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Redescription of *Heteraxine heterocerca* (Monogenea : Heteraxinidae)

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The yellowtail, *Seriola quinqueradiata*, is an important fish for food, and cultured widely in the southwest of Japan. The gill of cultured yellowtails is frequently parasitized by a monogenean parasite, *Heteraxine heterocerca*. Sometimes more than one thousand of the parasites are observed on the gills of a single host.

Since Goto (1894) originally described this parasite in detail, various authors have redescribed it (Yamaguti, 1934, 1938, 1942 ; Akazaki, 1965 ; Matsusato, 1968). As all the descriptions, including the original one are not complete from a viewpoint of the modern systematics of Monogenea, redescription of the present species is considered very timely.

Materials and methods

A number of specimens of *H. heterocerca* were obtained from the gills of more than ten yellowtails, *Seriola quinqueradiata* (O+ year) cultured in net-pens in Shizuoka Prefecture, Japan. They were fixed in Schaudinn's fluid or 70% alcohol under the coverslips, stained with haematoxylin or alum carmine, and mounted in Canada balsam. Description and measurement were carried out on the stained specimens. Determination of fine structures was supplemented with observation of some living specimens. Figures 1-4 were drawn with the aid of a camera lucida.

Results

Heteraxine heterocerca (Goto, 1894) Yamaguti, 1938

Host : Yellowtail, *Seriola quinqueradiata* (O+year)

Habitat : Gills

Locality and dates : Shizuoka Pref., Nov., Dec. 1975 and Feb. 1976.

Specimens : Deposited in the Meguro Parasitological Museum, M. P. M. Coll. No. 19240 and in the authors' collection.

Synonym : *Axine seriola* Ishii,1936.

Description : The body is up to 14 mm long, asymmetrical and approximately triangular in shape, and gradually tapers anteriorly. The mouth opens subterminally. The pharynx is 59-84 μm long by 34-43 μm wide. The esophagus with several pairs of side branches bifurcates just in front of the genital opening. The intestine runs on either side of the body with numerous side branches, terminating blindly. The anterior suckers are 124-175 μm (mean 147 μm)$\times$86-137 μm (mean 106 μm) in size.

The testes, 69-125 (mean 99) in number, occupy a large part of the posterior interintestinal region. The vas deferens arises from the anterior part of the testes in the median line, proceeding anteriorly with numerous convolutions, and leading into the narrow and almost straight ejaculatory duct. The latter is enclosed by the ejaculatory bulb, which is made up of well developed longitudinal muscle fibers. The cirrus is unarmed, projecting into the unarmed genital atrium and connected with the ejaculatory bulb at its posterior end.

The ovary is situated just in front of the testes, approximately inverted U-shaped, originating behind its distal end which directs backwards. The oviduct, after forming the receptaculum seminis, runs backwards and

branches off the genito-intestinal canal before receiving the common vitelline duct. The genito-intestinal canal ascends obliquely to the right and is united with the right intestine. A sphincter is present at the beginning of the ootype. The shell glands are well developed. The uterus runs forwards on the ventral side of the vas deferens,

