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Three species of *Calydiscoides* (Monogenea: Diplectanidae) from five *Lethrinus* spp. (Lethrinidae: Perciformes) off New Caledonia, with a description of *Calydiscoides terpsichore* sp. n.

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Key words: Monogenea, Diplectanidae, *Calydiscoides difficilis*, *Calydiscoides duplicostatus*, *Calydiscoides terpsichore*, *Lethrinus*, host specificity, South Pacific

Abstract. Numerous specimens of *Calydiscoides* spp. from *Lethrinus nebulosus* and *L. harak*, and fewer specimens from *L. lentjan*, *L. ravus* and *L. obsoletus*, collected off New Caledonia, South Pacific, were examined. Three species of *Calydiscoides* were recognized. *Calydiscoides difficilis* (Yamaguti, 1953) Young, 1969 was generally the most abundant species on the five hosts. Specimens of *C. difficilis* were measured and compared to the type specimens (from Indonesia) and museum vouchers (from Australia and the Arabian Gulf). The morphology of the massive male copulatory organ and of haptoral sclerotized parts was similar, but specimens from the same host and from different hosts showed wide morphometric variations; it is concluded that *C. difficilis* has a high degree of variability, although the possibility of a species complex remains. *Calydiscoides duplicostatus* (Yamaguti, 1953) Young, 1969 was found on *L. nebulosus*, *L. harak* and *L. lentjan*; specimens were homogeneous in the three hosts and similar to the type specimens. *Calydiscoides terpsichore* sp. n. is described from *L. nebulosus* (type host) and *L. harak* and was uncommon in both fish. The new species, a member of the 'australis group', is characterized by its Y-shaped male copulatory organ, with the left branch bearing a trifurcated secondary branch. *Lethrinus nebulosus* and *L. harak* shared the 3 species of *Calydiscoides* studied here, a fact probably related with their close phylogenetic relationships. Among the 15 species of *Lethrinus* present in New Caledonia, 11 were examined and 9 species harboured 1–3 species of *Calydiscoides* each. Only 7 species of *Calydiscoides* were found, due to their stenoxenous specificity. Each species of *Calydiscoides* has 1 to 5 hosts.

The fish fauna of the lagoon of New Caledonia is characterized by an exceptional abundance of lethrinids, or emperors (Laboute and Grandperrin 2000). The family is represented in New Caledonia by 25 species, including 15 species of *Lethrinus* (see Fricke and Kulbicki 2006; Table 4). Most of these *Lethrinus* spp. harbour species of *Calydiscoides*. Justine (2007a) reported *Calydiscoides* spp. from *L. miniatus*, *L. atkinsoni*, *L. rubrioperculatus* and *L. xanthochilus*. In this paper, we continue a survey of the monogenean fauna of lethrinids with *L. nebulosus*, locally called 'bec de cane', probably the most important species for local fisheries, and *L. harak*, which is closely related to the former species (Lo Galbo et al. 2002). Both species have a wide distribution in the Indo-Pacific region. Information on a smaller number of specimens was also obtained for three additional species, *L. lentjan*, *L. ravus* and *L. obsoletus*, and negative results are reported for *L. genivittatus* and *L. variegatus*. Finally, data about the diplectanid fauna are reported for 11 of the 15 species of *Lethrinus* present in New Caledonia.

Members of *Calydiscoides* Young, 1969 are characterized by two lamellodiscs with concentric lamellae which telescope into each other, and are parasites exclusively in fishes of the family Lethrinidae and Nemipteridae in the Indo-Pacific region. The genus was revised by Oliver (1987), Thoney (1989), and Lim (2003). Justine (2007a) updated the lists of species and hosts, described *C. euzeti* Justine, 2007 from *L. rubrioperculatus* and *L. xanthochilus* and proposed to distinguish two groups within *Calydiscoides* on the basis of the male copulatory organ, the 'difficilis group' and the 'australis group'.

MATERIALS AND METHODS

Specimens of *Lethrinus* spp. were caught with hand lines on board R/V "Coris" or spear-fished (see list of stations). Live fish were kept in a container with seawater and immediately brought back to the laboratory. All fish were measured, weighed, and photographed. A unique number (JNC) was assigned to each fish. The parasitological material was then assigned a corresponding JNC linked to the respective fish host. Measurements of hosts (FL, fork length, in mm; W, weight, in g) are indicated for possible future comparison of parasite prevalence and host age in other localities and because the monogenean fauna has been showed to change according to fish size (Hinsinger and Justine 2006).

List of stations. Stations are within the lagoon off Nouméa, New Caledonia, with a depth of 2–20 m. Stn I1, 26.iii.2003, Grande Rade, 22°14'S, 166°24'E; Stn I2, 20.xi.2003, Baie de Maa, 22°12'S, 166°20'E; Stn I3, 21.ii.2006, Ilôt Maître, 22°20'S, 166°24'; Stn I4, 7.iii.2006,

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Ilôt La Regnière, 22°19'S, 166°19'; Stn I5, 14.iii.2006, Ilôt Canard, 22°18'S, 166°26'E; Stn I6, 28.iii.2006, Ilôt Canard; Stn I7, 4.iv.2006, Ilôt Maître; Stn I8, 16.v.2006, Ilôt Signal, 22°17'S, 166°17'E; Stn I9, 17.x.2006, Baie des Citrons, 22°18'S, 166°26'E.

Fish used for collection of *Calydiscoides* spp. *Lethrinus harak:* 7 individuals, JNC1750, FL 232, W 239, Stn I3; JNC1751, FL 228, W 230, Stn I3; JNC1752, FL 238, W 247, Stn I3; JNC1770, FL 260, W 337, Stn I5; JNC1771, FL 213, W 189, Stn I5; JNC1772, FL 256, W 321, Stn I5; JNC1784, FL 148, W 289, Stn I6. *L. nebulosus*: 2 individuals, JNC967, FL 280, W 402, Stn I2; JNC1785, FL 470, W 1800, Stn I7. *L. lentjan*: 2 individuals, JNC334, FL 225, W 205, Stn H1; JNC335, FL 185, W 115, Stn H1. *L. ravus:* 3 individuals, JNC1761, FL 190, W 133, Stn I4; JNC1762, FL 195, W 142, Stn I4; JNC1763, FL 201, W 157, Stn I4. *L. obsoletus:* 1 individual, JNC1829, FL 241, W 275, Stn I8. *L. variegatus*: 1 individual, JNC2077, FL 198, W 119, Stn I9 (no diplectanid, but presence of ancyrocephalids). *L. genivittatus*: numerous (>30) specimens of this very common fish, from various stations around Nouméa, not enumerated, 2003–2006, no monogenean found.

Monogeneans were collected, prepared and drawn as indicated in Justine (2005, 2007a). Measurements of male copulatory organs (MCOs), taken as longest length of organ, and measurement of haptoral hard-parts, were as in Justine 2007a, fig. 1; after a preliminary test to check absence of lateral asymmetry, measurements of the right-hand haptoral hard-parts and left-hand equivalents were pooled. Measurements of monogeneans in ammonium picrate preparations and in specimens prepared in ethanol are significantly different (Justine 2005); in this paper, only measurements of 'carmine' specimens are given for soft parts; measurements of 'carmine' and 'picrate' specimens are both given for sclerotized parts. 'Unflattened carmine' specimens were not used for the description of the new species. All measurements are given in micrometres as the holotype and mean followed by the range and number of measurements in parentheses. Names of fish are according to Froese and Pauly (2006).

Abbreviations. MNHN, Muséum national d'Histoire Naturelle, Paris; BMNH, Natural History Museum, London; USNPC, United States National Parasite Collection, Beltsville; MPM, Meguro Parasitological Museum, Tokyo; HCIP, Helminthological Collection, Institute of Parasitology, Biology Centre, Academy of Sciences of the Czech Republic, České Budějovice.

