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Correlation between the occurrence of parasites and body length of roach, carp bream, European perch, zander, and ruffe in the Vistula Lagoon estuary

Leszek Rolbiecki[1]

Institute of Biology, Department of Invertebrate Zoology
University of Gdańsk, Poland

Key words: parasites, fish length, roach, carp bream, European perch, ruffe, zander, Vistula Lagoon

Abstract

The abundance and composition of parasitic faunas change with fish size (age). The correlation between the occurrence of parasites and body length of cyprinids (carp bream and roach) and percids (European perch, zander, and ruffe) in the Vistula Lagoon was analysed, based on 1856 fish specimens caught between 1994-1997. Of the 63 parasitic taxa identified, the presence of 17 was found to correlate with fish size. Differences in parasitic infection between fish length classes could be caused by body size (fish body surface), volume of water swallowed during active breathing of the fish, type of food ingested, life history (migrations, aggregation of fish fry and spawning adults), and the degree of resistance as well as accumulation of parasites (particularly larvae), predation (elimination of infected fish), and commercial fisheries.

[1] *e-mail: lrolbiecki@sat.ocean.univ.gda.pl*

INTRODUCTION

The abundance and composition of parasitic faunas change with fish size (age). Fish belonging to different length classes differ in their mode of life, and hence in their degree of exposure to parasites. Invasive forms of parasites actively seek their hosts or are passively transmitted to them via food or water swallowed during active breathing. Fish fry form aggregations nearshore and at shallow locations; adults are often solitary, frequently migrate, and aggregate mainly for spawning and/or overwintering. The parasitic species transmitted via food are closely related to the type of food ingested by the fish. Food preferences change with fish size (age), hence the parasitic fauna changes as well. Sometimes the composition of the parasitic fauna may be an indicator of habitat, food type, and even migration routes of hosts, including the fish.

Some authors have analysed relationships between infection and fish age, others have explored correlations between parasitic occurrence and fish length. As the fish length does not always reflect age, we decided to elucidate the correlations, if any, between the fish length and the extent of parasitic infection.

MATERIAL AND METHODS

The study included a total of 1856 specimens of cyprinids and percids caught between December 1994 and March 1997 in the Polish part of the Vistula Lagoon (Rolbiecki 2003). A total of 376 carp bream *Abramis brama* (Linnaeus, 1758), 9-59.2 cm; 389 roach *Rutilus rutilus* (Linnaeus, 1758), 10-32.5 cm; 371 European perch *Perca fluviatilis* Linnaeus, 1758, 11.7-31 cm; 330 ruffe *Gymnocephalus cernuus* (Linnaeus, 1758), 6.5-18 cm; and 390 zander *Sander lucioperca* (Linnaeus, 1758), 6.5-72 cm were examined.

Each fish was measured to within 1 mm. The fish were divided into a number of length classes. The length classes specified for carp bream were: below 15 cm (n=47); 15-20 cm (n=49); 20.1-25 cm (n=62); 25.1-30 cm (n=47); 30.1-35 cm (n=43); 35.1-40 cm (n=41); 40.1- 45 cm (n=41); and above 45 cm (n=46). The length classes established for roach were: below 15 cm (n=60); 15-18 cm (n=70); 18.1-21 cm (n=93); 21.1-24 cm (n=59); 24.1-27 cm (n=57); and above 27 cm (n=50). The length classes specified for European perch were: below 15 cm (n=85); 15-18 cm (n=97); 18.1-21 cm (n=71); 21.1-24 cm (n=37); 24.1-27 cm (n=37); and above 27 cm (n=44). The length classes established for ruffe were: below 8 cm (n=61); 8-10 cm (n=55); 10.1-12 cm (n=68); 12.1-14 cm (n=85); and above 14 cm (61). The length classes used for zander were: below 15 cm (n=79); 15-30 cm (n=79); 30.1-45 cm (n=76); 45.1-60 cm (n=78); and above 60 cm (n=78). Length classes were established with appropriate consideration to fish growth rate and the number of specimens examined.

To detect parasites, the fish skin, fins, mouth cavity, gills, body cavity, and internal organs were examined under a stereomicroscope. The collected parasites were subjected to standard parasitological procedures. The Myxozoa were fixed and preserved in 70% ethanol, while the remaining parasites were fixed in 19:1 glacial acetic acid-formalin mixture and preserved in 70% ethanol. For the purpose of identification, the parasites were mounted temporarily or permanently. The Myxozoa were embedded in glycerol-gelatine. Nematodes were cleared in lactophenol and embedded in glycerol-gelatine. Trematodes, cestodes, and acanthocephalans were stained with borax carmine, dehydrated in an alcohol series or acetic acid, and cleared in creosote or benzyl alcohol. Some helminths were mounted permanently in Canada balsam.