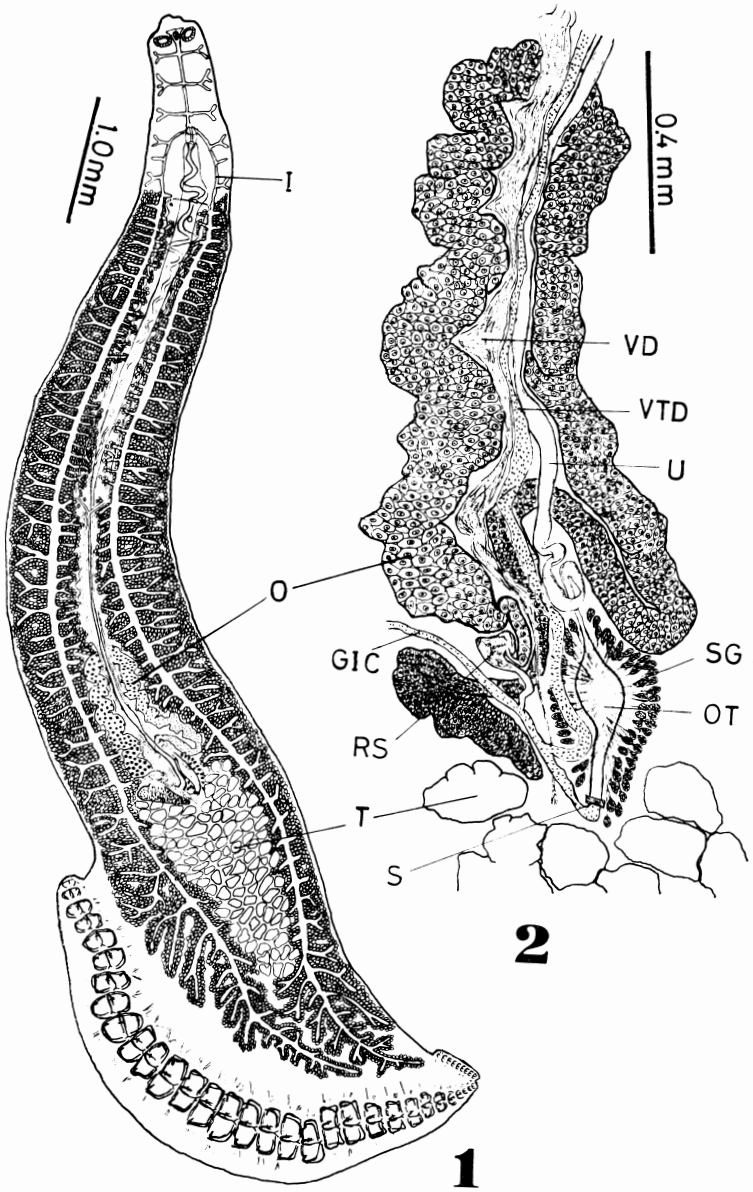
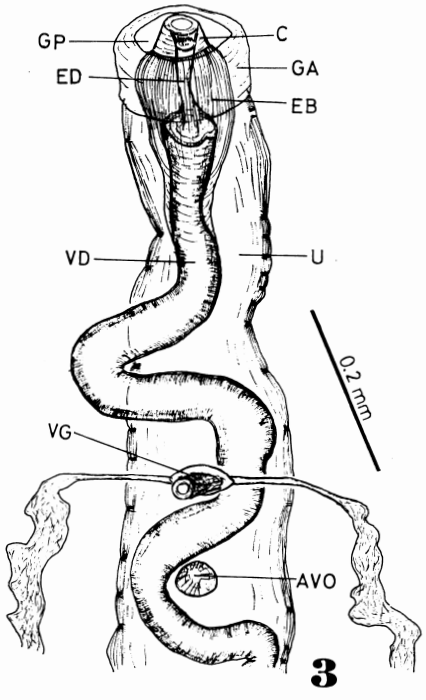


Fig. 1: The whole worm of *H. heterocerca*, ventral view.
Fig. 2: The ovarian complex, ventral view (GIC: genito-intestinal canal, I: intestine, O: ovary, OT: ootype, RS: receptaculum seminis, S: sphincter, SG: shell glands, T: testes, U: uterus, VD: vas deferens, VTD: vitelline duct).



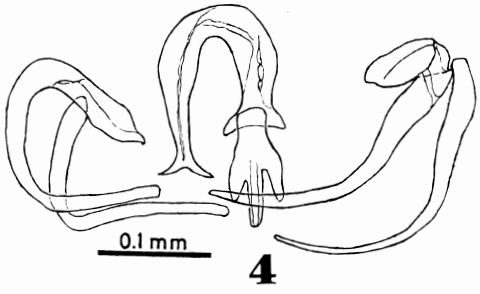


Fig. 3 The terminal genitalia and the vagina, dorsal view (AVO : accessory vaginal opening, C : cirrus, EB : ejaculatory bulb, ED : ejaculatory duct, GA : genital atrium, GP : genital pore, U : uterus,VD : vas deferens, VG : vagina).

