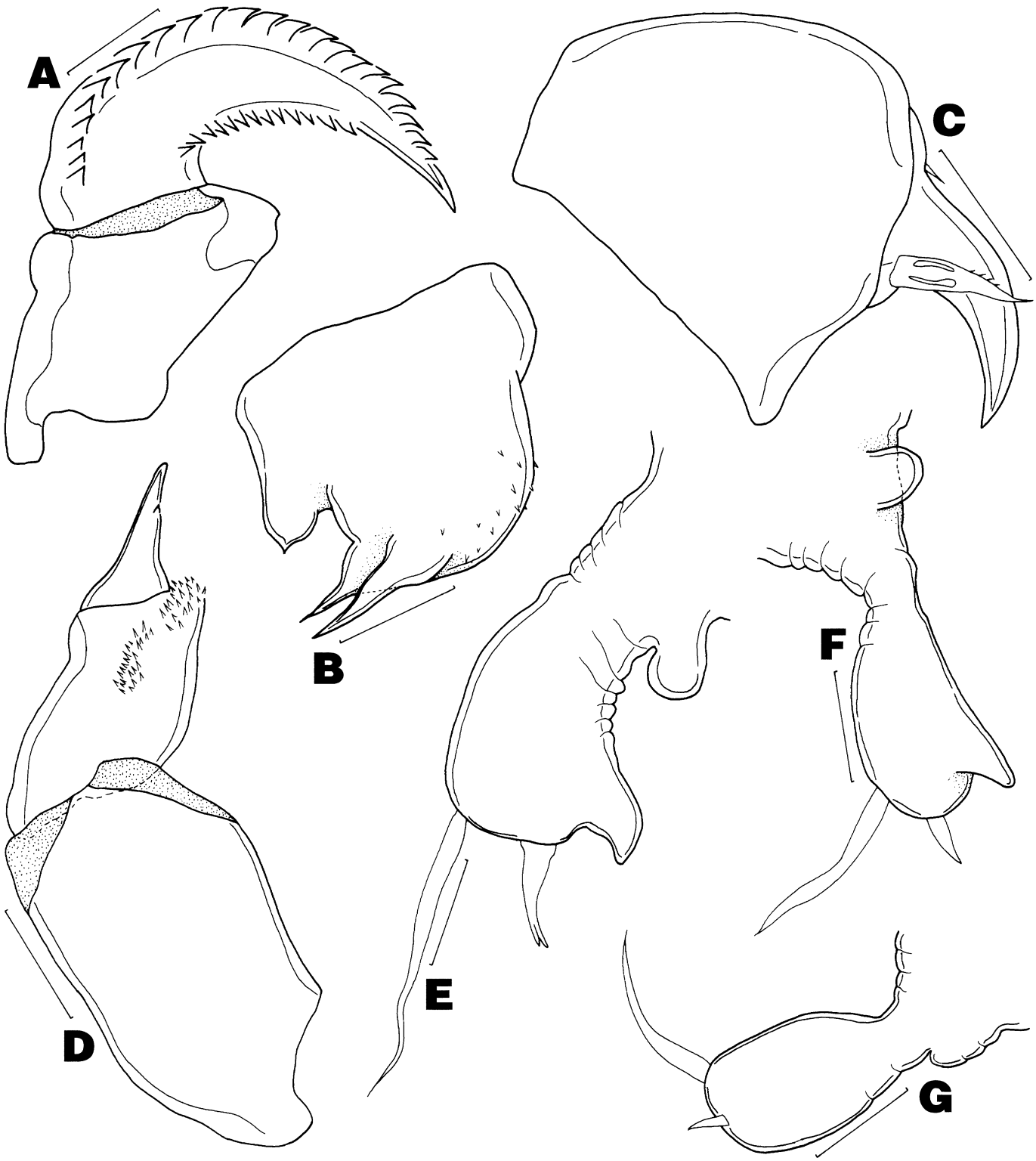

FIGURE 4. *Chondracanthus goldsmidi* n. sp., adult male. (**A**) Mandible, (**B**) maxillule, (**C**) maxilla, (**D**) maxilliped, (**E**) leg 1, (**F**) leg 2, (**G**) abnormal leg 2. Scale bars: **A**, **B**, **E**, **F**, **G** = 12.5 μm; **C**, **D** = 25 μm.

