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DIVERSITY OF THE PARASITE FAUNA OF CYPRINID (CYPRINIDAE) AND PERCID (PERCIDAE) FISHES IN THE VISTULA LAGOON, POLAND*

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ABSTRACT. A total of 2398 fish specimens (1091 Percidae and 1307 Cyprinidae) belonging to 16 species (3 Percidae and 13 Cyprinidae), caught in the Polish part of the Vistula Lagoon were examined within December 1994-March 1997. The parasites found were identified as belonging to 63 taxa (61 species as well as *Diplostomum* spp. flukes and glochidia Unionidae gen. sp. which could not be identified to species) of the Microsporea (1), Protozoa (1), Myxozoa (2), Monogenea (10), Digenea (15), Cestoda (11), Nematoda (11), Acanthocephala (5), Hirudinea (1), Mollusca (1), Copepoda (4), and Branchiura (1). The percids and cyprinids were found to support 37 and 40 parasitic taxa, respectively, the taxon-richest parasite fauna occurring in zander, *Sander lucioperca* (26 taxa), followed by carp bream, *Abramis brama* (24), European perch, *Perca fluviatilis* (24), roach, *Rutilus rutilus* (19), ruffe, *Gymnocephalus cernuus* (15), and Prussian carp, *Carassius gibelio* (11). The remaining fish species hosted less than 10 parasitic species each. Metacercariae of the genus *Diplostomum*, found in about 37% of the fish examined, and *Tylodelphys clavata*, recorded in about 24% of the fish, proved the commonest parasites. The study showed the Vistula Lagoon cyprinid and percid parasite fauna to be dominated by freshwater species, frequencies of their occurrence in the brackishwater lagoon being lower than those in freshwater reservoirs. Frequencies of the 6 marine parasitic species found in the lagoon were, too, lower than those in the sea. It is suggested that some of the parasites (*Ancyrocephalus paradoxus*, *Diplozoon paradoxum* of the Monogenea, *Diplostomum* spp., *Tylodelphys clavata* of the Digenea, and *Achtheres percarum* of the Copepoda) prefer brackishwater habitats.

Key words: Cyprinidae, parasites, Percidae, Vistula Lagoon.

INTRODUCTION

The knowledge on fish parasites in the Vistula Lagoon, both in the Polish and in the Russian parts, is fragmentary at best. Fish parasites in the area were first mentioned in 1844 by Zaddach who reported on the occurrence of the copepod

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Ergasilus gibbus in eel. Wegener (1909) described ectoparasites of a few fish species in East Prussia, including the Vistula Lagoon. The research carried out later on in the Polish part of the lagoon was restricted to selected taxonomic groups, or even species, of parasites. Prost (1959) studied monogeneans, while Grabda (1956, 1962) as well as Grabda and Grabda (1959) focused on copepods. Few papers only deals with digeneans of trout (Ślusarski 1958a, b, c) and helminths of herring (Szostakowska and Sulgostowska 2001). Recently, a study has been undertaken on the occurrence of anisakid nematodes (Myjak et al. 1996, Rolbiecki and Rokicki 2002) and *Anguillicola crassus* (Rolbiecki et al. 1996; Własow et al. 1996, 1997, 1998; Rokicki et al. 2002). In addition, the question of black cormorant's effects on fish parasites in the Vistula Lagoon has been taken up (Własow et al. 1996, 1997). The studies in the Russian part of the lagoon, in the Kaliningrad Lagoon, were scarce as well. Some authors dealt with the Myxozoa in fish (Evdokimova et al. 1994, 1996; Zaostrovceva 1996; Grudnev 1998), while others studied parasitic faunas of selected fish species (Gaevskaja and Zhudova 1979, Evdokimova et al. 1989, Zaostrovceva 1993, Evdokimova et al. 1994, Rodjuk and Shuhgalter 1998).

It is, however, worth mentioning that earlier studies were often limited, at most, to several fish specimens of a species. Some of the data (Własow et al. 1996, 1997, 1998) were obtained from fish regurgitated by the cormorants dwelling in a breeding colony at Kąty Rybackie on the Vistula Lagoon. One could not be absolutely certain, however, that the birds had been feeding only in the lagoon or that they had not used other areas as their feeding grounds as well, e.g., the Gulf of Gdańsk or Lake Drużno where the structure of the parasite fauna may differ from that in the Lagoon. Some autors did not specify which fish species were infected (e.g. Evdokimova et al. 1996). Next some studies lack data on parasite frequency, or else the data are reported jointly, without separating the fish examined into those obtained from the Vistula Lagoon and from other water bodies (e.g. Wegener 1909).

The Cyprinidae and Percidae are the species-richest families in the Vistula Lagoon and play an important role in the lagoon's ecosystem. For this reason, it seems important that the knowledge on the parasite fauna (mainly the poorly known Digenea, Cestoda, Nematoda, and Acanthocephala) of the fish belonging to those families be as complete as possible. Also, information on parasites of the remaining fish species, less common in the lagoon and not studied in this respect so far, is highly desirable.

MATERIALS AND METHODS

General characteristics of the Vistula Lagoon cyprinids and percids

The Vistula Lagoon fish fauna comprises 40 species; 23 of them show preference to fresh water, 5 species are migratory, and 12 are marine. The lagoon's cyprinids and percids include species that are valuable for both commercial and conservational (protected species) reasons. The percids include zander (*Sander lucioperca)*, European perch (*Perca fluviatilis*), ziege *Pelecus Cultrens* and ruffe (*Gymnocephalus cernuus*), while the cyprinids consist of carp bream (*Abramis brama*), roach (*Rutilus rutilus*), Prussian carp (*Carassius gibelio*), rudd (*Scardinius erythrophthalmus*), bleak (*Alburnus alburnus*), ziege (*Pelecus cultratus*), gudgeon (*Gobio gobio*), tench (*Tinca tinca*), white bream (*Abramis bjoerkna*), common carp, wild carp (*Cyprinus carpio carpio*), asp (*Aspius aspius*), Baltic vimba (*Vimba vimba*), ide (*Leuciscus idus*), common dace (*Leuciscus leuciscus*), and belica (*Leucaspius delineatus*). The most important commercially are zander, carp bream, European perch, and roach, while ziege is moderately important. The numerically dominant species are roach, carp bream, and ruffe which, taken together, account for more than 70% of all the fish fauna. European perch, zander, ziege, and Prussian carp are less abundant, while the remaining species occur sporadically (Lugovaja 1992, Borowski and Dąbrowski 1996).

The present study involved all the percid species mentioned as well as the cyprinids with the exception of wild carp, gudgeon, and sunbleak (Table 1).

Table 1. List of cyprinid and percid species examined

Fish species	No. of fish	Length range [cm]	Weight range [g]
Rutilus rutilus, roach	389	10-32.5	15-535
Abramis brama, carp bream	376	9-59.2	5-3800
Pelecus cultratus, ziege	322	15.5-44	23-740
Carassius gibelio, Prussian carp	101	10-33	20-770
Tinca tinca, tench	39	13.8-27	50-320
Abramis bjoerkna, white bream	31	20-32.2	100-550
Alburnus alburnus, bleak	29	11.5-15	15-29
Aspius aspius, asp	7	28-36.5	140-440
Vimba vimba, Baltic vimba	5	25-26	155-200
Scardinius erythrophthalmus, rudd	4	19-25	98-200
Cyprinus carpio carpio, common carp	2	16	143-154
Leuciscus leuciscus, common dace	1	16	40
Leuciscus idus, ide	1	32	480
Sander luciopercae, zander	390	6.5-72	5-4700
Perca fluviatilis, European perch	371	11.7-31	15-800
Gymnocephalus cernuus, ruffe	330	6.5-18	5-70

Description of the Vistula Lagoon

According to the physiographic division of Poland, the Vistula Lagoon is situated within the southern Baltic coastal area (Kondracki 1994). The lagoon is an elongated and narrow, rectilinear body of water, 90.7 km long and up to 13 km wide. The lagoon's mean and maximum depths are 2.6 and 5.1 m, respectively. The lagoon and its neighbourhood is intersected by the state border between Poland and Russia. The border runs across the lagoon about 1 km north of the Pasłęka River delta. A characteristic area within the Russian part of the lagoon is the Kaliningrad Lagoon situated near the city of Kaliningrad. The lagoon connects with the Baltic Sea off Baltiysk *via* the Pilawa Strait. The lagoon receives runoff from numerous rivers, including the Pregola, Vistula (*via* Nogat), Pasłęka, and Elbląg. The Vistula Lagoon's salinity is determined by the river discharge; the salinity changes from 0.5‰ in the western part and in the Kalinigrad Lagoon area to more that 6‰ in the mid-eastern part (Łomniewski 1958, Łazarenko and Majewski 1975, Berenbejm 1992).

Ichthyological and parasitological analyses

The study was carried out within December 1994-March 1997. The prolonged winter of 1995/1996 precluded collection of data. The fishes to be examined were obtained from landings delivered to Tolkmicko by fishermen who operated zander-bream gill nets and traps in eight fishing grounds within the Polish part of the lagoon. The fish were examined within 3-10 h after capture.

A total of 2398 specimens of fish belonging to 2 families and 16 species (Table 1) were examined.

The study focused predominantly on the Metazoa; some Protozoa, Myxozoa and Microsporea were included as well. Parasites were looked for on the skin, fins, in the mouth cavity, gills, eyes, body cavity, and internal organs. Myxozoan and microsporean cysts collected were placed in 70% ethanol. Metazoans were fixed in a 19:1 glacial acetic acid-formalin mixture and preserved in 70% alcohol.

The parasites collected were mounted temporally or permanently. The Myxozoa and Microsporea were embedded in glycero-gelatin. Similarly, nematodes, crustaceans, and some monogeneas were embedded in glycero-gelatin after clearing in lactophenol (Rolbiecki 2002a). Flukes, tapeworms, and acanthocephalans were stained in Gower's acetic carmine, dehydrated in the alcohol series or in the glacial acetic acid, and cleared in creosote or benzyl alcohol. Leeches were treated similarly to helminths, except for the staining stage which was omitted. Some helminths were permanently mounted in Canada balsam, while others were left in creosote, benzyl alcohol, or in ethyl alcohol. The prevalence data were tested for statistical significance of differences with the Pearson chi square test, while the mean intensities were subjected to the analysis of variance (ANOVA). The tests were run with the SPSS v. 7.0 for Windows software.

RESULTS

The fish were found to act as hosts to 61 parasitic species and to flukes *Diplostomum* spp. and glochidia Unionidae gen. sp. The cyprinids harboured 40 and the percids 37 species, *Diplostomum* spp. and Unionidae occurring in both families (Table 2).

Microsporea

Glugea acerinae Jirovec, 1930: the cysts were recorded in summer 1995 in the intestines of two ruffe specimens (Table 18).

Myxozoa

Myxobolus muelleri Bütschli, 1882: found on gills of carp bream and roach (Tables 3, 4); they occurred in spring (25 cysts in roach and 200 cysts in bream) and in summer (20 cysts in roach and 99 cysts in bream) (in bream $p < 0.001$ for prevalence and $p < 0.01$ for mean intensity).

Henneguya psorospermica Thélohan, 1895: cysts were found on gills of European perch (Table 17). A significant correlation was observed between the infection level and season ($p < 0.001$), the highest prevalence being observed in spring, while the intensity in autumn and spring (Fig. 1).

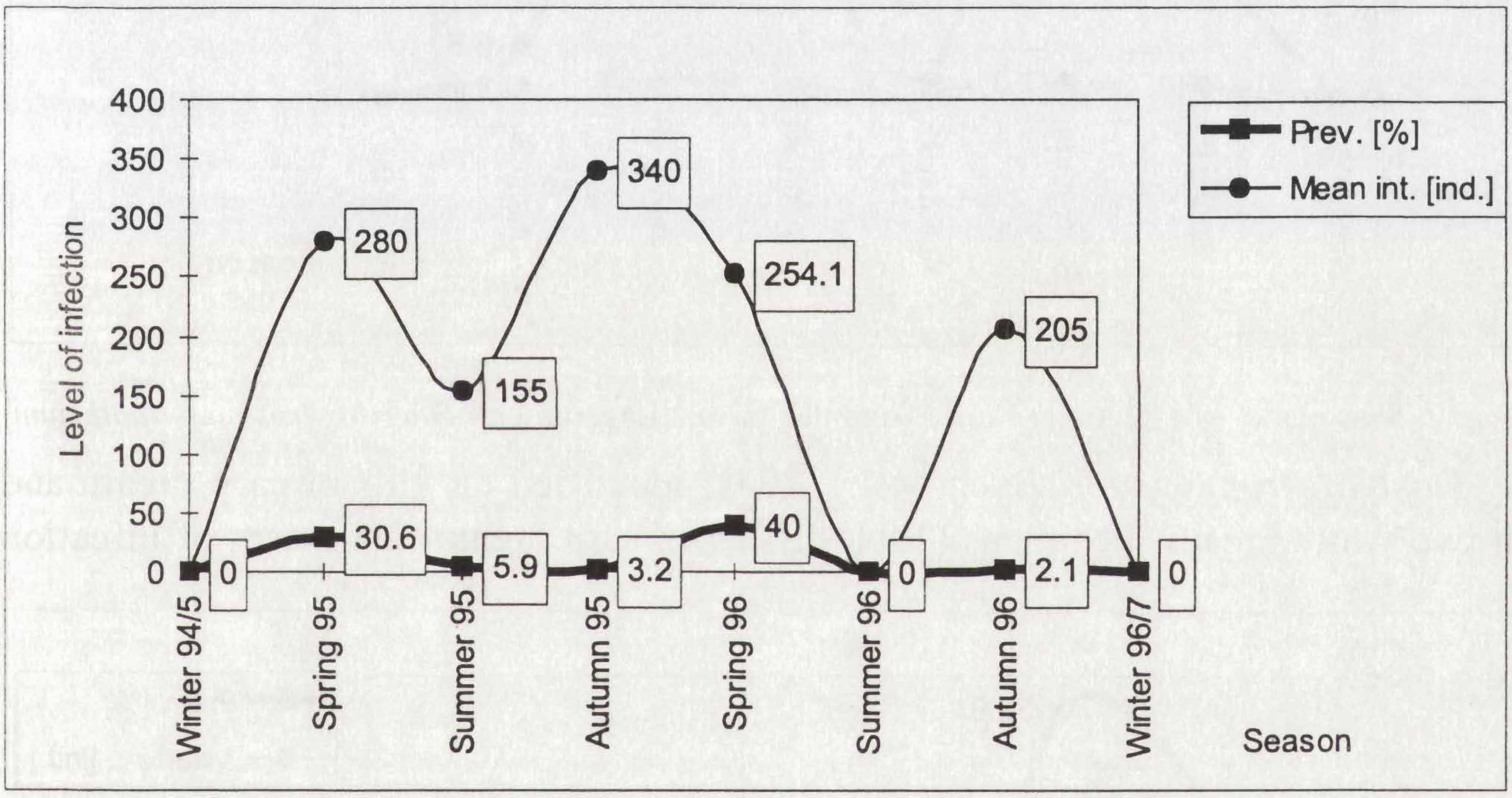

Fig. 1. Seasonality of infection of European perch from the Vistula Lagoon with *Henneguya psorospermica*

Protozoa

Ichthyophthirius multifiliis Fouquet, 1876: revealed on gills of common carp in early March 1997 (Table 12).

Monogenea

Dactylogyrus vastator Nybelin, 1924: found on gills of Prussian carp (Table 5); recorded only in spring (22 specimens) and autumn (18) ($p < 0.001$ for mean intensity).

Dactylogyrus vistulae Prost, 1957: found on gills of roach (Table 4) in summer (69 specimens) spring (63), and autumn (2).

Dactylogyrus extensus Mueller et Van Cleave, 1932: found in early March 1997 on gills of two common carp specimens (Table 12).

Dactylogyrus amphibothrium Wagener, 1857: collected from gills of ruffe (Table 18). The occurrence of the parasites was observed to be season-dependent ($p < 0.001$); the highest infection level being in summer (Fig. 2).

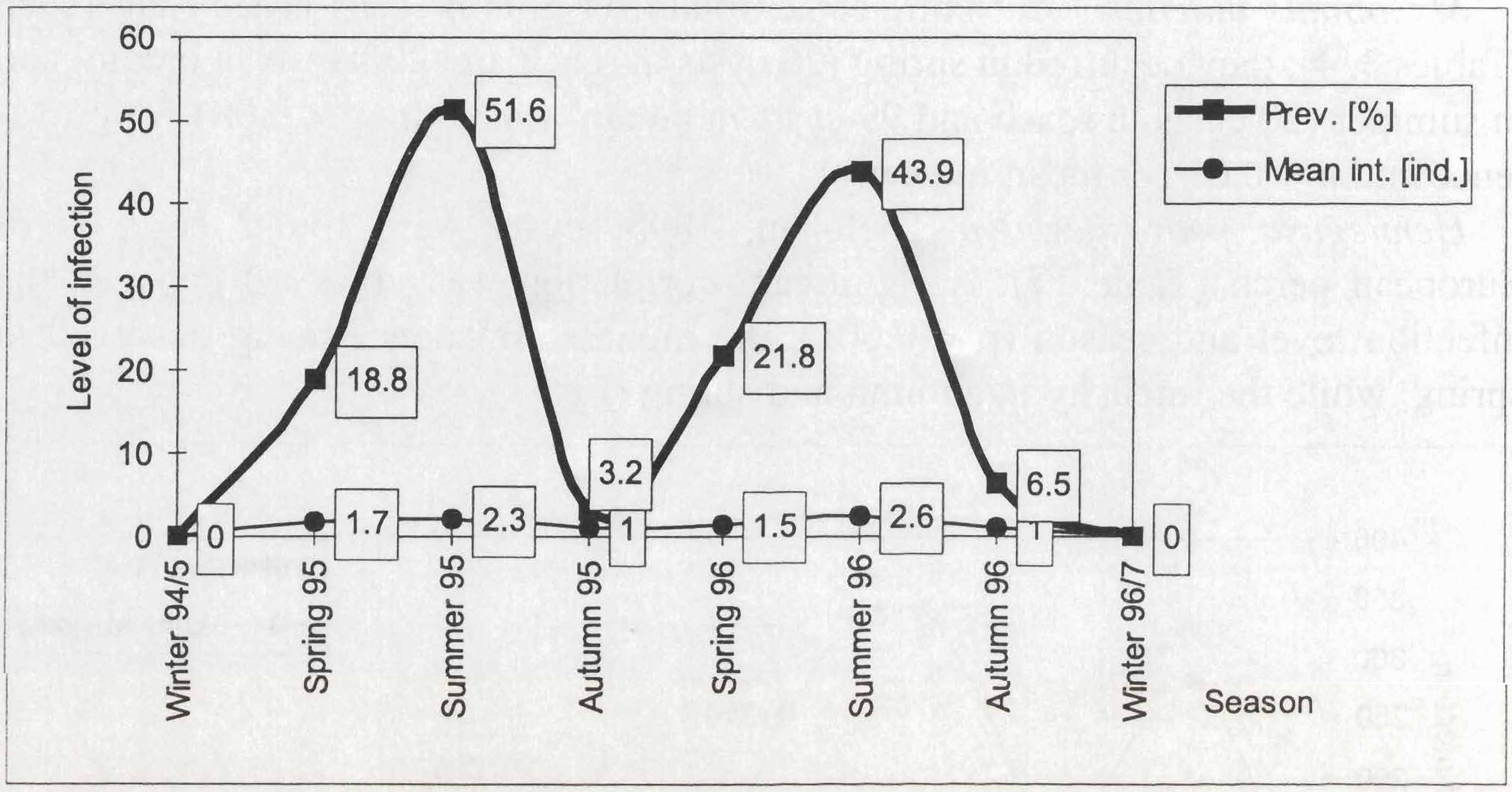

Fig. 2. Seasonality of infection of ruffe from the Vistula Lagoon with *Dactylogyrus amphibothrium*

Dactylogyrus wunderi Bychowsky, 1931: identified on gills of carp bream and in two white bream specimens (Tables 3, 7); in carp bream, the extent of infection