Fig. 4 A clamp.

gradually widened distally, and opens into the genital atrium ventrally to the ejaculatory bulb. The unarmed vagina opens middorsally a little behind to the genital opening. It consists of a transversely elongated central part with a dorsally projecting opening and two transverse tubes, from the distal ends of which the vaginal ducts arise posteriorly. Proceeding backwards, the latter are united with the arms of the Y-shaped vitelline duct. Behind the vaginal opening, a rounded pore (34–70 μm × 44–101 μm) opens dorsally on the median line. It is not armed with spines, but has soft and frill-like structures around it. Since any duct does not emerge from the pore, it is considered to be an accessory vaginal opening, whose function is unknown. Distance between the vaginal opening and the accessory ranges from 103 to 167 μm. The vitellaria are co-existent with the intestine and distribute from the level of the vagina to the end of the intestine.

The opisthaptor is provided with two rows of clamps of *Microcotyle* type. It bears 24–32 clamps on one side, 3–14 on the other, and, in most cases, ranges 26–30 and 7–9 in number on the respective side (Fig. 5). Each clamp is identical in shape, provided with a trident appendage attached to the median spring. The largest clamp is present in the middle of each row, from where the clamps decrease in size anteriorly and posteriorly. The posteriormost, the largest and the anteriormost clamps on the short side are 39–44 μm (mean 42 μm), 58–64 μm (mean 60 μm) and 38–54 μm in diameter, respectively. Those on the long side are 38–44 μm (mean 41 μm), 360–407 μm (mean 381 μm) and 30–127 μm in diameter, respectively. As shown by these measurements, the clamps on the short side do not differ in size very much (the largest is less than two times as large as the posteriormost or the smallest), while those on the long side vary greatly in size to such a degree that the largest is about ten times as large as the posteriormost or the smallest. The terminal anchors are absent in the present species.

The whole body, ovarian complex, terminal genitalia and vagina, and clamp are presented on Figs. 1–4.

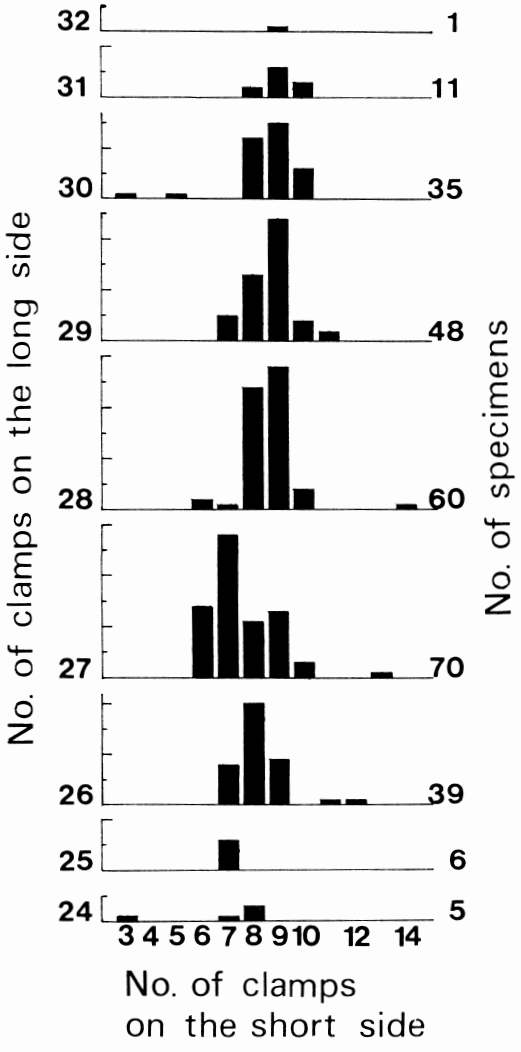


Fig. 5 Number of clamps on both sides of the opisthaptor (N : 275).

Discussion

Heteraxine heterocerca was originally reported by Goto (1894) as *Axine heterocerca*. Yamaguti (1938) proposed a new subgenus *Heteraxine* for this species, and Sproston (1946) emended it to the generic status. Goto (1894) described this species so precisely that further description is scarcely needed except in some points such as the terminal genitalia.