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FIGURE 3. *Chondracanthus goldsmidi* n. sp., adult female (**A**) and adult male (**B–F**). (**A**) Leg 2; (**B**) habitus, lateral; (**C**) genitoabdomen, ventral; (**D**) antennule; (**E**) antenna; (**F**) labrum. Scale bars: **A** = 200 μm; **B** = 100 μm; **C**, **E**, **F** = 25 μm; **D** = 12.5 μm.

manian waters will be sampled and examined to determine whether *Ch. goldsmidi* is a natural parasite of this finfish species.

Key to the species of *Chondracanthus*

In his preliminary review of *Chondracanthus*, Ho (1991a) recognized 37 valid species. Subsequently, Ho and Kim (1995) transferred *Acanthochondria solida* Gusev, 1951 to *Chondracanthus*, and Tang and Ho (2005) transferred *Chondracanthus quadratus* (Heegaard, 1945) to *Acanthocanthopsis* Heegaard, 1945. Although Ho et al. (2005) established 2 new *Chondracanthus* species, *Ch. parvus* and *Ch. yabei*, we consider the former species to be synonymous with *Chondracanthus solidus* (Gusev, 1951), as there are no marked differences between the descriptions and drawings of *Ch. solidus* and *Ch. parvus* given in Ho and Kim (1995) and Ho et al. (2005), respectively. Thus, with the establishment of *Ch. goldsmidi*, a total of 39 *Chondracanthus* species are currently considered valid.

The following key, which utilizes features of the transformed adult female only, is adapted from Ho (1991a). Additionally, the following errors from Ho (1991a) have been amended in this revised key: (1) *Chondracanthus neali* Leigh-Sharpe, 1930, which was omitted previously, was added; (2) the first option in step 15 should state ''trunk region with outgrowths on middorsal surface'' rather than ''trunk region with an outgrowth on midventral surface'' as previously noted; and (3) the reference given for *Chondracanthus colligens* Barnard, 1955, should be Ho (1972b) rather than Ho (1972a), as previously noted. Following Ho (1991a), the species identified with this revised key should be confirmed by checking with the reference given following the species name.