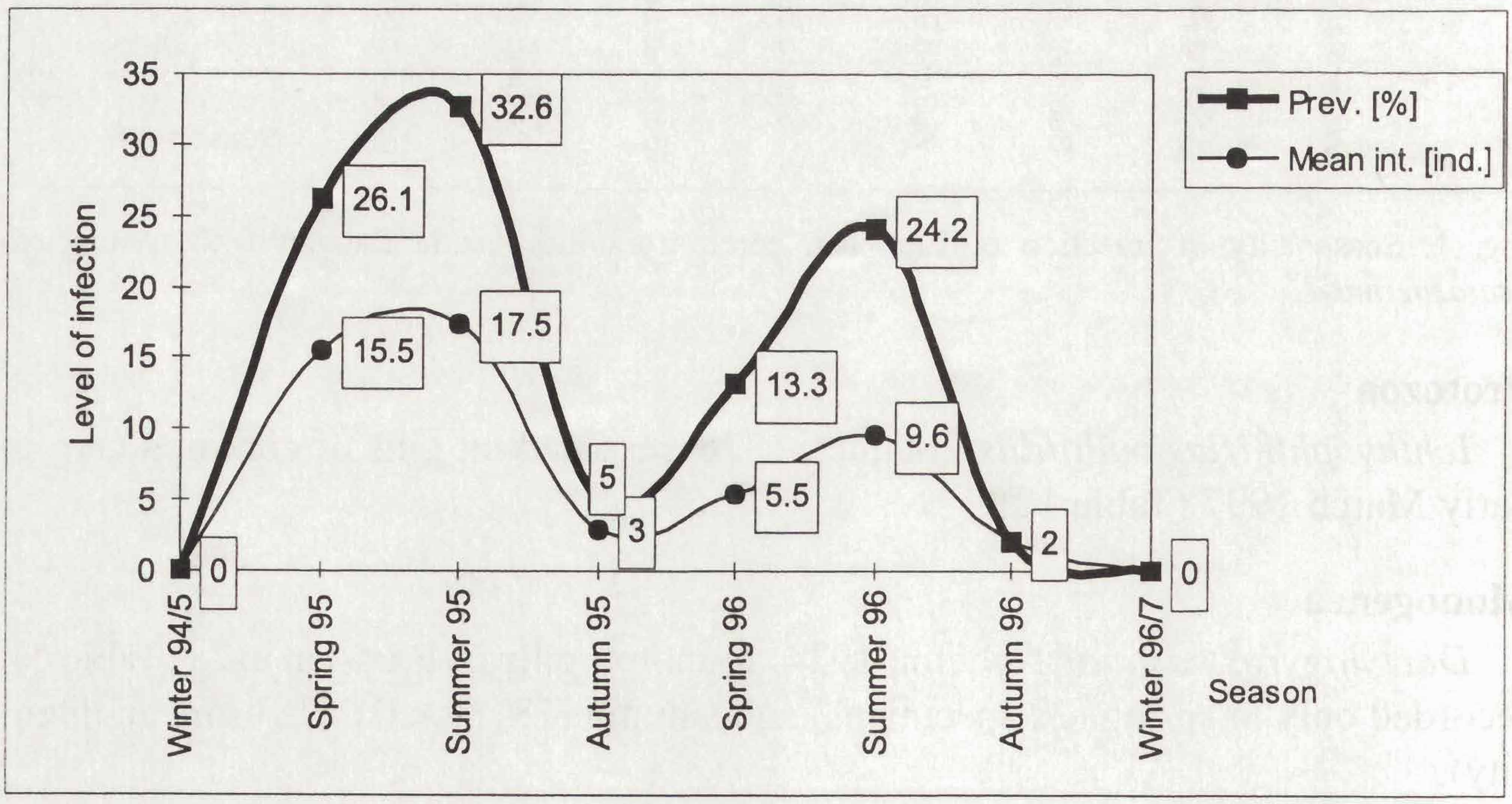

Fig. 3. Seasonality of infection of carp bream from the Vistula Lagoon with *Dactylogyrus wunderi*

was found to be season-dependent ($p < 0.001$), the highest infection level being observed in summer (Fig. 3).

Dactylogyrus crucifer Wagener, 1857: found in roach only (Table 4); the infection level varied from season to season, the highest infection being recorded in spring and summer (prevalence only, $p < 0.001$) (Fig. 4).

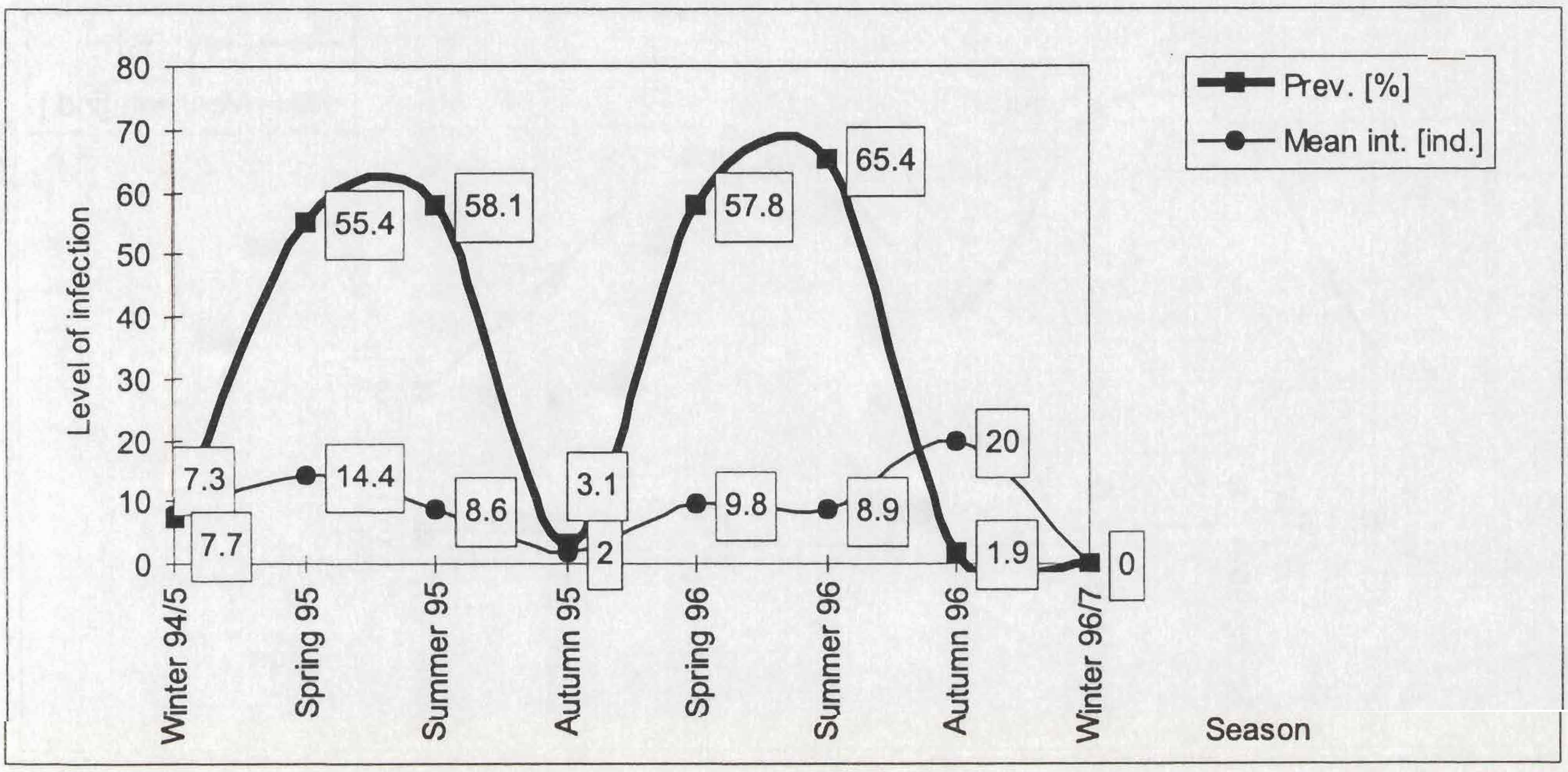

Fig. 4. Seasonality of infection of roach from the Vistula Lagoon with *Dactylogyrus crucifer*

Ancyrocephalus paradoxus Creplin, 1839: collected from gills of zander (Table 16). The highest infection prevalence and mean intensity were recorded in summer; lower values were observed in spring and autumn, the lowest prevalence and mean infection intensity being typical of winter ($p < 0.001$) (Fig. 5). The majority of parasites (90.5%) were located on the gill filaments of the fold of the fourth arch.

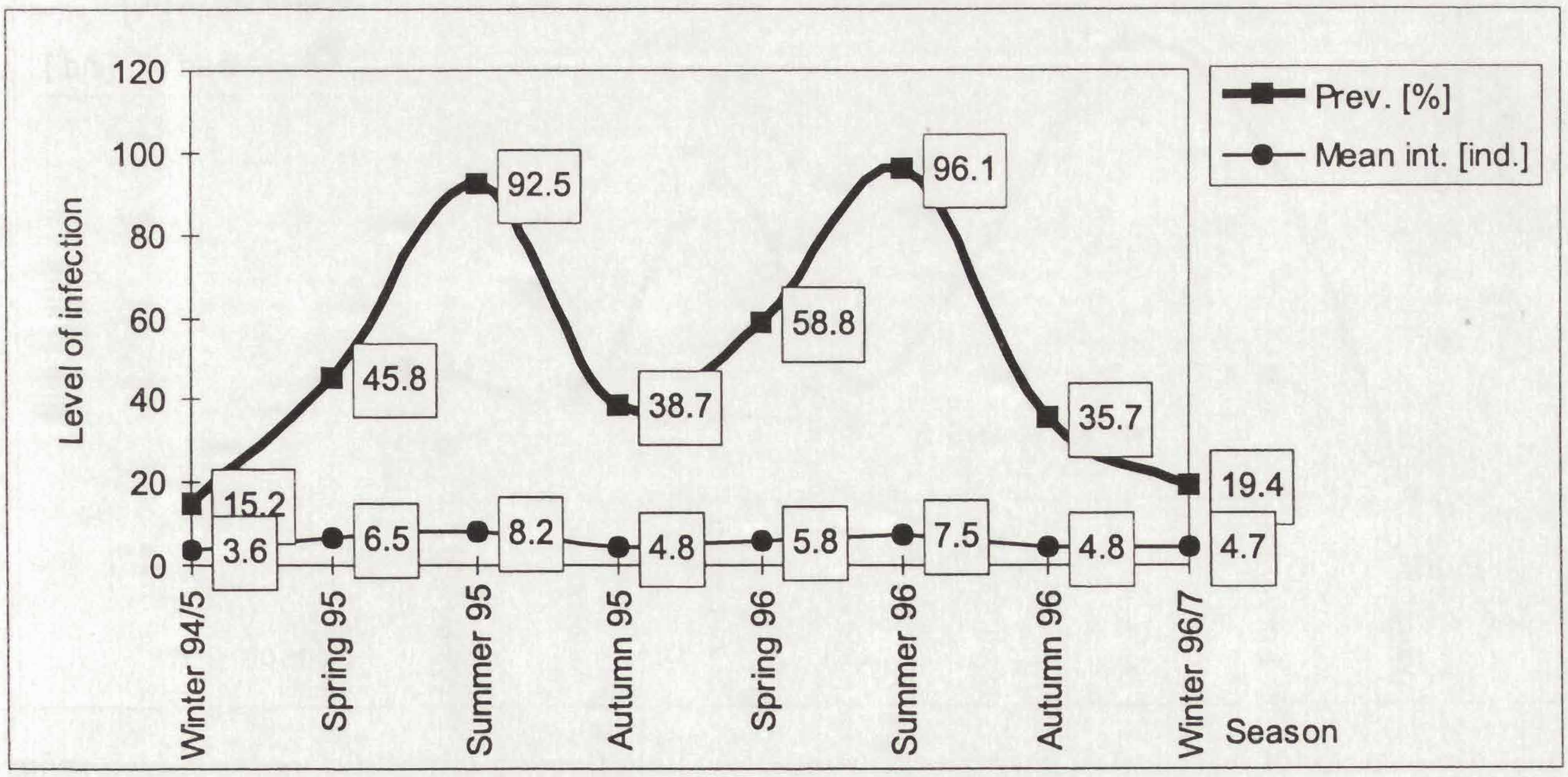

Fig. 5. Seasonality of infection of zander from the Vistula Lagoon with *Ancyrocephalus paradoxus*

Paradiplozoon rutili (Gläser, 1967): found only in spring (21 specimens) and summer (5) on gills of roach (Table 4).

Paradiplozoon bliccae (Reichenbach-Klinke, 1961): a single Baltic vimba caught in summer 1996 was a host to two parasites (Table 11).

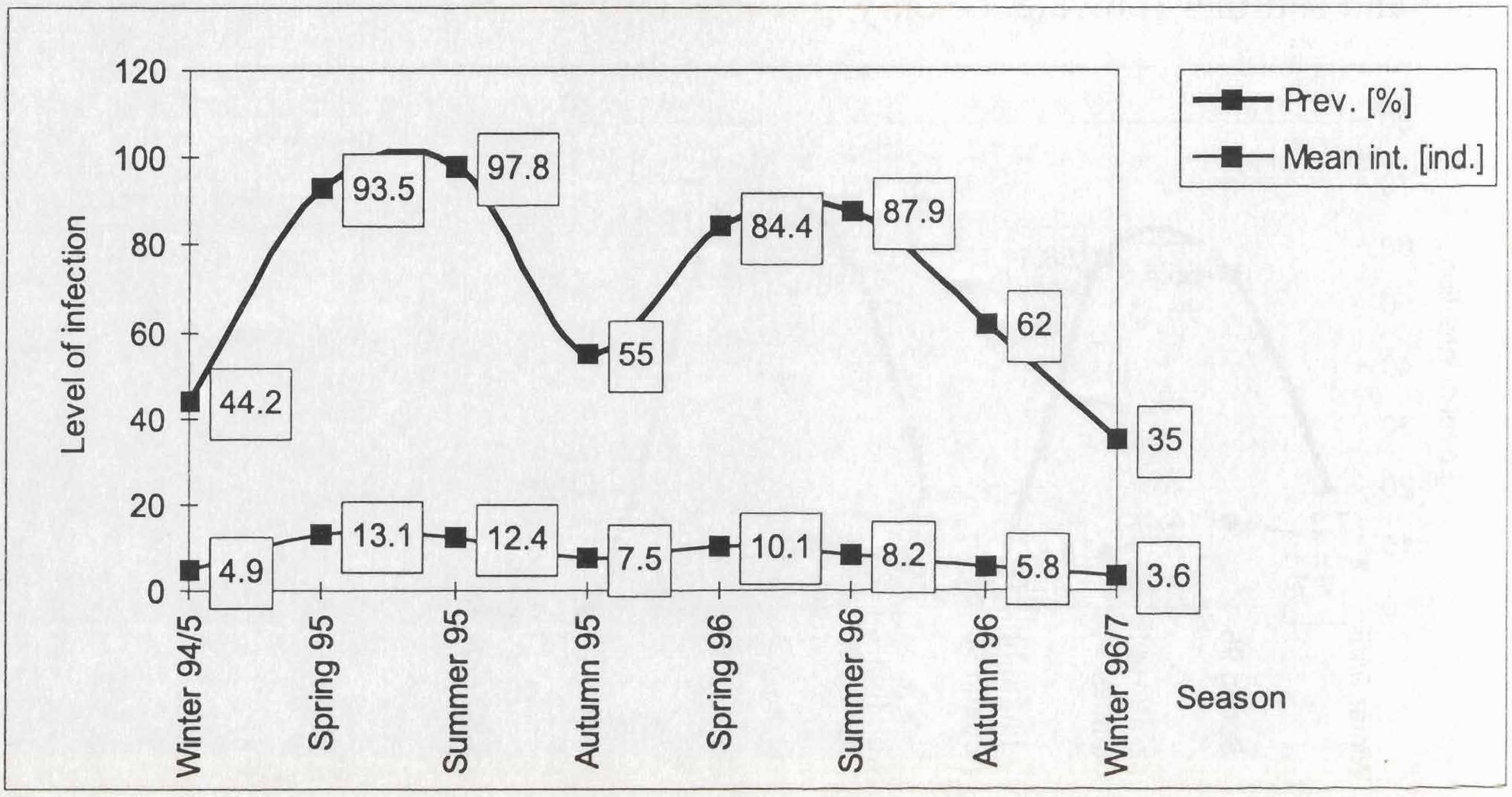

Fig. 6. Seasonality of infection of carp bream from the Vistula Lagoon with *Diplozoon paradoxum*

Diplozoon paradoxum Nordmann, 1832: occurred in carp bream, roach, Prussian carp, and white bream (Tables 3-5, 7). The parasites were most frequent in carp bream and sporadic in other species. A correlation between the level of carp bream

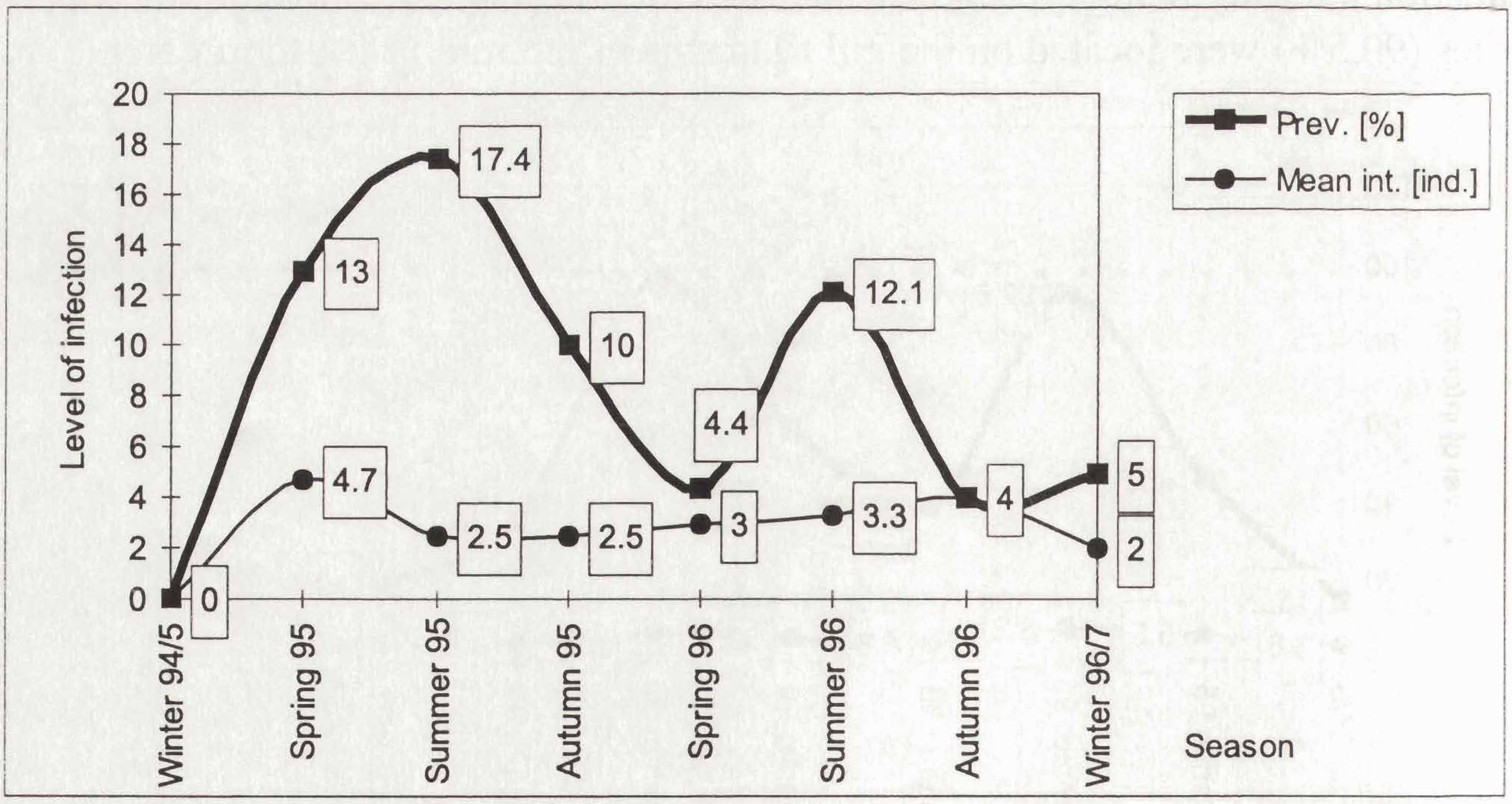

Fig. 7. Seasonality of infection of carp bream from the Vistula Lagoon with *Bucephalus polymorphus* metacercariae

infection and season was observed. The highest values were recorded in spring and summer, the lowest ones being typical of winter ($p < 0.001$) (Fig. 6).

