Results of Parasitological Investigations on the Health of *Esox lucius* L. in the Lipno Reservoir

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Abstract. The paper presents the results of parasitological studies on the health of *Esox lucius* in the Lipno reservoir, carried out in the years 1961–1963. The determined parasitofauna was evaluated with regard to the species variety and to the worm load. We were interested mostly in parasites with the highest values in the intensity and extensity of invasion (*Hennegaya lobosa*, *Tetraonchus monenteron*, *Triaenophorus nodulosus*, *Camallanus lacustris*, *Ergasilus sieboldi*). These results may help to elucidate some fundamental ecological dependencies related to the biotic and abiotic factors in the Lipno reservoir.

The Lipno reservoir, (40 km long and 10 km wide) built on the river Vltava in 1958, belongs to the biggest reservoirs in Czechoslovakia. When the water level is highest (726 m above sea level), this reservoir covers an area of 46.5 km², its cubage is 306 million meters, its maximum depth 21.5 m, the average depth 6.5 m. Approximately one forth of the flooded territory is peat-bog; this influences the chemical properties of the water which is soft, slightly acid, brownish, purity grade I–II.

The average annual temperature of the influent Vltava is 8.2 °C. Water is also supplied by some rivulets, the Medvědí potok, Nivský potok and Ježová from the right, the Olšina, Lukavický and Černý potok from the left.

A feature characteristic for the Lipno reservoir is the frequent changing of the water level. After the first filling in 1958, the water level was 720.35 m above sea level in May of that year. In October 1958 the reservoir was let out and slowly refilled in November. In September 1959 the water level was 723.65, becoming slightly lower in the winter months; in September 1960 the water level reached almost its maximum height by 725.61 m above the sea. Since then, the reservoir was not let out, the water level, however, still changes slightly.

The investigation on the state of health of the pike in the Lipno reservoir, carried out in the years 1961–1963, was part of a complex investigation on the yields of

fish in this reservoir. It was found that the pike, an economically important fish, suffers heavy losses partly from parasitic invasions.

The extensity and intensity of invasions of the pike seem frequently conditioned by the extensity and intensity of invasions of other fish species, mainly the perch (*Perca fluviatilis*), living with it in the Lipno reservoir. Our investigations were therefore not only carried out on pikes but also on perches and, for our orientation, on *Lota lota* and *Rutilus rutilus*.

MATERIAL AND METHODS

In post mortem we examined 186 pikes (age 1—4 years), 131 perches (age 1—5), 17 *Lota lota* (age 1—3) and 11 *Rutilus rutilus* (age 1—6). Moreover we examined another 150 perches and 60 pikes only for the presence of the cestode *Triaenophorus nodulosus* to confirm some ecological dependencies.

The fishes caught by various means the whole year round were examined immediately after the catch. Attention was payed mainly to the parasites on the gills and in the intestine because of their great effect on the general health of the host. The specimens are deposited in the collections of the Institute of Parasitology of the Czechoslovak Academy of Sciences in Prague. Our investigations were based on the results of our previous ichthyoparasitological works on the Lipno reservoir in the years 1959—1960.

QUALITATIVE COMPOSITION OF THE PARASITOFAUNA OF *ESOX LUCIUS* IN THE LIPNO RESERVOIR.

During our investigations we found 16 species of parasites in the pikes examined: 3 species of protozoa *Henneguya lobosa* (Cohn, 1895), *Trichodina domerguei f. esocis* Lom, 1960, *Ichthyophthirius multifiliis* Fouquet, 1876; 2 species of monogenetic trematodes—*Tetraonchus monenteron* Diesing, 1858, *Gyrodactylus lucii* Kulakovskaya, 1951; 2 digenetic trematodes—*Azygia lucii* (Müller, 1776), *Diplostomum spathaceum* (Rudolphi, 1819); one cestode—*Triaenophorus nodulosus* (Pallas, 1781); two nematodes—*Raphidascaris acus* (Bloch, 1779), *Camallanus lacustris* (Zoega, 1776); two acanthocephala—*Neoechinorhynchus rutili* (Müller, 1780), *Pseudoechinorhynchus clavula* (Dujardin, 1845); one leech—*Piscicola geometra* (L., 1761); one mollusc—*Anodonta cygnea* L. (larval stage) and two crustaceans—*Ergasilus sieboldi* Nordmann, 1832, *Argulus foliaceus* (L., 1758).

For theoretical and practical reasons it was necessary to determine the original parasitofauna of the pikes from the rivers, which are now flooded, to ascertain which species were acquired in the new living conditions. Although the determination of the original parasitofauna is rather problematic because no exact parasitological examinations of the original fish populations had been carried out in the previous years, we assume that the original parasitofauna of the pike consisted of the

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following species: *Henneguya lobosa*, *Trichodina domerguei f. esocis*, *Tetraonchus monenteron*, *Gyrodactylus lucii*, *Triaenophorus nodulosus*, *Raphidascaris acus*, *Camallanus lacustris*, *Neoechinorhynchus rutili*, *Pseudoechinorhynchus clavula*, *Anodonta cygnea larv.* and *Argulus foliaceus*. All these species may be considered common to the pike, living in rivers with similar living conditions as those in the flooded part of the river, because these species were also found in some of the pikes from tributary streams. The only doubtful species is *Azygia lucii*.