The prevalence data were subjected to an analysis of variance (ANOVA), while multiple regression was applied to mean intensities.

RESULTS

The occurrence of 17 out of the 63 parasitic taxa identified (Rolbiecki 2003) was found to correlate significantly with fish length (Fig. 1-18). An increase in infection parameters with fish length was observed for: *Ancyrocephalus paradoxus* Creplin, 1839 in zander ($p<0.001$ for prevalence, $p<0.001$ for mean intensity, Fig. 2); *Posthodiplostomum cuticola* (Nordmann, 1832) met. in carp bream ($p<0.001$, Fig. 9); *Caryophylleus laticeps* (Pallas, 1781) in carp bream ($p<0.001$, Fig. 12); and *Achtheres percarum* Nordmann, 1832 in zander ($p<0.001$, Fig. 18). In contrast, a reduction in infection parameters with fish length was observed for *Bunodera luciopercae* (Müller, 1776) in European perch ($p<0.001$, Fig. 7) and *Camallanus truncatus* (Rudolphi, 1814) in European perch (prevalence only, $p<0.001$, Fig. 15). In addition, some parasites occurred in particular fish length classes only; that was the case for *Dactylogyrus amphibothrium* Wagener, 1857 in ruffe ($p<0.001$, Fig. 3), *Bucephalus polymorphus* Baer, 1827 ad. in zander ($p<0.001$, Fig. 6), *Rhipidocotyle campanula* (Dujardin, 1845) ad. in zander ($p<0.001$, Fig. 10), and *Eustrongylides mergorum* (Rudolphi, 1809) L3 in ruffe ($p<0.001$, Fig. 16). In these cases, infection showed a tendency to increase with fish length. Infection of certain fish length classes tended to decrease with fish length in the following cases: *Henneguya psorospermica* Thélohan, 1895 in European perch ($p<0.001$, Fig. 1), *Bucephalus polymorphus* met. in roach ($p<0.001$, Fig. 5), *Diplostomum* spp. met. in European perch ($p<0.01$ for prevalence, $p<0.05$ for mean intensity, Fig. 8), and *Acanthocephalus lucii* (Müller, 1776) in European perch ($p<0.001$ for prevalence, $p<0.01$ for mean intensity, Fig. 17). In contrast, infections with *Diplozoon paradoxum* Nordmann, 1832 in carp bream (mean intensity only, $p<0.01$, Fig. 4), *Tylodelphys clavata* (Nordmann, 1832) met. in European perch

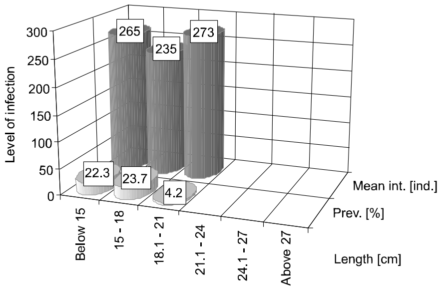

Fig. 1. Correlation between the occurrence of *Henneguya psorospermica* and European perch length in the Vistula Lagoon.

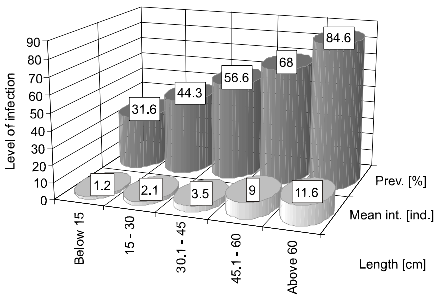

Fig. 2. Correlation between the occurrence of *Ancyrocephalus paradoxus* and zander length in the Vistula Lagoon.

