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STUDIES ON GILL PARASITOSIS OF THE GRASS-CARP (CTENOPHARYNGODON IDELLA) CAUSED BY DACTYLOGYRUS LAMELLATUS ACHMEROW, 1952

I. MORPHOLOGY AND BIOLOGY OF DACTYLOGYRUS LAMELLATUS

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The morphology, development and other biological properties of *Dactylogyrus lamellatus* were little studied until the last decade, when it was found to cause economically important damages in cultured grasscarp *(Ctenopharyngodon idella)* populations.

The parasite was originally described by AKHMEROW (1952) from fishes taken from the river Amur, and in 1955 he demonstrated it also among grasscarps naturalized in the European waters of the USSR. The occurrence of the species was later reported in Roumania (RADULESCU and GEORGESCU, 1962) and in different states of the USSR, such as Kazakhstan (AGAPOVA and AKHMETOVA, 1966), Turkmenistan (BABAYEV, 1964), Daghestan (ALIGADZHIEV, 1968), and the Ukraine (KULAKOVSKAYA and IVASIK, 1967). The *Dactylogyrus* sp. observed by MATTHEIS (1967) in a grasscarp in Germany may also have been *D. lamellatus*. The pathogenicity of the species was first noted by BAUER and STRELKOV (1963), but AKHMEROV (1963) has doubted it.

In Hungary, *D. lamellatus* was first observed by SZAKOLCZAI and MOLNÁR in 1964, and two years later MOLNÁR (1966) reported an outbreak of the gill disease caused by this parasite.

As yet only MUSSELIUS (1966, 1968a, 1969) and MUSSELIUS and PTASUK (1970) have studied the biological properties of *D. lamellatus*. Since basic information has been scanty, they had to rely on earlier observations on the life cycle of other monogenean parasites, above all *Dactylogyrus vastator* (WUNDER, 1929; LYAJMAN, 1951; IZYUMOVA, 1956, 1958; BAUER, 1959; PAPERNA, 1963a, b; GRÖBEN, 1940), although certain observations on *D. anchoratus* and *D. extensus* (MALEVICKAYA, 1952; PROST, 1963), *D. aristichthys* (MUSSELIUS, 1968b), *D. nobilis* (MUSSELIUS and PTASHUK, 1969), and *D. chranilovi* (IZYUMOVA, 1969), have also been helpful. Similar studies on *Ancylodiscoides vistulensis* have been reported by MOLNÁR (1968).

This paper is a report of investigations into the biological properties of *D. lamellatus* under natural and experimental conditions over the period 1967—1970.

Materials and methods

The fishes were procured from the pond farms of Szarvas and Dinnyés. Artificially hatched, parasite-free fry was used in most experiments. They were maintained in the laboratory in aquaria of 0.5 cubic meter volume. In a few experiments pond-reared fishes were used after having first been

checked for parasites and treated with appropriate bathing solutions when necessary. Fingerlings or, exceptionally, two-summer fishes with dactylogyrosis served as the source of infection, after elimination of other parasitoses as far as possible. Most experiments had to be limited to the spawning season in June and July, but certain examinations could also be performed in other months of the year.

The laboratory examinations were carried out in Budapest; fishes for this purpose were secured every other week from the pond farms, where their maintenance was easier. Most experimental fishes were the offspring of the same parents. Fishes longer than 25 mm were fed only if the experiment lasted longer than a week, to prevent deleterious effects due to spoilage of the aquarium water. As by-pass aquarium systems interfere with the multiplication of *D. lamellatus*, aeration of the aquarium water was carried out by means of a ventilating device. Further experiments were made in ten by twelve meter spawning ponds, nursery ponds and other types of pond.

In the aquarium experiments, the parasite donors and the fry to be infected were separated by a delicate mesh permeable to *D. lamellatus* larvae. The younger fishes were placed in small mesh-covered boxes floated just below the water surface, to prevent damages by water depth and the decomposing substances depositing on the bottom of the aquarium.

The size of the fishes was measured from the mouth to the tip of the tail fin.

The majority of the experimental fishes were sectioned under a stereomicroscope immediately after extermination; in certain cases, particularly at the end of an experiment, the fry with yolk sac were preserved in a 4% formalin solution and examined later. The parasites secured from the fishes were preserved in lactophenol or ammonium picrate.

Studies on egg production of D. lamellatus

The number of eggs discharged by one parasite in unit time (oviposition rate), was assessed by different methods. Misleading results were obtained by the procedures of Lyaiman (1951) and Bauer (1954), who observed the oviposition of parasites removed from the gills of the host. As a rapid discharge of mature and half-mature ova takes place immediately upon the extermination of the host, the subsequent oviposit is immature and therefore inconclusive. To eliminate this error, egg production was always studied with parasites attached in situ to the gills of a living host, using in some cases the method proposed by Izyumova (1953) and Paperna (1963) for the counting of *D. vastator* eggs. A small 10—20 mm long fish infected with a few parasites was placed in a small Petri dish half filled with water and after a known time exterminated. The individual egg production was estimated from the number of

mature parasites attached to the gills and the number of eggs deposited at the bottom of the Petri dish.

More precise results were obtained when a fish infected with several hundred or several thousand parasites was placed in a container of known volume and aerated to keep the host alive for a longer time. After numbers of mature trematodes and eggs had been counted, the water was thoroughly stirred; the number of eggs present in 10 ml water permitted a fairly certain estimation of the oviposition rate. Conical glass containers are preferable, because they enable the collection also of parasites which detach from the gills. A large glass bead or pebble at the bottom of the container prevents the fish from sucking up parasite eggs. Initially many larva-containing eggs discharged by the host were found to have admixed with the oviposit; this was prevented by placing the fish above a mesh before the experiment began, to prevent uptake of eggs from the bottom of the container, and by not giving the fish food, to minimize excreta.

Determinations of the oviposition rate were carried out in a temperature range of 12—28 °C. As shown in Table I, this rate increased with the rise of the temperature.