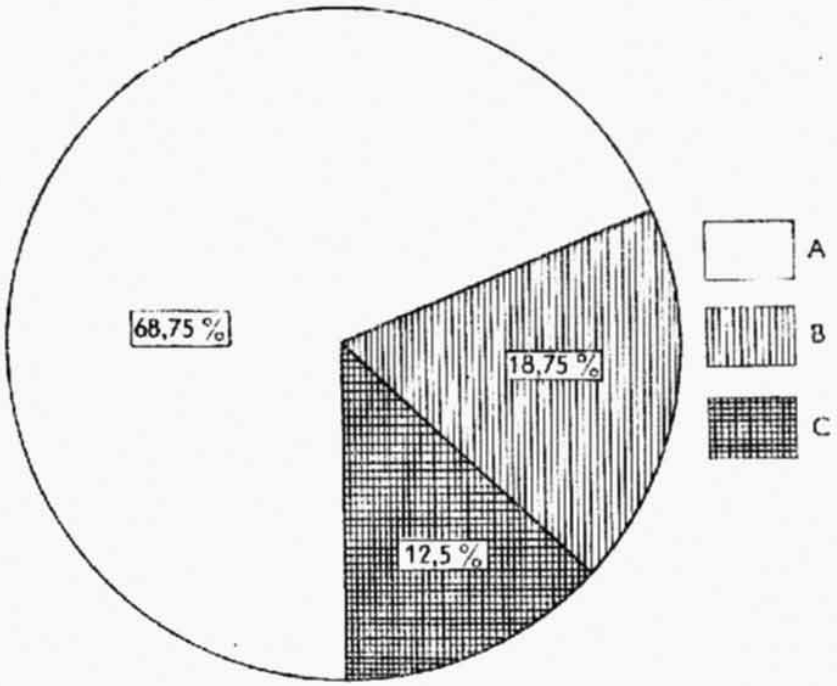

Fig. 1. Graphical illustration of the division of the parasitofauna of *Esox lucius* in the Lipno water reservoir, according to the specificity grade. A — nonspecific parasites, B — parasites, of which *E. lucius* is the principle host, C — strictly specific parasites.

The remaining 4 species (*Ichthyophthirius multifiliis*, *Diplostomum spathaceum*, *Piscicola geometra* and *Ergasilus sieboldi*) seem to have been acquired after the filling of the reservoir. Responsible for the distribution of *Ichthyophthirius multifiliis*, *Piscicola geometra* and *Ergasilus sieboldi* were the newly introduced fishes *Cyprinus carpio* and *Tinca tinca; Diplostomum spathaceum* was introduced by various fish catching birds (*Larus ridibundus* a.o.) which either visited or settled on the new reservoir.

In connection with the afore said we conclude that to date, the parasitofauna of the pike in the Lipno reservoir consists mostly of the species, which originally parasitized the pikes in the now flooded part of the river, whereby we are keeping in mind that certain changes in the qualitative composition of the parasitofauna may still occur. In consequence of the scarcity of benthic intermediate hosts some biohelminths (e.g. acanthocephala) may disappear completely or, the development of plankton components may provide convenient conditions for the development of some parasites, which now are not present in the pikes (*Proteocephalus esocis*).

Certain qualitative changes occurred in the parasitofauna of pikes during our investigations. Although not so remarkable as the quantitive changes (see above) we still consider it necessary to mention them.

When starting our investigations in 1961 and also in 1959 and 1960, *Trichodina domerguei f. esocis* and *Gyrodactylus lucii* were frequently found in the pike. In 1962 and 1963 these two parasite species were absent. Contrary to that *Diplostomum spathaceum* and *Piscicola geometra* were first observed in the pike in 1963. The qualitative analysis of the parasitofauna of the pike is given in Tab. 1.

Evaluating the specificity of the parasites to the pike, we found only a small percentage of parasites strictly host specific (Fig. 1): *Henneguya lobosa*, *Trichodina domerquei f. esocis*, and *Tetraonchus monenteron*. Less host specific to the pike are the species *Azygia lucii* and *Triaenophorus nodulosus;* although we found these species only in the pike it seems possible that they may also parasitize other fish

Tab. 1. The qualitative representation of the parasitofauna of *Esox lucius* in the individual research stages

Stage of research			Parasite species
1961	1962	1963	
+	+	+	*Henneguya lobosa*
+	-		*Trichodina domerguei f. esocis*
+	+	+	*Ichthyophthirius multifiliis*
+	+	+	*Tetraonchus monenteron*
+	-	-	*Gyrodactylus lucii*
		+	*Azygia lucii*
	-	+	*Diplostomum spathaceum*
-	+	+	*Triaenophorus nodulosus*
+	+	+	*Raphidascaris acus*
+	+	+	*Camallanus lacustris*
+	-	+	*Neoechinorhynchus rutili*
+	+	+	*Pseudoechinorhynchus clavula*
-	-	+	*Piscicola geometra*
-	-	+	*Anodonta cygnea larvae*
+	+	+	*Ergasilus sieboldi*
+	-	+	*Argulus foliaceus*

species such as *Anguilla anguilla*, *Lota lota* and *Lucioperca lucioperca*. The remaining 11 parasite species—*Ichthyophthirius multifiliis*, *Gyrodactylus lucii*, *Diplostomum spathaceum*, *Raphidascaris acus*, *Camallanus lacustris*, *Neoechinorhynchus rutili*, *Pseudoechinorhynchus clavula*, *Piscicola geometra*, *Anodonta cygnea* larv., *Ergasilus sieboldi* and *Argulus foliaceus* can be considered unspecific for the pike because they parasitize various other fish species in the Lipno reservoir, e.g. *Perca fluviatilis*, *Lota lota*, *Rutilus rutilus* (Fig. 2). The health of the pike in the Lipno reservoir is,

