EXPERIMENTAL VERIFICATION OF THE EFFECT OF CONSTANT AND CHANGING WATER TEMPERATURE ON THE MICROPOPULATION GROWTH IN GYRODACTYLUS GOBIENSIS GLÄSER, 1974 (MONOGENEA) PARASITIZING GUDGEON (GOBIO GOBIO L.)

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Abstract. It has been verified under laboratory conditions that constant and changing water temperature markedly affects the micropopulation growth in *Gyrodactylus gobiensis* parasitic on the body surface of gudgeons (*Gobio gobio* L.). At a water temperature of 12 °C, the number of gyrodactylids gradually increased up to the mean value of 63 specimens per host, which was reached on days 27–28 after experimental infection. At a constant temperature of 18 °C, the parasites completely disappeared from the bodies of infected fishes on days 15–20 p.i. A similar effect was produced by gradually increasing temperature from 12 to 18 °C, while the decrease in water temperature from 18 to 12 °C resulted in an increase in the parasite number.

This study is a continuation of a series of experiments verifying the effect of environmental factors on the life cycles of viviparous monogeneans of the genus *Gyrodactylus* Nordmann, 1832. Whereas our previous papers (Gelnar 1987 a, b, 1990) dealt with the effect of a constant water temperature on the micropopulation**) growth in gyrodactylids, in the present one we have studied additionally the effect of changing water temperature on the reproduction intensity of *Gyrodactylus gobiensis* Gläser, 1974 parasitizing the fins and body surface of gudgeons (*Gobio gobio* L.)

MATERIALS AND METHODS

The experiments were performed using *Gyrodactylus gobiensis* Gläser, 1974 as a model species. The parasites were obtained from the fish host *Gobio gobio* L. caught in the river Malše near České Budějovice, South Bohemia, Czechoslovakia, in autumn 1984. They were maintained in the laboratory on fishes of the same species measuring 8.5–10.5 cm. The fish were maintained each other. The mode of fish breeding and preparation for the experiment, as well as the method of parasite transfer and observation, were described in previous papers (Gelnar 1987a, b) in which also the device enabling the imitation of water regimens is described. The effect of water temperature on this model species of parasites was verified in four experimental variants: 1) constant temperature of 12 °C, 2) constant temperature of 18 °C, 3) temperature increasing from 12 to 18 °C, and 4) temperature decreasing from 18 to 12 °C. The speed of temperature changes never exceeded one degree per day

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** Terminology after Beklemishev (1959).

RESULTS

Effect of constant water temperature of 12 °C. The effect of constant water temperature of 12 °C was tested on six experimental micropopulations maintained on the fins and body surface of infected fishes. Exact data on the increase in gyrodactylid numbers on individual fishes are given in Table 1; the graphic illustration of the course of the mean parasite burden is shown in Fig. 1. At the beginning of the experiment 2, 2, 2, 2, 2, and 3 parasites were transferred to the fishes. The parasites originated from an experimental micropopulation of *G. gobiensis* kept at a constant temperature in the laboratory of the Institute of Parasitology, Czechoslovak Academy of Sciences. The numbers of gyrodactylids in individual experimental micropopulations slowly increased even from the first day after transfer. On day 5, there were 5 parasites per fish host (p/h) on the average, and on day 10, 9 p/h. Then the gradual increase continued, being 16 p/h on day 15, 30 p/h on day 20, and 56 p/h on day 25. The maximum mean value (63 p/h) was reached on days 27 and 28. Then the numbers of gyrodactylids started to decrease to 55 p/h on day 30 and 41 p/h on day 32, when the experiment was terminated. Some of the parasites found on the body surface of experimental fishes were used for further experiments and others were fixed in ammonium picrate for further examination (Ergens and Lom 1970).