Table I

Oviposition rates of *Dactylogyrus* species at different temperatures

Temperature °C	Average numbers of eggs deposited in 24 hours		
	Dactylogyrus anchoratus [Data of PROST (1963)]	*Dactylogyrus vastator* [Data of PAPERNA (1963a)]	*Dactylogyrus lamellatus* (Own observations)
12	—	1.5	2.5 (1.8— 3.7)
14	1.8	—	—
17—19	—	—	8.5 (5.9—11)
20—22	—	—	9.0 (7.2—12.2)
23	3.87	—	—
24	—	25.0	10.3 (7.2—15)
28	2.13	29.0	15.0 (14—16)

There was no notable difference between nocturnal and diurnal oviposition rates, nor between those determined at the same temperature in different experiments. PAPERNA (1963a) observed a variation of the oviposition rate between 7 and 46 at one and the same temperature, but I have found that large deviations are always due to some technical error. For example, if the experiment was carried on beyond 24 hours, a greater number of trematodes detached from the gills, resulting in a virtual increase of the

oviposition rate. On the other hand, maturation of some of the parasites during the period of determination results in a virtual decrease of the rate. Thus rates of 2.2 and 32 were obtained in two experiments carried out at 20 °C; such obviously erroneous results were excluded from the evaluation.

On comparing the present findings with the data of PAPERNA (1963a) and PROST (1963), it appears that the oviposition rate of *D. lamellatus* is somewhat higher than that of *D. anchoratus*, but lower than that of *D. vastator*. Considering the body dimensions of the three parasite species, these differences seem to be realistic. The oviposition rate increases proportionally with temperature up to 17 °C, but not notably above that level. The optimal temperature range for egg production by *D. lamellatus* is as wide as 17—28 °C.

The majority of the discharged eggs deposit on the bottom of the container, but a small number may get trapped in the gill and remain there for some time, as is indicated by the observation of embryonated ova in that location.

The egg

The eggs of *D. lamellatus* differ morphologically from those of other *Dactylogyrus* species in several respects, particularly in upper and lateral views. Viewed from above, they are like pointed ovals, one end being slightly more rounded than the other. Each pole bears a filament, that at the blunt end being the shorter and having a club-shaped ending. The opposite longer filament may show a few thickenings and may come off during maturation. The more pointed end of the egg carries a cap which opens when the larva escapes. The eggs are of yellowish brown or brown colour. In the lateral view, one side of the egg is convex, the other concave or straight (Fig. 1). The egg is 66—88 (75) μ long by 44—46 (45) μ wide and 44—48 (46) μ thick; the shorter filament measures 14—22 (17) μ, the longer one 15—35 (20) μ.

Development of the embryo within the egg

The freshly deposited egg is filled uniformly by an opaque granular zygote in which a small clear area arises when development starts. This area appears first in the central region, close to the convex surface. Later the dark granular substance, representing probably nutriments, is absorbed and the egg becomes transparent. The contours and eye spots of the larva are soon revealed and by the final stage of intraoval life the larva develops to a motile body (Fig. 1).

Intraoval development was followed up by various methods. The maturation of larvae in eggs deposited on a watch glass or in a small Petri dish will only take place if contaminating bacteria or protozoa are absent. Such microorganisms destroy the embryo sooner or later, probably by consuming its

oxygen supply, as IZYUMOVA (1958) demonstrated with artificially hatched *D. extensus* eggs. Hatching under an appropriately thick layer of water provides optimal conditions for larval development.

My observations on the time and temperature required for larval development are in good accordance with those of MUSSELIUS and PTASHUK (1970)

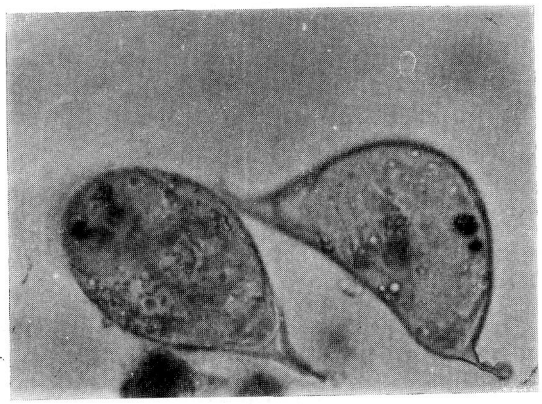

Fig. 1. Larva-containing *Dactylogyrus lamellatus* eggs in upper and lateral views

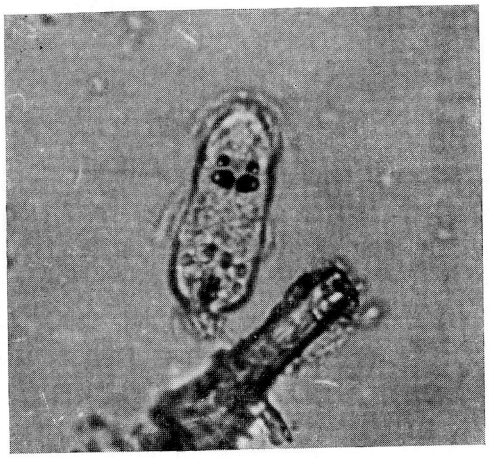

Fig. 2. Freely moving oncomiracidium

(Table II). At the optimal temperature of about 26 °C the miracidia hatch in one and a half days. At temperatures below and above that the time of larval development is prolonged. A short exposure to low temperature scarcely damages the viability of the eggs, as 40% of the eggs kept at +4 °C for 4 days produced normal larvae when the temperature was subsequently raised. Of the eggs hatched throughout at temperatures of 18—26 °C 90% gave rise

Table II

Time of intraoval development of the *D. lamellatus* larva at various temperatures

Hatching temperature °C	Time of larval development in the egg (days)	
	According to Musselius and Ptashuk (1970)	Own observations
4—6	No development	No development
13—14	—	8 —10*
14—15	5—5.5	—
18	—	4
19	3—3.5	3 —3.5
21	2—2.5	2 —2.5
24	—	2
26	—	1.5
26—29	1—1.5	—
32	No development	2.5—3
34	No development	3**

* The larva develops, but does not hatch from the egg and deteriorates within it in 1—3 weeks.

