Two New Species of *Gyrodactylus* (Monogenea: Gyrodactylidae) of Eel, *Anguilla japonica*, with Some Data on the Occurrence of Gyrodactylids in Greenhouse Culture at Yoshida, Shizuoka Prefecture, Japan

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Descriptions are given of two new species of *Gyrodactylus* collected from the body surface of eel, *Anguilla japonica*, in greenhouse ponds at Yoshida, Shizuoka Pref. *G. egusai* sp. nov. differs from most similar *G. varicorhini* ERGENS et IBRAGIMOV, 1976 in considerably smaller hamuli and marginal hook proper. *G. joi* sp. nov. is distinguished from most related *G. anudarini* ERGENS et DULMAA, 1968 in the shape of the marginal hook proper.

Long term changes in the occurrence of *Gyrodactylus nipponensis* on the gill fillaments and *G. egusai* and *G. joi* on the body surface were studied during 1980-1985. *Gyrodactylus* on the body surface was more frequently found than *G. nipponensis* throughout the study period. Gyrodactylids on both sites were less frequently observed in 1983-1985 than in 1980-1982, and also in summer than in the other seasons. Possible reasons for the seasonal and yearly fluctuations in *Gyrodactylus* populations are briefly discussed.

Yoshida area, Shizuoka Pref. is one of the centers of eel culture industry in Japan, with a total of about 100 ha ponds and annual production of well over 3,000 tons in 1984. Recently, gyrodactylids have been collected from the body surface of eel, *Anguilla japonica*, cultured there. A parasitological investigation has revealed that the gyrodactylids on the body surface are different from *Gyrodactylus nipponensis* OGAWA et EGUSA, 1978, the only known gyrodactylid from the host, and, therefore, represent two new species.

The junior author, a member of the local eel farmers' cooperative association, routinely conducts diagnostical work on health conditions of cultured eel. The work includes check for parasites on the gills and body surface. The record of the results for recent six years had been kept there, which enabled us to study the seasonal and yearly fluctuations in the occurrence of the gyrodactylids in the area.

Materials and Methods

Gyrodactylus specimens were collected from scrapings of the body surface of eel cultured at Yoshida, Shizuoka Pref. They were fixed in ammonium picrate-glycerin, dehydrated in alcohol, and mounted in Canada balsam, or fixed in 10% formalin and mounted in glycerol-gelatine. A phase-contrast microscope was used for measurement and drawing of the type specimens with the aid of a camera lucida. Measurements are given in μm unless otherwise stated.

Long term changes in the occurrence of eel gyrodactylids were investigated based on the results of diagnostical work carried out by the junior author. A total of 11,152 samples (62-301 per month) of eel from elvers to marketable size in greenhouse ponds were diagnosed during 1980-1985, each sample usually consisting of five specimens of eel (rarely less than five). For diagnoses of parasitoses, a gill on either side of body and

scrapings of the body surface of all the five eel were examined under a microscope ($40\times$). Samples, in which at least one out of five eel was infected with gyrodactylids, were recorded as positive about the parasite; the percentage occurrence in this paper does not represent the prevalence of infection in the true sense of the term.

Results

Description of the new species

Gyrodactylus egusai sp. nov.

(Figs. 1–4)

Host and habitat: On the body surface of *Anguilla japonica*.

Locality and date of collection: Yoshida, Shizuoka Pref. on 12 Sept. 1981.

No. of specimens: 20 (all fixed in ammonium picrate-glycerin).

Specimens: Holotype and some paratypes deposited in the Meguro Parasitological Museum, M. P. M. Coll. No. 19480 and the other paratypes in the authors' collection.

Description: Body, of medium size, 0.51–0.65 mm long. Hamuli 46–51 in total length with inwardly bent root, 13–16 long, base (shaft) 34–38 long and point 25–28 long. Ratio of root to base 2.2–2.8. Ventral bar slightly arcuate, $20\text{--}23 \times 4.5\text{--}7$ in size with short lateral processes, 1.5–2 long and membrane 12–17 long, tapering distally with rounded margin. Dorsal bar $18\text{--}21 \times 1.5\text{--}2$ in size, with lateral spurs near the junction with bullae. Marginal hooks 25–28 in total length; handle 20–23 long and domus (loop) 14–16 long. Hook proper somewhat stout, 5–5.5 long, with strongly curved blade and well developed outer protrusion of base, 5–6 in distal width and 4 in proximal width. Male copulatory organ 11–17 in diameter, cirrus short and tapering distally, 3.5–5 long, guarded by a single row of about 6–8 minute spines.

Remarks: *Gyrodactylus egusai* sp. nov. is most similar to *G. varicorhini* ERGENS et IBRAGIMOV, 1976 in the shape of the opisthohaptoral hard parts, but can be separated from it in considerably smaller hamuli and marginal hook proper. This new species is named in honor of Dr. S. EGUSA, emeritus professor of the University of Tokyo.

Gyrodactylus joi sp. nov.

(Figs. 5–7)

Host and habitat: On the body surface of *Anguilla japonica*.

Locality and dates of collection: Yoshida, Shizuoka Pref. on 30 June and 03 July, 1981.

No. of specimens: 16 (all fixed in formalin).