Effect of constant water temperature of 18 °C. The effect of this temperature regimen was experimentally verified on six parasite micropopulations maintained on experi-

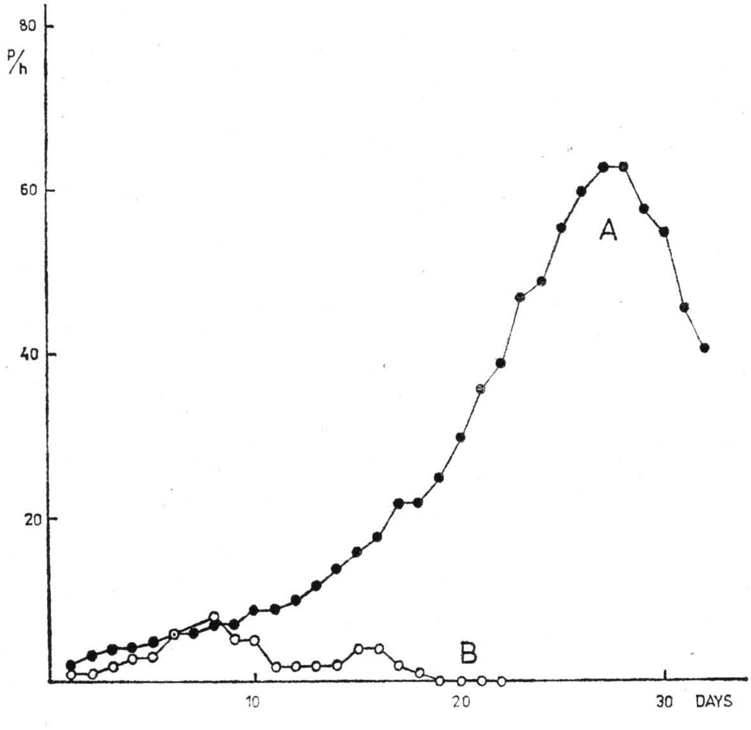


Fig. 1. Comparison of the mean number of parasites in 6 experimental micropopulations of *G. gobiensis*, Gläser, 1974 parasitizing *Gobio gobio* (L.) at constant water temperature of 12 °C (A) and in 6 experimental micropopulations of the parasite species at 18 °C (B). (x — time in days, y — number of parasites in a fish host.)

mental fishes. The data concerning the increase in the parasite numbers on individual fishes are given in Table 2. The graphic illustration of the mean parasite burden is shown in Fig. 1. At the beginning of this experiment, one parasite was transferred to a fin of each fish. As in the previous experiment, the number of parasites slightly increased. The mean parasite burden reached the value of 3 p/h on day 5 and the maximum value (8 p/h) was obtained on day 8 after the beginning of experimental infection. On day 10, the mean parasite burden was only 5 p/h and during the following five days the parasite burden gradually was reduced so that on day 15 they were present on only one fish (4 p/h). However, even in this case the parasites disappeared during the next three days. On day 19, no gyrodactylids were found even on this host. The experiment was therefore terminated on day 21, the fishes were killed and their detailed examination confirmed the absence of parasites on the surface of their bodies.

Effect of increasing water temperature from 12 to 18 °C. The exact course of the water temperature changes during the experiment is shown in Fig. 2. The effect of this water regimen was verified on three experimental micropopulations maintained

Table 1. *G. gobiensis* Gläser, 1974 reproduction in six experimental micropopulations maintained on *Gobio gobio* (L.) at a constant water temperature of 12 °C