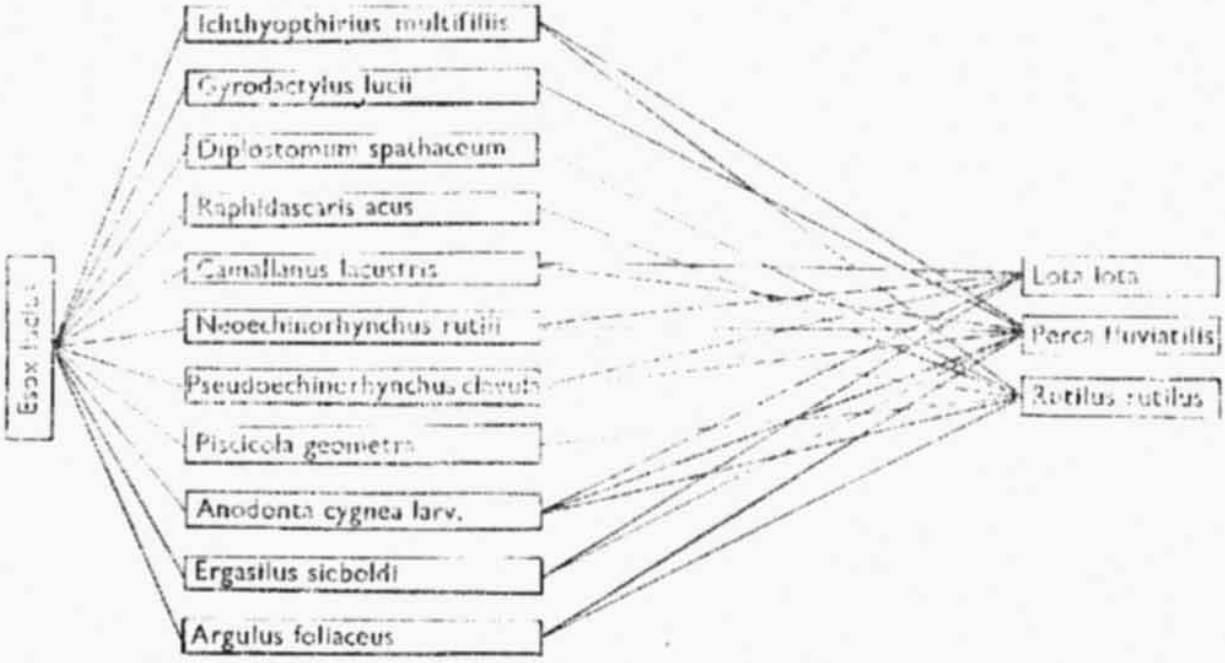

Fig. 2. Scheme of a possible exchange of nonspecific parasites among *Lota lota*, *Perca fluviatilis*, *Rutilus rutilus* and *Esox lucius*.

therefore, influenced principally by parasites invading also other fish species (mainly forage fishes) which act as reservoir hosts and, the abundance of which will have to be effectively regulated.

QUANTITATIVE COMPOSITION OF THE PARASITOFAUNA OF *ESOX LUCIUS* IN THE LIPNO RESERVOIR.

Basing on the fact that some of the ascertained parasites became less frequent in the pike in the course of our investigations (Tab. 2), we made a quantitative analysis of only the following species: *Henneguya lobosa*, *Tetraonchus monenteron*, *Triaenophorus nodulosus*, *Camallanus lacustris* and *Ergasilus sieboldi*.

Henneguya lobosa: its extensity and intensity of invasion of pikes varies greatly in the Lipno reservoir. The maximum of invasion was always attained in the autumn, a sudden decrease in both the extensity and intensity of invasion was observed regularly in the spring (Fig. 3, 4). Our observations are in agreement with the findings of IZYUMOVA (1960) from the Rybinsk reservoir in the U.S.S.R. who, in some instances, noticed the complete absence of *Henneguya lobosa* from the

227 **Tab. 2.** Extensity and the maximal intensity of invasion of rare or irregularly occurring parasites of *Esox lucius*

Parasite species	1961		1962		1963	
	Ext. %	Max. intens.	Ext. %	Max. intens.	Ext. %	Max. intens.
Trichodina domerguei f. esocis	1.1	*	-	-	-	-
Ichthyophthirius multifiliis	3.8	9			9.2	6
Gyrodactylus lucii	2.3	2	-	-	-	-
Azygia lucii			2.5	3	7.5	7
Diplostomum spathaceum	-	-	-	-	11.1	3
Raphidascaris acus	1.1	1	4.1	2	11.1	11
Neoechinorhynchus rutili	1.1	2			1.8	2
Pseudoechinorhynchus clavula	1.1	1	12	2	3.7	1
Piscicola geometra	-	-	-	-	3.7	2
Anodonta cygnea larv.	1.1	2	-	-	1.8	4
Argulus foliaceus	4.6	2	4.1	1	5.5	2

* Weak invasion (solitary specimens).

end of spring to the end of the summer, although these fishes were rather heavily invaded during the winter.

Fig. 3. shows the increase of the extensity of *H. lobosa* in pikes of the Lipno reservoir in 1961. A similar picture was found in the intensity of invasion, in spite

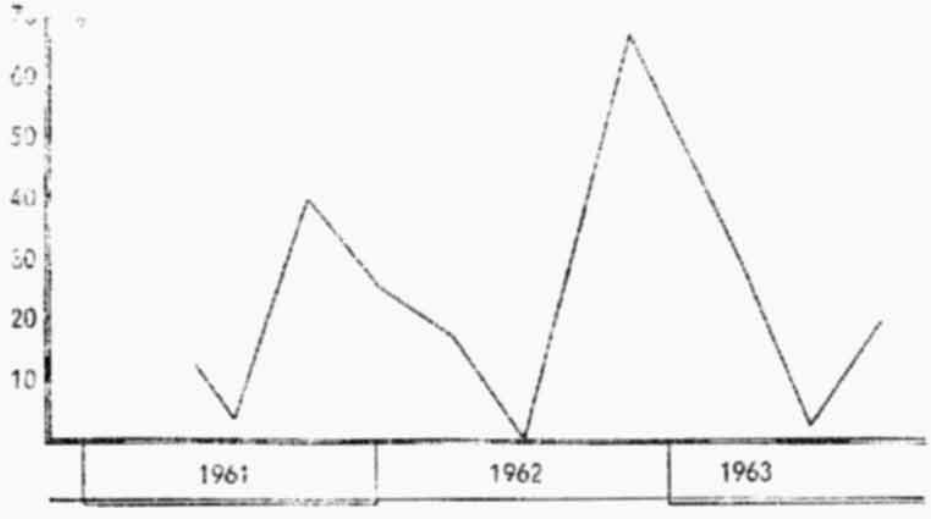

Fig. 3. Extensity of invasion of the species *Henneguya lobosa* in *E. lucius*. The changing of full and double lines on axis x = the changing of the yearly seasons (implies to Fig. 3—12).

of a sudden decrease in 1962. In consequence, an increase of the extensity and intensity of invasions of this parasite should be expected in the following years. At present it is difficult to forecast the peak of the intensity of invasion, which will be followed by serious damage to the health of the invaded fishes, especially to the young fishes.