** The larva develops in 5—10% of the eggs, but does not hatch and deteriorates in 1—2 days.

to oncomiricidia. Occasional failures of larval development in a greater proportion of the eggs were mostly due to factors other than temperature, such as oxygen depletion, bacterial or fungal growth, etc.

The developing oncomiracidium lies along the convex side of the egg, with the anterior end at the capped pole and the tail end, sometimes slightly recurved, at the opposite pole. The larval flagella already move vigorously during intraoval life. Growth of the larva causes the egg cap to open, thus allowing for release on maturation.

Larval development and hatching in dark and light did not differ.

The oncomiracidium (larva)

The terms "larva" and "oncomiracidium" are not quite synonymous. "Oncomiracidium" applies to the motile, flagellated developmental stage capable of independent movement, while "larva" covers all developmental stages from the first indication of the embryo within the egg to the stage which has already settled on the gills and lost its flagella but has not yet commenced further development.

On hatching, the viable larva is cigar-shaped and 57—110 μ long by 22—30 μ wide. There are two pairs of black eye-spots on the anterior third of the body. The posterior third of the body carries a spine apparatus consisting of 14 lateral hocks, each 13—14 μ long. A conical protrusion is sometimes present on the anterior end. The oncomiracidium bears on either side of the anterior and middle third of the body and around the entire posterior third a row of 8—10 μ long cilia. In water the larva moves very rapidly, rotating its body around its longitudinal axis and changing its shape on changing the direction of its movement (Fig. 2). MUSSELIUS and PTASHUK (1970) observed that larvae may remain viable outside the host for 9—14 hours if the temperature is right. I can confirm this on the basis of my own examinations, with the remark that freely floating viable larvae could still be found even after 24 hours.

Many experiments were performed to determine whether or not the oncomiracidia are phototropic. Oncomiracidia in fluid medium were poured into water held in a specially constructed tube with one end kept in the dark and the other exposed to light. Samples withdrawn from the "light" and "dark" ends four hours later contained similar amounts of miracidia in replica experiments, suggesting the absence of distinct larval phototropism.

Another experiment was carried out to determine whether the larvae prefer to localize along the pond bottom or in the free water under natural conditions. Water samples were taken along the sides, at the bottom and at the surface of an infected pond (Table III), and dactylogyrosis-free grass-carps were placed in each. The fact that the fishes placed in water samples from the bottom and sides became infected, suggests that the oncomiracidia prefer to localize close to the soil. This is supported by the observation that even the most mobile miracidia would often descend to rest at the bottom of the container.

Table III

Experimental infection of grasscarp fry with *D. lamellatus* oncomiricidia usinb water samples taken from different parts of a pond stocked with an infected population

No. of experiment	Sites of sampling					
	Off shore		Bottom of pond		Surface of pond	
	I	II	I	II	I	II
No. of fish exposed	4	5	4	5	4	5
No. of fish invaded	1	3	1	2	—	—
Degree of infestation	2	1—2	2	1—3	—	—

Mode of infection by oncomiracidia

Many theories have been advanced as to the mode of infection by monogenean parasites. NYBELIN (1925) believed that the larvae swept to the gills with the water and attaching there play the primary role in infestation.

WUNDER (1929) thought that the infection could occur in three ways: (1) by means of eggs becoming fixed to the gills, (2) by means of larvae swept passively through the gills with the water, or (3) by means of larvae migrating actively to the gills via the skin. GRÖBEN (1940), LYAIMAN (1946) and PROST (1963) have agreed to the priority of infection via the skin, while BYCHOVSKY (1933) and IZYUMOVA (1956), with regard to the frequent establishment of

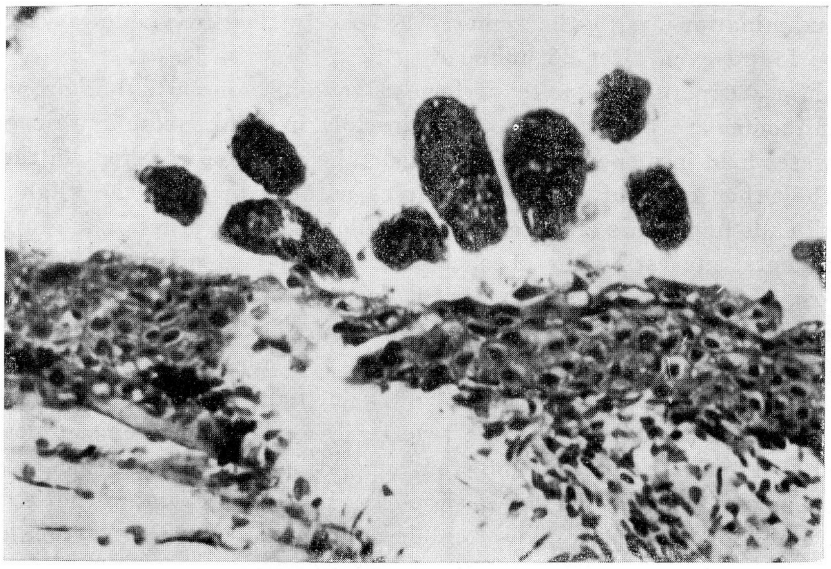

Fig. 3. Dactylogyrus lamellatus larvae settled on the skin at the base of the dorsal fin. (Microphotograph of histological section stained with haematoxylin and eosin.)

larvae in the oral cavity, to that of passive larval infection. As to *Ancylodiscoides vistulensis*, both SIWAK (1932) and MOLNÁR (1968) interpreted the presence of many larvae on the skin as suggestive of an active larval infestation.

Infection by *D. lamellatus* can probably take place in all three ways, but passive infection seems to be most frequent with this particular trematode. Infected grasscarp fry carry considerably fewer larvae on their skin than sheatfish infected with *A. vistulensis*. Autoinfection by larvae hatched from the *D. lamellatus* eggs caught between the gills seems highly probable, as the flagella carried by such eggs on both poles can easily become entangled between the gill lamellae and many of them become fixed to the gills when already embryonated.

The larvae hatched from the eggs move vigorously in the water for some time and do not approach small fishes placed nearby until a few hours after hatching.