Digenea

Bucephalus polymorphus Baer, 1827

Metacercariae: collected from fins and gill lamellae of carp bream, roach, white bream, and Prussian carp (Tables 3-5, 7). They were most frequent in carp bream and roach. Carp bream showed a significant correlation ($p < 0.05$) between infection prevalence and season (the highest in summer); no significant differences were found for the mean intensity (Fig. 7).

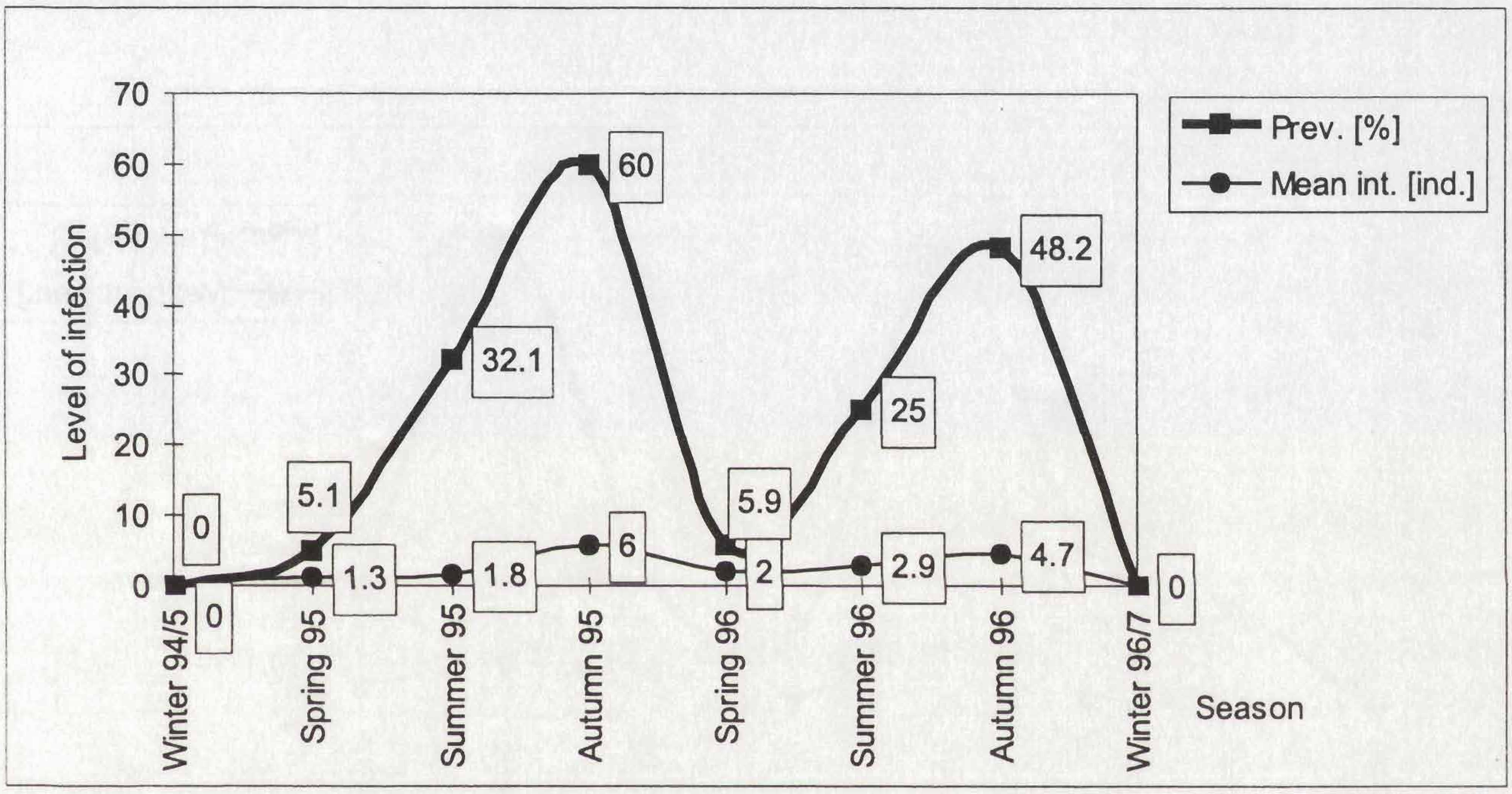

Fig. 8. Seasonality of infection of zander from the Vistula Lagoon with *Bucephalus polymorphus* adults

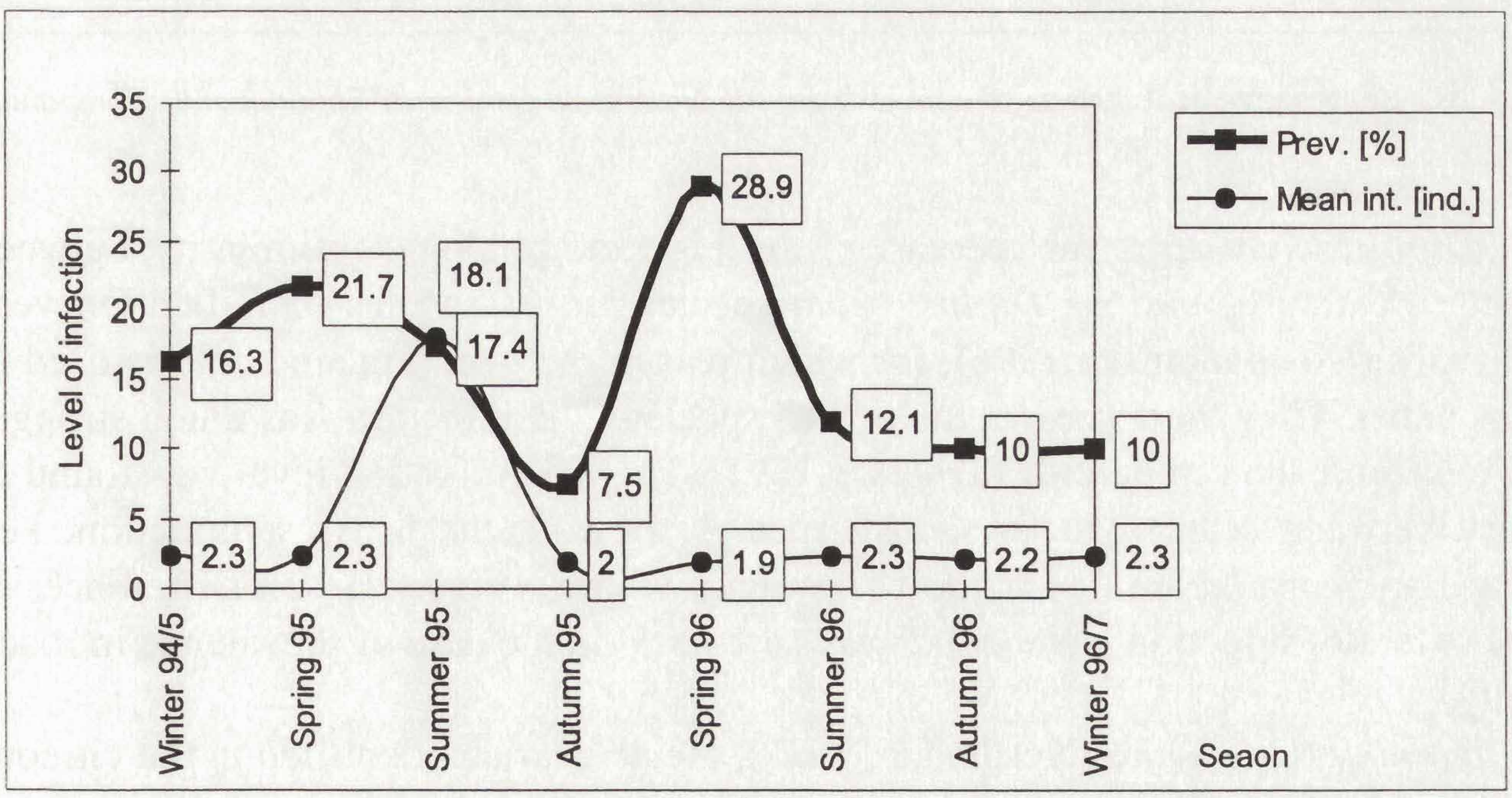

Fig. 9. Seasonality of infection of carp bream from the Vistula Lagoon with *Rhipidocotyle campanula* metacercariae

Adults: were found in the intestine and pyloric caeca of zander and European perch (Tables 16, 17). In zander, the fluke's occurrence was observed to be season-dependent ($p < 0.001$): the highest infection parameters were observed in autumn (Fig. 8).

Rhipidocotyle campanula (Dujardin, 1845)

Metacercariae: identified in the pectoral, ventral, and caudal fins of carp bream (Table 3). A correlation between the level of infection and season was observed (Fig. 9); the differences were significant in the case of prevalence only (the highest in spring) ($p < 0.05$).

Adults: recorded in the intestine and pyloric caeca of zander (Table 16). The flukes were most frequent in autumn ($p < 0.001$) (Fig. 10).

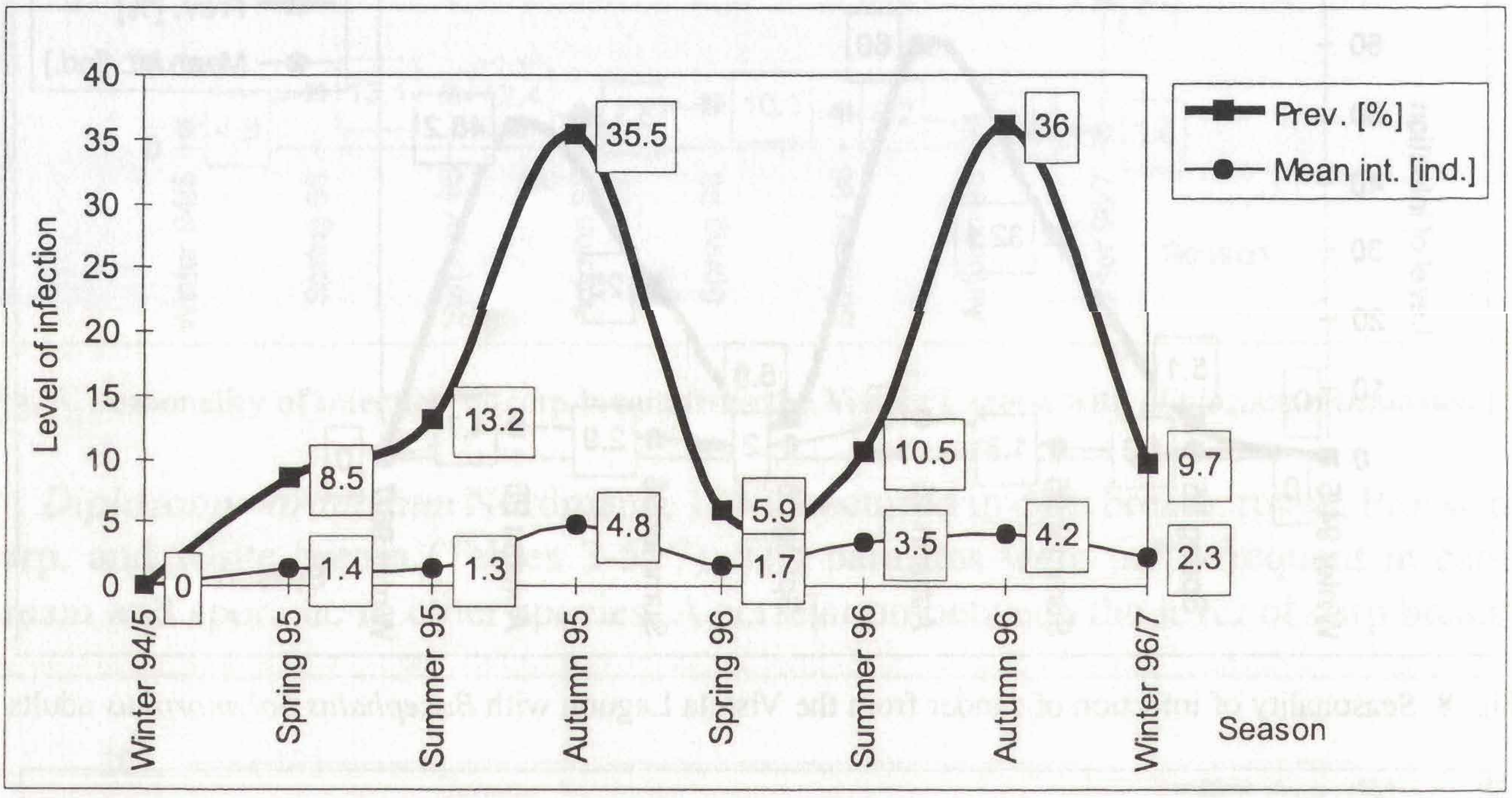

Fig. 10. Seasonality of infection of zander from the Vistula Lagoon with *Rhipidocotyle campanula* adults

Diplostomum spp., metacercariae: the high morphological similarity between metacercariae of various *Diplostomum* species makes species identification very difficult (Niewiadomska 1996), for which reason the generic name only is used in this paper. They were present in 15 fish species. The infection was much stronger in cyprinids than in percids (Tables 3-11, 13-18). The infection level was found to vary between seasons in those fish species showing the heaviest infection, i.e., roach and carp bream (the highest in autumn-winter) (Figs. 11, 12). Differences in the extent of infection were significant ($p < 0.05$) in the case of prevalence in roach only.

Tylodelphys clavata (Nordmann, 1832), metacercariae: identified in the vitreous body of 10 fish (Tables 3-5, 7-10, 16-18). The heaviest infection was that in roach

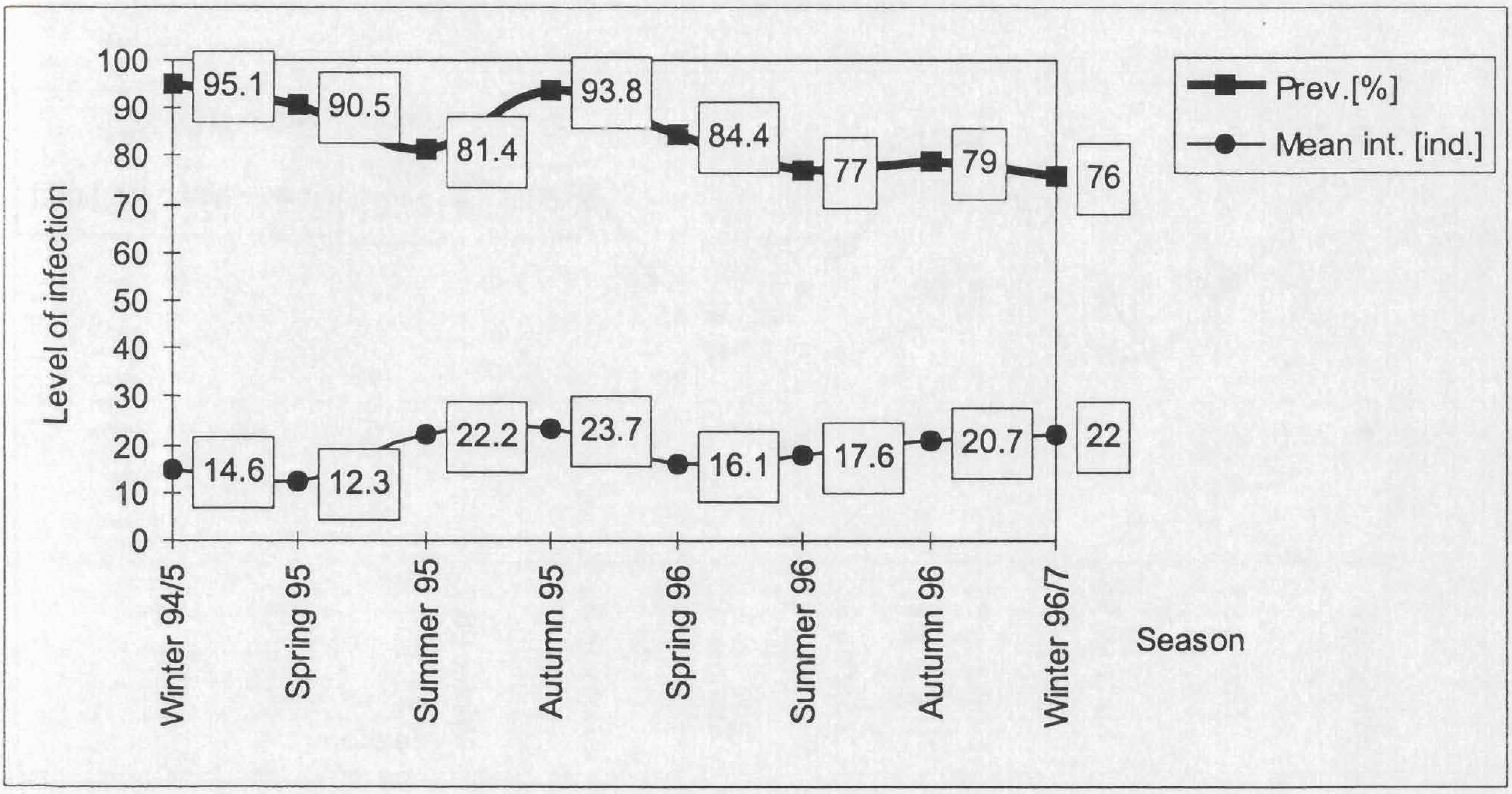

Fig. 11. Seasonality of infection of roach from the Vistula Lagoon with *Diplostomum* spp. metacercariae

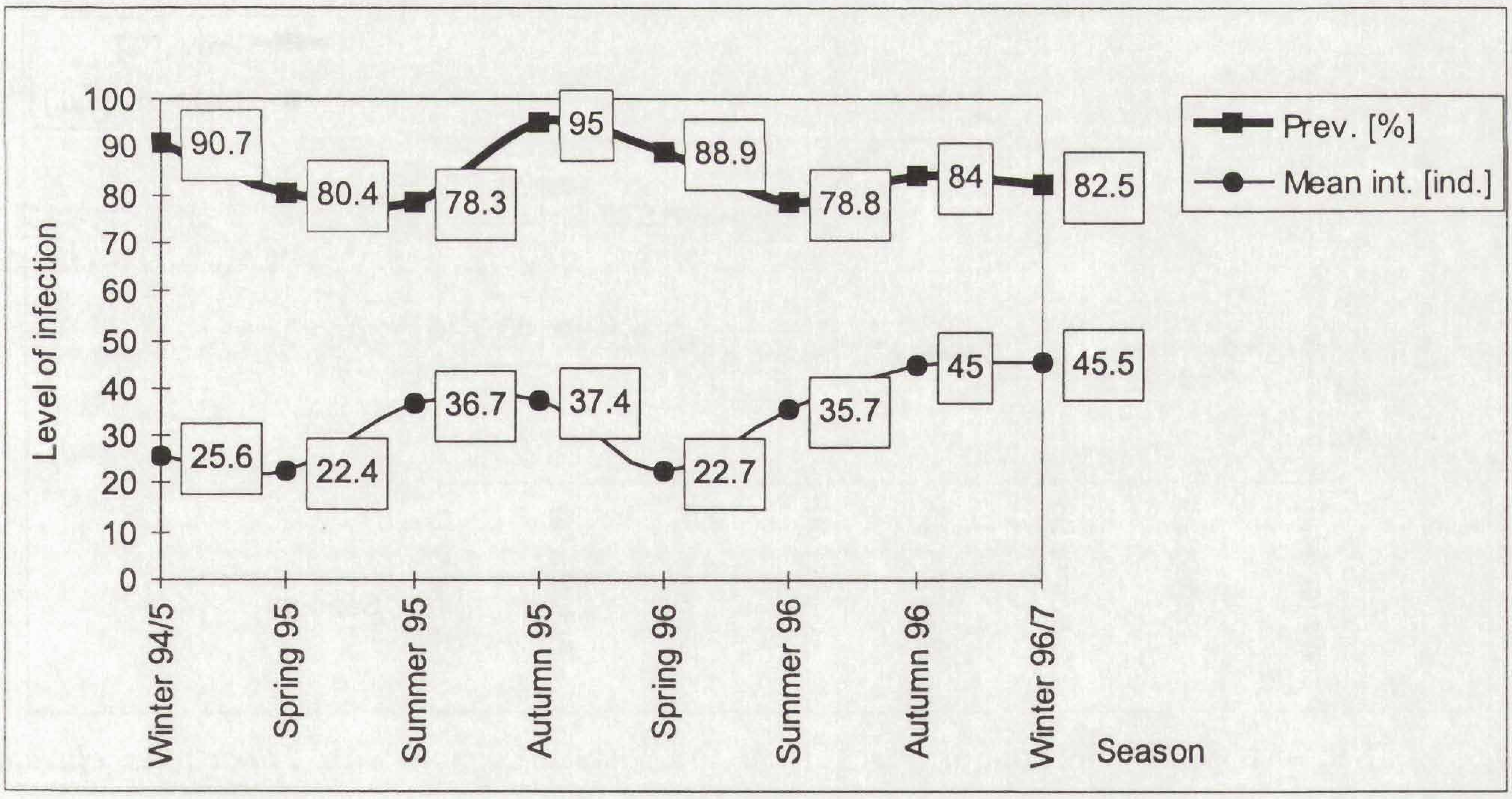

Fig. 12. Seasonality of infection of carp bream from the Vistula Lagoon with *Diplostomum* spp. metacercariae

and European perch. A significant correlation was found between infection parameters and season in European perch ($p < 0.001$) and roach (prevalence only; $p < 0.01$). The heaviest infection was typical of autumn-winter (Figs. 13, 14).