Tetraonchus monenteron: a parasite with remarkable changes in the value of its maximum intensity of invasion (Fig. 5, 6). The decrease in the intensity of invasion, observed during our investigations (Fig. 6) can be explained by the

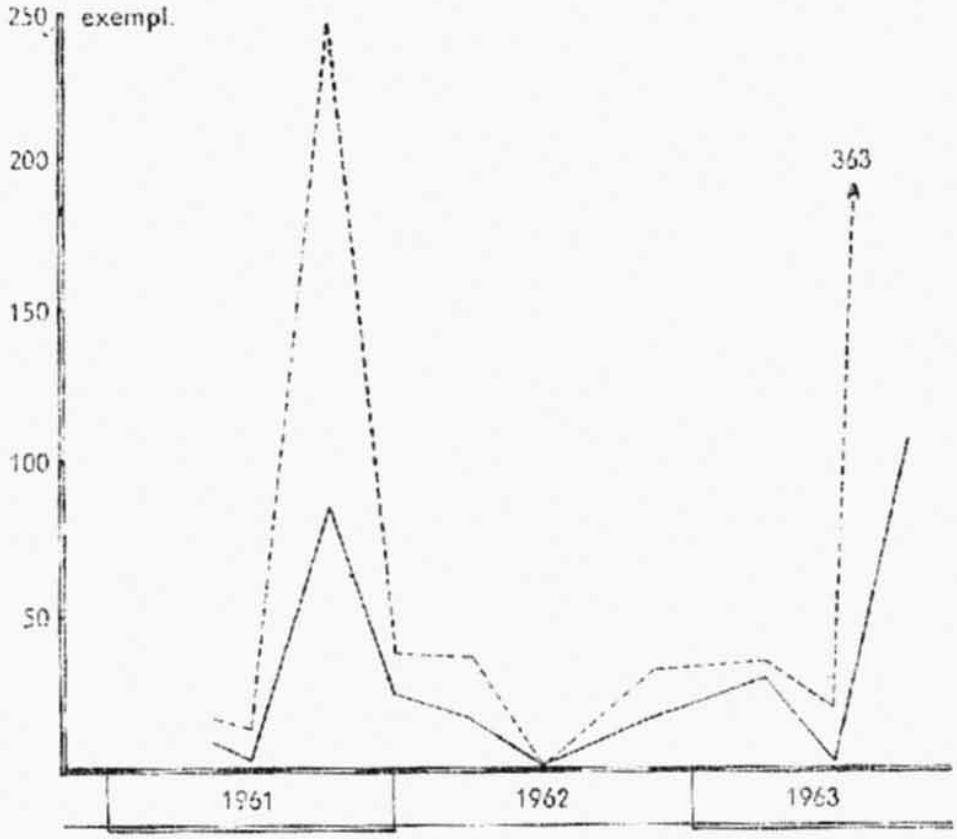

Fig. 4. Average (— — —) and maximal (— — —) intensity of invasion of the species *Henneguya lobosa* in *E. lucius*.

frequent changes of the water level in the reservoir, causing the desiccation of considerably large areas and, of the very warm and light penetrated littoral, offering the best conditions for the development of this parasite. Assuming that the water level will become stabilized vertically, an increased concentration of the invasive stages may be expected, which means consequently a heavier parasitation of the hosts.

Triaenophorus nodulosus: is one of the most dangerous parasites of *Esox lucius*. The second larval stage of this cestode attacks mainly the liver of *Perca fluviatilis*, *Trutta trutta*, *Lota lota* and young *Esox lucius*. The adult cestode invades also the eel and, according to MARKEVICH (1951), the pikeperch.

At Lipno we found this parasite only in the pike and the perch but consider it possible that the sexually mature stages of this worm may also occur in eels and pikeperches in this reservoir. For the scanty material this possibility could not be proved.

An interesting fact, which seems difficult to explain, is the absence of plerocercoids in the examined *Lota lota* and *Trutta trutta* because, normally, these fishes are most susceptible to this kind of parasitic disease. Regarding the high extensity and intensity of invasion of perches we cannot accept the explanation of GINETSINSKAYA (in DOGEL et al. 1958, p. 162) that only 1—2 % of the ingested procercoids are capable of further development, because the species *Perca fluviatilis*, *Lota lota* and *Trutta trutta* find about the same feeding conditions in the Lipno reservoir especially during the first two years of their life.

Fig. 5. Extensity of invasion of the species *Tetraonchus monenteron* in *E. lucius*.

Triaenophorus nodulosus, the definitive host of which are pikes, invades this host during all seasons of the year in the Lipno reservoir. The worm load, however, varies greatly, attaining its maximum (up to 472 specimens in one fish) in late spring and the first half of the summer (Fig. 7). Later invasions, at the end of the summer, during the autumn or in the winter were observed only exceptionally; we never found more than 7—9 attached worms of about 10 cm length or sexually mature in the intestine of the fish. A similar situation was noted by SCHEURING (1930) who explains it by the existence of a so-called superinvasive immunity. After SCHEURING the pikes are invaded by these cestodes only in the first half of the summer (May to June) although invasive plerocercoids are present all the year. He explained this by the formation of certain specific antibodies in the intestine of the attacked pike, preventing a further invasion.

The results of SCHEURING's research are very similar to ours without directly proving the existence and basis of this superinvasive immunity. In this connection we would like to mention the results of IZYUMOVA (1960) who found that in the Rybinsk reservoir pikes were invaded by plerocercoids of the cestode *Triaenophorus nodulosus* from May to the end of August with a maximum of invasion in the

autumn. At that period she found both young and sexually mature stages of the worm in the intestine of the pikes. At the present stage of research it is difficult to explain the differences in the results obtained by IZYUMOVA, SCHEURING