DESCRIPTIONS

Calydiscoides difficilis (Yamaguti, 1953) Young, 1969

Syn. *Lamellodiscus difficilis* Yamaguti, 1953.

Description of the material from New Caledonia (Figs. 1, 2). Organisation of internal soft organs similar to *Calydiscoides terpsichore* (see later). MCO massive, made up of two parts, anterior and posterior, both heavily sclerotized (measurements in Table 2). Sclerotized vagina a round sac sometimes filled with material. Haptoral parts: elongate ventral bar, slightly bow-shaped and curved posteriorly, with indentation on central part of posterior edge and extremities curved posteriorly; dorsal (lateral) bars elongate, each with an external (lateral) hook, directed posteriorly, and medial bifurcated extremity; ventral hamuli elongate, with distinct inner and outer roots; dorsal hamuli elongate, with indistinct inner root (guard). Large lamellodiscs, with 10–11 lamellae including 3 closed rings.

Measurements of sclerotized parts were taken on more than 100 specimens mainly from *Lethrinus nebulosus* and *L. harak*, and also from *L. lentjan*, *L. ravus* and *L. obsoletus*, and are presented in Table 2. Histograms of measurements generally used for systematics of diplectanids are shown in Fig. 2 for specimens from two hosts, *L. nebulosus* and *L. harak*. Measurements of specimens from each host show wide intra-host variation, and we could not detect morphological differences between the specimens, even in comparing the specimens with smallest and largest measurements (Fig. 1). Specimens from *L. nebulosus* generally have longer measurements for the MCO and all haptoral parts than specimens from *L. harak*. The means are often significantly different, but histograms show that measurements from the two hosts overlap for all structures (Fig. 2). Measurements of the holotype generally fall in the zone of overlap of the two main host species, *L. nebulosus* vs. *L. harak* (Fig. 2).

Type host: *Lethrinus* sp. (Lethrinidae). Species not indicated in the original description (Yamaguti 1953), but it was the same individual fish as for *C. duplicostatus* (see Justine 2007a).

Other hosts: *L. laticaudis* (designated as *L. fletus*, see Young 1969, 1970); *L. reticulatus* (see Young 1969, 1970); *L. nebulosus* (see Oliver 1984, and this work); *L. miniatus* (see Oliver 1984, Rohde et al. 1994, 1995); *L. harak*, *L. lentjan*, *L. ravus*, *L. obsoletus* (this work).

Site: Between secondary gill lamellae.

Type locality: Macassar, Celebes (now Ujungpandang, Sulawesi), Indonesia.

Other localities: Australia (Young 1969, 1970, Oliver 1984); Arabian Gulf (this work); New Caledonia (this work).

Material from New Caledonia: 639 specimens examined; 246 from *L. nebulosus*; 329 from *L. harak*; 11 from *L. lentjan*; 4 from *L. ravus*; 49 from *L. obsoletus* (see Table 1).

Other material examined: MPM 22559, 1 slide SY 6730, holotype and other specimens in type slide (redescribed in Justine 2007a); USNPC 63155, 2 slides 1004-25 and 1004-26, from *L. laticaudis* (designated as *L. fletus*) from Tangalooma, Australia, deposited by Young and probably corresponding to the material mentioned in Young (1969, 1970); MNHN 186TC Tj126, from *L. nebulosus* from Heron Island, Australia (described in Oliver 1984); BMNH 1994.8.10.96–97 and 1994.8.1.98–100, 2 slides from *L. harak* from the Arabian Gulf, deposited by I. Al Mathal; these slides contain 5 specimens of *C. difficilis* and an undescribed ancyrocephalid, and were apparently never mentioned in a publication.

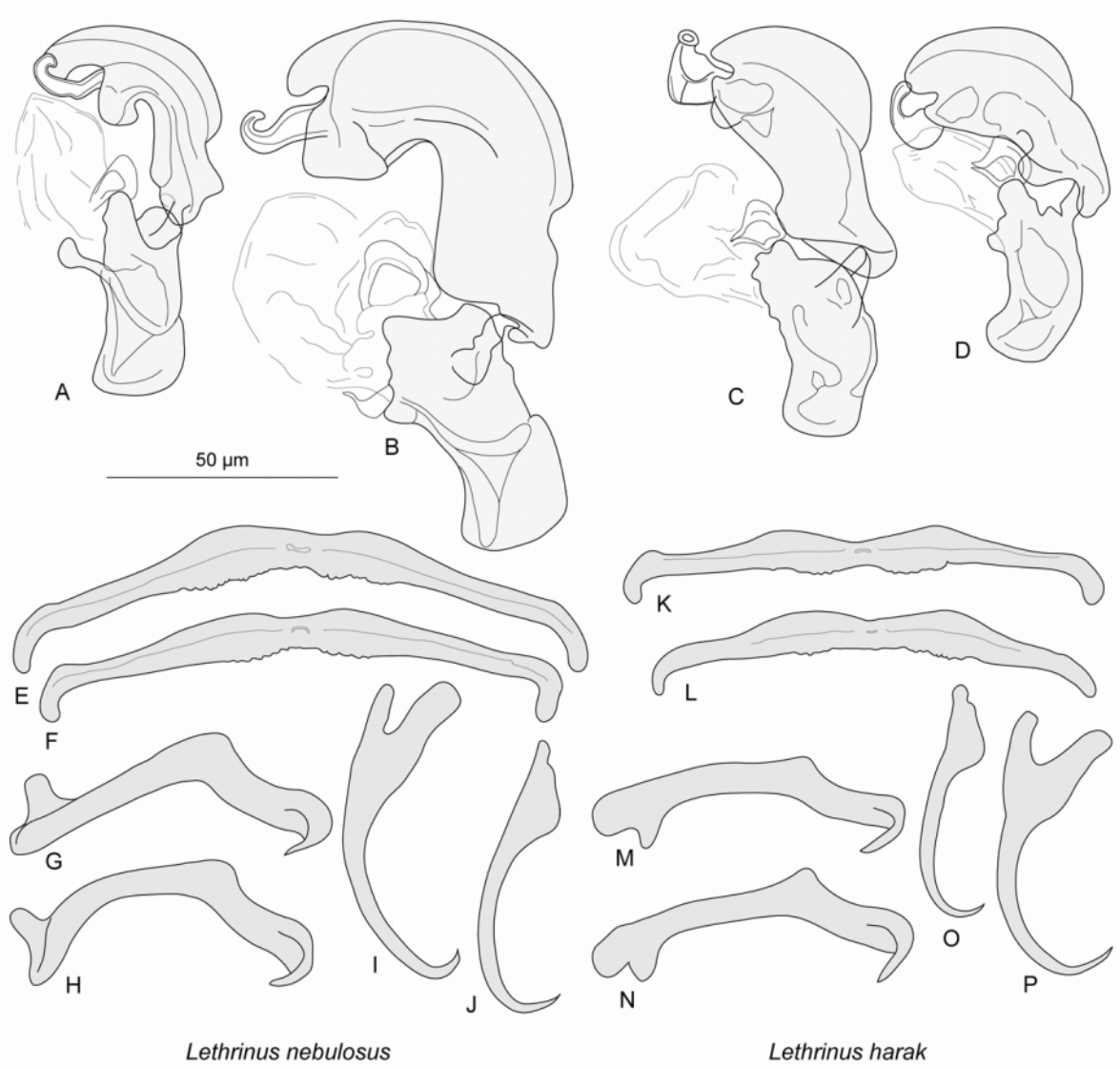

Fig. 1. *Calydiscoides difficilis* from two hosts, *Lethrinus nebulosus* (A, B, E–J, left) and *L. harak* (C, D, K–P, right). For each host is figured a specimen among those having the smallest MCO (A, C), ventral bar (F, L) and dorsal bars (G, M) and those having the largest MCO (B, D), ventral bar (E, K) and dorsal bars (H, N). E, F, K, L – ventral bars; G, H, M, N – dorsal bars; I, P – ventral hamuli; J, O – dorsal hamuli. All picrate.