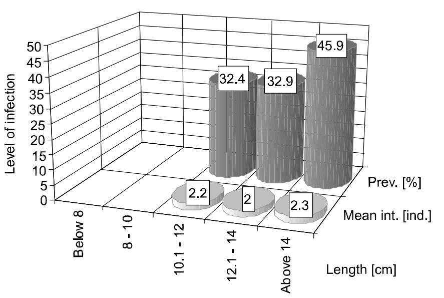

Fig. 3. Correlation between the occurrence of *Dactylogyrus amphibothrium* and ruffe length in the Vistula Lagoon

($p<0.001$, Fig. 11), *Ligula intestinalis* (Linnaeus, 1758) pl. in carp bream (prevalence only, $p<0.05$, Fig. 13), and *Triaenophorus nodulosus* (Pallas, 1781) pl. in European perch ($p<0.001$, Fig. 14) were observed to increase initially followed by a drop, but the large carp bream and European perch were free of *L. intestinalis* and *T. nodulosus*. It is also worth noting that prevalence of various parasites changed in a more distinct manner than intensities. The data on correlations between fish size and the presence of *Anguillicola crassus* in ruffe (Rolbiecki 2002) and *Anisakis simplex* in zander (Rolbiecki and Rokicki 2000a) have been previously published.

DISCUSSION

As shown by both this study and earlier research described by various authors (e.g., Starovojtov 1995), parasitic fauna undergoes a number of qualitative and quantitative changes accompanying fish growth. The most important changes include increases and decreases in the extent of infection. However, the pattern of change frequently includes both effects, for example an initial increase in infection followed by a decrease, or an identical infection level in all length classes. In addition, some parasites may occur in certain length classes and be absent in others.

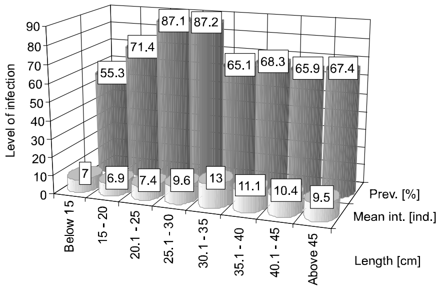

Fig. 4. Correlation between the occurrence of *Diplozoon paradoxum* and carp bream length in the Vistula Lagoon.

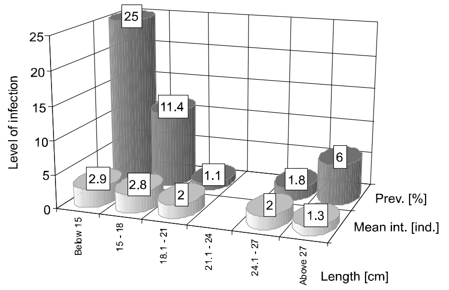

Fig. 5. Correlation between the occurrence of *Bucephalus polymorphus,* met. and roach length in the Vistula Lagoon.

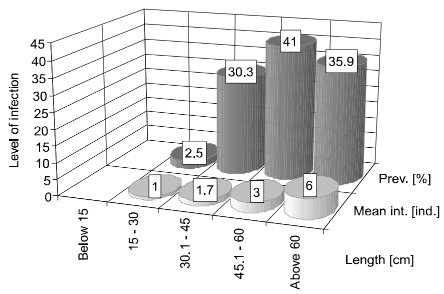

Fig. 6. Correlation between the occurrence of *Bucephalus polymorphus*, ad. and zander length in the Vistula Lagoon.

The dependence of parasitic infection on fish length is the result of numerous influences. However, for an infection to occur, the niches of invasive parasitic forms (free-living or occurring in intermediate or paratenic hosts) have to overlap with the niches of the hosts.

Many parasites actively attack a host. In that case, the host size is the most important factor facilitating infection. Larger fish, with a large body surface, are a target that is easy to spot and colonise by free-living parasites. Examples included in this study are the monogeneans *Ancyrocephalus paradoxus* in zander (Fig. 2), *Dactylogyrus amphibothrium* in ruffe (Fig. 3), the trematode *Posthodiplostomum cuticola* in carp bream (Fig. 9), and the copepod *Achtheres percarum* in zander (Fig. 18). It is worth mentioning that the *D. amphibothrium* infection involved only the ruffe longer than 10 cm. A fish size-dependent increase in the infection of *A. paradoxus* was reported from zander in the Gulf of Gdańsk (Rolbiecki and Rokicki 1996) and the Curonian Lagoon (Starovojtov et al. 1985). In addition, an *A. percaum* infection that increased with fish length was also observed in Lake Jamno (Kozikowska et al. 1956), in the Gulf of Gdańsk (Rolbiecki and Rokicki 2000b), and in Lake Peurunka in Finland (Valtonen et al. 1993).