Specimens: Holotype and some paratypes deposited in the Meguro Parasitological Museum, M. P. M. Coll. No. 19481 and the other paratypes in the authors' collection.

Description: Body 0.26–0.41 mm long. Hamuli 47–52 in total length with straight root, 16–21 long, base (shaft) 35–38 long and point 26–28 long. Ratio of root to base 1.8–2.3. Ventral bar well developed, arcuate, $26\text{--}28 \times 4\text{--}5$ in size with short lateral processes, 1.5–2.5 long and membrane 22–26 long. The latter tapering posteriorly with increasing thickness, developing lateral outgrowths at posterior end. Dorsal bar $18\text{--}26 \times 2\text{--}3.5$ in size with lateral spurs near the junction with bullae. Marginal hooks 24–27 in total length; handle 18–21 long and domus (loop) 13–15 long. Hook proper 5.5–6 long with less sharply curved blade and broad base, 5–5.5 in distal width and 4 in proximal width. Male copulatory organ 14–24 in diameter, cirrus 6.5–8 long, curved and surrounded by a single row of about 6–8 spines.

Remarks: *Gyrodactylus joi* sp. nov. is most related to *G. anudarini* ERGENS et DULMAA, 1968 in the shape of hamuli and bars, but can easily be distinguished from the latter in the shape of the marginal hook proper. The specific name, *joi*, is taken from Dr. Y. JO, Tokushima Prefectural

Figs. 1–4. *Gyrodactylus egusai* sp. nov. 1: hamuli, bars and marginal hook of holotype, 2: same of paratype, 3: marginal hook proper of holotype, 4: male copulatory organ of paratype. Scale *a* for Fig. 3 and *b* for Figs. 1, 2 and 4.

Figs. 5–7. *Gyrodactylus joi* sp. nov. 5: hamuli, bars and marginal hooks of holotype, 6: marginal hook proper of holotype, 7: male copulatory organ of holotype (left) and of paratype (right). Scale *a* for Fig. 6 and *b* for Figs. 5 and 7.

Fig. 9. Long term changes in the occurrence of *Gyrodactylus* of eel in greenhouse ponds in 1980–1985. Symbols as in Fig. 8.

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Occurrence of gyrodactylids in greenhouse culture in 1980–1985

An examination of some preserved *Gyrodactylus* specimens has revealed that out of seven samples of scrapings of the body surface of the host, five were infected with *G. egusai* sp. nov., one with *G. joi* sp. nov. and one with both species, while all gills were infected with *G. nipponensis*. Thus, it is supposed that *Gyrodactylus* on the gill filaments represented *G. nipponensis*. On the other hand, *Gyrodactylus* on the body surface included the two new species.

Of total of 11, 152 samples of eel in greenhouse ponds, *Gyrodactylus* were found from the body surface of 296 samples (2.65%) and from the gill filaments of 83 samples (0.74%).

The record is arranged on a monthly basis (Fig. 8). *Gyrodactylus* on the body surface was found from 0 to 12.2% of the samples, while gill *Gyrodactylus* (= *G. nipponensis*) from 0 to 6.3%; the latter seldom outnumbered the former in each month. With regard to seasonal fluctuations, *Gyrodactylus* both on the body surface and on the gills tended to be less abundant in summer than in the other seasons. Changes in the occurrence with year (Fig. 9) have shown that gyrodactylids on both sites of the host were much more frequently ob-

served in 1980–1982 than in 1983–1985.

Discussion

Gyrodactylus egusai sp. nov. and *G. joi* sp. nov. are the second and third species of *Gyrodactylus* of eel, *Anguilla japonica*, following *G. nipponensis* on gill filaments. *G. anguillae* and *G. nipponensis* have been known from the gill filaments of European eel, *Anguilla anguilla*, introduced to Japan for culture (OGAWA and EGUSA, 1980).

All the eel examined in the present study had been cultured in greenhouse ponds, where water temperature was usually about 25°C or above. In summer, it rose as high as 30°C. The lower frequency in the occurrence in summer was possibly caused by the higher water temperature.

It is interesting to note that *Gyrodactylus* on the body surface and gill filaments has been less frequently found since 1983 (Fig. 9). An environmental change, if any, is most likely to be the cause, and the quality of pond water has been one of the most marked changes in recent years. All greenhouses are equipped with boilers to keep pond water warm in cold seasons. Turnover rate of water in greenhouse ponds has considerably decreased and the water quality has become worsened because of a great rise in the price of heavy oil for boilers. This may be responsible for the recent decrease in *Gyrodactylus* populations in eel ponds

Fig. 8. Monthly fluctuations in the occurrence of *Gyrodactylus* of eel in greenhouse ponds in 1980–1985. Vertical bars: no. of samples examined, ■: occurrence of *Gyrodactylus* on the body surface, □: occurrence of *Gyrodactylus* on the gill filaments.

there.

In Yoshida area, eel is also cultured in outdoor ponds, especially in summer. 464 samples of eel in outdoor ponds had been examined for parasites during the same period. No infection with *Gyrodactylus* had been found on the gill filaments, and seven cases of infection on the body surface had been recorded. Because of much smaller number of samples, no tendency in the occurrence was clear and it also seems difficult to compare the result with the data in greenhouse ponds.

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