Material deposited: vouchers from *L. nebulosus*, *L. harak*, *L. obsoletus*, *L. lentjan*, *L. ravus* in MNHN, JNC334–335; JNC967, JNC1750–1752; JNC1761; JNC1763; JNC1770–1772; JNC1784–1785; JNC1829; vouchers from *L. nebulosus* (2 in each), BMNH 2006.12.13.4–5, USNPC 99432, MPM 18845–6, HCIP M-428/1; vouchers from *L. harak*, BMNH 2006.12.13.3, USNPC 99433, MPM 18847, HCIP M-428/2; vouchers from *L. obsoletus*, BMNH 2006.12.13.2, USNPC 99434, MPM 18848, HCIP M-428/3.

Prevalence: 100% in *L. harak* and *L. nebulosus*, probably 100% in *L. lentjan*, *L. obsoletus* and *L. ravus* (data incomplete) (Table 1).

Intensity: Up to hundreds of specimens per fish. Always the dominant species (see Table 1).

Remarks. The specimens examined are similar to the type specimens (redescribed by Justine 2007a). Oliver (1987) already mentioned that several morphologies of the MCO were visible in the material he examined. We confirm this observation on a much higher number of specimens. *C. difficilis* has a massive MCO in which it is difficult to recognize key structures which could help to differentiate species. Measurements of MCOs are different for specimens from various hosts, but measurements of the MCO are highly variable within a single host, and we could not recognize specific structures in the MCO which could differentiate different species. Measurements of sclerotized parts of the haptor are generally different for the two main host species (*L. nebulosus* and *L. harak*) but the curves overlap (Fig. 2)

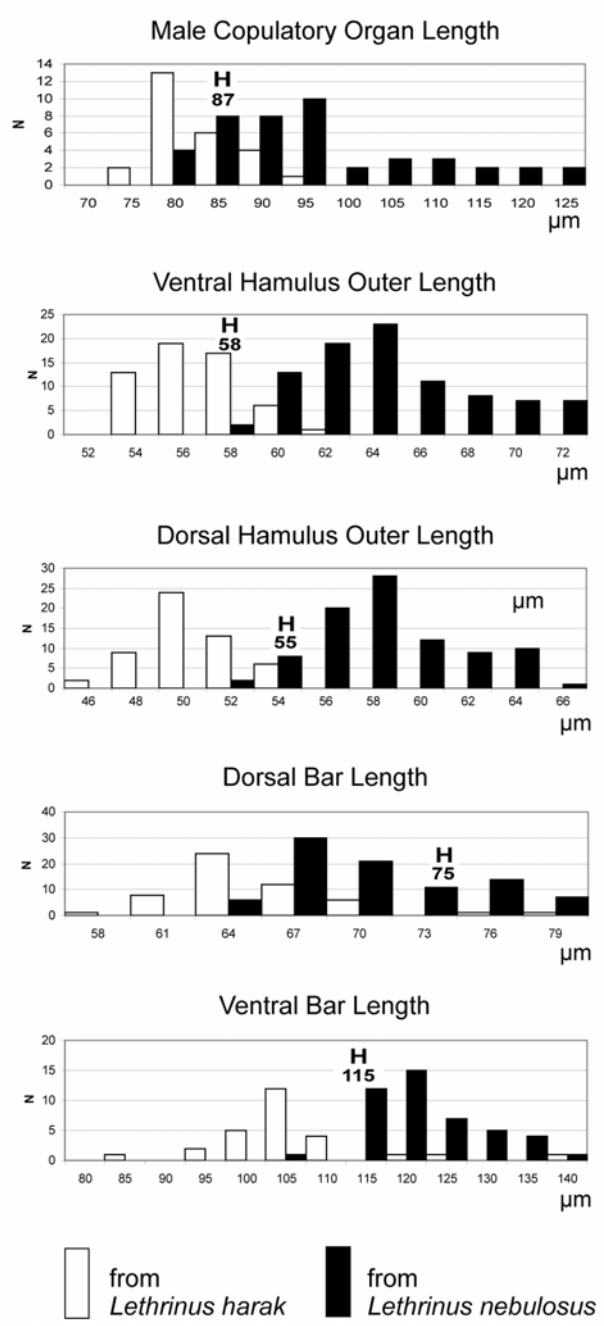

Fig. 2. *Calydiscoides difficilis* from two hosts, *Lethrinus nebulosus* and *L. harak*: histograms of selected measurements. The measurements of the holotype (from an unidentified *Lethrinus* from Indonesia, Yamaguti 1953) are indicated as H on each histogram.

and it would be impossible to define taxa on any of these measurements. We performed various statistical tests on measurements (not shown here for brevity) but mainly considered that absence of a key morphological character in the MCO precludes recognition of different taxa. Finally, we conclude that a single species is present: *C. difficilis* has thus a stenoxenous specificity (several hosts with close phylogenetic relationships). However, the high level of morphometric variability suggests that *C. difficilis* may be a species complex, with perhaps one (or sometimes two) cryptic species, each strictly specific, in each host. Absence of *C. difficilis* in several species of *Lethrinus*, such as *L. genivittatus*, might be an additional argument for the existence of several cryptic species and against a single generalist species.

Lethrinus harak, *L. lentjan*, *L. ravus* and *L. obsoletus* are new host records; New Caledonia is a new geographical record for *C. difficilis*. The Arabian Gulf (BMNH slides by I. Al-Mathal) is a new geographic record for *C. difficilis* in *L. lentjan*. *L. nebulosus*, *L. harak* and *L. lentjan* have a wide geographical distribution including Indonesia, the type locality, and also harbour *C. duplicostatus*: one of these species could be the type host of *C. difficilis* (and also *C. duplicostatus*) designated as *Lethrinus* sp. by Yamaguti (1953). *C. difficilis* was never found in *L. miniatus* in New Caledonia (Justine 2007a) although it was recorded from this host in Australia (Oliver 1984, Rohde et al. 1994, 1995).

Calydiscoides duplicostatus (Yamaguti, 1953) Young, 1969

Syn. *Lamellodiscus duplicostatus* Yamaguti, 1953.

Description of the material from New Caledonia (Fig. 3). Organisation of internal soft organs similar to *C. terpsichore* (see later). MCO very complex, with two branched processes on superposed planes (Fig. 3 D–H); the MCO shows some variation in morphology according to the specimen and orientation, but measurements are relatively homogeneous (Table 3). Sclerotized vagina: a spherical sac, lightly sclerotized, without special differentiation. Haptoral parts: short ventral bar with blunt extremities; dorsal (lateral) bars massive, without external (lateral) hook, medial bifurcated extremity; ventral hamuli elongate, with distinct inner and outer roots; dorsal hamuli elongate, with indistinct inner root (guard). Small lamellodiscs with 9–10 lamellae including 3 closed rings.

Type host: *Lethrinus* sp. (Lethrinidae). Species not indicated in the original description, but it was the same individual fish as for *C. difficilis* (see Justine 2007a).

Other hosts: *L. nebulosus*, *L. harak*, *L. lentjan* (this work).

Site: Between secondary gill lamellae.

Type locality: Macassar, Celebes (now Ujungpandang, Sulawesi), Indonesia.

Other locality: New Caledonia (this work).

Material from New Caledonia: 66 specimens; 26 from *L. nebulosus*; 18 from *L. harak*; 22 from *L. lentjan* (see Table 1).

Comparative material examined: MPM 22559, slide SY 6730, holotype and other specimens in type slide (redescribed in Justine 2007a).