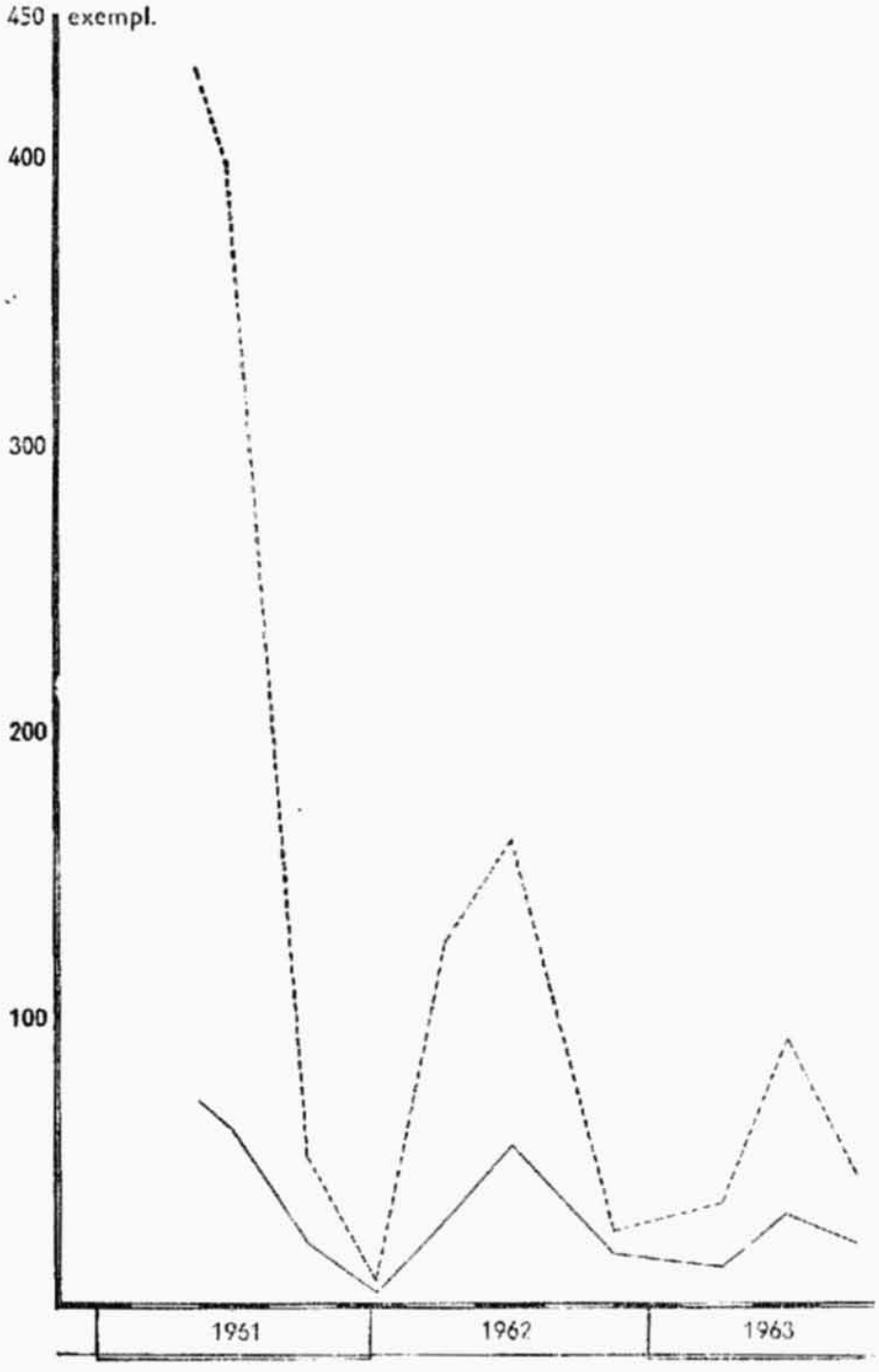

Fig. 6. Average (———) and maximal (— — — —) intensity of invasion of the species *Tetraonchus monenteron* in *E. lucius*.

and by us. The problems of the seasonal variation in the intensity of invasion, including the proof of an eventual immunity to *Triaenophorus nodulosus*, will have to be solved not only in different ecological conditions but also experimentally.

In comparing the values of the intensity of invasion of *Triaenophorus nodulosus* in pikes of the Lipno reservoir during the separate seasons of the research, a de-

231 creasing trend was observed. In recent years the pike has started to choose its food consuming predominently forage fishes of the family *Cyprinidae*, very often the fry of carps. The perch, till 1961 the most abundand fish in the reservoir, was

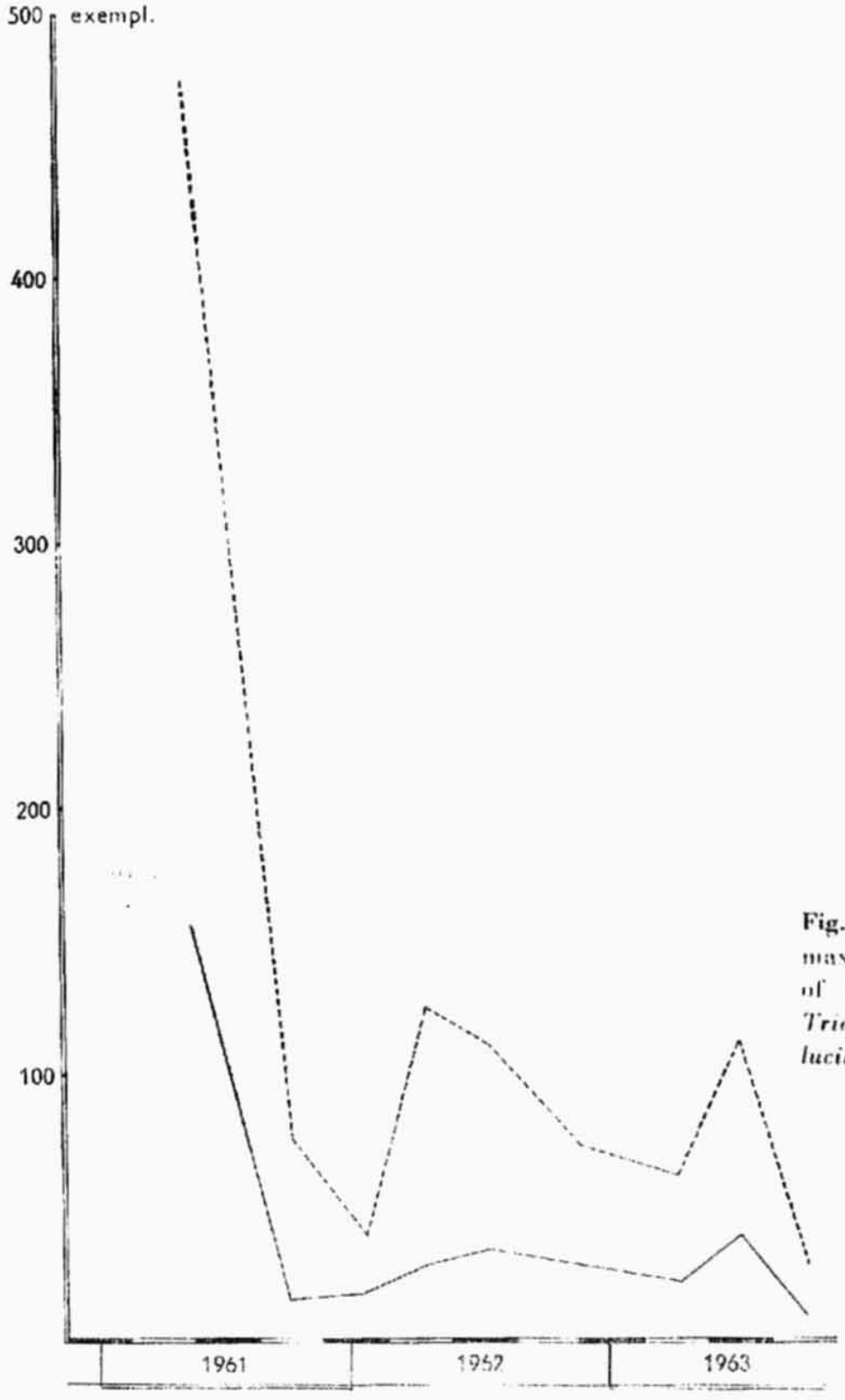

Fig. 7. Average (-) and maximal ( ) intensity of invasion of the species *Triaenophorus nodulosus* in *E. lucius*.

at that time the basic food of the pike, providing convenient conditions for continuous invasions with plerocercoids. At the present this fish is only occasionally devoured by the pike. Moreover, the numbers of perches are reducing in consequence

of heavy invasions with the plerocercoids of *T. nodulosus* and because an increasing number of older perches (5—6 years) feeds almost exclusively on 1—2 year old perches, heavily invaded by the larval stages of this cestode.