In many cases, a fish becomes a

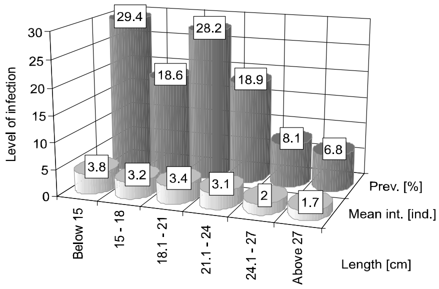

Fig. 7. Correlation between the occurrence of *Bunodera luciopercae* and European perch length in the Vistula Lagoon.

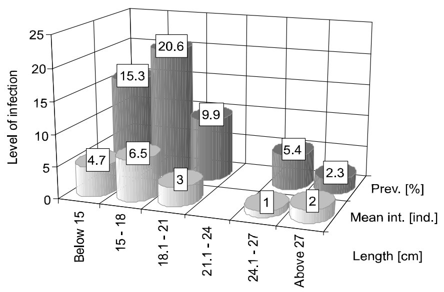

Fig. 8. Correlation between the occurrence of *Diplostomum* spp. and European perch length in the Vistula Lagoon.

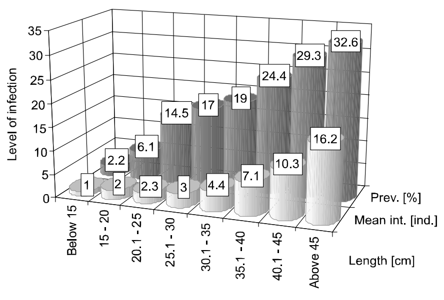

Fig. 9. Correlation between the occurrence of *Posthodiplostomum cuticola* and carp bream length in the Vistula Lagoon.

parasite host by swallowing it with water or ingesting it with food that may contain invertebrates or vertebrates that function as intermediate or paratenic hosts.

In the first case, the larger fish (endowed with a larger mouth opening) swallow more water than the smaller fish do, and are thus more exposed to parasitic invasion. Many parasites that actively attack the host may get into the host passively, when the fish breathes. One example from the present study is *Achtheres percarum* in zander (Fig. 18).

Examples of the second case, when parasites are ingested with food, are provided by *Caryophylleus laticeps* and *Eustrongylides mergorum* in oligochaetes as intermediate hosts; *Bunodera lucioperca*, *Camallanus truncatus*, *Ligula intestinalis,* and *Triaenophorus nodulosus* in copepods; *Bucephalus polymorphus* ad. and *Rhipidocotyle campanula* ad. in cyprinids; and the acanthocephalan *Acanthocephalus lucii* in the isopod *Asellus aquaticus*. One important component is that the food ingested by the fish changes during its life span. For example, a fish length-related increase in bream infection with the cestode *C. laticeps* (Fig. 12) results from a dietary shift: larger fish switch to feeding on benthic organisms, including oligochaetes (Brylińska and Tadajewska 1991). A similar pattern

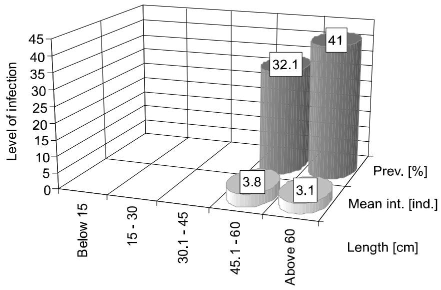

Fig. 10. Correlation between the occurrence of *Rhipidocotyle campanula* and zander length in the Vistula Lagoon.

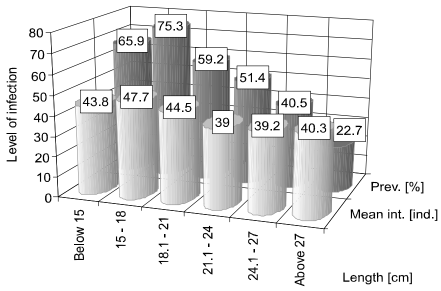

Fig. 11. Correlation between the occurrence of *Tylodelphys clavata* and European perch length in the Vistula Lagoon.