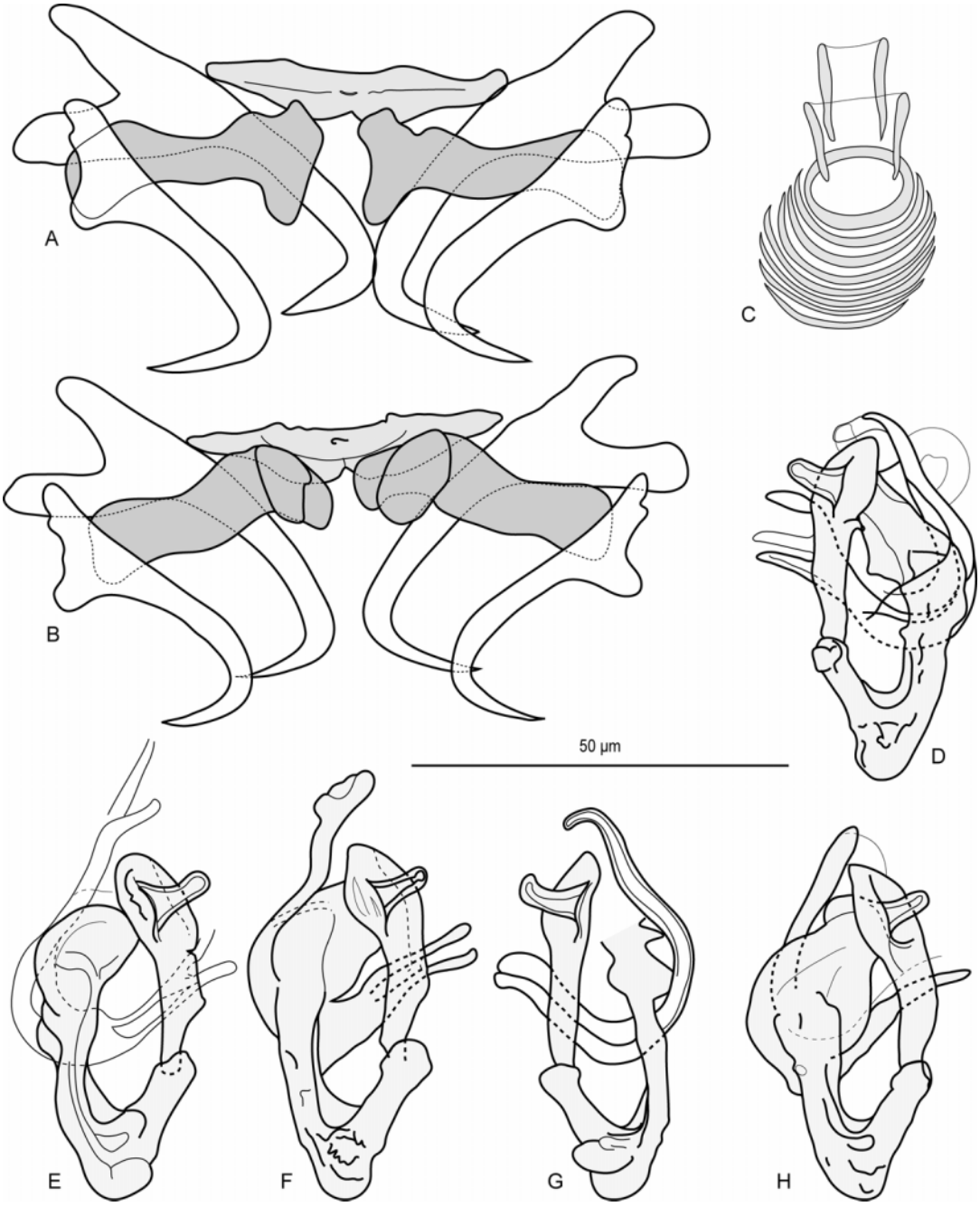

Fig. 3. *Calydiscoides duplicostatus* from two hosts, *Lethrinus nebulosus* and *L. harak.* **A, B** – haptoral hard parts (A, from *L. nebulosus*; B, from *L. harak*); **C** – ventral lamellodisc, from *L. nebulosus*; **D–H** – variations of the male copulatory organ according to specimens and orientation (D–G, from *L. nebulosus*; H, from *L. harak*); C, D, G, ventral view; A, B, E, F, H, dorsal view.

Material deposited: Vouchers in MNHN, JNC334–335; JNC967; JNC1770–1772; JNC1784–1785.

Prevalence: *L. nebulosus* 2/2, 100%; *L. lentjan* 2/2, 100%; *L. harak* 4/7, 57% (Table 1).

Intensity: Up to 18 per fish (Table 1); second in number after *C. difficilis.*

Remarks. The specimens examined from the three host species are similar to the type specimens (redescribed by Justine, 2007a). The measurements and morphology are similar in specimens from the three hosts examined and there is no reason to doubt that a single species is present in the different hosts. *C. duplicostatus* has thus a stenoxenous specificity (several hosts with close phylogenetic relationships). This species has the smallest lamellodiscs of all *Calydiscoides* from lethrinids.

Table 1. Number of *Calydiscoides* spp. in *Lethrinus* spp.

		Calydiscoides			
	Fish number	*difficilis*	*duplicostatus*	*terpsichore* sp. n.	undetermined
Lethrinus harak	JNC 1751	37	0	0	0
	JNC1750	1	0	0	0
	JNC 1752	14	0	0	1
	JNC 1770	63	5	2	0
	JNC 1771	18	1	1	1
	JNC 1772	102	10	0	1
	JNC 1784	94	2	2	0
	Total	329 (92.7%)	18 (5.1%)	5 (1.4%)	3
Lethrinus nebulosus	JNC 967	25	8	8	3
	JNC 1785	221	18	19	6
	Total	246 (79.9%)	26 (8.4%)	27 (8.8%)	9
Lethrinus lentjan	JNC334	11	16	0	1
	JNC335	0	6	0	0
	Total	11 (32%)	22 (65%)		
Lethrinus ravus	JNC1761	3	0	0	0
	JNC1763	1	0	0	0
	Total	4 (100 %)			
Lethrinus obsoletus	JNC1829	49 (100%)	0	0	1

Collections were generally not exhaustive and numbers are given mainly to indicate proportions (indicated as percentages) of various species. A single *L. variegatus* examined had no diplectanid.

Lethrinus nebulosus, *L. harak*, and *L. lentjan* are new host records; New Caledonia is a new geographical record. One of these species could be the unnamed type host of *C. duplicostatus* and *C. difficilis* (see above).

Calydiscoides terpsichore sp. n.

Description of specimens from the type host, *L. nebulosus* (Figs. 4, 5). (Measurements of soft parts only from 'carmine' specimens; measurements of hard-parts as indicated). Body elongate, lanceolate, length 600, 573 (500–620, n = 4), width 150, 106 (75–150, n = 6). Tegument smooth. Anterior region with 3 pairs of head organs and 2 pairs of eye-spots; distance between outer margins of anterior eye-spot pair 43, 32 (26–43, n = 7), of posterior eye-spot pair 46, 36 (31–46, n = 7). Haptor differentiated from rest of body, width 120, 117 (103–130, n = 7), provided with 2 similar lamellodiscs, 2 pairs of lateral hamuli, 3 bars and 14 marginal hooklets.