1. Legs 1 and 2 unilobate . . . . . *angustatus* (Raibaut et al., 1971, p. 190–193)
   Legs 1 and 2 trilobate 2
   Legs 1 and 2 bilobate 5
2. Trunk region with outgrowths in the form of knobs, processes or protrusions on dorsal surface 3
   Trunk region without outgrowths on dorsal surface 4
3. Head without processes; trunk region with more than a dozen processes . . . . . *zei* (Ho, 1991a, p. 50–54)
   Head with a pair of posterolateral processes; trunk region with less than a dozen processes . . . . . *horridus* (Heller, 1865, p. 232–233)
   Head with lateral expansions; trunk region with less than a dozen processes . . . . . *ornatus* (Kabata, 1979, p. 122–123)
4. Antennule extremely small; maxilliped claw with only 1 hooklet; caudal ramus with usual long terminal process . . . . . *nodosus* (Ho, 1971, p. 27–31)
   Antennule large and fleshy; maxilliped claw bearing numerous hooklets; caudal ramus lacking long terminal process . . . . . *wilsoni* (Ho, 1971, p. 31–33)
5. Trunk region with only 1 pair of lateral outgrowths (knobs, protrusions, or processes) 6
   Trunk region with more than 1 pair of lateral outgrowths (knobs, protrusions or processes) 13
6. Head with 1 or 2 pairs of small knobs on lateral surface . . . 7
   Head with a pair of prominent lateral processes 8
   Head without knobs or processes 9
7. Head with 1 pair of small knobs; second pedigerous somite with pair of lateral processes . . . . . *solidus* (Ho and Kim, 1995, p. 31–34)
   Head with 2 pairs of small knobs; second pedigerous somite without pair of lateral processes . . . . . *deltoideus* (Kabata, 1984, p. 1710–1713)
8. Posterodorsal portion of head protruded into a large crestlike outgrowth; abdomen greatly elongated . . . . . *janebennettae* (Ho, 1971, p. 20–23)
   Head without crestlike outgrowth; abdomen smaller than genital area . . . . . *merluccii* (Ho, 1971, p. 23–27)
9. Rami of leg 2 short and stout 10
   Rami of leg 2 long and slender 11
10. Trunk with a knoblike outgrowth on dorsal surface; posterior processes long . . . . . *gracilis* (Kabata, 1968, p. 332–335)
    Trunk without knoblike outgrowth on dorsal surface; posterior processes short . . . . . *lepidionis* (Kabata, 1970, p. 180–182)
11. Anterior end of head distinctly narrower than its posterior end; posterior end of trunk with a ventral swelling 12
    Anterior end of head as wide as or slightly wider than its posterior end; posterior end of trunk without ventral swelling . . . . . *psetti* (Ho, 1977, p. 164–165)
12. Leg 2 long, reaching or passing the posterior end of trunk . . . . . *palpifer* (Ho, 1991b, p. 2–4)
    Leg 2 short, barely reaching the posterior end of the third pedigerous somite . . . . . *australis* (Ho, 1991b, p. 5–8)
13. Trunk region with 2 pairs of lateral outgrowths (knobs, protrusions, or processes) 14
    Trunk region with more than 2 pairs of lateral outgrowths (knobs, protrusions, or processes) 26
14. Posterior processes well developed; head with or without lateral processes 15
    Posterior processes poorly developed, appearing as a corner knob; head without lateral processes . . . . . *narium* (Kabata, 1969, p. 3044–3047)
15. Trunk region with outgrowths on middorsal surface 16
    Trunk region without outgrowths on middorsal surface 21
16. Head with 1 pair of posterolateral processes or lateral expansions 17
    Head without processes or lateral expansions 20
17. First pedigerous somite with an outgrowth on dorsal surface 18
    First pedigerous somite without an outgrowth on dorsal surface 19
18. Lateral outgrowths on head and trunk short and stubby . . . . . *multituberculatus* (Markevich, 1956, p. 161–162)
    Lateral outgrowths on head and trunk long and attenuate . . . . . *pinguis* (Kabata, 1968, p. 329–332)
    Lateral outgrowths on head and trunk medium size and bluntly pointed . . . . . *polymixiae* (Shiino, 1955, p. 77–79)
19. Trunk with 2 cylindrical dorsal processes; head with bilobate lateral protrusion . . . . . *heterostichi* (Ho, 1972a, p. 527–529)
    Trunk with 3 rounded dorsal processes; head with lateral expansions . . . . . *yabei* (Ho et al., 2005, p. 416–418)
20. All outgrowths on body large and massive; protopods of legs 1 and 2 with bulging outer surface . . . . . *lotellae* (Ho, 1975, p. 308–311)
    All outgrowths on body small and minute; protopods of legs 1 and 2 without bulging outer surface . . . . . *pusillus* (Kabata, 1968, p. 335–339)
21. Head with 1 pair of posterolateral processes 22
    Head with lateral expansions, but not in form of process . . . . . *yanezi* (Ho, 1982, p. 451–455)
    Head with lateral expansions and a knob in the anterior corners . . . . . *cottunculi* (Ho, 1971, p. 17–20)
    Head without expansions, knobs or processes 24
22. Legs 1 and 2 long and slender 23
    Legs 1 and 2 short and stubby . . . . . *theragrae* (Shiino, 1955, p. 74–77)
23. Exopods of legs 1 and 2 nearly twice as long as their respective protopods . . . . . *lepophidi* (Ho, 1974, p. 870–873)
    Exopods of legs 1 and 2 as long as their respective protopods . . . . . *triventricosus* (Sekerak, 1970, p. 1944–1950)
24. Oral region separated from antennal area to form the first part of neck region; exopod of leg 1 twice as long as endopod . . . . . *brotulae* (Ho and Rokicki, 1987, p. 1031–1033)
    Oral region set far behind antennal area but not separated into a neck region; exopod of leg 1 as long as endopod 25
25. Legs 1 and 2 short and blunt; each protopod with prominent outer swelling . . . . . *genypteri* (Ho, 1975, p. 306–308)
    Legs 1 and 2 long and attenuate; protopods without such swelling . . . . . *colligens* (Ho, 1972b, p. 151–152)
26. Head with 1 pair of lateral processes 27
    Head with 2 pairs of lateral processes 29
    Head without lateral processes 30
27. Head large, its length about ¾ of trunk length . . . . . *tuberculatus* (Ho, 1972b, p. 155–158)
    Head small, its length shorter than ¼ of trunk length 28
28. Posterior end of trunk with 3 processes (including paired posterior processes) . . . . . *lophii* (Kabata, 1979, p. 118–119)
    Posterior end of trunk with 5 processes (including paired posterior processes) . . . . . *barnardi* (Ho, 1972b, p. 149–152)