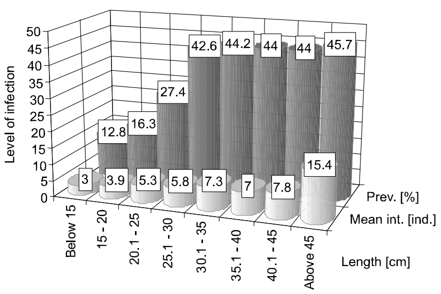

Fig. 12. Correlation between the occurrence of *Caryophylleus laticeps* and carp bream length in the Vistula Lagoon.

was reported by Pojmańska (1994) in carp infected with *Khavia sinensis*, another caryophillid cestode. The increased infection of *E. mergorum* in larger ruffe (Fig. 16) also can be explained by the increasing fraction of oligochaetes in the diet of those fish. The absence of nematodes in ruffe smaller than 8 cm suggests a lack of oligochaetes in their food. The life cycle of *E. mergorum* is incompletely known; it remains to be found if, as in other congeners, it involves paratenic hosts (fish) that could pass the infection on to ruffe (Moravec 1994). However, because ruffe is a small predator feeding primarily on invertebrates, the fish has a low probability of being infected via paratenic hosts. Such exposure is usually common in larger fish species, e.g. channel catfish (*Ictalurus punctatus*), which, as a large (up to 60 cm in length) predator, becomes infected with *Eustrongylides* sp. nematodes not only via oligochaetes, but also via small fish (Lawrence et al. 1978). Infections of the parasites *B. luciopercae* (Fig. 7), *C. truncatus* (Fig. 15), *L. intestinalis* (Fig. 13), and *T. nodulosus* (Fig. 14) were observed to decrease with fish length, although the prevalence of *T. nodulosus* initially increased up to 18 cm fish length, and the prevalence and intensity of infection of *L. intestinalis* were increasing up to 25 and 20 cm fish length, respectively. Similarly, Evlanov (1987) and

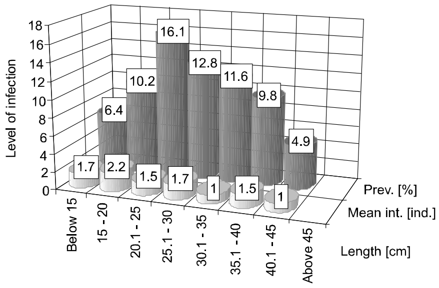

Fig. 13. Correlation between the occurrence of *Ligula intestinalis* and carp bream length in the Vistula Lagoon.

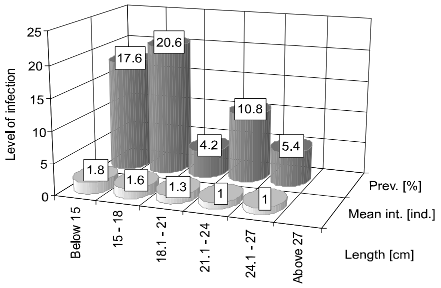

Fig. 14. Correlation between the occurrence of *Triaenophorus nodulosus* and European perch length in the Vistula Lagoon.

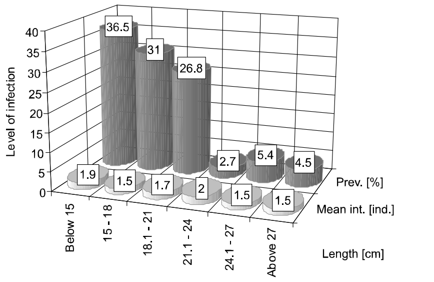

Fig. 15. Correlation between the occurrence of *Camallanus truncatus* and European perch length in the Vistula Lagoon.

Oškinis (1993) recorded increasing infections of *T. nodulosus* in European perch up to 15 and 14 cm long, respectively, with a reduction in larger fish in Lake Vystichio (near Kaliningrad) and Lake Druksiai (Lithuania). A reduction in infection of *B. lucioperace*, *C. truncatus* and *T. nodulosus* in larger European perch and that of *L. intestinalis* in carp bream must have been caused by a reduced contribution of copepods, the intermediate hosts, in the fish diet. As described by Terlecki (1991), European perch switch to feeding on fish at an average length of 15 cm, with fish becoming the major, or only, food item of large specimens. In contrast, small carp bream feed primarily on copepods and, as previously mentioned, switch to feeding on benthic organisms, including oligochaetes, when they become older (Brylińska and Tadajewska 1991). The *A. lucii* infected European perch (Fig. 17) also showed a decreasing extent of infection with fish length (fish larger than 24 cm were free of acanthocephalans), which suggests a decreasing dietary importance of the isopod *Asellus aquaticus*, the parasite's intermediate host. The presence of sexually mature *B. polymorphus* and *R. campanula* in the large zander (Figs. 6 and 10) was due to the fact that it was the only large fish that could ingest intermediate hosts such as cyprinids

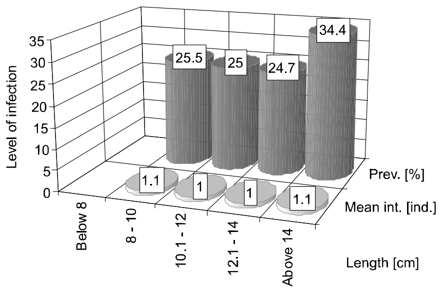

Fig. 16. Correlation between the occurrence of *Eustrongylides mergorum* and ruffe length in the Vistula Lagoon.