Lamellodiscs made up of concentric tubular lamellae. Details of lamellae from centre to periphery (numbering from centre to periphery): 3 complete circles (rings 1–3), 7 incomplete rings (rings 4–10); rings 1–3 thicker than 4–10, with ring 3 distinctly thicker than all others; rings 4–10 progressively less and less complete, from ring 4 an almost complete circle to ring 10 a short posterior crescent. Ventral and dorsal lamellodiscs similar but ventral slightly larger than dorsal. Ventral lamellodisc round in shape, with 10 (n = 7) lamellae, length 37, 41 (34–46, n = 5), width 40, 41 (40–45, n = 5), internal diameter of first ring 11, 12 (11–15, n = 6); dorsal lamellodisc round in shape, with 10 (n = 7) lamellae, length 40, 42 (39–45, n = 5), width 41, 42 (38–44, n = 4), internal diameter of first ring 12, 12 (10–14, n = 4). In disturbed lamellodiscs observed laterally, the first ring shows an anteriorly directed triangular point (Fig. 4E); the point is sometimes visible in lamellodiscs observed in polar orientation (Fig. 4D). Ventral hamulus elongate, with tubular outer root and thin flattened inner root, outer length in carmine 46, 47 (44–53, n = 10), in picrate 51 ± 1.5 (49–55, n = 31), inner length in carmine 47, 48 (46–52, n = 10), in picrate 52 ± 1.4 (49–54, n = 32). Dorsal hamulus elongate, with indistinct inner root, outer length in carmine 40, 39 (36–42, n = 9), in picrate 40 ± 1.2 (38–42, n = 32), inner length in carmine 26, 27 (23–30, n = 9), in picrate 29 ± 1.6 (24–32, n = 32). Dorsal (lateral) bars massive, curved anteriorly; curvature c. 150°, at mid length; medial extremity bifurcated; medial ventral and dorsal branches overlapping in moderately flattened ('carmine') specimens, not overlapping and very distinct in highly flattened ('picrate') specimens (Fig. 5); lateral extremity with posteriorly directed blunt protuberance. Length, in carmine 37, 36 (34–39, n = 10), in picrate 41 ± 2.3 (37–47, n = 32), width of external part, in carmine 6, 7 (6–7, n = 10), in picrate 8 ± 1.4 (6–11, n = 32). Ventral bar thick, with median incision, centre of anterior edge indented, extremities straight, blunt, length in carmine 43, 41 (39–43, n = 3), in picrate 46 (41–48, n = 13), maximum width in carmine 8, 8 (7–8, n = 5), in picrate 9 (7–11, n = 16); groove visible on its ventral side, with crescent-shaped incision in the middle.

Pharynx elongate, length 44, 39 (27–45, n = 5), width 36, 32 (26–36, n = 5). Oesophagus apparently absent, such that intestinal bifurcation immediately follows pharynx. Caeca simple, terminate blindly at level of posterior margin of vitelline field.

Testis subspherical, intercaecal, length 82, 71 (63–82, n = 5), width 85, 65 (56–85, n = 7). Vas deferens conspicuous, emerges from antero-sinistral part of testis, enlarges into wide seminal vesicle; seminal vesicle in middle region of body, forms bends, then connects with male copulatory organ (MCO). Prostatic glands con-

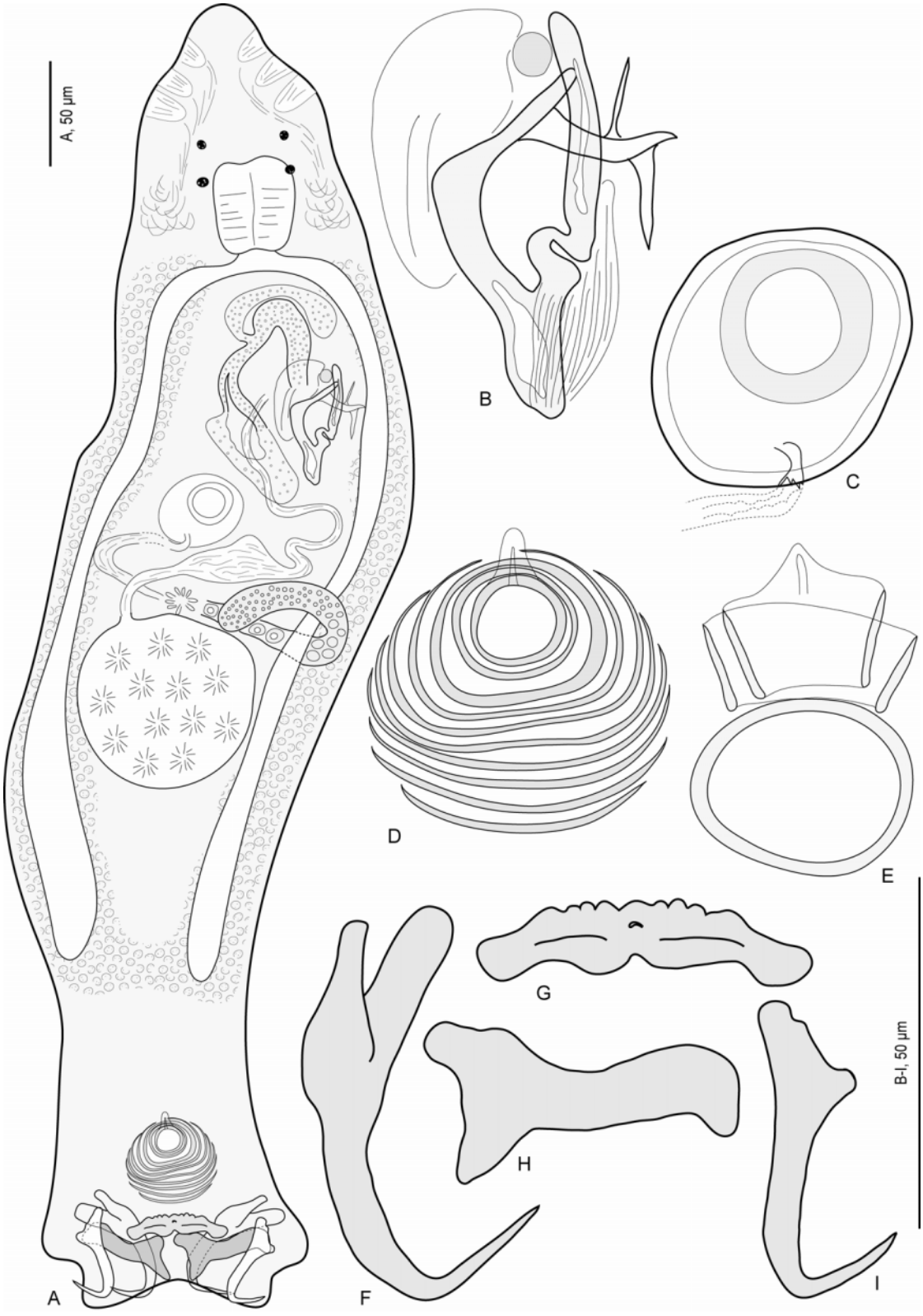

Fig. 4. *Calydiscoides terpsichore* sp. n. from *Lethrinus nebulosus* (type host) and *L. harak*. **A** – composite view of body, dorsal view; **B** – male copulatory organ; **C** – sclerotized vagina; **D** – lamellodisc, polar view, carmine slide; **E** – disturbed lamellodisc showing the shape of the two central rings in 'lateral' view (only three inner rings are figured); **F** – ventral hamulus; **G** – ventral bar; **H** – dorsal bar; **I** – dorsal hamulus. B, C, holotype from *L. nebulosus*; E–I, paratypes from *L. harak*.