The ejaculatory duct is present at the male terminalia, indicating that there is no essential difference between *Heteraxine* and *Zeuxapta*. Therefore, it seems to be an error that there is no such a structure in *Heteraxine* (Yamaguti, 1963). The only difference between the two genera is the number and size of clamps of each row or the shape of the opisthaptor. In *Heteraxine*, the clamps on one side reduce greatly in number and size, while in *Zeuxapta*, they don't differ very much from those on the other in number and size, having subsymmetrical opisthaptor. The number of clamps of the present species ranges 23–34 on one side and 6–10 on the other, according to all the data reported so far (Goto, 1894 ; Yamaguti, 1934, 1938, 1942 ; Ishii, 1936 ; Akazaki, 1965 ; Matsusato, 1968). Based on our specimens (Nos. examined : 275) they are 24–32 and 3–14 in number on the respective side, and mostly 26–30 and 7–9. An accessory opening exists behind the vagina. As pointed out by Price (1962), no such structure has been reported from any other monogeneans. Although its function is still unknown, this may be a remnant of another opening of the vagina.

H. heterocerca is the type species of the genus *Hetraxine*, and many authors have included various species in this genus. Ishii (1936) reported *Axine seriola* from the gills of *Seriola quinqueradiata*. Although there was no remark on the accessory vaginal opening in his description, Price (1962) redescribed the opening from Ishii's specimen. Considering that there seems to be no difference in the morphology including that of the vagina between the present species and *A. seriola*, the latter species is regarded as a synonym of *H. heterocerca*. According to Yamaguti (1963), the genus *Heteraxine* includes two other species ; *H. karavoli* Unnithan, 1957 and *H. mcintoshi* (Price, 1962). The former which differs from the present species in that the single vaginal duct is not confluent with the arms of the vitelline duct and both the cirrus and the genital atrium are armed with spines, should be classified into the independent genus *Karavolicola*

Table 1 Comparison of some morphological characteristics between *Heteraxine heterocerca*, *Axine belones* and *Microcotyle donavini*

	A. belones	*H. heterocerca*	*M. donavini*
Clamps: rows	Two rows in a straight line	Two separate rows	Two separate rows
Clamps: number and size	Equal in each row	Clamps at one row much smaller than those at the other	Equal in each row
Opisthaptor	Asymmetrical	Asymmetrical	Symmetrical
Vaginal opening	Lateral	Middorsal	Middorsal
Ovary	U-shaped	Inverted U-shaped	Inverted U-shaped
Terminal anchors	Present	Absent	Absent

Price, 1962. The latter species, *H. mcintoshi*, should remain as originally reported, *Allencotyla mcintoshi* Price, 1962 on account of the lack of the detailed description on the vagina and the presence of the spinous armament of the genital atrium. Unnithan (1971 b) asserted *Microcotyle scorpis* Sanders, 1944 to be assigned to *Heteraxine*. This species, however, should be classified into *Heteraxinoides*, because the vagina is absent in this species (Price, 1962). Crane (1974) proposed to assign *Pseudochauhanea argentea* Crane, 1972 to *Heteraxine*. This species evidently differs from *Heteraxine* in having the unilateral row of clamps, double vaginal pores, bipolar filaments of egg* and so on, and should be excluded from *Heteraxine*. Accordingly, *Heteraxine* includes a single species, *H. heterocerca*.

The present parasite has been as yet classified either into the family Axinidae or into Heteraxinidae. After the proposal of a new family Heteraxinidae for the parasite by Price (1962), Lebedev (1968) classified it into the latter family, while it was still included into the former by Yamaguti (1963), Dillon and Hargis (1965) and Unnithan (1971 a). In this context, it seems quite necessary to make its systematical position clear. The morphological characteristics of *H. heterocerca* are compared with those of *Axine belones* and *Microcotyle donavini* which are the representatives of the families Axinidae and Microcotylidae, respectively (Table 1) (Lorenz, 1878; Sposton, 1946; Yamaguti, 1963; Strelkov, 1953; Euzet and Marc, 1963; Euzet and Lopez-Roman, 1973). Numerous specimens of these two species are also examined which was collected at Plymouth, England by Dr. P. C. Young in 1940 and 1945, and deposited in the Meguro Parasitological Museum, Tokyo. In *A. belones*, two rows of clamps are disposed linearly as if they were in a single, continuous line of clamps. The terminal anchors exist approximately in the center of the straight row of clamps. The clamps of one side almost equal in number and size with those of the other unlike in case of the present species. Clamps in process of formation are observed at the anterior end of each row of clamps in *A. belones* (Euzet and Lopez-Roman, 1973), suggesting that the mode of linear disposition of clamps in the axinid may be identical with that of *Discocotyle sagittata* shown by Llewellyn and Owen (1960) and that of *Rhinecotyle crepitacula* by Euzet and Wahl (1970). In the latter two species, one row of clamps moves posterior to the other to form an approximately straight line of clamps, and as a result, the clamps of each row are arranged in such a fashon that a new born clamp is added anterior to the older ones. The mode in *A. belones* explained by Strelkov (1953) that one row of clamps pivoted around the terminal anchors and fell into line with the other may be an error,