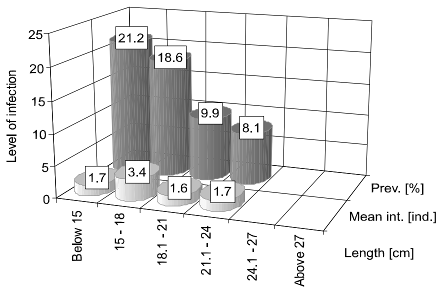

Fig. 17. Correlation between the occurrence of *Acanthocephalus lucii* and European perch length in the Vistula Lagoon.

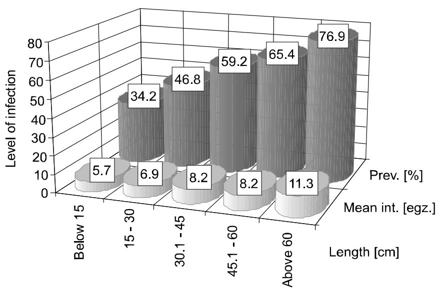

Fig. 18. Correlation between the occurrence of *Achtheres percarum* and zander length in the Vistula Lagoon.

(in the present study represented by roach), which support the invasive metacercariae.

In addition, fish may become accidentally infected with free-living invasive forms of parasites when feeding. For instance, spores of *Henneguya psorospermica* sedimented on the bottom (Šul'man et al. 1980) are inadvertently ingested when fish (European perch) feed near the bottom.

A reduction in infection as the fish grow, down to total absence, also can be induced by predators (predatory fish, birds, and mammals). One case in the present study was the *Bucephalus polymorphus* metacercariae-infected roach (Fig. 5) preyed upon by zander, the definitive host of the trematode. Another example would be the plerocercoids of *Ligula intestinalis* in carp bream (Fig. 13). The pressure exerted by *L. intestinalis* (a large cestode growing to 92 cm and 29.2 g; Rolbiecki, unpubl. data) on the carp bream's swim bladder affects the swimming ability of the fish, causing cestode infected carp bream to be easy prey for predatory birds and fish. In addition, a reduction in parasitic prevalence in fish as large as 20.1-25.0 cm may indicate that, initially, the cestode produces no major pathological changes in its hosts and it is only the large plerocercoids that more seriously affect the function of the fish body. Due to their size, large carp bream are not preyed upon by birds and other fish; therefore a reduction in infection in large fish may be due to natural and, certainly, fisheries-related mortality. Metacercariae of *Diplostomum* spp. and *Tylodelphys clavata* in European perch (Fig. 8 and Fig. 11) are a second example. The trematodes live in the eyes and impair the host's vision, so that, as reported by Crowden and Broom (1980) for common dace (*Leuciscus leuciscus*), the fish spend more time near the water surface and become increasingly threatened with elimination by piscivorous birds, the trematodes' definitive hosts.

Another important factor increasing the infection level in larger (mostly older) fish is the accumulation of parasites, and in particular, their larvae. *Posthodiplostomum cuticola* metacercariae in carp bream (Fig. 9) provide an example from the present study.

In addition, the transmission of ectoparasites is enhanced when the fish aggregate to spawn. An increase in infection of the copepod *Achtheres percarum* in the large zander (Fig. 18) was associated with**,** i.a.**,** spawning (Kozikowska et al. 1956). The fish usually spawn in shallow areas which support numerous intermediate hosts (e.g., molluscs) of many parasites. Therefore, the fish are more exposed to invasive parasitic forms. On the other hand, the larger fish are more mobile and, as opposed to smaller specimens, spend less time nearshore.

As can be observed, the problem of correlations between parasitic occurrence and fish length is very complex. Frequently, the presence of a parasitic species is the net effect of many factors, and the most important among them are very difficult to identify. Moreover, repeated infections may be enhanced by suppressed resistance in the fish, which is caused by many factors. These are usually difficult to identify under natural conditions, but also include parasitic invasions.

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