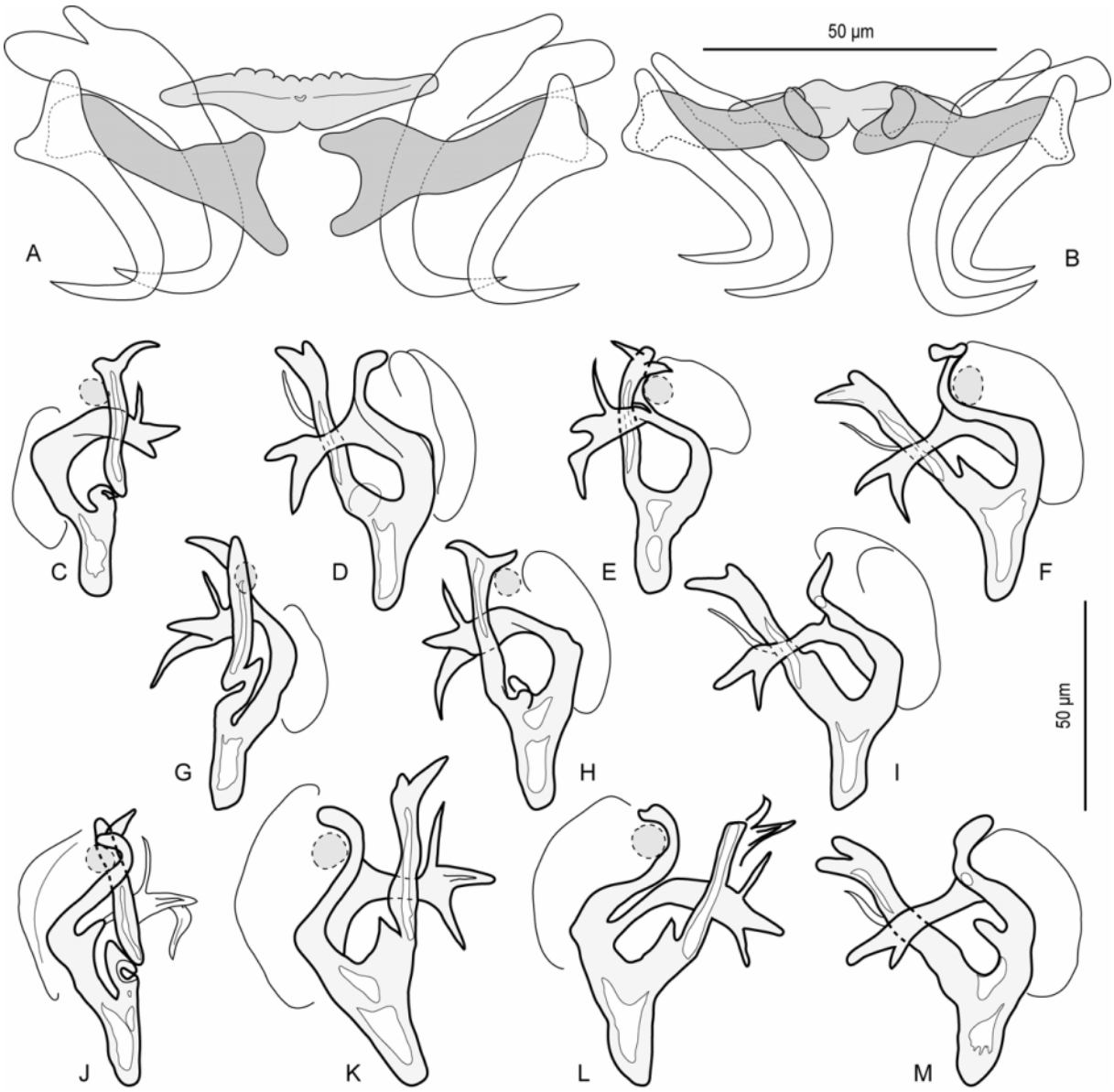

Fig. 5. *Calydiscoides terpsichore* sp. n. from *Lethrinus nebulosus* (type host) and *L. harak*. **A** – haptoral hard parts, picrate specimen showing forked shape of dorsal bar internal extremities; **B** – haptoral hard parts, carmine specimen in which the dorsal bar internal extremities do not appear forked; **C–M** – male copulatory organ, slight variations according to specimen and orientation. A, B, C, G, J, K, L, dorsal view; D–I, M, ventral view; C–I, from *L. nebulosus*; A, B, J–M, from *L. harak*.

spicuous, anterior and lateral to MCO, connected with conspicuous reservoir; reservoir bends posteriorly to connect with MCO. Sclerotized MCO complex; Y-shaped, with base posterior and branches anterior; base and right branch apparently alveolated, left branch solid; right branch straight, with bifurcated extremity; left branch complex, S-shaped in ventral view, with trifurcated branch connected at right angle at mid-length; trifurcated branch crosses ventrally right branch; left branch bordered by sclerotized membrane on its left side; a spherical element, heavily stained by carmine, is often visible in distal curve of S-shaped left branch. Longitudinal muscular fibres are visible along the basal part of the sclerotized MCO. Total length of MCO in carmine 58, 61 (58–66, n = 8), in picrate 65 (59–68, n = 16).

Ovary subequatorial, intercaecal, pre-testicular, encircles dorso-ventrally right caecum. Ovary width 85, 61 (48–85, n = 3), length 45, 34 (25–45, n = 3). Oviduct passes medially to form oötype, surrounded by Mehlis' gland; oötype short, opens into uterus. Uterus dextral. Sclerotized vagina: spherical, with small tubular sclerotized element leading to unsclerotized duct. A strong "ring", apparently heavily sclerotized in living specimens or in picrate preparations, coloured in red in carmine specimens, in present in the centre of the sclero-

Table 2. Measurements of *Calydiscoides difficilis* in five species of *Lethrinus*.