The decrease of intensity of invasion in the definitive hosts is followed by a lower concentration of invasive stages in the external environment, which lowers the possibility of attacking the intermediate, and later, the definitive hosts. Although the concentration of invasive stages is much lower than in the previous years, there still exist conditions for this cestode to complete its life cycle. This is illustrated partly on Fig. 8. showing the course of the intensity of invasion of the definitive hosts during the seasons of the year.

It becomes evident that any interference with the regulation of the fish population (natural or artificial) especially of perches and the other forage fishes may lead to an increased parasitation of the definitive host with the cestode *T. nodulosus*.

Regarding the fact that the parasitation of the pike with the cestode *T. nodulosus* is closely connected with the perch it seems necessary to make a short note on the attack of this fish by *T. nodulosus*. In the perches the perocercoids are localized mostly in the liver tissue and, in heavy invasions followed by great losses of the young fishes of 1 —2 years of age, also on the external side of the intestinal wall and in all other organs of the abdominal cavity.

In histological examinations Dr K. Blažek, head of the veterinary group of our Institute, found a swelling of the collagenic connective tissue and a lymphohistiocytic infiltration round the bladder of the plerocercoid. In heavy invasions (about 30 40 plerocercoids) the liver tissue succumbs to a pressure atrophy and to heavy morphological changes.

The extensity and intensity of invasions of perches with the plerocercoids of this cestode was approximately the same during the period of one year and during the complete period of research (1961 —1963). The extensity of invasion ranged from

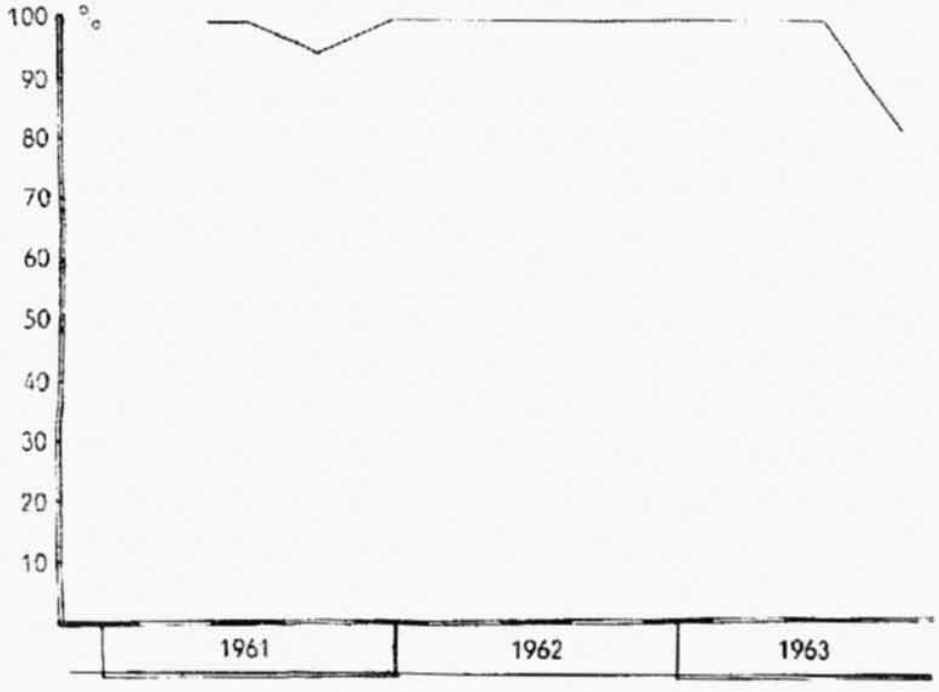

Fig. 8. Extensity of invasion of the species *Triaenophorus nodulosus* in *E. lucius*.

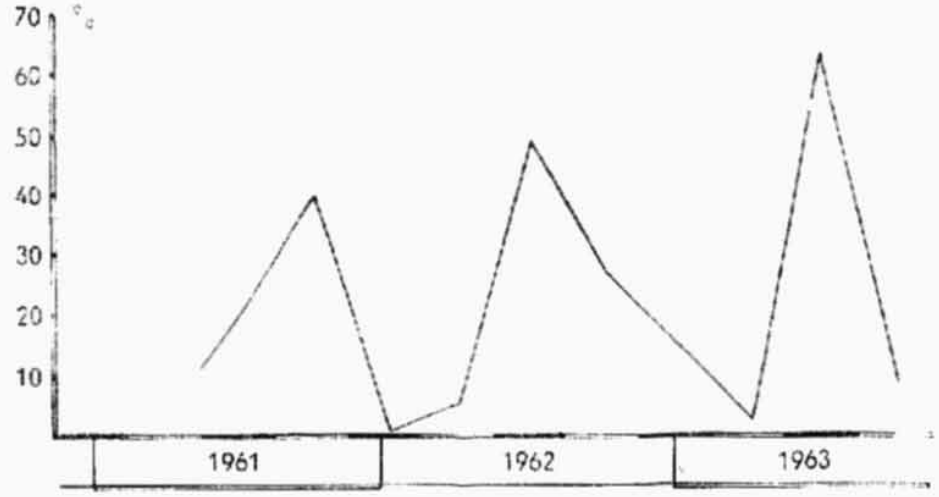

Fig. 9. Extensity of invasion of the species *Camallanus lacustris* in *E. lucius*.