Posthodiplostomum cuticola (Nordmann, 1832), metacercariae: found in carp bream, roach, Prussian carp, ziege, white bream, and common dace, the heaviest infection being recorded in roach and carp bream (Tables 3-7, 14). The extent of

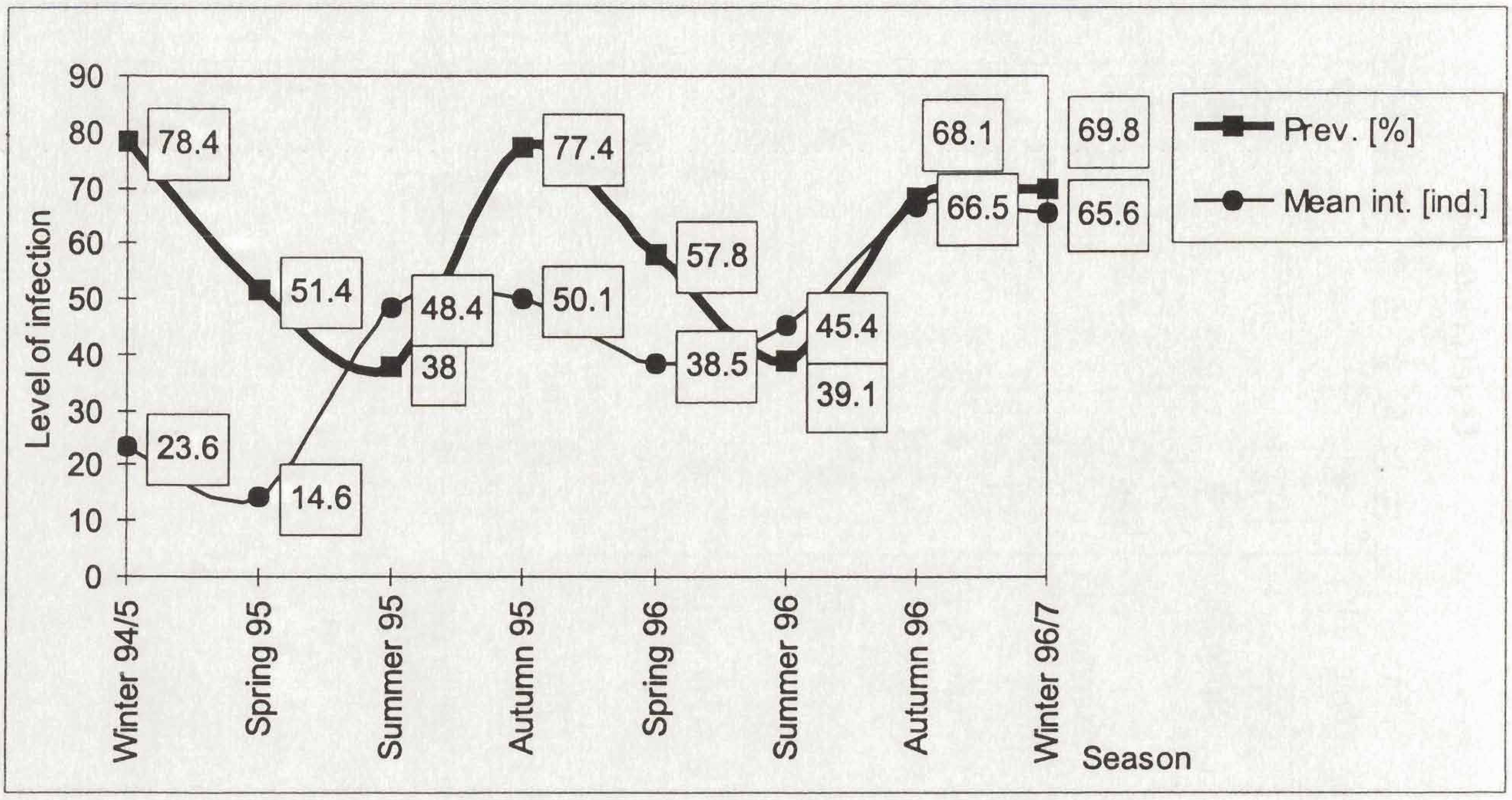

Fig. 13. Seasonality of infection of European perch from the Vistula Lagoon with *Tylodelphys clavata* metacercariae

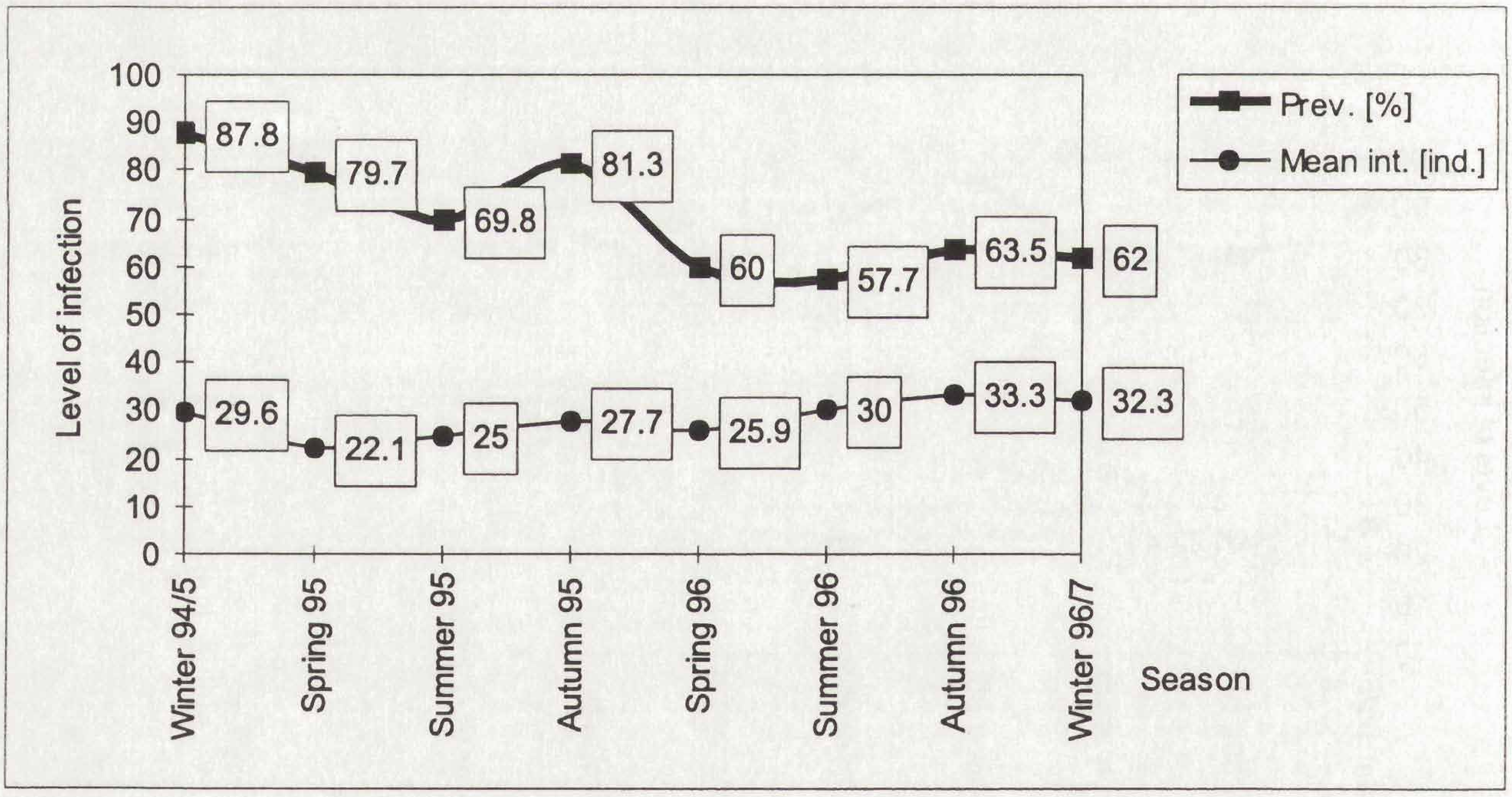

Fig. 14. Seasonality of infection of roach from the Vistula Lagoon with *Tylodelphys clavata* metacercariae

infection in carp bream and roach is presented in Figs. 15 and 16; the differences were significant in the case of prevalence only (the highest in summer) (bream: $p < 0.05$; roach: $p < 0.01$).

Posthodiplostomum brevicaudatum (Nordmann, 1832), metacerkariae: present in European perch (Table 17). They occurred only in spring and summer (40 specimens in each season).

Ichthyocotylurus platycephalus (Creplin, 1852), metacercariae: found in roach, carp bream, Baltic vimba, ide, zander, European perch, and ruffe (Tables 3, 4, 9, 11,

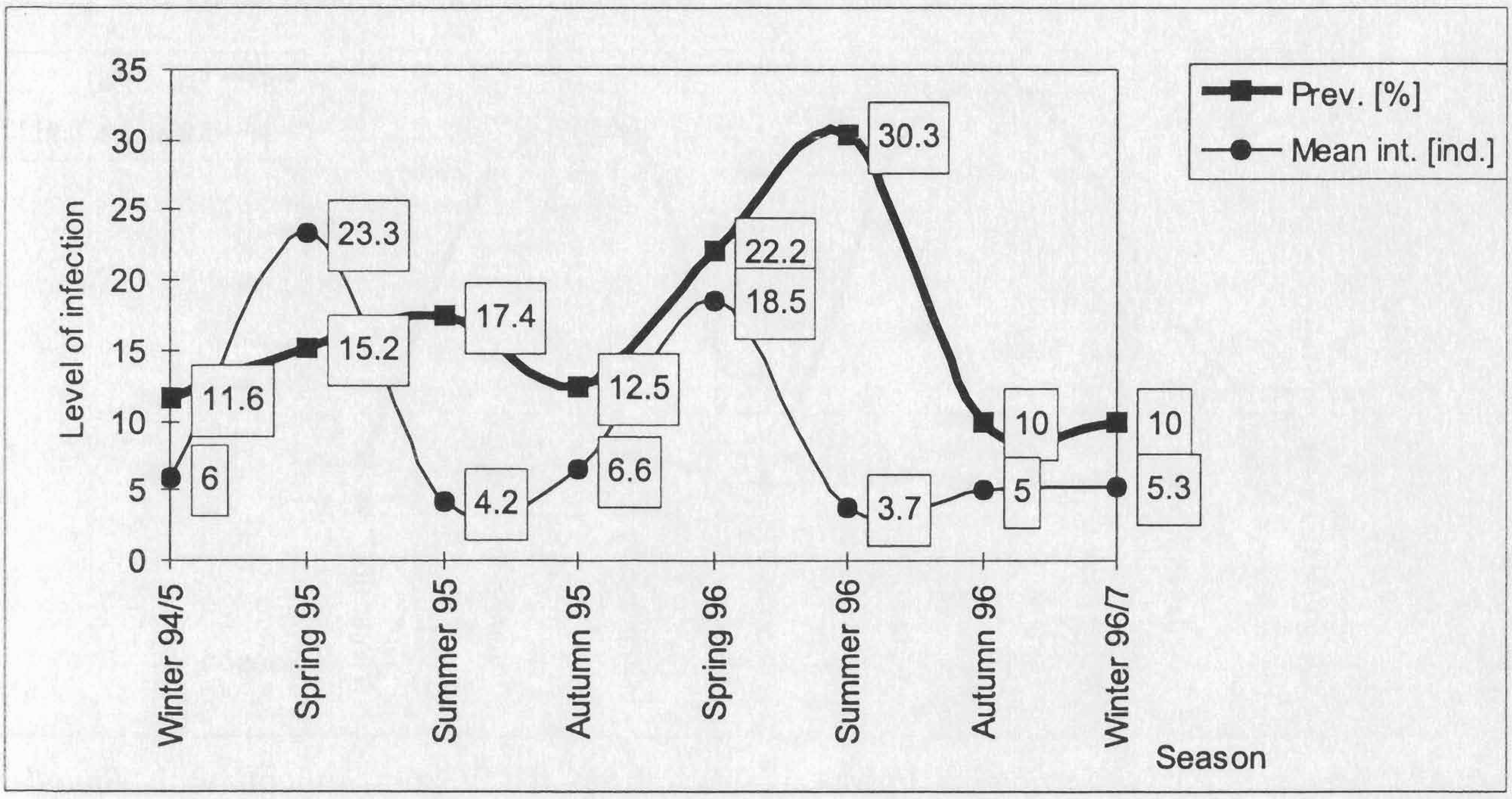

Fig. 15. Seasonality of infection of carp bream from the Vistula Lagoon with *Posthodiplostomum cuticola* metacercariae

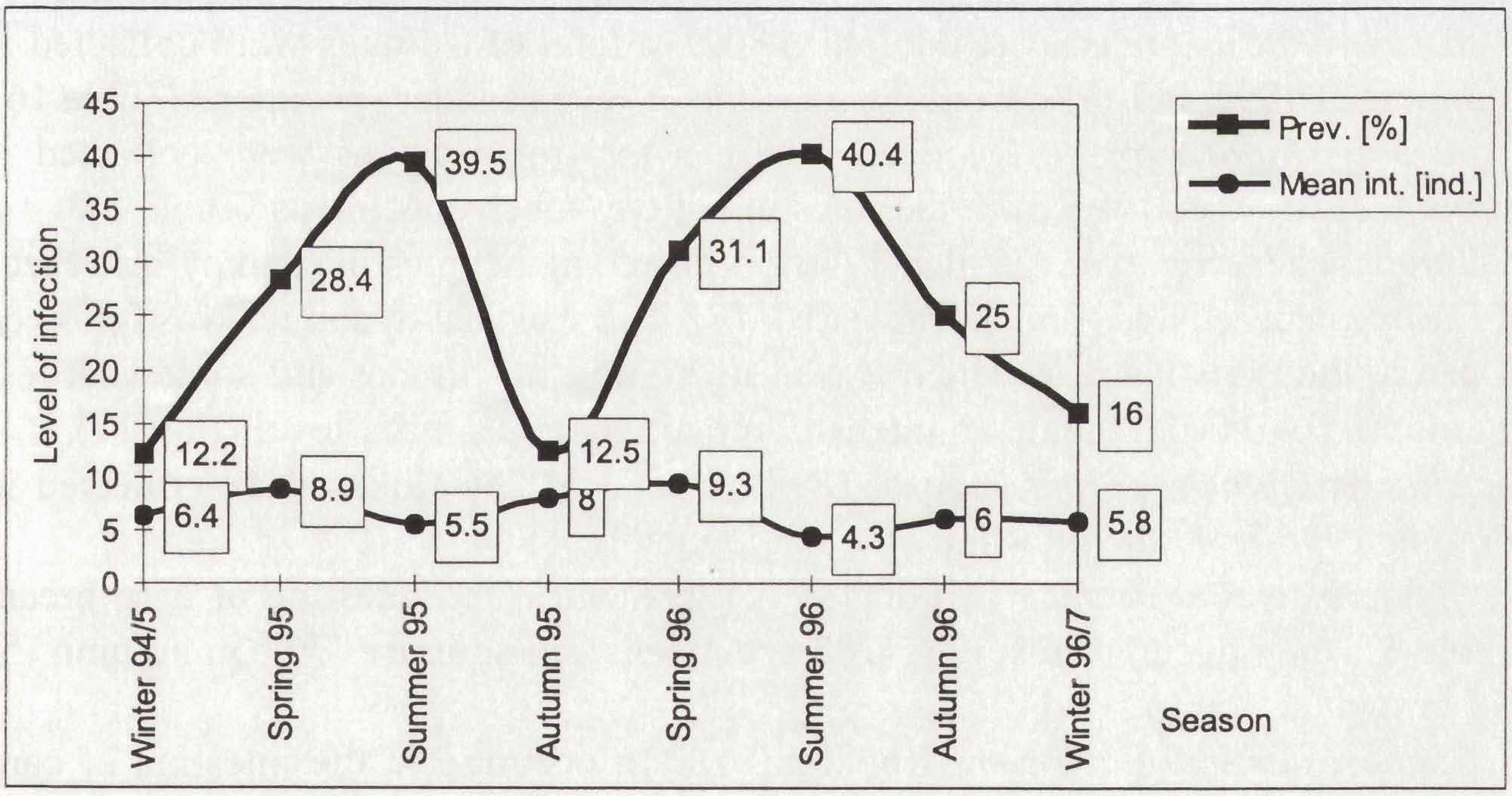

Fig. 16. Seasonality of infection of roach from the Vistula Lagoon with *Posthodiplostomum cuticola* metacercariae

16-18), the heaviest infection being typical of bream. The metacercariae were collected from fish gills (20 specimens), heart (27), kidney (12), liver (127), and intestinal mesentery (18). The metacercariae were found in winter (47 specimens), spring (36), summer (81), and autumn (40).

Ichthyocotylurus variegatus (Creplin, 1825), metacercariae: a total of 34 flukes were collected from livers of 14 European perch and 1 ruffe (Tables 17, 18) in spring (6 specimens), summer (21), and autumn (7).