Calydiscoides difficilis	*L. nebulosus*	*L. harak*	*L. lentjan*	*L. ravus*	*L. obsoletus*
BODY					
Body length	c 593 (450–745, n = 17)	c 432 (200–560, n = 19)	uc 413 (340–480, n = 3)	p 621 (530–715, n = 4)	p 807 (610–930, n = 3)
Body width	c 96 (71–130, n = 19)	c 90 (47–135, n = 25)	uc 90 (70–110, n = 3)	p 123 (90–160, n = 4)	p 109 (85–120, n = 4)
Haptor width	c 170 (120–200, n = 19)	c 138 (105–170, n = 25)	uc 165 (150–180, n = 5)	p 190 (165–215, n = 4)	p 193 (170–210, n = 5)
MALE ORGANS					
Testis length	c 52 (40–80, n = 10)	c 42 (24–64, n = 15)			
Testis width	c 51 (37–63, n = 11)	c 44 (22–64, n = 15)			
MCO total length	c 82 (70–101, n = 25) p 94 ± 12 (77–124, n = 42)	c 66 (56–92, n = 23) p 81 (72–93, n = 26)	uc 97 (96–99, n = 5)	p 87 (77–93, n = 4)	p 87 (71–93, n = 5)
MCO posterior part length	c 64 (53–74, n = 25) p 72 ± 8 (62–93, n = 44)	c 49 (42–69, n = 23) p 60 (52–77, n = 28)	uc 75 (66–83, n = 5)	p 67 (58–75, n = 4)	p 69 (61–76, n = 5)
MCO anterior part length	c 54 (47–67, n = 25) p 65 ± 11 (47–92, n = 44)	c 45 (41–58, n = 23) p 58 (47–67, n = 27)	uc 60 (59–62, n = 5)	p 58 (52–63, n = 4)	p 57 (53–59, n = 5)
FEMALE ORGANS					
Ovary width	c 36 (25–45, n = 4)	c 37 (19–68, n = 12)			
Ovary length	c 32 (18–49, n = 4)	c 33 (22–52, n = 13)			
HAPTORAL PARTS					
Ventral hook outer length	p 64 ± 3.4 (58–72, n = 86)	c 51 ± 3.3 (44–57, n = 40) p 56 ± 2.0 (53–62, n = 56)	uc 57 (48–62, n=10)	p 51 (49–54, n = 8)	p 58 (53–62, n = 10)
Ventral hook inner length	p 60 ± 2.7 (53–64, n = 86)	c 51 ± 3.3 (43–59, n = 37) p 54 ± 1.9 (50–58, n = 54)	uc 58 (39–64, n = 10)	p 49 (46–53, n = 8)	p 55 (52–57, n = 10)
Dorsal hook outer length	p 58 ± 3.0 (52–65, n = 86)	c 46 ± 4.2 (36–57, n = 40) p 50 ± 1.9 (46–54, n = 54)	uc 50 (31–56, n = 10)	p 45 (43–47, n = 8)	p 53 (47–56, n = 10)
Dorsal hook inner length	p 41 ± 2.4 (34–46, n = 86)	c 32 ± 3.0 (25–39, n = 42) p 34 ± 1.6 (30–37, n = 54)	uc 35 (30–38, n = 10)	p 30 (29–31, n = 8)	p 36 (30–40, n = 10)
Dorsal bar length	p 69 ± 4.3 (63–79, n = 85)	c 57 ± 5.2 (45–67, n = 45) p 64 ± 3.6 (58–77, n = 53)	uc 69 (61–75, n = 10)	p 61 (56–67, n = 8)	p 65 (58–68, n = 10)
Dorsal bar width	p 8 ± 0.9 (6–11, n = 85)	c 5 ± 0.8 (4–7, n = 44) p 7 ± 0.7 (6–9, n = 56)	uc 7 (6–8, n = 10)	p 7 (6–9, n = 8)	p 7(5–8, n = 10)
Ventral bar length	p 119 ± 7.0 (104–138, n = 43)	c 90 (72–114, n = 17) p 104 (82–138, n = 27)	uc 122 (113–128, n = 5)	p 92 (87–100, n = 4)	p 116 (96–125, n = 5)
Ventral bar width	p 11 ± 1.2 (8–14, n = 43)	c 8 (6–14, n = 23) p 10 (8–12, n = 28)	uc 8 (8–9, n = 5)	p 10 (9–12, n = 4)	p 10 (9–12, n = 5)
Ventral lamellodisc length	c 42 (36–48, n = 6)	c 36 (26–44, n = 14)			
Ventral lamellodisc width	c 54 (44–61, n = 6)	c 42 (33–56, n = 18)			
Ventral lamellodisc number	cp 10–11	cp 10–11	uc 10 (n = 5)	p 10 (n = 3)	p 10 (n = 5)
Ventral lamellodisc closed ring number	cp 3 (n = 39)	cp 3 (n = 27)	uc 3 (n = 3)	p 3 (n = 3)	p 3 (n = 3)
Ventral lamellodisc internal diameter	c 16 (12–18, n = 6)	c 13 (11–17, n = 22)			
Dorsal lamellodisc length	c 47 (38–56, n = 8)	c 36 (22–43, n = 14)			
Dorsal lamellodisc width	c 53 (40–60, n = 8)	c 40 ± 4.5 (34–52)			
Dorsal lamellodisc number	cp 10–11	cp 9–12	uc 10 (n = 5)	p 10 (n = 3)	p 10 (n = 5)
Dorsal lamellodisc closed ring number	cp 3 (n = 40)	cp 10–11		p 3 (n = 3)	p 3 (n = 3)
Dorsal lamellodisc internal diameter	c17 (13–21, n = 10)	c 12 (6–16, n = 22)			

c – carmine; p – picrate; uc – unflattened carmine; cp – carmine and picrate.

tized vagina in certain specimens, or completely absent. This very visible, but very variable structure, is tentatively interpreted as the content of the vagina, full in recently inseminated specimens. Vitelline fields extend posteriorly from posterior to pharyngeal level in 2 lateral bands, confluent in post-testicular region and terminate anterior to peduncle. Bilateral connections from vitelline fields to oötype inconspicuous. Egg *in utero* elongate, ovoid.

Specimens from *L. harak*. Specimens from this host are similar to specimens from the type host for morphology and measurements. MCO total length, picrate, 69 (61–75, n = 3), width 30 (27–34, n = 3). Ventral hamulus, outer length in picrate 51 (47–55, n = 6), inner length in picrate 51 (48–54, n = 6). Dorsal hamulus, outer length in picrate 40 (38–42, n = 6), inner length in picrate 30 (28–32, n = 6). Dorsal (lateral) bars, length ipicrate 41 (35–45, n = 6), width of external part in picrate 9 (9–11, n = 6). Ventral bar, length in picrate 48 (46–50, n = 3), maximum width in picrate 10 (8–11, n = 3).

Type host: *Lethrinus nebulosus* Forsskål (Lethrinidae).

Table 3. Measurements of *Calydiscoides duplicostatus* in three species of *Lethrinus*.

Calydiscoides duplicostatus	*L. nebulosus*	*L. harak*	*L. lentjan*
BODY			
Body length		c 421 (355–470, n = 4)	uc 294 (200–340, n = 5)
Body width		c 75 (65–85, n = 4)	uc 66 (60–70, n = 5)
Haptor width		c 69 (65–70, n = 4)	uc 73 (70–80, n = 4)
MALE ORGANS			
MCO total length	p 48 (44–52, n = 9)	c 37–45 (n = 2) p 47 (45–48, n = 7)	uc 37 (33–41, n = 5)
MCO branches maximum width	p 20 (17–23, n = 9)	c 19–21 (n = 2) p 22 (17–24, n = 7)	uc 12 (7–15, n = 5)
HAPTORAL PARTS			
Ventral hook outer length	p 49 (46–52, n = 18)	p 49 (45–54, n = 14)	uc 38 (34–42, n = 10)
Ventral hook Inner length	p 47 (45–52, n = 18)	p 47 (44–50, n = 14)	uc 40 (29–44, n = 10)
Dorsal hook outer length	p 38 (35–40, n = 18)	p 38 (34–43, n = 14)	uc 33 (32–36, n = 10)
Dorsal hook Inner length	p 26 (24–28, n = 18)	p 27 (24–31, n = 14)	uc 22 (21–24, n = 10)
Dorsal bar length	p 31 (29–34, n = 18)	p 32 (27–35, n = 14)	uc 25 (23–25, n = 7)
Dorsal bar width	p 8 (6–13, n = 18)	p 9 (7–12, n = 14)	uc 6 (6–7, n = 7)
Ventral bar length	p 38 (34–41, n = 9)	p 40 (36–43, n = 7)	
Ventral bar width	p 6 (5–8, n = 8)	p 7 (5–9, n=7)	uc 6 (5–6, n = 4)
Ventral lamellodisc number	cp 10 (n = 11)	cp 9–11 (n=8)	c 10 (n = 5)
Ventral lamellodisc closed ring number		cp 3 (n = 3)	uc 3 (n = 3)
Ventral lamellodisc internal diameter	c 8 (6–10, n = 6)	c 7 (6–8, n = 5)	
Dorsal lamellodisc number	cp 10 (n = 12)	cp (9–10, n = 8)	uc 10 (n = 5)
Dorsal lamellodisc closed ring number		cp 3 (n = 3)	
Dorsal lamellodisc internal diameter	c 8 (6–12, n = 7)	c 6 (5–7, n = 5)	

c – carmine; p – picrate; uc – unflattened carmine; cp – carmine and picrate.

Table 4. Species of *Lethrinus* present off New Caledonia and their *Calydiscoides* species. From Justine (2007a), and this paper.

Lethrinus spp.	Examined	*Calydiscoides* spp.
L. atkinsoni Seale	+	*C. rohdei*
L. erythracanthus Valenciennes		
L. genivittatus Valenciennes	+	0*
L. harak Forsskål	+	*C. difficilis*, *C. duplicostatus*, *C. terpsichore* sp. n.
L. laticaudis Alleyne et Macleay		
L. lentjan Lacépède	+	*C. difficilis*, *C. duplicostatus*
L. miniatus Schneider	+	*C. australis*, *C. gussevi*
L. nebulosus Forsskål	+	*C. difficilis*, *C. duplicostatus*, *C. terpsichore* sp. n.
L. obsoletus Forsskål	+	*C. difficilis*
L. olivaceus Valenciennes		
L. ravus Carpenter et Randall	+	*C. difficilis*
L. rubrioperculatus Sato	+	*C. euzeti*
L. semicinctus Valenciennes		
L. variegatus Valenciennes	+	0**
L. xanthochilus Klunzinger	+	*C. euzeti*

*based on numerous (>30) observations; **based on a single fish examined.