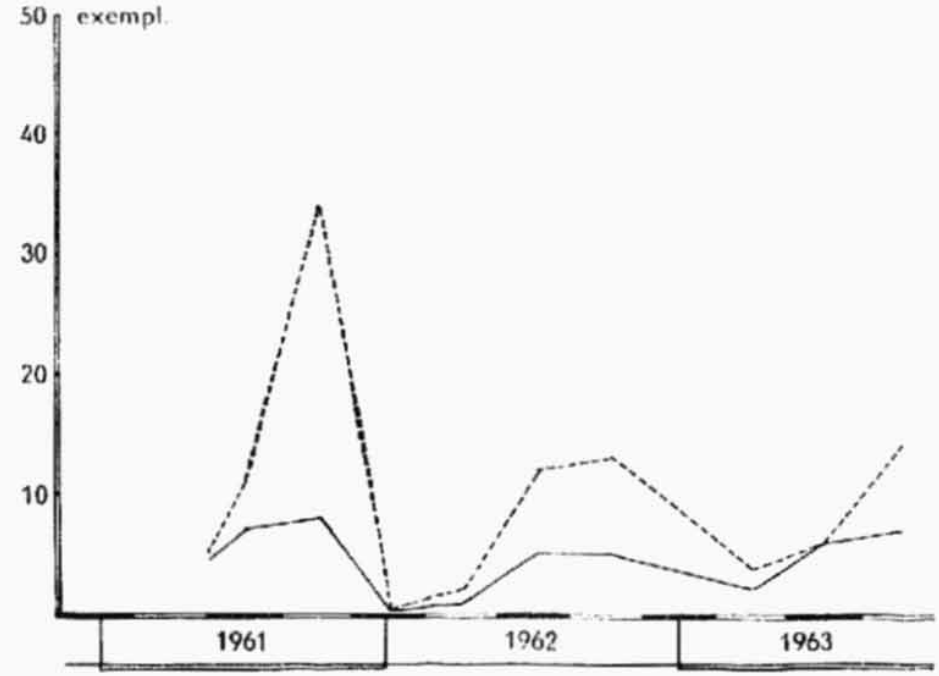

Fig. 10. Average (———) and maximal (— — —) intensity of invasion of the species *Camallanus lacustris* in *E. lucius*.

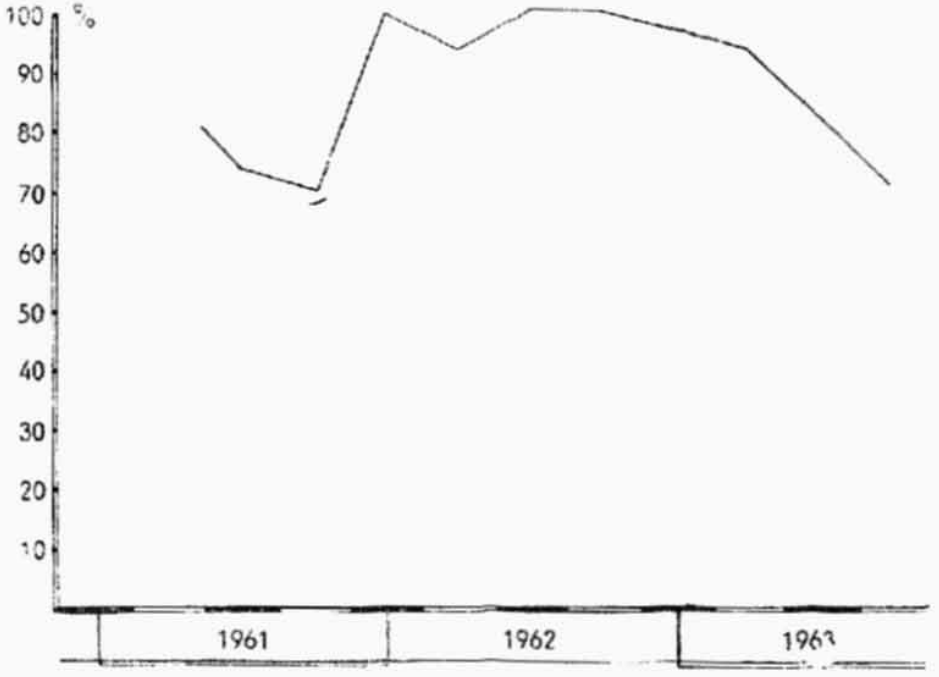

Fig. 11. Extensity of invasion of the species *Ergasilus sieboldi* in *E. lucius*.

87—100 %, the average intensity was 16—29 plerocercoids to one fish. The maximum load was 67 plerocercoids in one fish. This indicates convenient conditions for this cestode to complete its life cycle; the decrease of invasions of the definitive hosts are mainly due to their choice of food.

In heavy invasions of the definitive host *T. nodulosus* causes deep, chronical inflammations of the intestinal mucosa. Close to the attached cestodes we observed