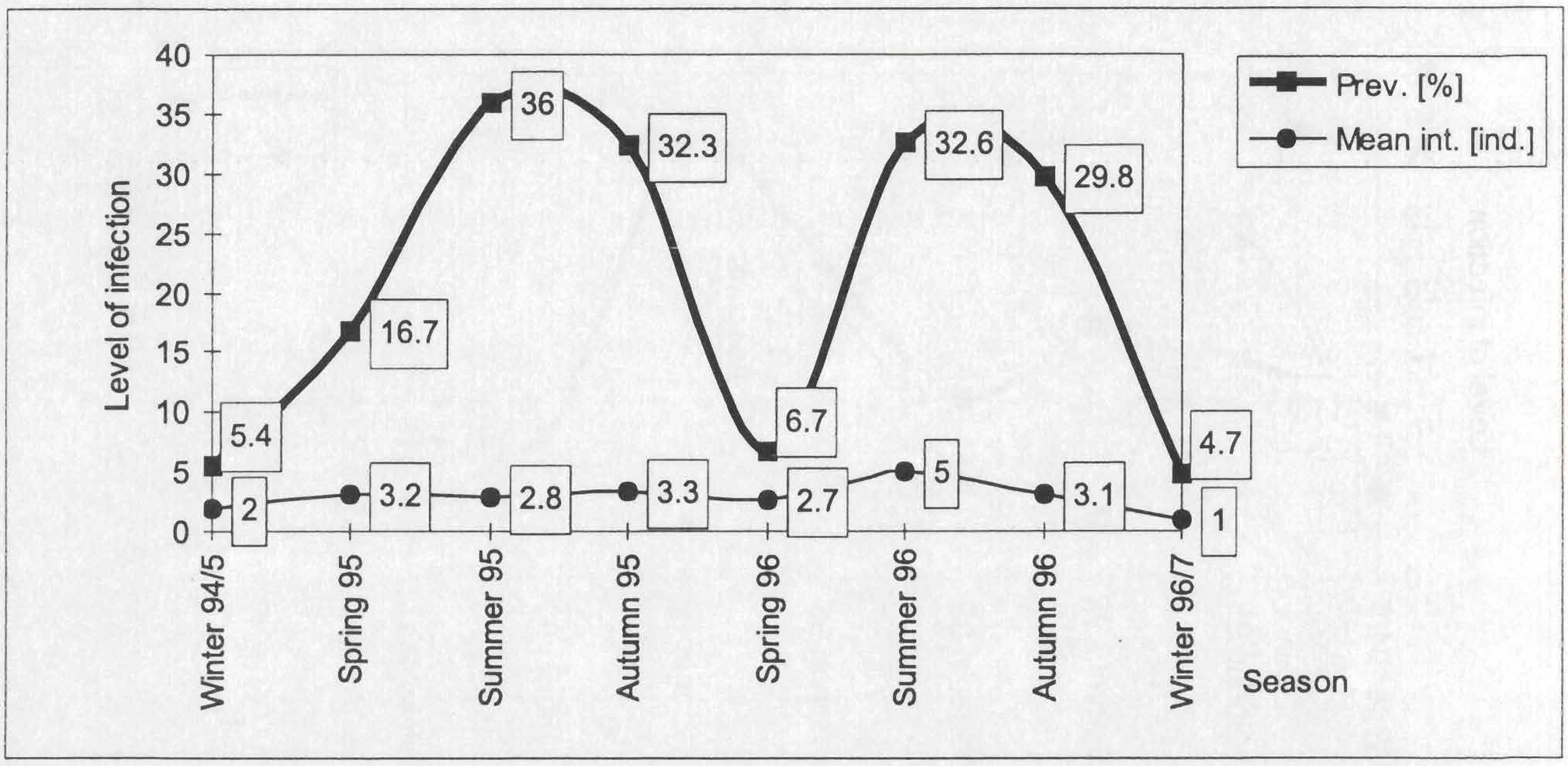

Fig. 17. Seasonality of infection of European perch from the Vistula Lagoon with *Bunodera luciopercae*

Apatemon annuligerum (Nordmann, 1832), metacercariae: found to occur in European perch (Table 17) in spring (48 specimens), summer (19), and autumn (4).

Brachyphallus crenatus (Rudolphi, 1802): a total of 8 flukes were collected in summers of 1995 and 1996 from the intestine of seven zander specimens (Table 16).

Asymphylodora tincae (Modeer, 1790): a total of 5 flukes were collected in spring and summer 1995 from the intestine of two tench specimens (Table 8).

Bunodera luciopercae (Müller, 1776): occurred in the intestine and pyloric caeca of European perch and zander (Tables 16, 17). The seasonal dynamics was followed in perch, the prevalence in which was at its highest in summer and somewhat less in autumn ($p<0.001$), the mean intensity remaining at a similar level (Fig. 17).

Allocreadium isoporum (Looss, 1894): a total of 256 flukes were collected in summer 1996 from the intestine of a single ide (Table 9).

Sphaerostomum bramae (Müller, 1776): present in the intestine of carp bream (Table 3); they occured in spring (108 specimens), in summer (76), in autumn (5) and in winter (15) ($p > 0.1$).

Sphaerostomum globiorum (Rudolphi, 1802): occurred in the intestine of carp bream (Table 3) and were collected in winter (2 specimens), spring (11) summer (12), and autumn (9).

Cestoda

Caryophyllaeus laticeps (Pallas, 1781): present in the intestine of carp bream, roach, Prussian carp, tench, and rudd (Tables 3-5, 8, 13). In bream, the parasite's occurrence showed seasonality manifested as the highest infection parameters in spring ($p < 0.001$ for prevalence and $p < 0.01$ for mean intensity) (Fig. 18).

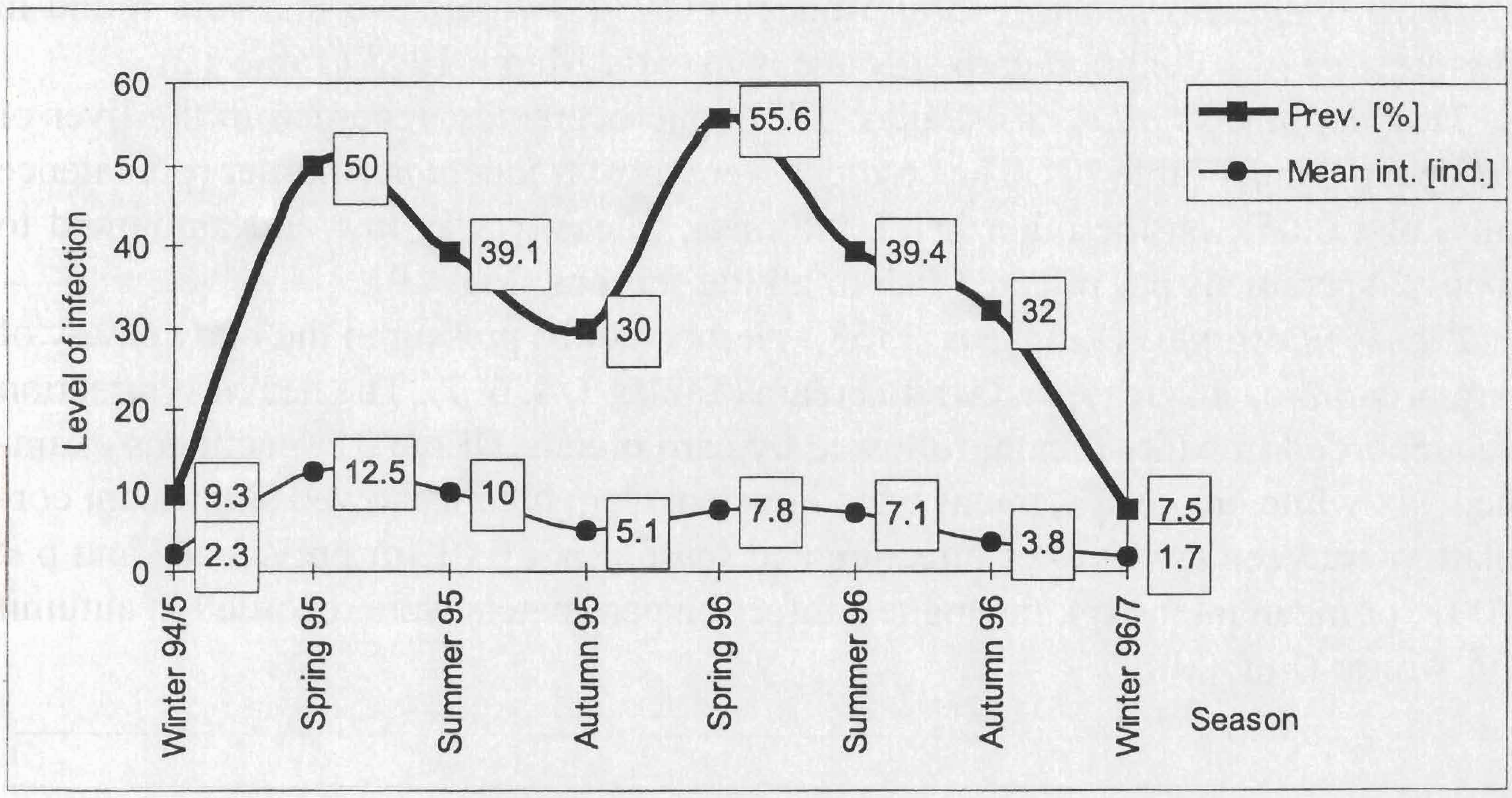

Fig. 18. Seasonality of infection of carp bream from the Vistula Lagoon with *Caryophylleus laticeps*

Caryophyllaeides fennica (Schneider, 1902): a total of 6 cestodes were found in spring 1995 and in summer 1996 in the intestine of 4 roach specimens (Table 4).

Eubothrium crassum (Bloch, 1779), plerocercoids: collected from the intestine of zander (winter 1994/95 and spring 1995), European perch (spring 1995), ruffe (summer 1996), and ziege (spring 1995) (Tables 6, 16-18).

Bothriocephalus scorpii (Müller, 1776), plerocercoids: present in the intestine and pyloric caeca of zander (spring 1995 and summer 1996) (Table 16).

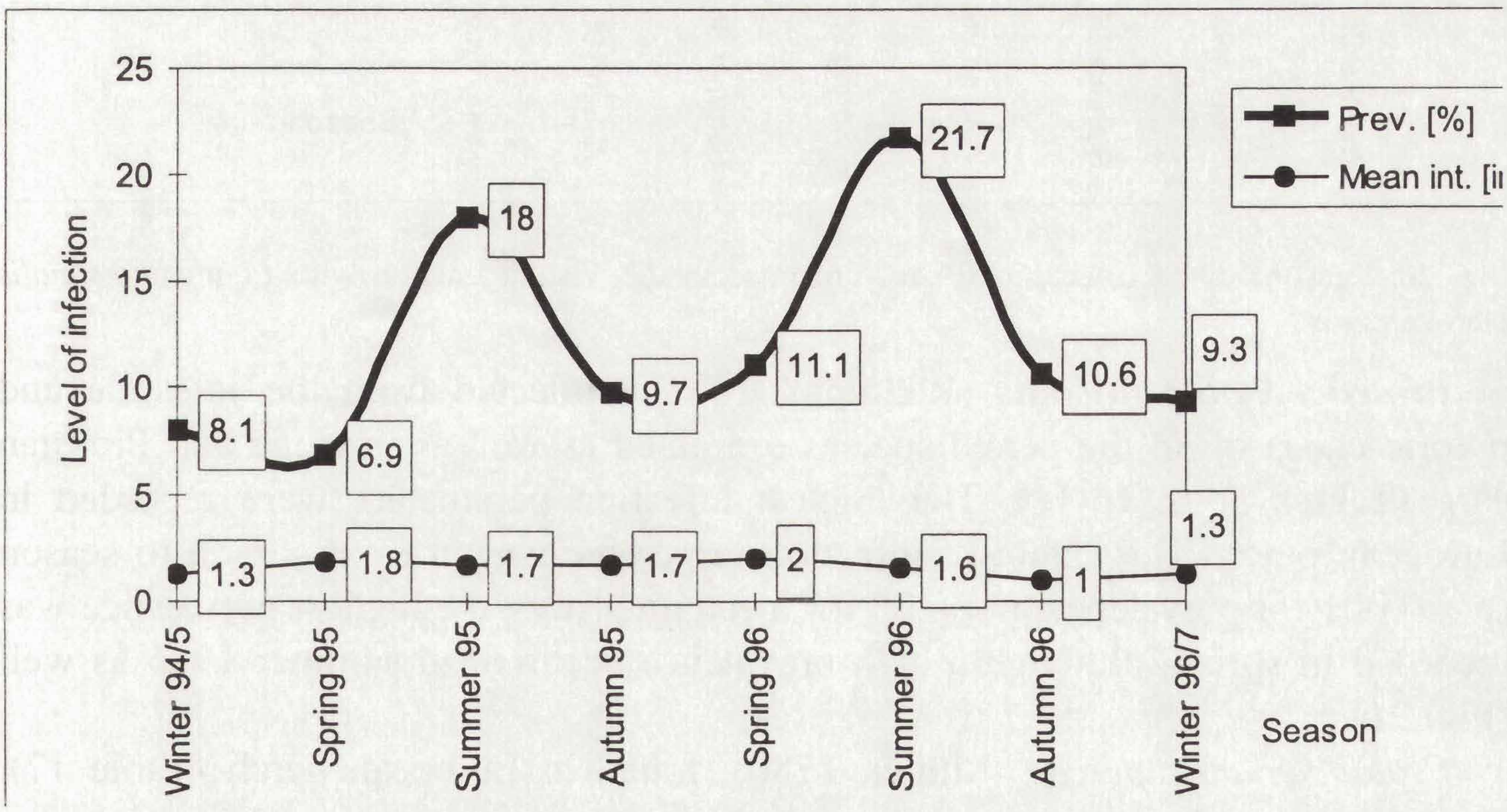

Fig. 19. Seasonality of infection of European perch from the Vistula Lagoon with *Triaenophorus nodulosus* plerocercoids

Bothriocephalus acheilognathi Yamaguti, 1934: two tapeworms were found in the intestine of a common carp specimens in early March 1997 (Table 12).

Triaenophorus nodulosus (Pallas, 1781), plerocercoids: recorded in the liver of European perch (Table 17). The cestodes were most frequent in summer (prevalence only, $p < 0.05$); on the other hand, the mean intensity was low and amounted to about 2 specimeus per infected fish in all the seasons (Fig. 19).

Ligula intestinalis (Linnaeus, 1758), plerocercoids: present in the body cavity of carp bream, roach, ziege, and white bream (Tables 3, 4, 6, 7). The heaviest infection was recorded in white bream, followed by carp bream. Of the 31 specimens examined, six white bream specimens were infected. Carp bream showed significant correlation between the level of infection and season ($p < 0.01$ for prevalence and $p < 0.001$ for mean intensity); the highest infection parameters were recorded in autumn and winter (Fig. 20).

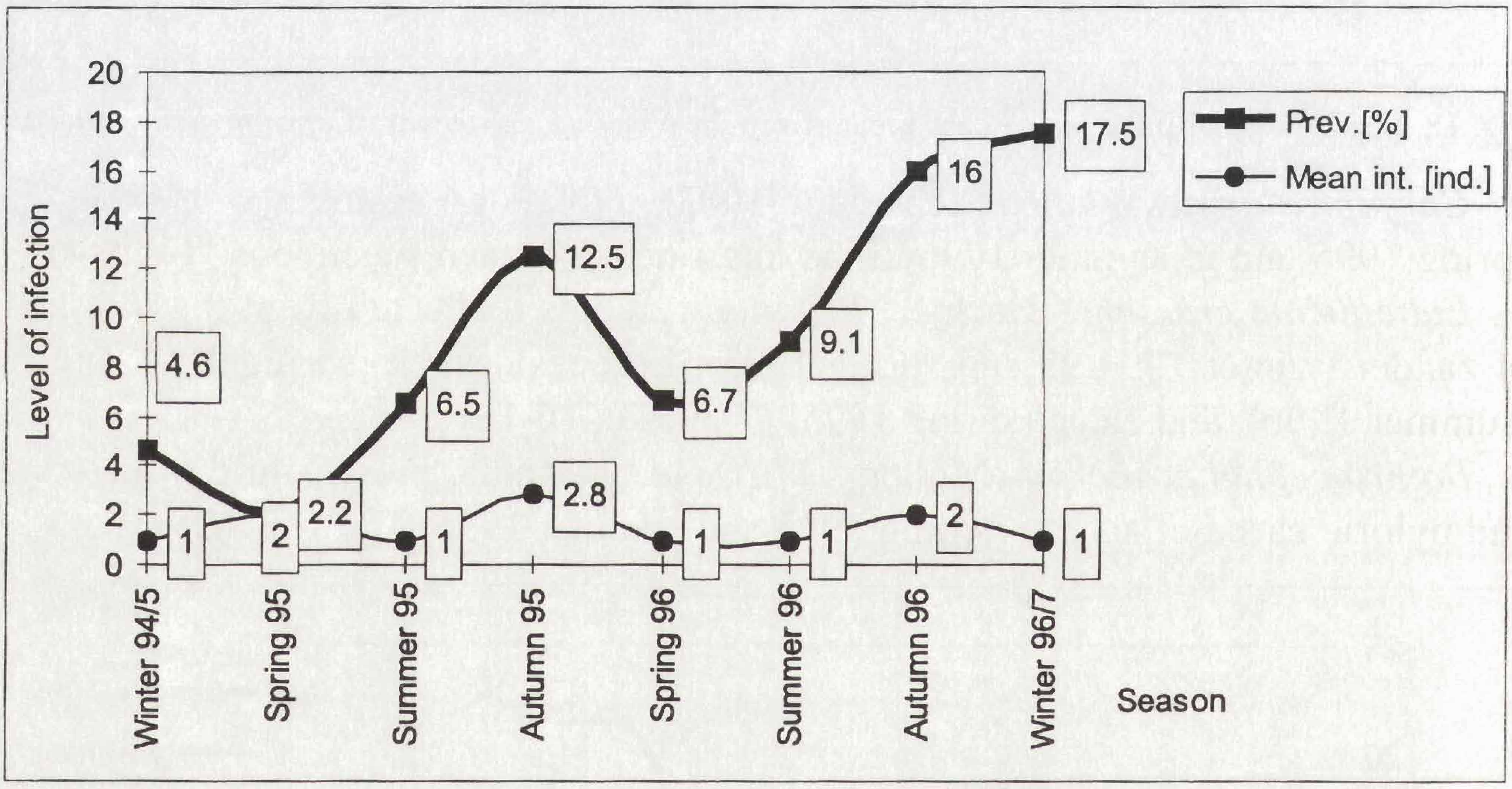

Fig. 20. Seasonality of infection of carp bream from the Vistula Lagoon with *Ligula intestinalis* plerocercoids

Proteocephalus filicollis (Rudolphi, 1802): collected from the intestine and pyloric caeca of all the percid species examined as well as in ziege and Prussian carp (Tables 5, 6, 16-18). The highest infection parameters were recorded in European perch. The extent of infection in perch changed from season to season ($p < 0.001$ for prevalence, $p < 0.05$ for mean intensity), the highest prevalence was recorded in spring, although a high prevalence occurred in summer 1996 as well (Fig. 21).

Proteocephalus percae (Müller, 1780): found in European perch (Table 17). Two, 13, 4, and 7 parasites were collected in winter, spring, summer, and autumn, respectively.