The establishment of larvae can be easily followed up if they infect the host via the skin (Fig. 3). Settled larvae soon loose their cilia and move on the host's skin in a span worm-like fashion. Those gaining access to the gill cavity settle not only on the lamellae, but also on the arches and the internal surface of the operculum, and they may remain viable for a long time without showing any indication of further development. Some of the settled larvae are brushed off by powerful movements of the gills and larvae which invade a resistant host may also fall off. Such fallen-off, de-ciliated larvae usually deteriorate under natural conditions, though they may survive for two to four days if the water temperature is below 20 °C and may re-invade the host if the conditions are optimal. This was proved experimentally by successful infection of susceptible fishes placed in a small amount of water together with many young *D. lamellatus* stages.

Correlation between the age of the grasscarp fry and the establishment and further development of D. lamellatus larvae

It is known that each dactylogyrus species affects the carp at a different critical age; MALEVICKAJA (1952) and PROST (1963) give this as above 8 days for *D. anchoratus* and IZYUMOVA (1956) as above 10 days for *D. vastator*, although PAPERNA (1963b) observed that fry were most susceptible to the latter after 4 days. MOLNÁR (1968) found that fry of the sheatfish carried *A. vistulensis* larvae as early as at 2 days of age. IZYUMOVA and PAPERNA note that the larvae sometimes prefer to settle on the gill arches and pharyngeal epithelium rather than on the gill lamellae, particularly in the initial stage of infection.

IZYUMOVA attributes the frequent failure of infection of very young fishes to the not fully differentiated state of the gill apparatus, and believes that gill differentiation is related to age rather than to body dimensions. She failed to infect 8—9 mm long fishes aged 8—10 days, but succeeded in infecting retarded 1.5-month-old fishes of the same length. PAPERNA disagreed with IZYUMOVA on this point, reporting successful infection of four to six days old fry (i.e. fry with yolk sac and undifferentiated gills) with *D. vastator* larvae. PAPERNA thought that the failure of the larvae to settle on the gills of fry with yolk sac is due to small size rather than to inadequate differentiation of the gills, which causes the parasite to prefer the surrounding tissues.

Since the susceptible age for *D. lamellatus* infection had not been previously observed, I attempted to determine it in several experiments. Freshly hatched grasscarps were placed in small mesh-covered floating boxes and put

Table IV.

Susceptibility of grasscarp fry to *Dactylogyrus lamellatus*

A						B		
Water temperature: 24—26 °C						Water temperature:		
Date of hatching: 17. 6. 1970						Date of hatching:		
Start of experiment: 17. 6. 1970						Start of experiment:		
Killed daily: 4 fishes						Killed daily:		
Date of extermination	Length of host mm	No. of infected fishes	No. of parasites			Date of extermination	Length of host mm	No. of infected fishes
			Adult	Developing	Larval			
18.6	7	—	—	—	—	29.6	6.5	—
19.6	7	—	—	—	—	30.6	7	—
20.6	7	—	—	—	—	1.7	7	—
21.6	7	—	—	—	—	2.7	7	—
22.6	7 —8	1	—	—	2	3.7	7	—
23.6	7.5—8	4	—	1—2	3—8	4.7	7—8	1
24.6	7.5—8	4	—	2	4—6	5.7	7.5—9	4
25.6	7 —8	2	1	1	—	6.7	8 — 9	3
26.6	8.5—9	4	1—3	4—8	2—3	7.7	8 —10	3
						8.7	7.5— 8	1
						9.7	7.5— 9	1
						10.7	7.5—10	2
						11.7	8 —11	4
						12.7	8 —10	3
						13.7	10 —11	3
						14.7	11 —13	4
						15.7	9 —13	4
						16.7	12 —16	3
						17.7	12 —16	4
						18.7	11 —17	4

nito an aquarium together with donors infested to a medium degree with *D. lamellatus*. The course of infection was followed up by exterminating four recipients every day. The fry was fed with plankton during the experiment. Three experimental groups, A, B and C, were established. The fry belonging to groups A and B was maintained at optimal temperature and fed well, while those of group C were kept at a temperature below optimal and fed slightly below the requirement, to produce a retarded population in respect of length, profile index and state of nutrition.

Development of D. lamellatus on the gills of the grasscarp

MUSSELIUS and PTASHUK (1970) have reported that the chitinous organs of *D. lamellatus* attain their final shape and size 7—8 days after infection at a temperature of 14—18 °C, but they give no information about the time of the formation of the first egg. According to IZYUMOVA (1956) and PROST (1963), the completion of the chitinous organs does not necessarily coincide with sexual maturation; the former author reports that *D. vastator* starts to produce eggs only after its chitinous organs have fully developed,