29. Trunk with dorsal outgrowths; abdomen extended posteriorly . . . . . *neali* (Ho, 1972b, p. 152–155)
    Trunk lacking dorsal outgrowths; abdomen not extended posteriorly . . . . . *distortus* (Shiino, 1955, p. 71–74)
30. Trunk with 3 pairs of lateral outgrowths 31
    Trunk with 6 pairs of lateral outgrowths . . . . . *shiinoi* (Shiino, 1955, p. 79–83)
31. Midlateral trunk outgrowth with ventrolateral, digitiform outgrowth; antennule large and fleshy . . . . . *irregularis* (Kabata, 1968, p. 323–328)
    Mid-lateral trunk outgrowth without ventrolateral, digitiform outgrowth; antennule small and subcylindrical . . . . . *goldsmidi* (this report)

ACKNOWLEDGMENTS

The work formed part of a project of the Aquafin CRC, and received funds from the Australian Government's CRC Program and other CRC Participants. We thank the Department of Zoology at The University of Western Australia for use of laboratory facilities, Stephen Battaglene and Barbara Nowak for comments on the draft manuscript, and the striped trumpeter research team of the TAFI, Marine Research Laboratories for animal husbandry, particularly Ross Goldsmid and Anna Overweter for assistance with parasite collection. We are grateful to George W. Benz and an anonymous reviewer for their comments on the manuscript.

LITERATURE CITED

BATTAGLENE, S. C., AND J. M. COBCROFT. 2007. Advances in the culture of striped trumpeter larvae: A review. Aquaculture. doi: 10.1016/j.aquaculture.2007.04.048.

BOXSHALL, G. A., AND S. H. HALSEY. 2004. An introduction to copepod diversity. The Ray Society, London, U.K., 966 p.

BRANSDEN, M. P., S. C. BATTAGLENE, D. T. MOREHEAD, G. A. DUNSTAN, AND P. D. NICHOLS. 2005. Effect of dietary 22:6n-3 on growth, survival and tissue fatty acid profile of striped trumpeter (*Latris lineata*) larvae fed enriched *Artemia*. Aquaculture **243:** 331–344.

BROWN, M. R., S. C. BATTAGLENE, D. T. MOREHEAD, AND M. BROCK. 2005. Ontogenetic changes in amino acid and vitamins during early larval stages of striped trumpeter (*Latris lineata*). Aquaculture **248:** 263–274.

GROSSEL, G. W., I. DYKOVÀ, J. HANDLINGER, AND B. L. MUNDAY. 2003. *Pentacapsula neurophila* sp. n. (Multivalvulida) from the central nervous system of striped trumpeter, *Latris lineata* (Forster). Journal of Fish Diseases **26:** 315–320.

HELLER, C. 1865. Crustaceen. Reise der Österreichischen Fregatte Novara um die Erde in den Jahren 1857, 1858, 1859. Zoologie **2:** 1–280.

HO, J. S. 1971. Parasitic copepods of the family Chondracanthidae from fishes of eastern North America. Smithsonian Contributions to Zoology **87:** 1–39.

———. 1972a. Four new parasitic copepods of the family Chondracanthidae from California inshore fishes. Proceedings of the Biological Society of Washington **85:** 523–540.

———. 1972b. Copepods of the family Chondracanthidae (Cyclopoida) parasitic on South African marine fishes. Parasitology **65:** 147–158.

———. 1974. A new species of *Chondracanthus* (Copepoda, Chondracanthidae) parasitic on Peruvian cusk eels. Journal of Parasitology **60:** 870–873.

———. 1975. Cyclopoid copepods of the family Chondracanthidae parasitic on New Zealand marine fishes. Publications of the Seto Marine Biological Laboratory **22:** 303–319.

———. 1977. Parasitic copepods of the family Chondracanthidae from fishes of the south eastern Pacific (Crustacea, Copepoda). Steenstrupia **4:** 157–165.