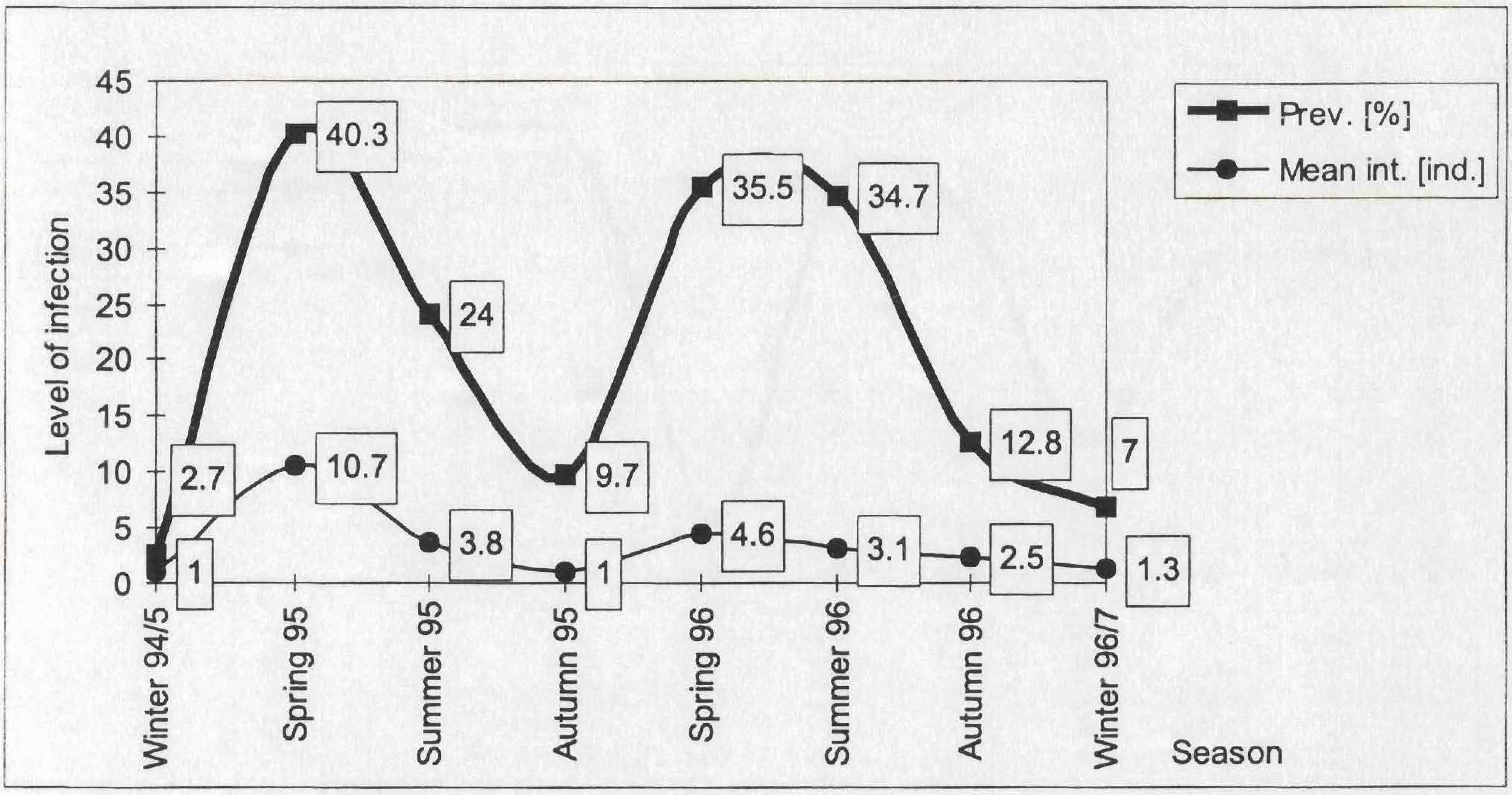

Fig. 21. Seasonality of infection of Europen perch from the Vistula Lagoon with *Proteocephalus filicollis*

Proteocephalus torulosus (Batsch, 1786): a total of 10 cestodes were collected in autumn 1995 and spring 1996 from the intestine of asp (Table 10).

Paradilepis scolecina (Rudolphi, 1819), plerocercus: a total of 23 plerocerci were found in the intestinal wall of roach, carp bream, and tench (Tables 3, 4, 8). One cestode was collected in winter 1994/1995, the remaining specimens being obtained in summer of 1995 and 1996.

Nematoda

Capillaria tomentosa Dujardin, 1843: the intestine of three carp bream specimens examined in spring and summer 1996 were found to contain 3 nematodes, including two ovigerous females and one male (Table 3).

Schulmanella petruschewskii (Shulman, 1948): the liver of two ruffe examined in summer 1995 supplied 6 nematodes of the species (5 females, including 3 ovigerous ones, and a single male) (Table 18).

Eustrongylides mergorum (Rudolphi, 1809), stage III larvae: found encysted on the intestine of ruffe (Table 18) and a single asp (autumn 1995) (Table 10). The presence of the parasite in ruffe was found to be season-dependent; the level of infection was observed to increase towards the end of the year ($p < 0.01$) (Fig. 22).

Cystidicoloides ephemeridarum (Linstow, 1872): recorded in zander (winter 1996/97) and European perch (summer 1996). A total of 10 nematodes, including two non-ovigerous females and 1 male, were found (Tables 16, 17).

Camallanus lacustris (Zoega, 1776): the intestine and pyloric caeca of two carp bream, 6 zander, and 13 European perch specimens were found to contain a total of

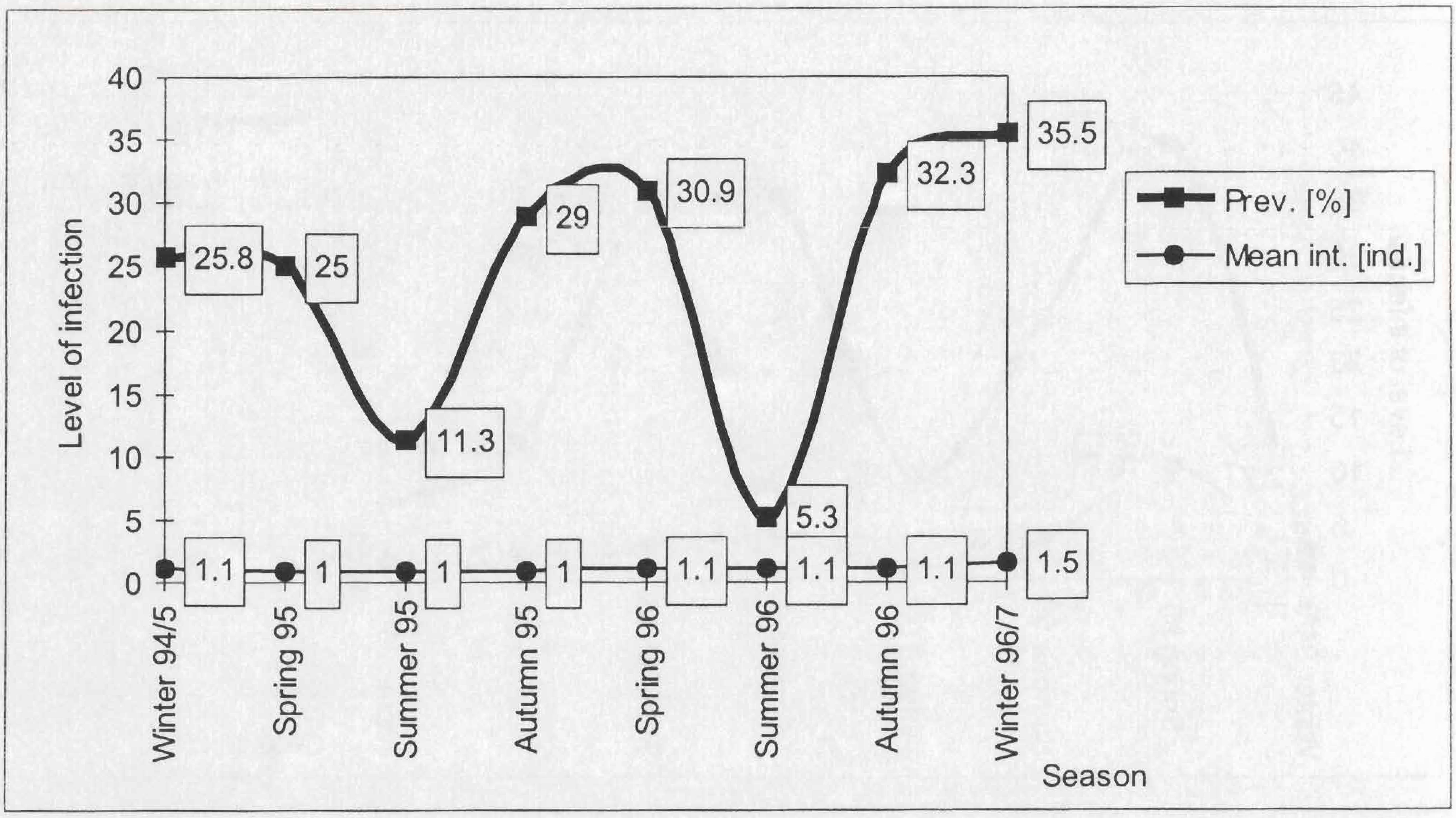

Fig. 22. Seasonality of infection of ruffe from the Vistula Lagoon with *Eustrongylides mergorum* L_3

28 *nematodes of the species* (13 *females and* 15 *males*) (Tables 3, 16, 17), 8 females containing larvae. The parasites occurred in all seasons of the year: 18 were collected in spring, 5 in summer, 2 in autumn, and 3 in winter.

Camallanus truncatus (Rudolphi, 1814): present in the intestine and pyloric caeca of zander and European perch, the latter being the principal host (Tables 16, 17). The perch infection level varied from season to season ($p < 0.001$), the heavi-

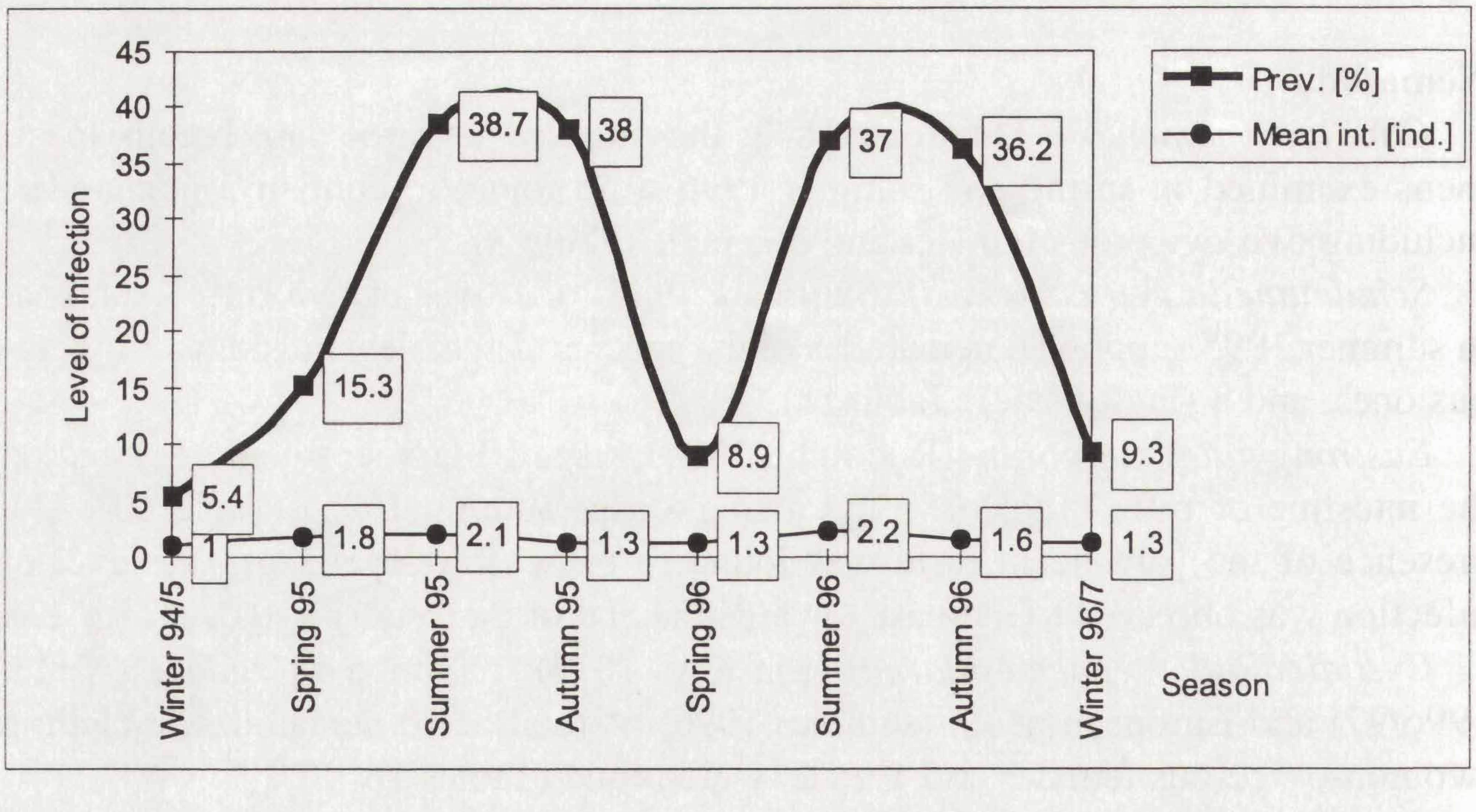

Fig. 23. Seasonality of infection of European perch from the Vistula Lagoon with *Camallanus truncatus*

est infection being recorded in summer (Fig. 23). Among the nematodes found, 95 were male and 79 female. The uteri of 51 females contained larvae.

Philometra kotlani (Molnár, 1969): the body and gill cavity (the latter under the operculum) of carp bream (Table 3) were found to harbour 5 and 4 ovigerous females respectively, 4 parasites being found in summer and 5 in autumn.

Anguillicola crassus Kuwahara, Niimi et Itagaki, 1974, stage III larvae: collected from ruffe, European perch, zander, carp bream, roach, and ziege, ruffe being affected by the heaviest infection (Tables 3, 4, 6, 16-18).

Hysterothylacium aduncum (Rudolphi, 1802): the zander, European perch, and ruffe examined in summer 1995 and autumn 1996 were found to host 11 nematodes of the species (Tables 16-18). Both stage IV larvae and adults were present; zander: 2 larvae and 3 adults (2 ovigerous females and 1 male); perch: 4 larvae, 1 adult male; ruffe: 1 larva.

Anisakis simplex (Rudolphi, 1809), stage III larvae: a total of 111 nematodes were found in the zander (Table 16).

Raphidascaris acus (Bloch, 1779): the intestine of 3 European perch specimens was found to contain altogether 6 females (including 4 ovigerous ones) of the species (Table 17). The nematodes were collected in summer 1995 (4 specimens) and in winter 1996/1997 (2 specimens).

Acanthocephala

Neoechinorhynchus rutili (Müller, 1780): in spring 1996, the intestine of one zander (Table 16) was found to contain 3 acanthocephalans of the species, including 2 non-ovigerous females and a male.

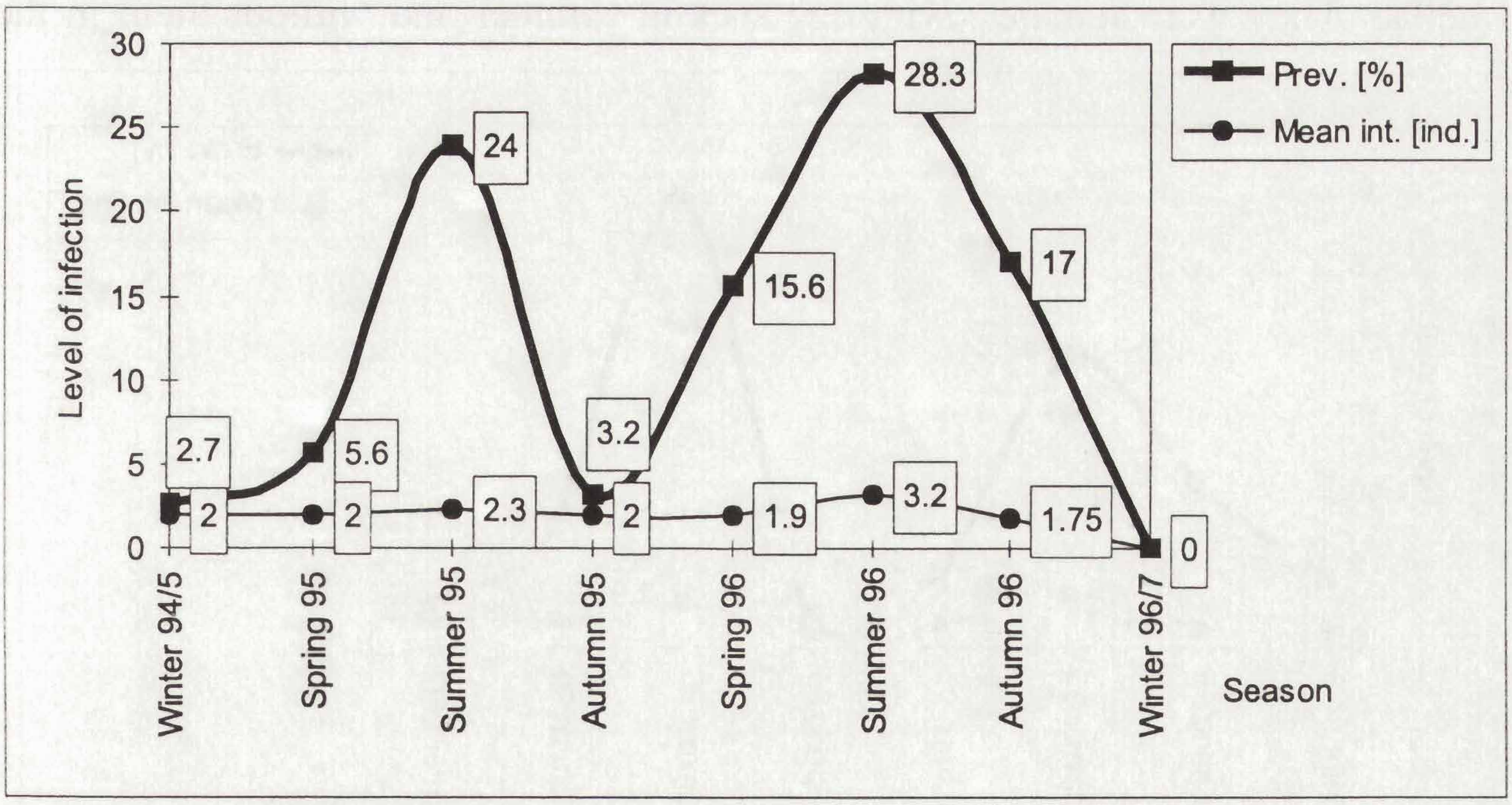

Fig. 24. Seasonality of infection of European perch from the Vistula Lagoon with *Acanthocephalus lucii*

Corynosoma strumosum (Rudolphi, 1802), cystacanths: two cystacanths were collected from the intestinal wall of two zander (Table 16) caught in summer 1995.

Corynosoma semerme (Forssel, 1904), cystacanths: the intestinal wall of 3 zander specimens, examined in summer 1996, were found to contain 3 cystacanths of the species (Table 16).

Paracanthocephalus gracilacanthus (Meyer, 1932): the intestine of one ide caught in summer 1995 was found to host 3 acathocephalans of the species (2 ovigerous females and 1 male) (Table 9).

Acanthocephalus lucii (Müller, 1776): present mainly in the intestine of European perch and in 2 zander (Tables 16, 17). In perch, the *A. lucii* occurrence was found to be season-dependent ($p < 0.001$), the highest level of infection was recorded in summer (Fig. 24). Among the 111 acanthocephalans found, females (represented by 77 specimens, including 57 ovigerous ones) were more numerous than males (34 specimens).

Hirudinea

Piscicola geometra (Linnaeus, 1761): collected from the skin, mouth cavity, and gills of roach, carp bream, zander, and European perch (Tables 3, 4, 16, 17). Twenty leeches were found in spring 1996, six in summer 1996, and one each in autumn 1995 and in winter 1994/1995.