Table 5. Host specificity of *Calydiscoides* spp. from *Lethrinus* spp. in New Caledonia. From Justine (2007a), and this paper. Specificity is strict (1 host species) or stenoxenous (2–5 host species).

Species	Number of hosts	Hosts
C. australis	1	*L. miniatus*
C. rohdei	1	*L. atkinsoni*
C. gussevi	1	*L. miniatus*
C. euzeti	2	*L. rubrioperculatus*, *L. xanthochilus*
C. terpsichore	2	*L. nebulosus*, *L. harak*
C. duplicostatus	3	*L. nebulosus*, *L. harak*, *L. lentjan*
*C. difficilis**	5	*L. nebulosus*, *L. harak*, *L. lentjan*, *L. ravus*, *L. obsoletus*

*additional hosts in Australia are *L. laticaudis*, *L. reticulatus* and *L. miniatus* (Young 1969, 1970, Oliver 1984, Rohde et al. 1994, 1995), producing a total number of 8 host species for *C. difficilis* for both locations.

Other host: *Lethrinus harak* Forsskål.

Site: Between secondary gill lamellae.

Type locality: Lagoon off Nouméa, New Caledonia.

Type specimens: Holotype, slide JNC967A17; 30 paratypes.

Material examined: 32 specimens.

Material deposited: Holotype and 21 paratypes from *L. nebulosus* (3 'carmine', 18 'picrate' in 14 slides), MNHN JNC967, JNC1985; 5 paratypes from *L. harak* (2 'carmine', 3 'picrate' in 2 slides, MNHN JNC1770, JNC1771, JNC1784; paratypes from *L. nebulosus*, 'carmine': BMNH 2006.12.13.7; USNPC 99431; MPM 18844; HCIP M-427.

Prevalence: *L. nebulosus* 2/2, 100%; *L. harak* 3/7, 42% (Table 1).

Intensity: Up to 19 per fish. Always less abundant than *C. difficilis*; apparently as abundant as *C. duplicostatus* in *L. nebulosus*, but the less abundant species in *L. harak* (Table 1).

Etymology: Specific name is from Terpsichore, the Muse of dancing, in reference to the morphology of the MCO which evokes the leg of a dancer to the first author.

Differential diagnosis. Justine (2007a) proposed to differentiate two groups within the *Calydiscoides* from lethrinids, i.e. the 'difficilis group' (including *C. difficilis* and *C. rohdei*), characterized by heavily sclerotized MCO, and the 'australis group' (including *C. australis*, *C. duplicostatus*, *C. gussevi* and *C. euzeti*) in which the MCO is branched. *C. terpsichore* clearly belongs to the australis group. It can be differentiated from other members of the group by the morphology of its MCO, particularly the lateral trifurcated branch. Haptoral hard parts are similar in size in all five members of the australis group (including *C. terpsichore*); *C. terpsichore* can be distinguished from *C. euzeti*, but not from the three other species, by absence of hooks on dorsal bars. Lamellodiscs are also similar in all members in the groups; *C. terpsichore* can be distinguished from *C. duplicostatus*, but not from the three other species, by larger squamodiscs (37 vs 25).

DISCUSSION

Comments on the MCO

Homologies between the different parts of the MCO and functional morphology can be hypothesized from similar structures. The left branch is bordered, or ended, by a membranous element in *Calydiscoides terpsichore*, as it is in *C. australis* and *C. euzeti*. The right branch has a small bend at its base in *C. terpsichore* and *C. euzeti*: this could be a zone of flexion assuring mobility of this part.

Comments on host specificity of *Calydiscoides* spp. and numerical evaluation of parasite biodiversity

A host-parasite list is given in Table 4, and host specificity of the 7 *Calydiscoides* spp. collected from New Caledonian fish is indicated in Table 5. Specificity is not strict for several species. This contrasts with another diplectanid genus, *Pseudorhabdosynochus*, in which specificity in groupers is very strict (Justine 2007b). However, when a *Calydiscoides* species (identified by MCO morphology) is found in several hosts, morphometrics are different in each host (Justine 2007a, for *C. euzeti*; this paper, for *C. difficilis*); this suggests that species complexes might be involved.

In term of coincidences of host and parasite phylogeny, it is worth mentioning that *Lethrinus harak* and *L. nebulosus* are two members of a terminal clade, containing 4 members, in the phylogeny of Lethrinidae of Lo Galbo et al. (2002; their fig. 2); these two species are the only ones to harbour *C. terpsichore*, which is apparently limited to this terminal clade. *L. lentjan*, which is closely related to this clade, shares *C. duplicostatus* with the two former host species. *C. difficilis* has a wide host spectrum of five species in New Caledonia, plus *L. laticaudis* and *L. reticulatus* in Australia (Young 1969, 1970) and, if specimens mentioned by Oliver (1984) and Rohde et al. (1994) belong to the same species, also *L. miniatus* in Australia. *L. miniatus* is the basal species of the *Lethrinus* clade in Lo Galbo et al. (2002): *C. difficilis* is thus a species with a very wide host spectrum, occurring in all three major clades recognized within *Lethrinus* by Lo Galbo et al. (2002). However, measurement differences suggest that differentiation of several parasite species (perhaps a '*C. difficilis* species complex') is occurring, or has occurred, but morphological differences are too subtle to be ascertained to the observer, without genetic methods.

In term of numerical evaluation of parasite biodiversity, the case of stenoxenous species (which have several closely related hosts) such as *Calydiscoides* spp. produces a 'parasitic biodiversity ratio' (number of parasite species: number of host species) lower than for oioxenous species (which have a single host). In New Caledonia, Justine (2007b: his table 5) recorded that 7 species of groupers (Epinephelinae) had a total of 25 species of diplectanids, which were all strictly specific; this produces a parasitic biodiversity ratio of 3.57 (25:7). For *Lethrinus* and *Calydiscoides*, the counts for New Caledonia are of 7 species of diplectanids for 11 species of hosts (Table 4), thus a parasitic biodiversity ratio of 0.63 (7:11), inferior to 1. However, several species of *Haliotrema* are also present in almost all *Lethrinus* species (Justine 2007a; and unpublished results) and might show a higher degree of host specificity.

Other parasites from *L. harak* and *L. nebulosus*

In addition to the diplectanid species described above, *L. harak* has 3 species of the ancyrocephalid *Haliotrema*, all probably new, and *L. nebulosus* has one species, which is similar to one of the species from *L. harak*. Both fish have copepods on gills, identified by G. Boxshall (Natural History Museum, London) as *Hatschekia* sp. (Hatschekiidae). Both fish have capsalids, *Encotyllabe* sp. (probably the same species) on

pharyngeal teeth. *L. harak* has also a gnathiid isopod larvae, a filiform didymozoid digenean within the gill arches, and a leech (Hirudinea) was found once. Immature microcotylid polyopisthocotyleans were collected in *L. nebulosus*. Finally, *L. harak* has 10 gill and mouth parasites, including 7 monogeneans (3 diplectanids, 3 ancyrocephalids, 1 capsalid), 1 leech, 1 isopod and 1 copepod, and *L. nebulosus* has 7 gill and mouth parasites, including 6 monogeneans (3 diplectanids, 1 ancyrocephalid, 1 capsalid, 1 microcotylid) and 1 copepod. *L. nebulosus* and *L. harak* thus apparently share 3 diplectanids, 1 ancyrocephalid and 1 capsalid, thus confirming close relationships between the two species. Both species also have opecoelid digeneans, still unidentified, in the digestive tract; opecoelids have already been reported from various *Lethrinus* spp. off New Caledonia (Bray and Justine 2007).

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