———. 1982. Copepod parasites of *Psychrolutes* (Pisces: Scorpaeniformes) from deep water in the eastern Pacific. Parasitology **85:** 451–458.

———. 1991a. Redescription of *Chondracanthus zei* Delaroche (Copepoda, Poecilostomatoida) parasitic on *Zeus faber* L. in the Sea of Japan, with a preliminary review of the genus. Report of the Sado Marine Biological Station, Niigata University **21:** 49–79.

———. 1991b. Two species of chondracanthid copepods (Poecilostomatoida) parasitic on commercial fishes in the Pacific. Publications of the Seto Marine Biological Laboratory **35:** 1–10.

———, AND I. H. KIM. 1995. Chondracanthid copepods (Poecilostomatoida) parasitic on fishes of the Sea of Japan. Report of the Sado Marine Biological Station, Niigata University **25:** 31–44.

———, ———, AND K. NAGASAWA. 2005. Copepod parasites of the fatheads (Pisces, Psychrolutidae) and their implication on the phylogenetic relationships of psychrolutid genera. Zoological Science **22:** 411–425.

———, AND J. ROKICKI. 1987. Poecilostomatoid copepods parasitic on fishes off the west coast of Africa. Journal of Natural History **21:** 1025–1034.

HUMES, A. G., AND R. U. GOODING. 1964. A method for studying the external anatomy of copepods. Crustaceana **6:** 238–240.

KABATA, Z. 1968. Some Chondracanthidae (Copepoda) from fishes of British Columbia. Journal of the Fisheries Research Board of Canada **26:** 321–345.

———. 1969. *Chondracanthus narium* sp. n. (Copepoda: Chondracanthidae), a parasite of nasal cavities of *Ophiodon elongatus* (Pisces: Teleostei) in British Columbia. Journal of the Fisheries Research Board of Canada **26:** 3043–3047.

———. 1970. Three copepods (Crustacea) parasitic on fishes of the genus *Lepidion* Swainson, 1838 (Pisces: Teleostei). Journal of Parasitology **56:** 175–184.

———. 1979. Parasitic Copepoda of British fishes. The Ray Society, London, 468 p.

———. 1984. A contribution to the knowledge of Chondracanthidae (Copepoda: Poecilostomatoida) parasitic on fishes of British Columbia. Canadian Journal of Zoology **62:** 1703–1713.

KAILOLA, P. J., M. J. WILLIAMS, P. C. STEWART, R. E. REICHELT, A. MCNEE, AND C. GRIEVE. 1993. Australian fisheries resources. Bureau of Resource Sciences and the Fisheries Research and Development Corporation, Canberra, Australia, 422 p.

MARKEVICH, A. P. 1956. Parasitic Copepoda of fishes of the USSR. Akademiya Nauk Ukraine SSR, Institut Zoology, Kiev, Russia, 259 p.

MOREHEAD, D. T., AND P. R. HART. 2003. Effect of temperature on hatching success and size of striped trumpeter (*Latris lineata*) larvae. Aquaculture **220:** 595–606.

RAIBAUT, A., O. K. BEN HASSINE, AND K. MAAMOURI. 1971. Copépodes parasites des poissons de Tunisie (Première série). Bulletin de l'Institut National Scientifique et Technique d'Océanographie et de Pêche, Salammbô **2:** 169–197.

SEKERAK, A. D. 1970. Parasitic copepods of *Sebastodes alatus*, including *Chondracanthus triventricosus* sp. nov. and *Colobomatus kyphosus* sp. nov. Journal of the Fisheries Research Board of Canada **27:** 1943–1960.

SHIINO, S. M. 1955. Copepods parasitic on Japanese fishes. 9. Family Chondracanthidae, subfamily Chondracanthinae. Report of Faculty of Fisheries, Prefectural University of Mie **2:** 70–111.

TANG, D., AND J. S. HO. 2005. Resurrection of *Acanthocanthopsis* Heegaard, 1945 (Copepoda, Poecilostomatoida, Chondracanthidae), parasitic on tetraodontiform fishes. Crustaceana **78:** 809–818.

TROTTER, A. J., P. M. PANKHURST, AND P. R. HART. 2001. Swim bladder malformation in hatchery-reared striped trumpeter *Latris lineata* (Latridae). Aquaculture **198:** 41–54.