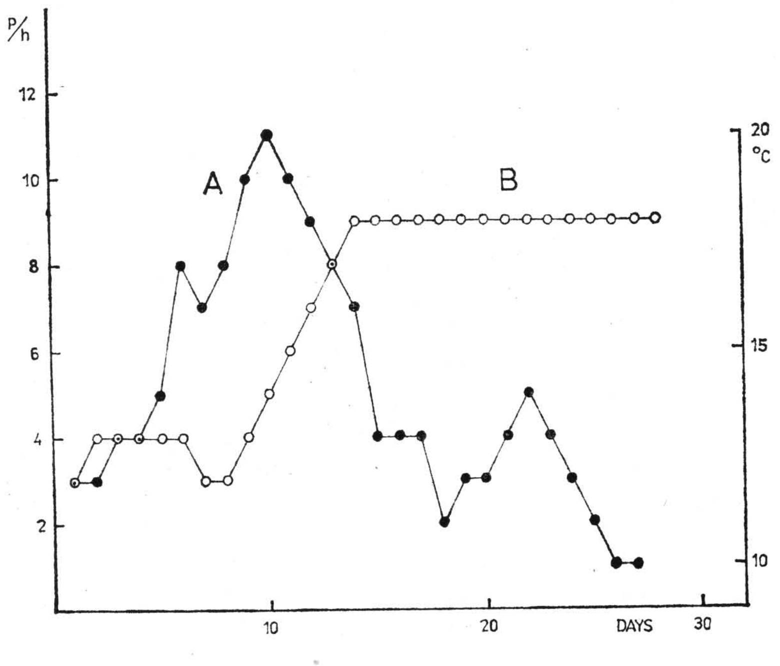
b \ a	1.	2.	3.	4.	5.	6.	m. p. b.
1.	2	2	2	2	2	3	2
2.	3	2	3	2	3	3	3
3.	3	4	4	4	4	3	4
4.	4	4	5	5	4	4	4
5.	3	5	4	5	5	8	5
6.	7	—	5	6	4	7	6
7.	6	6	4	6	5	8	6
8.	6	6	5	7	6	10	7
9.	5	—	6	6	6	10	7
10.	8	11	8	7	7	11	9
11.	8	11	9	7	6	10	9
12.	10	12	11	9	7	12	10
13.	13	13	8	12	10	17	12
14.	13	18	11	12	11	20	14
15.	18	17	12	14	12	24	16
16.	18	22	12	16	14	27	18
17.	21	25	17	20	15	31	22
18.	21	31	16	19	17	30	22
19.	30	39	16	22	20	—	25
20.	32	48	17	25	22	37	30
21.	37	56	19	29	31	46	36
22.	45	60	22	36	32	—	39
23.	50	68	25	42	39	58	47
24.	55	—	29	56	47	60	49
25.	63	68	29	60	58	55	56
26.	68	68	36	65	63	59	60
27.	81	56	38	79	72	52	63
28.	62	x	32	80	79	63	63
29.	x	—	36	80	60	57	58
30.	—	—	40	72	52	x	55
31.	—	—	45	50	36	—	46
32.	—	—	39	42	41	—	44

a ... number of experimental micropopulations, b ... days, — ... parasites were not counted on that day, x ... observations were terminated, m. p. b. ... mean parasite burden.

Table 2. *G. gobiensis* Gläser, 1974 reproduction in six experimental micropopulations maintained on *Gobio gobio* (L.) at a constant water temperature of 18 °C

b \ a	1.	2.	3.	4.	5.	6.	m. p. b.
1.	1	1	1	1	1	1	1
2.	1	1	1	1	1	2	1
3.	2	3	1	1	1	3	2
4.	1	2	1	3	1	6	3
5.	3	2	2	2	3	5	3
6.	3	7	9	2	2	10	6
7.	—	—	—	—	—	—	—
8.	1	6	6	13	6	12	8
9.	2	7	4	2	4	12	5
10.	1	9	2	2	3	9	5
11.	1	3	1	1	1	5	2
12.	2	4	1	1	1	4	2
13.	2	4	0	1	1	1	2
14.	0	5	0	1	1	1	2
15.	0	4	0	0	0	0	4+
16.	0	4	×	0	0	0	4+
17.	×	2	—	×	0	0	2+
18.	—	1	—	—	×	×	1+
19.	—	0	—	—	—	—	0
20.	—	0	—	—	—	—	0
21.	—	0	—	—	—	—	0
22.	—	×	—	—	—	—	

a ... number of experimental micropopulations, b ... days, — ... parasites were not counted on that day, × ... observations were terminated, m. p. b. ... mean parasite burden, + ... values obtained from micropopulation No. 2.