* According to Harada and Akazaki (1971), the present species lays eggs with a monopolar filament.

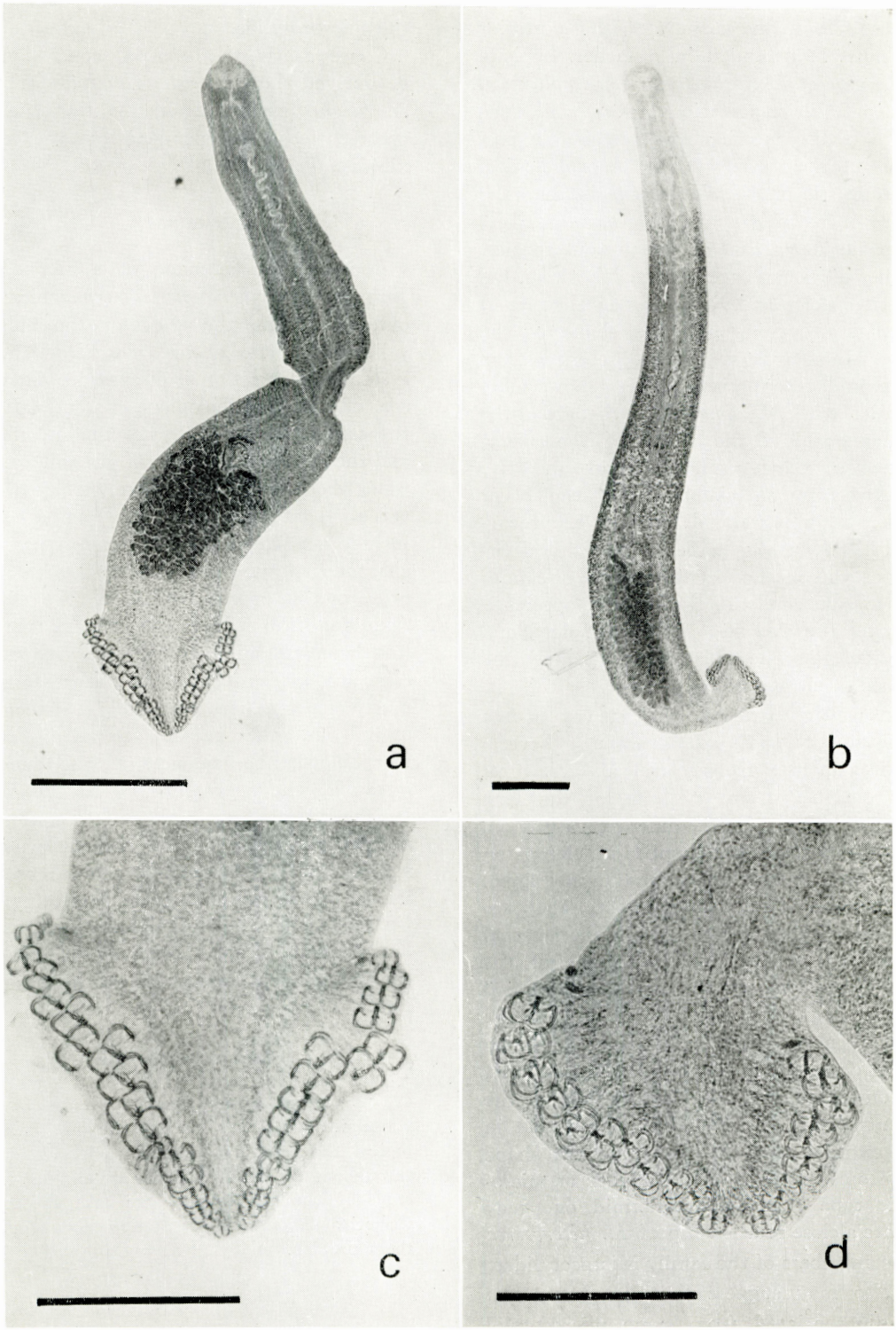


Fig. 6 a, b: Deformations of *H. heterocerca*. Scales for a and b; 1 mm. c, d: Opisthaptors of a and b. Scales for c and d; 500 μm and 300 μm, respectively.