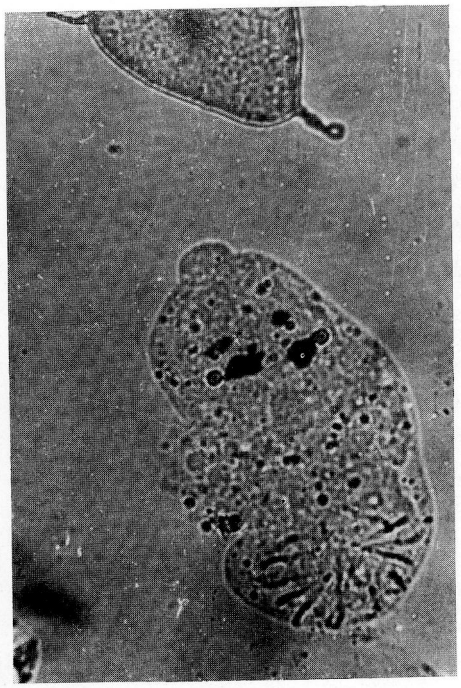

Fig. 4. Stage I parasite

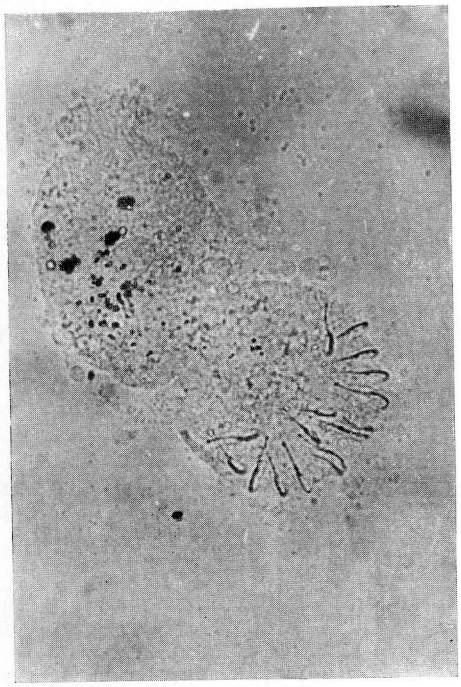

Fig. 5. Stage II parasite

the latter that in *D. anchoratus* the same organs continue to grow in size for some time after the beginning of egg production. As the rate of development of *D. lamellatus* depends largely on the environmental temperature, it can not be simply characterized by days and so I have defined eight main stages of its life cycle to obtain a basis for comparison.

Stage I is represented by just settled larval parasites devoid of cilia but with larval chitinous structures present (Fig. 4);

Stage II is represented by parasites already showing the comma-shaped point of the anchors between the marginal hooks (Fig. 5);

Stage III is represented by parasites showing the point and stalk of the anchors together, like a U-shaped structure (Fig. 6);

Stage IV is represented by parasites distinctly revealing the basal part of the anchors and the principal connecting bar (Fig. 7);

Stage V is represented by parasites which have already acquired inner and outer root, anchoral appendages and chitinous copulatory tube, and which may show a distinct indication of the auxiliary connecting bar (Fig. 8);

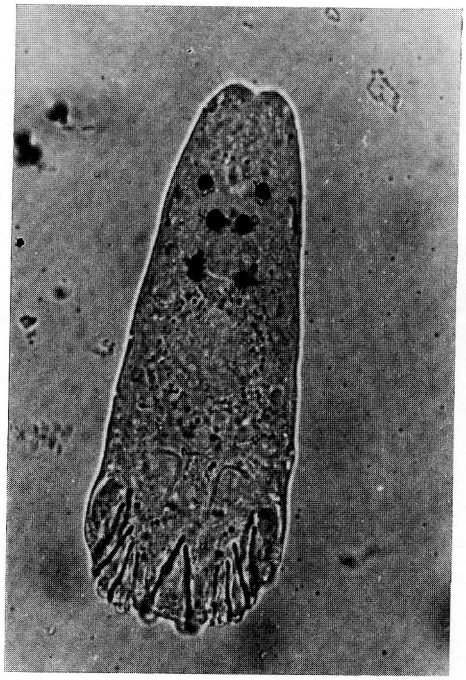

Fig. 6. Stage III parasite

Stage VI is represented by parasites revealing all chitinous organs in final form but not yet final size; the supporting structure of the copulatory complex, the chitinous vagina and auxiliary connecting bar develop at this stage (Fig. 9);

Stage VII is represented by parasites whose chitinous organs have attained full size and whose gonads and eggs can be recognized in the parenchyma. The highly developed yolk glands impart a whitish colour to the body (Fig. 10);

Stage VIII is represented by the fully developed, egg-producing adult (Fig. 11).