on the fins and body surface of infected fish hosts. The exact data concerning the increase in parasite numbers in individual micropopulations are given in Table 3 and the graphic illustration is shown in Fig. 2. At the beginning of the experiment, 2, 3, and 3 parasites were transferred to each of three fish. The parasites originated from an experimental micropopulation kept at a constant water temperature of 12 °C. On the first days of the experiment the number of parasite slowly increased so that the mean parasite burden was 8 p/h on day 6. The gradual warming of water started on day 9 and the maximum parasite burden (11 p/h) was reached on day 10, then their numbers decreased. On day 14, when the water temperature was 18 °C, the mean parasite burden was only 7 p/h. On day 28, no parasites could be found on the fish and after repeated negative examinations the experiment was terminated on day 30. As in the previous case, not even a detailed examination of dead fish revealed the presence of parasites.

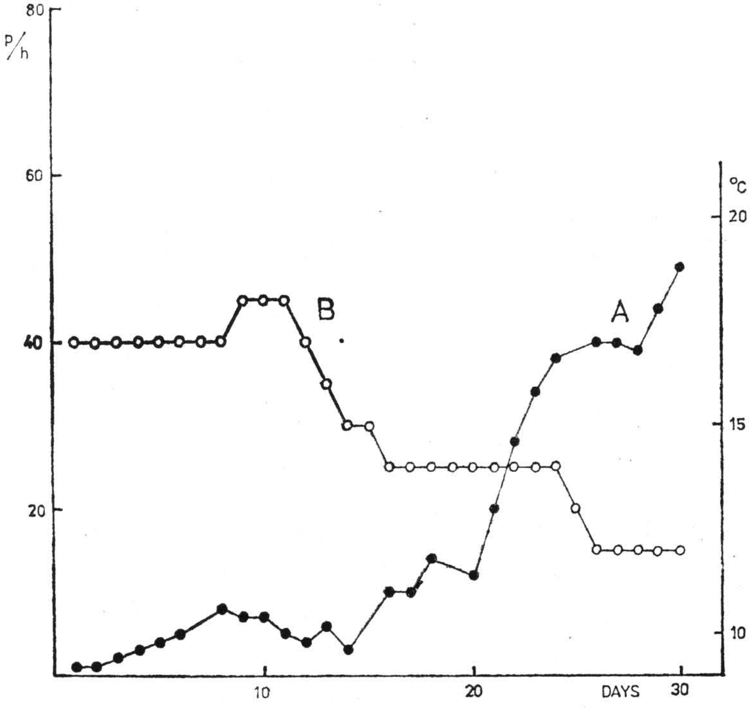


Fig. 3. The mean number of parasites in 3 experimental micropopulations (A) of *G. gobiensis* Gläser, 1974 parasitizing *Gobio gobio* (L.) at changing water temperature from 18 °C to 12 °C (B). (x — time in days, y (left side) — number of parasites in a fish host, y (right side) — water temperature in °C).

Effect of decreasing water temperature from 18 to 12 °C. The exact course of the water temperature changes is illustrated in Fig. 3. Detailed data concerning the increase in parasite numbers in individual experimental micropopulations are shown

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◀ **Fig. 2.** The mean number of parasites in 3 experimental micropopulations (A) of *G. gobiensis* Gläser, 1974 parasitizing *Gobio gobio* (L.) at changing water temperature from 12 °C to 18 °C (B). (x — time in days, y (left side) — number of parasites in a fish host, y (right side) — water temperature in °C).

in Table 4. As in the previous experiment, the effect of the temperature regimen was verified on three experimental micropopulations. Only one parasite was transferred to a fin of each experimental fish. In spite of the rather high water temperature (17 °C), after an initial stagnation the number of parasites slowly increased (see Fig. 3), so that the mean parasite burden was 4 p/h on day 5 and 8 p/h on day 8. However, another increase in the water temperature by 1 °C to 18 °C resulted in the cessation