because, if so, the clamps of the posterior row must be arranged in a fashon oppisite to the case of *D. sagittata* and *R. crepitacula*, i. e. in anterior-posterior order, while the clamps of the anterior row remains in posterior-anterior order. This morphological characteristic of *A. belones* reveals that the nature of asymmetry of the axinid differs essentially from that of the present species. Further differences are observed between the present species and *A. belones* in the site of the vaginal opening and the shape of the ovary. In contrast with the differences from the axinid, the present species shows more affinities with *M. donavini* in the site of the vaginal opening, the shape of the ovary, absence of the terminal anchors and two separate rows of clamps. On the other hand, the important differences are recognized between the present species and the microcotylid in the size variability of clamps (the largest clamp in the present species is about ten times as large as the smallest) and the shape of the opisthaptor, namely the number of clamps of each row.

During the parasitological survey of the yellowtail, *Seriola quinqueradiata*, several parasites different from typical *H. heterocerca* were obtained from the gills of the host (Fig. 6). Although they differs greatly from *H. heterocerca* in the number of clamps on both sides; 16 and 18 (a and c in Fig. 6) and 9 and 11 (b and d in Fig. 6), they are identical with *H. heterocerca* in the internal morphology as well as the shape of the clamps, and one of the specimens studied contains eggs in the uterus (b in Fig. 6). They are never taken as juveniles in which several clamps will be added. Accordingly, we considered them as deformations of the present species. It should be noted that in these extreme cases the subsymmetrical shape of the opisthaptor which is rather of microcotylid type than of heteraxinid one may indicate a close relationship of *H. heterocerca* to the members of the family Microcotylidae, and also may suggest that *H. heterocerca* was differentiated from some microcotylid ancestor or from some common ancestor with the microcotylids.

Consequently, the following conclusion will be derived that *H. heterocerca* is far from *A. belones* systematically, so that it should represent the independent family Heteraxinidae, Price, 1962.

Summary

Redescription is made of a monogenean parasite, *Heteraxine heterocerca* which was obtained from the gills of the cultured yellowtail, *Seriola quinqueradiata*, and its systematical position is discussed. Comparison of the morphological characteristics of the clamps on both sides of the opisthaptor and the genital organs of the present parasite with those of several closely related ones reveals that the genus *Heteraxine* should include a single species, *H. heterocerca*. The characteristics are also compared with *Axine belones*, the representative of the family Axinidae into which the present parasite has been classified by several authors. A clear account is given of the nature of asymmetry which differs essentially between the axinid and the present parasite. Many morphological coincidences with *Microcotyle donavini*, the representative of the family Microcotylidae, and several deformations of microcotylid type of the present parasites suggest that *H. heterocerca* shows more similarity in the morphology to Microcotylidae. Consequently, the following conclusion is derived that *H. heterocerca* should represent the independent family Heteraxinidae Price, 1962.

Acknowledgements

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単生目吸虫 *Heteraxine heterocerca* の再記載

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養殖ハマチの鰓に寄生していた単生目吸虫，*Heteraxine heterocerca* をもとに，その再記載を行なつた．後固着器の２列の把握器と生殖器の形態を近縁種と比較した結果，*Heteraxine* 属は本虫１種のみを含むのが妥当と考えられた．本虫はしばしば Axinidae 科に分類されるが，その科の代表種，*Axine belones* とは不対称性が本質的に異なる．また，Microcotylidae 科の代表種，*Microcotyle donavini* と形態的一致点が多いこと，本虫の *Microcotyle* 型の奇形が得られたことから，本虫はむしろ Microcotylidae 科に近いといえる．従つて，本虫は Axinidae 科から独立し，Heteraxinidae 科に分類されるべきであると結論した．