Copepoda

Ergasilus sieboldi von Nordmann, 1832: present in carp bream, Prussian carp, ziege, tench, ide, asp, zander, European perch, and ruffe (Tables 3, 5, 6, 8-10, 16-18), bream being the most heavily infected fish. The copepods were located on gill lamellae. They were females, with egg sacs in summer and without them in the

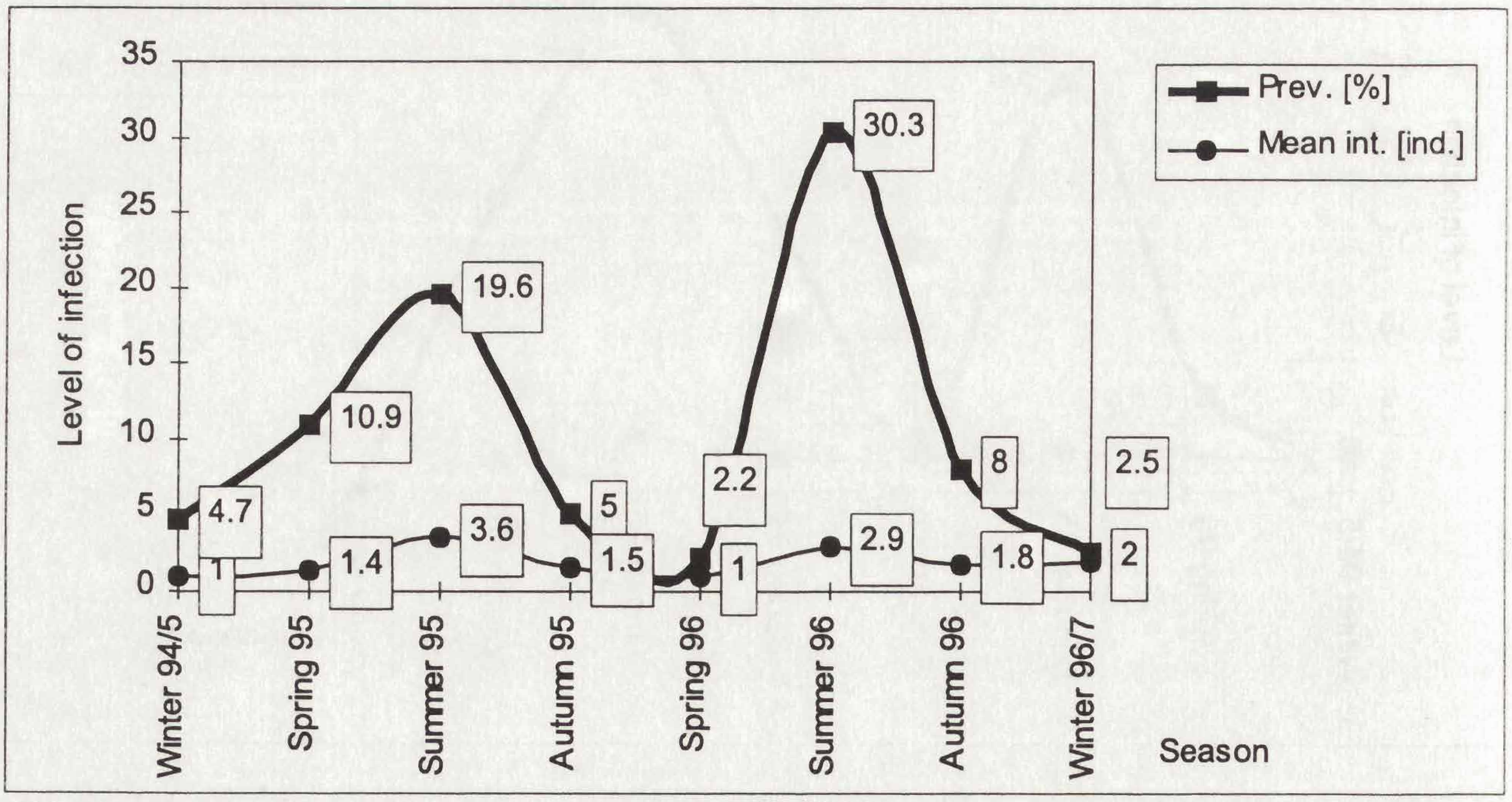

Fig. 25. Seasonality of infection of carp bream from the Vistula Lagoon with *Ergasilus sieboldi*

remaining seasons. A single, also live, female of *E. sieboldi* was found attached with its 2nd antennae to the fish's heart bulb. Such an unusual location was most probably a result of post mortem biochemical and physiological changes in the host. The extent of carp bream infection was found to be season-dependent ($p < 0.001$); the highest infection parameters were recorded in summer (Fig. 25).

Caligus lacustris Steenstrup et Lütken, 1861, chalimus III and IV and adults: a total of 44 fish belonging to 8 species (Tables 3-6, 11, 16-18) were found to host 55 copepods of the species. They were dominated by adult females (28 specimens), the adult males (9 specimens), chalimus stage III (11 specimens) and IV (7 specimens) being less abundant. The adult copepods were located on the skin and in the mouth cavity, while the larvae occurred on the fins only, mainly on the dorsal and pectoral ones. The copepods were collected in spring (11 specimens), summer (43), and autumn (1).

Achtheres percarum Nordmann, 1832, chalimus IV and adults: a total of 1872 copepods were collected from the gills (1498 specimens) and mouth cavity (374) of zander (Table 16). The copepods collected were females (1829 specimens) and males (43). 82% copepods were located on the gills and 18% in the mouth cavity. The parasite's occurrence was found to be season-dependent, the highest infection parameters being recorded in summer ($p < 0.001$) (Fig. 26).

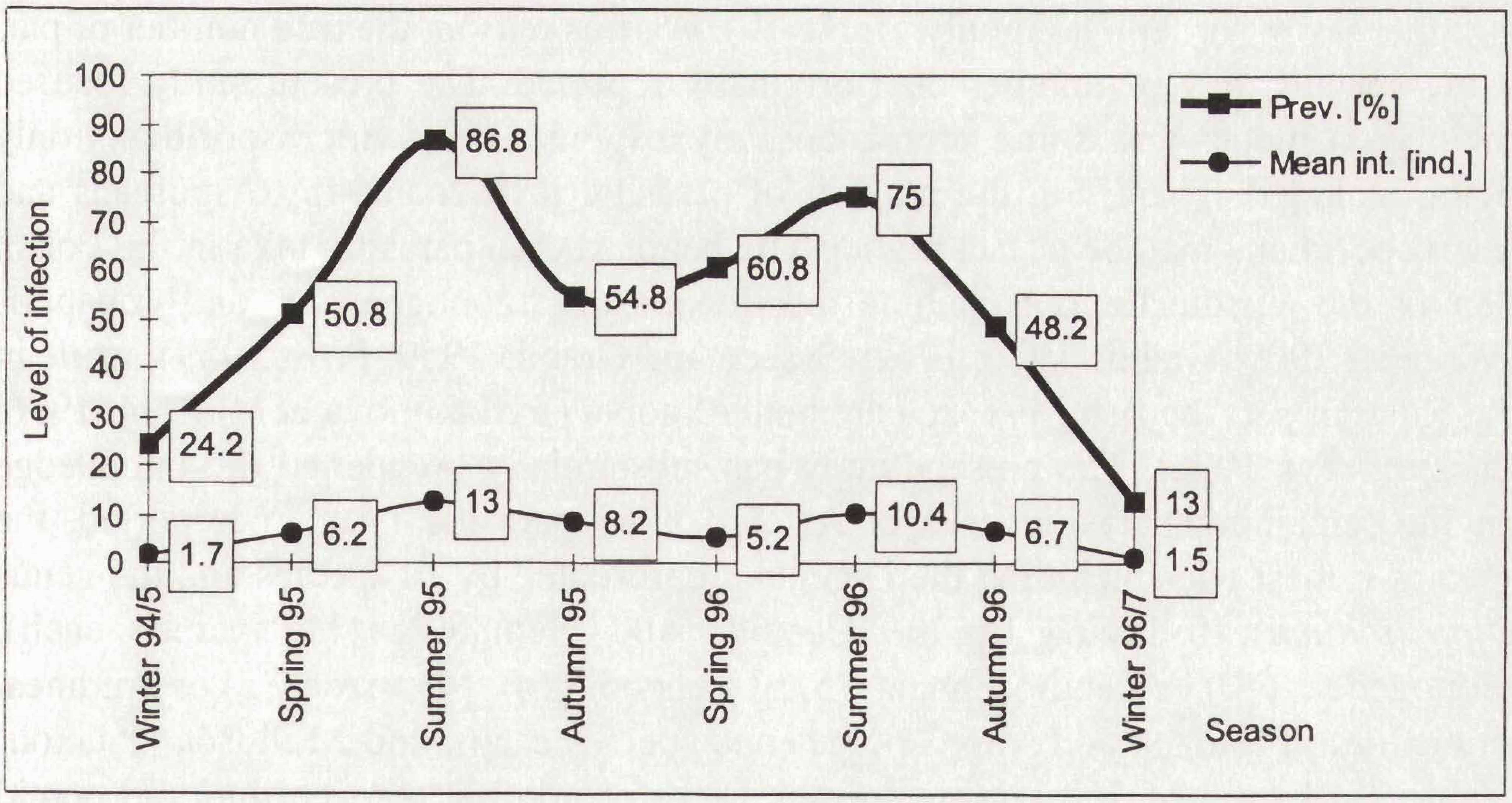

Fig. 26. Seasonality of infection of zander from the Vistula Lagoon with *Achtheres percarum*

Tracheliastes maculatus Kollar, 1836: located on the carp bream skin only (Table 3). All the parasites found were adult ovigerous females. They were collected in spring of 1995 and 1996 (5 specimens) and in summer of 1995 and 1996 (31).

Branchiura

Argulus foliaceus (Linnaeus, 1758): collected from skin and mouth cavity of carp bream, roach, and Prussian carp (Tables 3-5). Most of the parasites were found in summer (13 specimens), 1 and 2 specimens being collected in spring 1995 and autumn 1995, respectively. Of the parasites collected, 10 were females and 6 males.

Mollusca

Unionidae gen. sp., glochidia: present in carp bream, roach, zander, European perch, and ruffe (Tables 3, 4, 16-18). They were located subcutaneously on the abdomen (22 specimens) as well as in the dorsal (18), ventral (81), and pectoral (19) fins. Most of the glochidia were collected in spring 1995 (131 specimens), 4 and 5 specimens being found in spring 1996 and in summer 1995, respectively.

DISCUSSION

When the species composition of the cyprinids and percids of the Vistula Lagoon, observed in this study, is compared with that reported in earlier publications, certain differences become evident. The hitherto performed studies have revealed the presence of a total of 97 parasitic taxa, 63 being found in the Polish part and 47 in the Russian part of the lagoon. Numerous parasites were identified to genus, and even to a higher taxon (order, class) only (Table 19). For this reason, the true number of parasitic species may be another than originally reported. The present study focused mainly on metazoans, some protozoans, myxosporeans and microsporidians only being included. Therefore, the number of parasitic protozoans, myxosporeans and microsporidians may be in fact higher. The better known parasitic taxa in the Polish part of the Vistula Lagoon include the myxozoans, monogeneans, and copepods (Wegener 1909; Grabda 1956, 1962; Grabda and Grabda 1959; Prost 1959), while in the Russian part the fish Myxozoa are better known (Evdokimova et al. 1994, 1996; Zaostrovceva 1996). The present study has substantially broadened the knowledge on the remaining parasitic groups. A total of 63 parasitic taxa are reported, the species-richest ones including the Digenea (represented by 14 species and the genus *Diplostomum*), followed by the Cestoda and Nematoda (11 species each), Monogenea (10), Acanthocephala (5), Copepoda (4) Myxozoa (2), Hirudinea, Branchiura, Protozoa and Microsporea (one species each), and Mollusca (1 taxon) (Table 2). A total of 36 parasitic species were recorded in the cyprinid and percid fishes from the Vistula Lagoon for the first time, while 41 species being recorded for the first time in the Polish part of the lagoon. In addition to metacercariae of *Bucephalus polymorphus*, adults of the species were found. *Paradiplozoon bliccae* (Monogenea) and *Capillaria tomentosa* (Nematoda) were the species new to the Polish fauna. Detailed data on nematodes *Anisakis simplex* and *Anguillicola crassus* has been already published (Rolbiecki and Rokicki 2000a, b; Rolbiecki 2002b).

A comparison of the earlier and present lists of monogeneans and copepods provided some insights as well. The monogeneans, in this study, were represented by a lower number of species belonging to the genus *Dactylogyrus*, despite some new to this area species (*Dactylogyrus vastator*, *D. vistulae*) being found. The prevalence of some of the monogeneas clearly decreased: e.g., the prevalence of *Dactylogyrus crucifer* in roach decreased from 95.4% reported earlier (all data concerning *Dactylogyrus* spp. as well as *Diplozoon paradoxum* from Prost 1959) to 33.7% recorded in the present study, while the prevalence of *D. wunderi* in carp bream decreased from the earlier 60% to the present 13.8%. The prevalence of *Diplozoon paradoxum* was reduced from 45.4% to 4.6% in roach and from 64.2% to 3.2% in white bream, while carp bream retained its earlier level of infection (73.3% earlier and 71.8% in the present study). On the other hand, an increase in the prevalence of *Ancyrocephalus paradoxus* was observed in zander (57% at present relative to 37.5% earlier); the earlier data, however, were related to the Vistula and Kuronian Lagoons jointly (Wegener 1909). Compared with evidence for the Kaliningrad Lagoon, the presence of some monogeneans (*Dactylogyrus extensus*, *Ancyrocephalus paradoxus*, *Diplozoon paradoxum*, *Paradiplozoon rutili*) was confirmed. *A. paradoxus* was recorded in 10% of zander on one occasion and in 52% some other time; *D. paradoxum* was found once in 20% of carp bream and in 50% of roach, *P. rutili* was recorded in 10% of roach, while *D. extensus* was found in cyprinids, but the hosts affected were different than those in the present study: 20% of carp bream, 15% of roach, and 50% of white bream (Evdokimova et al. 1989, 1994). On the other hand, the copepod species composition did not change. In the Polish part of the lagoon, the copepods had earlier been recorded in cyprinids and percids, but in one season *Tracheliastes maculatus* was revealed to have infected as many as 100% of carp bream, while it was absent from bream in another year; *Achtheres percarum* was reported from 52.5% of zander (the combined prevalence in the Vistula and Kuronian Lagoons); *Caligus lacustris* and *Ergasilus sieboldi* were recorded in singular fish specimens (Wegener 1909, Grabda 1962). The Russian authors found only *Achtheres percarum* in zander (in another record, the authors reported only the presence of the genus *Achtheres*), 26% of the fish being infected (Evdokimova et al. 1994). In another study, the copepods were divided into those found in the mouth cavity (26%) and in the gills (62%) (Evdokimova et al. 1989).

Noteworthy is the study conducted by Wegener (1909) who listed a number of parasites (Myxozoa, Monogenea, and Copepoda) found in the Vistula Lagoon cyprinids and percids. However, the presence of many of those species failed to be confirmed in later studies carried out by Prost (1959) who dealt with monogeneas or by Zaostrovceva (1996) and Evdokimova et al. (1996) who investigated the Myxozoa.

The parasites showed differing host specificity by limiting their presence to one or the other family or to certain species only. Of the 40 species found in cyprinids, 26 were specific for them, while of the 37 species found in percids, 23 were percid-specific (Table 2). Both families were found to support the *Diplostomum* flukes and Unionidae glochidia. Some parasites (36 species) occurred in a single host, 9 species being present in two hosts, while 19 species as well as *Diplostomum* spp. and Unionidae gen. sp. occurred in numerous hosts. The frequency of occurrence varied between the fish species. Higher infection indices were typical of the principal host, while lower frequencies were indicative of auxiliary or paratenic hosts. In some cases only was the infection prevalence higher than 50%: that of *Diplostomum* spp. in carp bream and roach, *Tylodelphys clavata* in roach and European perch, *Diplozoon paradoxum* in carp bream as well as *Ancyrocephalus paradoxus* and *Achtheres percarum* in zander. Apart from metacercariae, the mean intensity did not exceed 10 parasites in a fish infected.

Metacercariae of *Diplostomum* spp. and *Tylodelphys clavata* were regarded as the dominant parasites, i.e., those that were frequent and present in numerous fish species. The *Diplostomum* spp. flukes were recorded in 15 out of the 16 fish species examined (Tables 3-11, 13-18); the parasites were absent from common carp only, the carp having been released into the lagoon within the framework of a stocking programme. The major role in the life cycle of the digeneans is played by cyprinids rather than percids, as confirmed by data of other authors (Wierzbicki 1970, Pojmańska et al. 1980, Pojmańska and Dzika 1987, Shigin 1986). The heaviest infection was recorded in carp bream (84.3% prevalence, mean intensity of 35.4 specimens, relative density of 29.8 specimens) and roach (84.5%, 17.9 specimens, and 15.1 specimens, respectively). On the other hand, the high mean intensity (84 specimens) in white bream may be spurious, as the relative density was as low as 8.1 specimens. Instead, the *Tylodelphys clavata* metacercariae were present in 10 fish species, European perch (53%, 44 specimens) and roach (69.9%, 27.6 specimens) bearing the brunt of the infection. The metacercariae were reported from more than 70 fish species belonging to numerous families as well as from amphibians (Sonin 1986, Niewiadomska 2002); high levels of infection were frequently observed in percids and cyprinids (e.g. Kozicka 1959, Pojmańska et al. 1980).

Diplozoon paradoxum was found mainly in carp bream which showed high values of infection parameters (71.8%, 9.1 specimens), and also in roach, white bream, and in a single Prussian carp specimens. According to Khotenovskij (1985) and Prost (1966), the monogeneans in question are common in numerous cyprinid species, bream being the most frequent host. On the other hand, two other single-host parasites: *Ancyrocephalus paradoxus* (57%, 6.7 specimens) and *Achtheres percarum* (56.4%, 8.5 specimens) were the dominant species in zander. The copepod *A. percarum* is regarded as a parasite specific for zander and European perch (Kozikowska 1957; Grabda and Grabda 1959; Piasecki 1991, 1993; Valtonen et al. 1993; Rolbiecki and Rokicki 2000c). The monogenean *A. paradoxus*, too, is a host-specific parasite of zander (Starovojtov 1986, 1995), although some workers

(Kozicka 1959, Prost 1966, Kennedy 1974) have mentioned another host, namely European perch. It seems interesting why it is only zander that is infected, although the other potential host is present in the area as well. Perhaps *Ancyrocephalus paradoxus* has been mistaken for *A. percae*, a European perch parasite (Gusev 1985). In the case of *Achtheres percarum*, two species or forms may be involved as well, as suggested by Kozikowska et al. (1956) and Kempter and Piasecki (2000, 2001) who were of the opinion that zander is a host to *A. sandrae*, while European perch supports *A. percarum*. However, the absence of those copepods, as well as that of members of the *Ancyrocephalus paradoxus* in perch may indicate that they are rare parasites, totally absent from the Vistula Lagoon.

In most cases, however, infection prevalence did not exceed 30%. Seventeen species which showed orientation towards certain hosts, reached prevalences ranging from 10 to 33%. Their mean intensities of infection were low and, except for *Henneguya psorospermica* in European perch (250.2 specimens), seldom exceeded 10 parasites in an infected fish individual. Those parasites included *Henneguya psorospermica* in European perch, *Dactylogyrus amphibothrium* in ruffe, *D. crucifer* in roach, *D. wunderi* in carp bream, *Rhipidocotyle campanula* in carp bream and zander, *Posthodiplostomum cuticola* in carp bream and roach, *Bunodera luciopperca* in European perch, *Caryophyllaeus laticeps* in carp bream, *Ligula intestinalis* in carp bream, *Triaenophorus nodulosus* in European perch, *Proteocephalus filicollis* in European perch, *Eustrongylides mergorum* in ruffe, *Camallanus truncatus* in zander, *Anguillicola crassus* in ruffe, *Anisakis simplex* in zander, *Acanthocephalus lucii* in European perch, *Ergasilus sieboldi* in carp bream, and *Achtheres percarum* in zander (Tables 3, 4, 16-18).

Salinity is certainly a factor controlling the specific qualitative and quantitative composition of the Vistula Lagoon fish parasite fauna. The estuarine nature of the lagoon makes it a habitat accessible to brackish- and freshwater as well as marine forms. Those parasites that have evolved a wider tolerance to salinity changes attain high prevalence and infection intensities. In most parasites, however, the values of those indicators are lower than those reported from freshwater or marine habitats, which may be stem from the fact that the Vistula Lagoon lies near the threshold of their ecological tolerance to salinity. The present study showed the Vistula Lagoon cyprinids and percids to support predominantly freshwater parasites. Moreover, as mentioned earlier, as few as five taxa (*Diplostomum* spp. and *Tylodelphys clavata*, *Ancyrocephalus paradoxus*, *Diplozoon paradoxum* and *Achtheres percarum*) showed the prevalence in principal hosts to be markedly higher than that of the remaining parasites. The prevalences in the Vistula Lagoon were often higher than the values recorded in the same fish species inhabiting freshwater reservoirs, which may be indicative of the brackishwater nature of those parasites; in any case, salinity changes within the range of 0.5-6‰ prevailing in the lagoon do not restrict their occurrence. The freshwater disposition of *D. paradoxum* had been already mentioned by Prost (1959).