Table 3. *G. gobiensis* Gläser, 1974 reproduction in three experimental micropopulations maintained on *Gobio gobio* (L.) at water temperatures increased from 12 to 18 °C

b \ a	°C	1.	2.	3.	n. p. b.
1.	12	2	3	3	3
2.	13	3	3	3	3
3.	13	4	4	4	4
4.	13	3	5	3	4
5.	13	4	4	5	5
6.	13	7	9	8	8
7.	12	5	9	8	7
8.	12	6	10	7	8
9.	13	9	13	9	10
10.	14	10	13	10	11
11.	15	10	11	9	10
12.	16	9	9	9	9
13.	17	—	—	—	—
14.	18	7	7	—	7
15.	18	4	2	5	4
16.	18	4	4	4	4
17.	18	3	4	4	4
18.	18	3	3	1	2
19.	18	4	5	2	3
20.	18	2	5	2	3
21.	18	4	4	4	4
22.	18	5	—	5	5
23.	18	5	3	5	4
24.	18	3	3	3	3
25.	18	2	2	1	2
26.	18	1	2	1	1
27.	18	1	1	1	1
28.	18	0	0	0	0
29.	18	0	0	0	0
30.	18	0	0	0	0
31.	18	×	×	×	

a ... number of experimental micropopulations, b ... days, — ... parasites were not counted on that day, × ... observations were terminated, m. p. b. ... mean parasite burden.

of the parasite number increase. In the following days their number decreased, being the lowest (3 p/h) on day 14, i.e. on the third day of gradual cooling of the water temperature. Then the number of parasites increased again and reached the mean parasite burden of 12 p/h on day 20 and 49 p/h on day 30, when the experiment was terminated.

Table 4. *G. gobiensis* Gläser, 1974 reproduction in three experimental micropopulations maintained on *Gobio gobio* (L.) at water temperatures decrease from 18 to 12 °C

Days	Temp. (°C)	Experimental population No			m. p. b.
		1.	2.	3.	
1.	17	1	1	1	1
2.	17	1	1	1	1
3.	17	2	1	2	2
4.	17	3	2	3	3
5.	17	7	2	3	4
6.	17	7	3	5	5
7.	17	—	—	—	—
8.	17	10	6	7	8
9.	18	7	7	7	7
10.	18	8	7	7	7
11.	18	7	2	5	5
12.	17	5	2	4	4
13.	16	7	3	7	6
14.	15	3	2	3	3
15.	15	—	—	—	—
16.	14	10	11	8	10
17.	14	10	9	10	10
18.	14	11	15	13	14
19.	14	—	—	—	—
20.	14	11	13	12	12
21.	14	12	30	19	20
22.	14	27	34	25	28
23.	14	42	29	30	34
24.	14	46	31	30	38
25.	13	—	—	—	—
26.	12	60	27	35	40
27.	12	59	23	40	40
28.	12	55	20	43	39
29.	12	63	25	45	44
30.	12	72	29	46	49
31.		×	×	×	

— ... parasites were not counted on that day, × ... observations were terminated, m. p. b.... mean parasite burden.

DISCUSSION

The results obtained indicate that the temperature of the water environment markedly affected the growth of numbers of *G. gobiensis* in individual experimental micropopulations on the fins and body surface of *Gobio gobio*. At a lower temperature the parasites reproduced more intensively than at a higher temperature, when they completely disappeared from the body surface of their fish host. It should be noted that the temperature dependence of *G. gobiensis* is contrary to that of *G. katharineri* and *G. rutilensis* (Gelnar 1987a, 1990), parasitizing the carp fry and *L. leuciscus*, respectively. These two species reproduced more intensively with increasing water temperature.