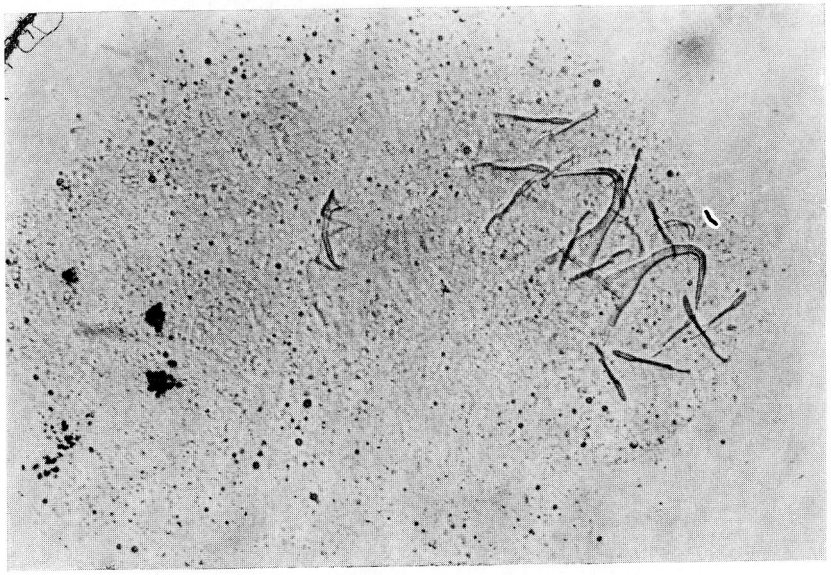

Fig. 8. Stage V parasite

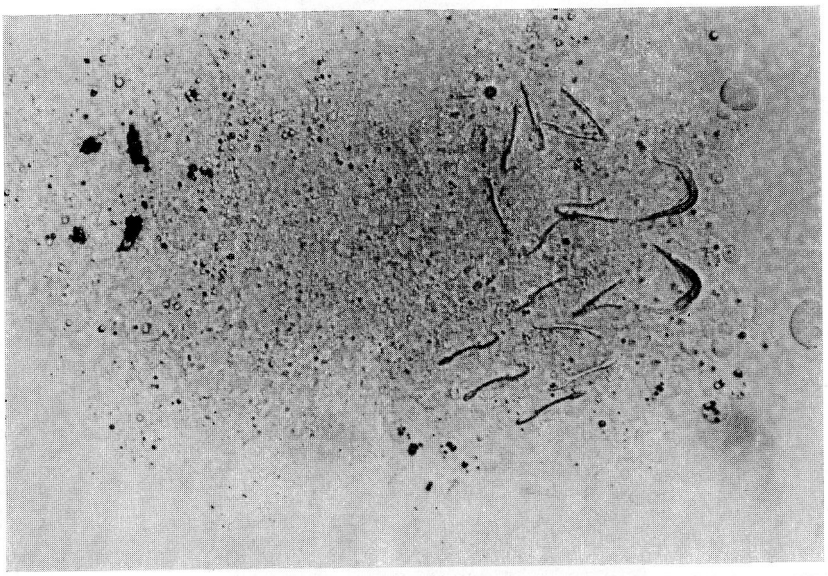

Fig. 7. Stage IV parasite

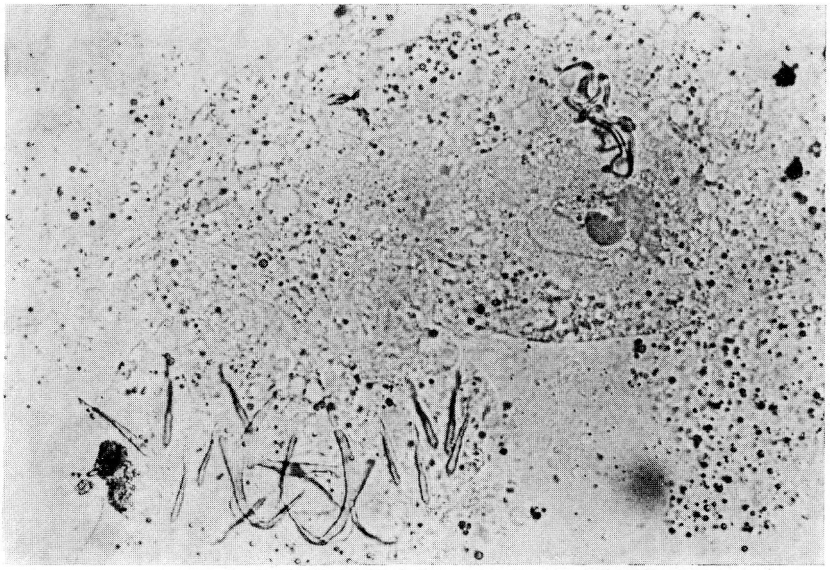

Fig. 9. Stage VI parasite

Fig. 10. Stage VII parasite

The characteristic measurements of the various stages and the sequence of appearance of the organs can be seen from Table V.

The time of sexual maturation depends on the temperature of the water: *D. lamellatus* develops much more slowly at a low than at a high temperature; in these experiments, egg production (stage VIII) began 8, 6 and 4 days after infection at temperatures of 17—19, 20—24 and 22—26 °C, respectively (Table VI).

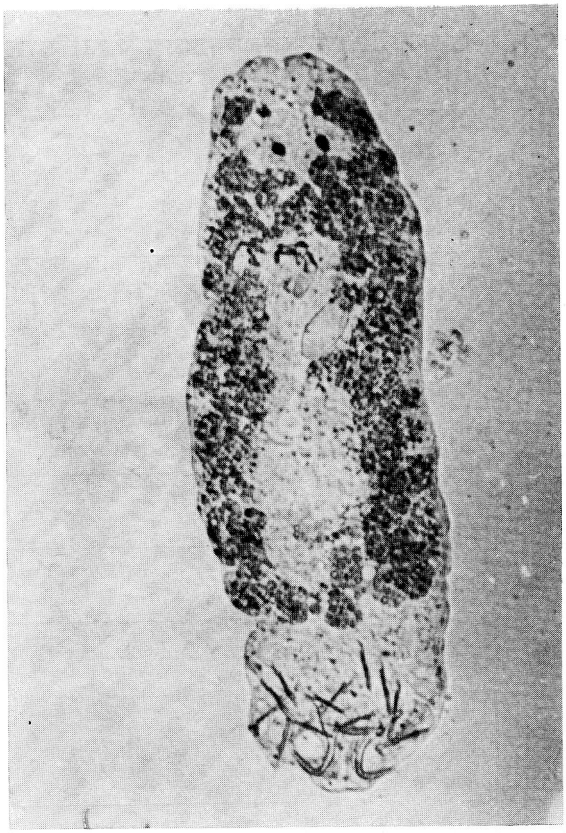

Fig. 11. Adult Dactylogyrus lamellatus carrying mature eggs in the ootype

The development of the parasite has not been observed at temperatures lower than those shown in the Table, but experiments performed for other purposes suggest that at 4—7 °C *D. lamellatus* practically ceases to develop and its different stages remain stagnant for prolonged periods.

In *D. lamellatus* the production of the first egg is always preceded by full development of the chitinous structures; stage VI parasites show the latter in almost final form, while they are still not fully grown and their eggs and yolk glands are scarcely seen.

Table V

Stage of development	Body dimensions (μ)	Length of marginal hooks (μ)	Anchors sequence of appearance and size of parts							Copulatory complex		Vagina	Glands	Egg
			Length (μ)	Point	Stalk	Root	Append. of anchor	Principal connecting bar width (μ)	Auxiliary connecting bar width (μ)	Supporting part	Copul. tube			
I	110—125 × 25— 30	17—19	—	—	—	—	—	—	—	—	—	—	—	—
II	110—150 × 30— 40	17—19	17—20	+	—	—	—	—	-	-	-	-	-	-
III	110—150 × 40— 44	18—22	17—21	+	+	—	—	—	—	—	—	—	—	—
IV	125—160 × 44— 53	22—24	26—28	+	+	—	—	24—25	—	—	—	—	—	—
V	150—180 × 48— 56	22—25	30—38	+	+	+	+	25—26	—+	—	+	—	—	—
VI	130—200 × 50—58	22—28	36—38	+	+	+	+	26—27	19	+	+	+	±	—
VII	260—280 × 70— 75	24—32	36—39	+	+	+	+	27—29	22—24	+	+	+	+	—
VIII	260—400 × 70—120	24—32	36—39	+	+	+	+	27—29	22—24	+	+	+	+	+

Table VI

Rate of development and day of appearance of the developmental stages of *D. lamellatus* at different temperatures

Days after infection	Stages of development		
	22—26 °C	20—24 °C	17—19 °C
1	III	II III	I
2	IV V	III IV	II
3	V VI	IV V	II III
4	VII VIII	V VI	III IV V
5		VI	V
6		VII VIII	V VI
7			VI VII
8			VII VIII

The fishes were exposed to infection for 24 hours. The first fishes were exterminated 24 hours after infection.