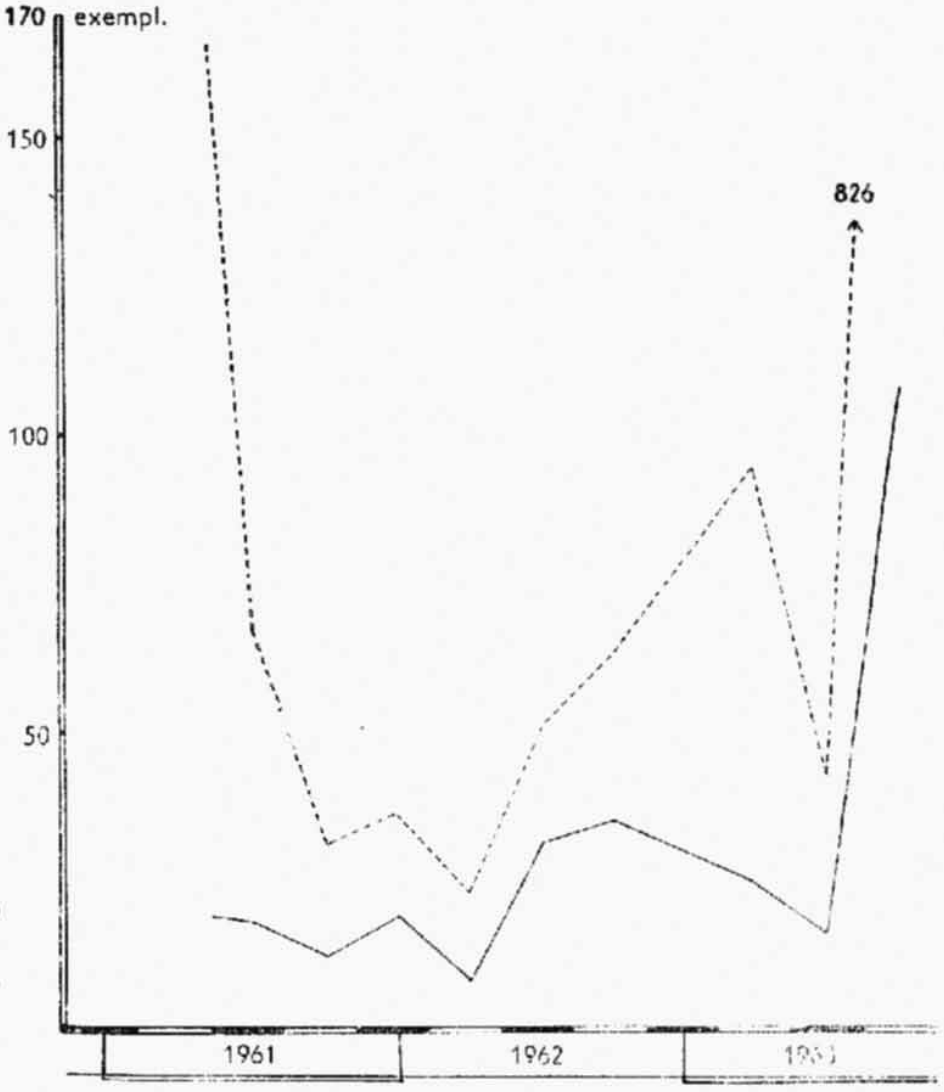

Fig. 12. Average (———) and maximal (— — — —) intensity of invasion of the species *Ergasilus sieboldi* in *E. lucius*.

a heavy inflammatory reaction of the mucous stroma and a mucotic metaplasy of the mucosa, a pressure atrophy and a necrobiosis of the epithelium. Inflammatory infiltrates project often to the elastic layers of the mucosa (lamina elastica) and immobilize them. The digestion of the attacked fish starts to become inadequate.

Camallanus lacustris is a parasite of pikes with relatively remarkable seasonal dynamics in the Lipno reservoir. The extensity and intensity of invasions attains its minimum in the winter months and its maximum in the summer months (Fig. 9, 10). Similar observations were made by IZYUMOVA (1960) in the Rybinsk reservoir.

Fig. 9. shows an increase in the extensity of invasions since 1961. We therefore conclude that recently the pikes of the Lipno reservoir will be attacked by this parasite by a 100 %. Basing on the results of our previous investigations on the

Vranov and Kníničský reservoirs, we believe that the worm load will not seriously endanger the pikes of the Lipno reservoir.

Ergasilus sieboldi is, besides the cestode *Triaenophorus nodulosus*, the most frequent parasite of pikes at the Lipno reservoir. The course of the extensity of invasion from 1961 to 1963 is illustrated on Fig. 11.

At the present, conditions are in favour of a development of *Ergasilus sieboldi*. Fig. 12. shows the course of the average and maximum intensity of invasion during our investigations.

With regard to the biology of *E. sieboldi* we assume an increased parasitation of the fishes at Lipno, which may lead to serious damages.

In conclusion we repeat that we did not evaluate the worm load of the parasites mentioned in Tab. 2, because their occurrence was rather scanty during the period of our research.

SUMMARY

Our parasitological investigations on the health of *Esox lucius* in the Lipno reservoir brought the following results:

1. During our investigations we found 16 species of parasites in pikes. Twelve of these species may have belonged to the original parasitofauna of the pike before the Lipno reservoir was filled.
2. The species *Ichthyophthirius multifiliis*, *Diplostomum spathaceum*, *Piscicola geometra* and *Ergasilus sieboldi* were acquired by the pike after the filling of the Lipno reservoir and, most propably, after the introduction of *Cyprinidae* to this reservoir.
3. During our investigations we observed some qualitative changes in the parasitofauna of the pike which may be connected with the process of stabilisation of the biological equilibrium in the new environments.
4. The qualitative composition of the parasitofauna of the pike is influenced, to a certain extent, by the qualitative composition of the parasitofauna of *Perca fluviatilis*, *Lota lota* and *Rutilus rutilus*. Only three species of parasites can be considered host specific to the pike: *Henneguya lobosa*, *Trichodina domerguei f. esocis*, *Tetraonchus monenteron*.
5. Most of the ascertained parasites, mainly *Ichthyophthirius multifiliis*, *Tetraonchus monenteron*, *Diplostomum spathaceum*, *Triaenophorus nodulosus*, *Ergasilus sieboldi* and *Argulus foliaceus* belong to a group of highly pathogenic parasites, which may be either directly or indirectly responsible for the death of especially the younger fishes.
6. During the course of our investigation, a considerable number of parasites became less frequent in occurrence in the pike. This does not exclude the possibility on an increase in their extensity and intensity of invasion in the future especially of parasites which are not strictly host-specific or which develop directly.

7. *Henneguya lobosa* is a species with a typical seasonal occurrence; it is found in pikes mostly in the autumn, the winter and the spring. In these seasons the extensity and intensity of invasions attain their maximum values.
8. *Tetraonchus monenteron* occurs all the year round in the pike. Seasonal changes become noticeable only in the average and maximum values of the worm load. If the water level of the reservoir will not become stabilized vertically within the next years, a lesser parasitation of the pike with *T. monenteron* may be expected, as observed during our research work.
9. The cestode *Triaenophorus nodulosus* seems to be the most dangerous parasite of the pike, causing heavy inflammations of the intestinal mucosa, followed be an inedaquate digestion of the fish and no increase in its weight.
10. We observed decreasing trends in the intensity of invasion with *T. nodulosus* in the pike, due to the choice of food. These trends cannot be considered final. Conditions in the Lipno reservoir are suitable for the parasite to conclude its life cycle which is proved not only by the extensity of invasion in pikes but also in perches, their second intermediate host.
11. At present the intensity and extensity of invasion of the species *Camallanus lacustris* seems not dangerous for the pike.
12. With regard to convenient developmental conditions and to the increasing intensity of invasion of *Ergasilus sieboldi* during the last three years, a further increase in the parasitation of fishes with this parasite may be expected. Consequently, serious damage may be caused not only to the pike but also to all other representatives of the ichthyofauna, populating the Lipno reservoir.

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