A similar temperature dependence was observed also in the size variability of some hard parts of gyrodactylids. For instance, Malmberg (1970), Ergens (1976, 1983) Kulemina (1977): and Ergens and Gelnar (1985), reported that the cooler water environment leads to the enlargement of some structures of the attaching apparatus in gyrodactylids. On the other hand, Ergens (1988) observed quite a contrary dependence of the size of hard parts of opisthaptor in *G. osoblahensis* parasitizing *L. cephalus* and *L. leuciscus*. In this relation, of interest are also the data published by Ergens (1981) and Ogawa (1986), who did not observe any significant changes in the size variability of hard parts of opisthaptor in *G. truttae* and *G. masu*, respectively, in spite of great seasonal changes of the water temperature. These facts show that not even numerous field experiments dealing with the study of seasonal changes in gyrodactylid numbers (e.g., MacKenzie 1970, Rawson and Rogers 1973, Barkamn and James 1979, Hanzelová and Žitňan 1982, Marris 1982, Kamiso and Olson 1986) could provide definitive information about the effect of such a primary ecological factor (in the sense of Monchadsky 1962) as periodically repeating water temperature changes. Only thorough experimental studies carried out under controlled laboratory conditions can provide satisfactory information about the role played by temperature in the course (in the sense of Bykhowsky 1957) of the gyrodactylid life cycles (e.g., Lester and Adams 1974, Harris 1980, Scott and Nokes 1984). Such studies should include the effect produced by temperature simultaneously with those of other environmental factors of both primary and secondary orders.

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ON THE DISSEMINATION OF TWO FAR EAST MONOGENEAN PARASITES (DACTYLOGYRUS ACHMEROVI GUSSEV, 1955 AND GYRODACTYLUS KHERULENSIS ERGENS, 1974, OF CARP (CYPRINUS CARPIO L.) IN CZECHOSLOVAKIA

Monogenean parasites developing without intermediate hosts can be transferred, with their hosts, over long distances and established in new conditions. In the last decade, many species of freshwater monogeneans have been introduced, together with their fish hosts, into new regions where they became acclimatized (Bauer O. N. et al. 1981: Diseases of Pond Fishes. Legkaya i pishchevaya promyshlenost, Moscow, 318 pp., in Russian; Johnson B. O., and Jensen A. J. 1986: J. Fish Biol. 29: 233—241; Dolmen D. 1987: In: Parasites and Diseases in Natural Waters and Aquaculture in Nordic Countries. (A. Stenmark, G. Malmberg (Eds.)), Stockholm, pp. 63—69; Buchmann K., et al. 1987: Dis. aquat. Org. 3: 51—57; Bauer O. N., 1988: International Symposium of Monogenea, 7—13 August 1988, České Budějovice, Czechoslovakia. Abstracts of papers, p. 2; Gelnar M., et al. 1989: 13th Conference of WAAVP, 7—11 August 1989. Berlin, GDR. Abstracts of papers, p. 59).

This study deals with the first finding of two monogenean parasites of carp, *Dactylogyrus achmerovi* Gussev, 1955 (Dactylogyridae) and *Gyrodactylus kherulensis* Ergens, 1974 (Gyrodactylidae), in Czechoslovakia. These two species, originating in the Far East, were found during studies of the parasite fauna of fish living in the Vltava River (Elbe River basin). They were caught near Týn nad Vltavou (about 30 km north-west of České Budějovice, Czechoslovakia) in September 1988. Two of 10 carp (*Cyprinus carpio* L.) examined were found to be infected. One 34 cm long specimen was infected with 13 specimens of *D. achmerovi* on the gills and the other, 29 cm long, had one specimen of *G. kherulensis* on its fins. Examinations of the fish hosts, as well as the collection and fixation of parasites, were carried out by common helminthological methods (Ergens R. and Lom J. 1970: Causative agents of parasitic diseases of fish. Academia Praha, 383 pp., in Czech). Since the descriptions of both parasite species correspond to the data published by other authors, they are not included in the present paper (Gussev A. V. 1985: Key to Parasites of Freshwater Fishes of the USSR, vol. 2. Nauka, Leningrad, 424 pp., in Russian).

Dactylogyrus achmerovi was originally described from the gills of *Cyprinus carpio haematopterus* from the Amur River basin. It was later introduced, together with its host, into many pond fish breeding farms in the European part of the USSR. Here it was found also capable of parasitizing *C. carpio* (Gussev op. cit.). Outside the territory of the USSR, this parasite is known in Europe only from the territory of Hungary (Molnár K. 1976: Parasit. hung. 9: 31—33). This study is the first record of *D. achmerovi* in Czechoslovakia.

According to present knowledge, *Gyrodacty-*