Table VII

Dimensions of the chitinous organs of *D. lamellatus* (μ)

	Dimensions according to		
	Achmerow (1952) μ	Gouseff (1962) μ	Molnár μ
Body dimensions of the adult	480×110	480×100	70—160
Anchors			260—580×
total length	38—41	35—41	36— 39
basal part	25—27	—	29— 30
inner root	12—13	—	11— 13
outer root	4	—	4
point	15—18	—	18—22
width of principal connecting bar	30	28—30	27—29
length of principal connecting bar	4	4	4
width of auxiliary connecting bar	19	21	22—24
length of auxuliary connecting bar	1	1— 2	1
Marginal hooks			
length	20—33	21—31	24—32
Copulatory complex			
total length	50	50	40—46
length of copulatory tube	35	25	22—24
Vagina total length	—	16	16—18
Appendage of anchor, length by width	8×2	9×3	8—10×4

The body dimensions of the adult still increase after the first oviposition; egg-producing parasites may double their size from 260 by 70 μ in a few days. The final size of *D. lamellatus* depends on the dimensions of its host (probably on that of the latter's gills). Thus fingerlings less than 10 cm long harbour parasites up to a maximum size of 400 by 120 μ, while fishes more than 30 cm long sometimes carry *D. lamellatus* individuals as large as 580 by 160 μ.

The adult D. lamellatus

The measurements of the body and certain organs of adult *D. lamellatus* as determined by AKHMEROV (1952), GOUSEFF (1962) and myself are shown in Table VII.

Host specificity of D. lamellatus

This was studied in great detail by MUSSELIUS and PTASHUK (1970) These workers characterized *D. lamellatus* as strictly host specific, because its larve did not settle in the fry of the common carp, silver carp or bighead. Mature *D. lamellatus* stages, on the other hand, can live for a long time on the gills of the silver carp and bighead when transferred experimentally.

I examined only the host specificity of larval stages and the results were in good agreement with those of MUSSELIUS and PTASHUK. Disease-free fry of grasscarp, common carp, silver carp, bighead and a hybrid (♀ carp × ♂ grasscarp) were placed in water containing *D. lamellatus* larvae. When the fry were examined ten days later only those of the grasscarp were infected; the larval parasite did not invade other hosts even if no grasscarp fry were present. Interestingly, the carp × grasscarp crosses did not become infected either, which implies that the host specificity of *D. lamellatus* is stronger than the genetic stability of the grasscarp. As the issue of the cross ♀ grasscarp × ♂ carp proved unviable no similar experiment could be performed on them, although the results might have been of interest, because certain carp × grasscarp crosses anatomically more closely related to the former have readily contracted infection with *D. vastator* and *D. extensus*.

Life span of D. lamellatus

Here I can give only rough estimates, because a precise determination is only possible if reinfection is prevented, and this would have required continuous exchange of aquarium water. But frequent exchange of water seems to damage the parasites, which then fall off the gills in increasing numbers. The practical experience that the parasites occur also during the winter, when reinfection is impossible, suggests that *D. lamellatus* can remain

alive for several months and that the massive reinfection occurring during the spring is brought about not so much by eggs which survive the winter, as by the activity of those dactylogyrus stages which have maintained their viability.

Localization of the parasite on the gills

Sexually mature trematodes and developmental stages select the same localizations on the gill; in older fishes they lie in practically all parts of this organ, but in younger ones they prefer the terminal areas.

The relationship between D. lamellatus and other parasites of the grasscarp

The greatest problem in our experiments was always presented by the elimination of the other parasites of the grasscarp, above all protozoa affecting the fry. The latter could not be eliminated with certainty, as they occurred in the water of the hatching ponds and could not be sure of their complete eradication from the donors either. Various *Trichodina* species, *Chilodonella cyprini*, *Ichthyophthirius multifiliis* and *Cryptobia branchialis* were the most frequently encountered and occasionally a *Spironucleus* sp. occurred in large numbers in the intestine. The presence of the latter parasite did not seem to have any bearing on *D. lamellatus* infection, but the other protozoa were often responsible for death of the fishes during the experiment. Nor could any evaluation be made in those cases in which the infestation by them was very massive. Such experiments, though inconclusive to their

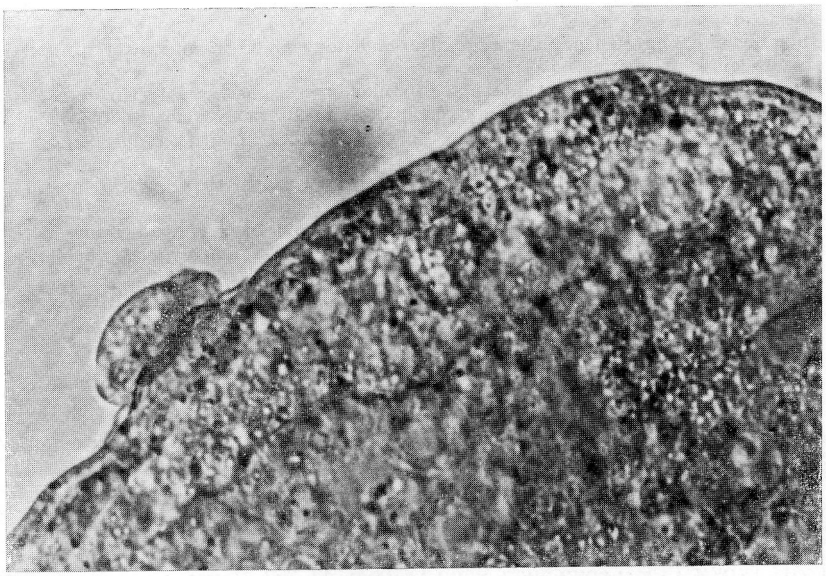

Fig. 12. Trichodina sp. on the body surface of an adult *Dactylogyrus lamellatus*

original purpose, permitted conclusions on the synergism or antagonism between *D. lamellatus* and other parasites of the grasscarp.

D. lamellatus and *I. multifiliis* do not interfere with one another in one and the same host and each seems to promote the development of the other by decreasing the resistance of the fish. They have different sites of preference; *D. lamellatus* settling on the surface of the gill epithelium, *I. multifiliis* below the surface. Death from such a mixed infection has been observed under natural conditions.

Trichodina, *Chilodonella* and *Cryptobia* species usually parasitize the grasscarp fry simultaneously and are often present in fishes with dactylogyrosis. With a low intensity of infestation, the protozoa or the trematode variably predominate the parasite fauna of fishes from one and the same pond. The prevalence of protozoa prevents the establishment of massive dactylogyrosis, to judge from observations in aquarium and pond experiments.

The antagonism between protozoan gill parasites and trematodes probably stems from the continuous irritation exerted by the motile protozoa on gill tissue and dactylogyrus stages alike, causing the latter to change their place frequently until they fall off the gills (Fig. 12). This antagonistic effect affects primarily the young larvae, which have weak prehensile organs.

SUMMARY

The development and biological properties of *Dactylogyrus lamellatus* Akhmerow, 1952 have been studied with the following results:

Oviposition rate is highest at 28 °C (on average 15 eggs per 24 hours), but the trematode is still able to deposit eggs at 12 °C.

Oncomiracidia hatch from the eggs after 1.5 days at 26 °C and after longer times at temperatures below or above that level.

The infestation of the host takes place primarily in a passive way through the mouth, but some larvae settling on the skin may reach the gills by active movement.

Grasscarp fry with a yolk sac become susceptible to *D. lamellatus larvae* at 5—6 days of age.

Larval parasites settling on the gills reach sexual maturity after 8, 6 and 4 days at temperatures of 17—19, 22—24 and 22—26 °C, respectively.

Egg production starts only after the chitinous organs have fully developed.

D. lamellatus is a specific parasite of the grasscarp *(Ctenopharyngodon idella)* and can not be transferred experimentally to other hosts.

D. lamellatus and certain protozoan parasites of the grasscarp may mutually antagonize each other's development.

REFERENCES

Antalfi, A. and Tölg, I.: Növényevő halak. Budapest, 1968. Ахмеров, А. Х.: Рыбное хозяйство **1** (1955), 1. Ахмеров, А. Х.: Паразитол. сб. Зоол. ин.-та АН СССР **14** (1952), 181—212. Ахмеров, А. Х.: Сборн. пробл. рыбхоз. использован. растительноядных рыб в водоемах СССР. Ашхабад, 1963, 161—166. Агапова, А. И. and Ахметова, Б.: Болезни рыб и меры борьбы с ними. Алма-Ата, 1966. Алигаджиев, А. Д.: 5-ое. Всес. Совещ. по болезням и паразитам рыб и водных беспозвоночных. Ленинград, 1968. Бабаев, Б.: Изв. АН Туркм. ССР. Серия биол. наук **1** (1964), 47—52. Бауер, О. Н.: Изв. Госниорх. **49** (1959), 1—16. Бауер, О. Н.: Тр. Ленингр. общ. естествоисп. **72** (1954), 9—15. Бауер, О. Н.

and Стрелков, Ю. А.: Проблемы рыбохозяйственного использования растительноядных рыб в водоемах СССР. Ашхабад, 1963. 150—153. Быховский, Б. Е.: Тр. Ленингр. общ. естествоисп. **62** (1933), 269—296. **Gröben, G.: Zeitschr. Parasitenk. 2** (1940), 611—636. Гусев, А. В.: In: Быховский, Б. Е. et al.: Определитель паразитов пресноводных рыб ССС. Ленинград, 1962. Изюмова, Н. А.: Биология **Dactylogyrus vastator Nybelin, D. solidus** Achmerow в карповых хозяйствах. Автореф. дисс., 1953. **Idem:** Паразитол. сб. Зоол. Инст АН СССР **16** (1956), 229—243. **Idem:** Ibidem **18** (1958), 295—303. **Idem:** Ibidem **24** (1969), 128—133. Кулаковская, О. П. and Ивасик, В. М.: Паразитология **1** (1967), 325—328. Ляйман, Э. М.: Сб., посв. К. И. Скрябину. 1946. 171—174. Ляйман, Э. М.: Моск. техн. инст. рыбн. пром. и хоз. им. Микояна **4** (1951), 197—204. Малевицкая, М. А.: Тр. Инст. пруд. и оз.-речн. рыбн. хоз. УССР **8** (1952), 117—126. **Matheis, Th.: Deutsche Fisch. Zeitung 14** (1967), 151—153. **Molnár, K.: Halászat, 1966.** 156—157. **Idem: Z. Fischerei NF. 16** (1968), 31—41. Мусселиус, В. А.: Болезни рыб и меры борьбы с ними. Алма-Ата, 1966. 99—105. **Idem:** 5. Всес. сов. по болезням и паразитам рыб и водных беспозвоночных. Ленинград, 1968a. 86—87. **Idem:** Паразитология **2** (1968б), 227—231. **Idem:** Ibidem **3** (1969), 236—243. Мусселиус, В. А. and Пташук, С. В.: Паразитол. сб. Зоол. инст. АН СССР **24** (1969), 192—196. **Idem:** Паразитология **4** (1970), 125—132. **Nybelin, O.: Särtyck u Skrifter utgivna av Södra Sveriges Fiskeriförening, 1925, 42—72. Paperna, I.: Bamidgeh. 15 (1963a),** 8—28. **Idem: Bamidgeh. 15** (1963b), 31—50. **Prost, M.: Acta parasit. polon. 11** (1963), 17—47. **Radulescu, J. and Georgescu, R.: Bull. I. C. P. R. 21** (1962), 85—91. **Siwak, J.: Bull. Acad. Pol. Sci. L. Cracove, Cl. Sci. Math.-Nat., Ser. B. 2** (1932), 669—679. Соин, С. Г.: Сб. пробл. рыбхоз. использован. растительноядных рыб в водоемах СССР. Ашхабад, 1963, 100—137. **Szakolczai, J. and Molnár, K.: Magyar Állatorvosok Lapja** 1964, 146—150. **Wunder, W.: Z. Fischerei 27** (1929), 511—541.

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