As few as 6 species (*Brachyphallus crenatus* of the Digenea, *Bothriocephalus scorpii* of the Cestoda, the nematodes *Hysterothylacium aduncum* and *Anisakis simplex*, and the acanthocephalans *Corynosoma semerme* and *C. strumosum*) were marine, although they can be introduced into brackish or even freshwater reservoirs with migrating hosts. The parasites mentioned were recorded in zander (in addition to few specimens of *H. aduncum* found in European perch and ruffe). The Vistula Lagoon zander performs feeding migrations to the Baltic where it can acquire the parasites. There is also a possibility that normally marine hosts may enter the lagoon with salt water intrusions. The source of the *Anisakis simplex* infection of zander is the herring entering the lagoon to spawn (Rolbiecki and Rokicki 2000b). Herring, a typical host of *Brachyphallus crenatus*, is also the most likely source of zander's infection with the parasite (Walter 1988).

Three parasitic species (*Ichthyophthirius multifilis*, *Dactylogyrus extensus*, and *Bothriocephalus acheilognathi*) found in common carp (Table 12) deserve mention. The fish occurred in the lagoon as a result of stocking activities and were caught two weeks after they had been released. Perhaps the parasites, the typically freshwater species, were introduced into the lagoon together with their hosts. On the other hand, one cannot rule out a possibility that those species are natural, but less common, components of the lagoon's fauna. *I. multifilis* was first recorded in the Polish part of the lagoon early in the 20th century (Wegener 1909), while *D. extensus* had been earlier reported from the Kalinigrad Lagoon only (Evdokimova et al. 1994). On the other hand, the present study is the first record of *B. acheilognathi* in the lagoon, which may strengthen the introduction argument.

The occurrence of numerous parasites followed a certain seasonal pattern. The most important underlying factor was the water temperature which can affect, i.a., the fish feeding activity and thus control the timing and level of infection with parasites a fish ingests with food. Water temperture affects also biology of the parasite and its other hosts (invertebrates); as a rule, increased water temperature increases the number and accelerates developmental rates of invasive forms. Another factor controlling the seasonality of parasites' occurrence is a reduced immunity-related fish mortality, the immunity being particularly low in winter. Important may also be the selection of infected hosts by predatory fish and piscivorous birds (definitive hosts) which, in temperate latitudes, feed on fish mainly in spring, summer, and autumn. When analysing the causes of parasitic dynamics, it should be remembered that it is a complex effect affected by a number od different factors. Water bodies differ in their characteristics (e.g., area, depth) as well as in their hydrological and biological variables (e.g., pH, salinity, prevalece of host species). Consequently, the parasites dwelling in different water bodies may differ in seasonal patterns they show as well.

Most of the parasites in the present study were recorded in summer; to a lesser extent were they prevalent in spring and autumn, the extent of infection being at the minimum in winter (Figs. 1-26). Some species only were equally frequent in summer and spring (*Dactylogyrus wunderi*, *D. crucifer*, *Diplozoon paradoxum*, *Proteocephalus filicollis*) or autumn (*Bunodera luciopercae*, *Camallanus truncatus*). In the case of *Diplostomum* spp., *Tylodelphys clavata*, *Ligula intestinalis*, and *Eustrongylides mergorum*, the extent of infection was found to be higher in autumn-winter. The latter four larvae are tissue parasites located primarily in the fish eye and body cavity, for which reason they may accumulate over the growing season. No such relationship, however, was observed in other larvae: neither in metacercariae of *Bucephalus polymorphus*, *Rhipidocotyle illense*, *Posthodiplostomum cuticola*, nor in plerocercoids of *Triaenophorus nodulosus* and larval L_3 *Anguillicola crassus*, and *Anisakis simplex* (Rolbiecki 2002b, Rolbiecki and Rokicki 2000b). Noteworthy is also the fact that the metacercariae of *Diplostomum* spp. and *T. clavata* were the only parasites that occurred in fish throughout the year at a high infection intensity, which has been also observed by other authors (Chubb 1979, Reda 1988).

Table 2. List of parasites found in the cyprinids and percids from the Vistula Lagoon

Cyprinid parasites	Percid parasites	Common parasites
Myxobolus muelleri	*Glugea acerinae*	*Bucephalus polymorphus**
Ichthyophthirius multifiliis	*Henneguya psorospermica*	*Rhipidocotyle campanula**
Dactylogyrus vastator	*Dactylogyrus amphibothrium*	*Diplostomum* spp.
Dactylogyrus vistulae	*Ancyrocephalus paradoxus*	*Tylodelphys clavata*
Dactylogyrus extensus	*Ichthocotylurus variegatus*	*Ichthyocotylurus platycephalus*
Dactylogyrus wunderi	*Posthodiplostomum brevicaudatum*	*Eubothrium crassum*
Dactylogyrus crucifer	*Apatemon annuligerum*	*Protocephalus filicollis*
Paradiplozoon rutili	*Brachyphallus crenatus*	*Eustrongylides mergorum*
Paradiplozoon bliccae	*Bunodera lucoipercae*	*Camallanus lacustris*
Diplozoon paradoxum	*Bothriocephalus scorpii*	*Anguillicola crassus*
Posthodiplostomum cuticola	*Triaenophorus nodulosus*	*Piscicola geometra*
Asymphylodora tincae	*Proteocephalus percae*	*Ergasilus sieboldi*
Allocreadium isoporum	*Schulmanella petruschewskii*	*Caligus lacustris*
Sphaerostomum bramae	*Cystidicoloides ephemeridarum*	Unionidae gen. sp. (glochidia)
Sphaerostomum globiorum	*Camallanus truncatus*	
Caryophyllaeus laticeps	*Hysterothylacium aduncum*	
Caryophyllaeides fennica	*Anisakis simplex*	
Bothriocephalus acheilognathi	*Raphidascaris acus*	
Ligula intestinalis	*Neochinorhynchus rutili*	
Protocephalus torulosus	*Corynosoma semerme*	
Paradilepis scolecina	*Corynosoma strumosum*	
Capillaria tomentosa	*Acanthocephalus lucii*	
Philometra kotlani	*Achtheres percaum*	
Paracanthocephalus gracilacanthus		
Tracheliastes maculatus		
Argulus foliaceus		

*metacercariae were recorded in cyprinids, while adults were found in percids

To sum up, it has to be pointed out that the changes taking place in the composition of fish parasites may be indicative of wider trends in environmental changes. This could be of a particular relevance for the Vistula Lagoon, one of the largest coastal water bodies of the southern Baltic, important from the economic, recreational, and scientific points of view.

Table 3. Parasitic fauna of carp bream from the Vistula Lagoon

Parasite	No. of parasites	Prev. [%]	Mean int.	R. int.	Dens.
Myxobolus muelleri	299	10.9	7.3	1-37	0.8
Dactylogyrus wunderi	644	13.8	12.4	2-104	1.7
Diplozoon paradoxum	2465	71.8	9.1	1-26	6.6
Bucephalus polymorphus (met.)	102	8.5	3.2	1-11	0.3
Rhipidocotyle campanula (met.)	256	15.4	4.4	1-71	0.7
Diplostomum spp. (met.)	11214	84.3	35.4	1-238	29.8
Tylodelphys clavata (met.)	436	14.9	7.8	1-38	1.2
Posthodiplostomum cuticola (met.)	573	17.8	8.6	1-66	1.5
Ichthyocotylurus platycephalus (met.)	84	6.1	3.7	1-13	0.2
Sphaerostomum bramae	204	6.9	7.8	2-30	0.5
Sphaerostomum globiorum	34	4.3	2.1	1-5	0.09
Caryophyllaeus laticeps	983	33.8	7.7	1-130	2.6
Ligula intestinalis (pl.)	54	9.3	1.5	1-4	0.1
Paradilepis scolecina (pl.)	1	0.3	1	1	0.003
Capillaria tomentosa	3	0.8	1	1	0.008
Camallanus lacustris	3	0.5	1.5	1-2	0.008
Philometra kotlani	9	2.4	1	1	0.02
Anguillicola crassus (III st.)	1	0.3	1	1	0.003
Piscicola geometra	10	1.3	2	1-3	0.03
Ergasilus sieboldi	111	11.7	2.5	1-12	0.3
Caligus lacustris (ch. III, IV and ad.)	17	3.4	1.3	1-3	0.05
Tracheliastes maculatus	36	6.6	1.4	1-3	0.1
Argulus foliaceus	5	1.1	1.3	1-2	0.01
Unionidae gen. sp. (glochidia)	23	1.3	4.6	2-8	0.06
Total	17567	97.3	48	1-238	46.7

Prev – prevalance, Mean int. – mean intensity, R. int. – Range of intensity, Dens. – relative density (the same for Tables 4-18)

Table 4. Parasitic fauna of roach from the Vistula Lagoon roach

Parasite	No. of parasites	Prev. [%]	Mean int.	R. int.	Dens.
Myxobolus muelleri	45	2.6	4.5	1-10	0.1
Dactylogyrus vistulae	134	6.9	5	1-10	0.3
Dactylogyru crucifer	1426	33.7	10.9	1-80	3.7
Paradiplozoon rutili	26	4.1	1.6	1-3	0.07
Diplozoon paradoxum	41	4.6	2.3	1-8	0.1
Bucephalus polymorphus (met.)	73	7.2	2.6	1-7	0.2
Diplostomum spp. (met.)	5869	84.3	17.9	1-202	15.1
Tylodelphys clavata (met.)	7519	69.9	27.6	1-223	19.3
Posthodiplostomum cuticola (met.)	689	26.5	6.7	1-67	1.8
Ichthyocotylurus platycephalus (met.)	5	0.5	2.5	2-3	0.01
Caryophyllaeus laticeps	5	0.8	1.7	1-2	0.01
Caryophyllaeides fennica	6	1	1.5	1-2	0.02
Ligula intestinalis (pl.)	4	1	1	1	0.01
Paradilepis scolecina (pl.)	17	0.8	5.7	4-8	0.04
Anguillicola crassus (III st.)	7	1.3	1.4	1-5	0.02
Piscicola geometra	11	2.1	1.4	1-2	0.03
Caligus lacustris (ch. III, IV and ad.)	5	1.3	1	1	0.01
Argulus foliaceus	6	0.8	2	1-3	0.02
Unionidae gen. sp. (glochidia)	5	0.8	1.7	1-3	0.01
Total	15893	93.8	43.5	1-223	40.9

Table 5. Parasitic fauna of Prussian carp from the Vistula Lagoon

Parasite	No. of parasites	Prev. [%]	Mean int.	R. int.	Dens.
Dactylogyrus vastator	40	9.9	4	1-8	0.4
Diplozoon paradoxum	5	2	2.5	2-3	0.05
Bucephalus polymorphus (met.)	5	1	5	5	0.05
Diplostomum spp. (met.)	70	28.7	2.4	1-7	0.7
Tylodelphys clavata (met.)	2	1	2	2	0.02
Posthodiplostomum cuticola (met.)	5	3	1.7	1-2	0.05
Caryophyllaeus laticeps	1	1	1	1	0.01
Proteocephalus filicollis	2	1	2	2	0.02
Ergasilus sieboldi	10	3	3.3	2-4	0.1
Caligus lacustris (ch. III, IV and ad.)	7	4	1.8	1-4	0.07
Argulus foliaceus	5	3	1.7	1-2	0.05
Total	152	36.6	4.1	1-8	1.5

Table 6. Parasitic fauna of ziege from the Vistula Lagoon

Parasite	No. of parasites	Prev. [%]	Mean int.	R. int.	Dens.
Diplostomum spp. (met.)	161	24.7	1.7	1-11	0.5
Posthodiplostomum cuticola (met.)	2	0.6	1	1	0.006
Eubothrium crassum (pl.)	3	0.3	3	1	0.01
Ligula intestinalis (pl.)	30	6	1.3	1-3	0.09
Proteocephalus filicollis	35	2.6	3.5	1-10	0.1
Anguillicola crassus (III st.)	1	0.3	1	1	0.003
Ergasilus sieboldi	10	2.1	1.3	1-2	0.03
Caligus lacustris (ch. III and ad.)	3	0.9	1	1	0.01
Total	245	13.7	5.6	1-11	0.8

Table 7. Parasitic fauna of white bream from the Vistula Lagoon

Parasite	No. of parasites	Prev. [%]	Mean int.	R. int.	Dens
Dactylogyrus wunderi	14	6.5	7	3-11	0.5
Diplozoon paradoxum	7	3.2	7	7	0.1
Bucephalus polymorphus (met.)	12	6.5	6	4-8	0.4
Diplostomum spp. (met.)	252	9.7	84	65-108	8.1
Tylodelphys clavata (met.)	7	3.2	7	7	0.2
Posthodiplostomum cuticola (met.)	12	9.7	4	1-9	0.4
Ligula intestinalis (pl.)	7	19.4	1.2	1-2	0.2
Total	311	25.8	38.9	1-108	10

Table 8. Parasitic fauna of tench from the Vistula Lagoon

Parasite	No. of parasites	Prev. [%]	Mean int.	R. int.	Dens.
Diplostomum spp. (met.)	6	7.7	2	1-3	0.2
Tylodelphys clavata (met.)	1	2.6	1	1	0.03
Asymphylodora tincae	5	5.1	2.5	2-3	0.1
Caryophyllaeus laticeps	1	2.6	1	1	0.03
Paradilepis scolecina (pl.)	5	5.1	2.5	2-3	0.1
Ergasilus sieboldi	15	7.7	5	2-11	0.4
Total	33	23.1	3.7	1-11	0.8

Table 9. Parasitic fauna of ide from the Vistula Lagoon

Parasite	No. of parasites	Prev. [%]	Mean int.	R. int.	Dens.
Diplostomum spp. (met.)	90	–	90	90	90
Tylodelphys clavata (met.)	41	–	41	41	41
Ichthyocotylurus platycephalus (met.)	3	–	3	3	3
Allocreadium isoporum	256	–	256	256	256
Paracanthocephalus gracilacanthus	3	–	3	3	3
Ergasilus sieboldi	5	–	5	5	5
Total	398	–	398	3-256	398

Table 10. Parasitic fauna of asp from the Vistula Lagoon

Parasite	No. of parasites	Prev. [%]	Mean int.	R. int.	Dens.
Diplostomum spp. (met.)	34	–	6.8	5-11	4.9
Tylodelphys clavata (met.)	5	–	5	5	0.7
Proteocephalus torulosus	10	–	2	1-3	1.4
Eustrongylides mergorum (III st.)	1	–	1	1	0.1
Ergasilus sieboldi	1	–	1	1	0.1
Total	51	–	8.5	1-11	7.3

Table 11. Parasitic fauna of Baltic vimba from the Vistula Lagoon

Parasite	No. of parasites	Prev. [%]	Mean int.	R. int.	Dens.
Paradiplozoon bliccae	2	–	2	2	0.4
Diplostomum spp. (met.)	64	–	32	13-51	12.8
Ichthyocotylurus platycephalus (met.)	1	–	1	1	0.2
Caligus lacustris (ad.)	1	–	1	1	0.2
Total	68	–	34	1-51	13.6

Table 12. Parasitic fauna of common carp from the Vistula Lagoon

Parasite	No. of parasites	Prev. [%]	Mean int.	R. int.	Dens.
Ichthyophthirius multifiliis	20	–	10	8-12	10
Dactylogyrus extensus	15	–	7.5	8-9	7.5
Bothriocephalus acheilognathi	2	–	2	2	12
Total	37	–	18.2	2-12	18.5

Table 13. Parasitic fauna of rudd from the Vistula Lagoon

Parasite	No. of parasites	Prev. [%]	Mean int.	R. int.	Dens.
Diplostomum spp. (met.)	155	–	51.7	38-77	38.8
Caryophyllaeus laticeps	2	–	2	2	0.5
Total	157	–	52.3	2-77	39.3

Table 14. Parasitic fauna of common dace from the Vistula Lagoon

Parasite	No. of parasites	Prev. [%]	Mean int.	R. int.	Dens.
Diplostomum spp. (met.)	190	–	190	190	190
Posthodiplostomum cuticola (met.)	6	--	6	6	6
Total	196	–	196	6-190	196

Table 15. Parasitic fauna of bleak from the Vistula Lagoon

Parasite	No. of parasites	Prev. [%]	Mean int.	R. int.	Dens.
Diplostomum spp. (met.)	12	–	2	1-3	0.4

Table 16. Parasitic fauna of zander from the Vistula Lagoon

Parasite	No. of parasite	Prev. [%]	Mean int.	R. int.	Dens.
Ancyrocephalus paradoxus	1498	57	6.7	1-22	3.8
Bucephalus polymorphus (ad.)	306	2.2	3.6	1-14	0.8
Rhipidocotyle campanula (ad.)	194	14.6	3.4	1-12	0.5
Diplostomum spp. (met.)	91	5.4	4.3	1-20	0.2
Tylodelphys clavata (met.)	20	2.8	1.8	1-3	0.05
Ichthyocotylurus platycephalus (met.)	35	4.4	2.1	1-5	0.09
Brachyphallus crenatus	8	1.8	1.1	1-2	0.02
Bunodera luciopercae	35	5.4	1.7	1-8	0.09
Eubothrium crassum (pl.)	15	1	3.8	1-8	0.04
Bothriocephalus scorpii (pl.)	12	2.1	1.5	1-3	0.03
Proteocephalus filicollis	167	4.4	9.8	1-40	0.4
Camallanus lacustris	7	1.5	1.2	1-2	0.02
Camallanus truncatus	29	5.4	1.4	1-4	0.07
Cystidicoloides ephemeridarum	5	0.5	0.1	2-3	0.01
Anguillicola crassus (III st.)	1	0.3	1	1	0.003
Anisakis simplex (III st.)	111	10.5	2.7	1-6	0.3
Hysterothylacium aduncum (IV and ad.)	5	1	1.3	1-2	0.01
Neoechinorhynchus rutili	3	0.3	3	3	0.008
Corynosoma semerme (cystacanth)	3	0.8	1	1	0.008
Corynosoma strumosum (cystacanth)	2	0.5	1	1	0.005
Acanthocephalus lucii	3	0.5	1.5	1-2	0.008
Piscicola geometra	4	1	1	1	0.01
Ergasilus sieboldi	1	0.3	1	1	0.003
Caligus lacustris (ch. III and ad.)	7	1.3	1.4	1-2	0.02
Achtheres percarum	1872	56.4	8.5	1-35	4.7
Unionidae gen sp. (glochidia)	2	0.3	2	2	0.005
Total	4436	79.2	14.6	1-40	11.4

Table 17. Parasitic fauna of European perch from the Vistula Lagoon

Parasite	No. of parasites	Prev. [%]	Mean int.	R. int.	Dens.
Henneguya psorospermica	11259	11.2	250.2	28-465	30.3
Bucephalus polymorphus (ad.)	5	0.8	1.7	1-2	0.01
Diplostomum spp. (met.)	216	11.6	5	1-41	0.6
Tylodelphys clavata (met.)	9259	53	44	1-171	25
Posthodiplostomum brevicaudatum (met.)	80	3.8	5.7	4-7	0.2
Ichthyocotylurus platycephalus (met.)	10	1.3	2	1-4	0.03
Ichthyocotylurus variegatus (met.)	33	3.8	2.4	1-5	0.09
Apatemon annuligerum (met.)	71	5.1	3.7	1-13	0.2
Bunodera luciopercae	254	20.5	3.3	1-23	0.7
Eubothrium crassum (pl.)	7	1.6	1.2	1-2	0.02
Triaenophorus nodulosus (pl.)	69	11.9	1.6	1-6	0.2
Proteocephalus filicollis	502	20.2	6.7	1-98	1.4
Proteocephalus percae	26	4.9	1.4	1-3	0.07
Camallanus lacustris	18	3.5	1.4	1-2	0.05
Camallanus truncatus	145	23.2	1.7	1-4	0.4
Cystidicoloides ephemeridarum	5	1.1	1.3	1-2	0.01
Anguillicola crassus (III st.)	2	0.5	1	1	0.005
Hysterothylacium aduncum (IV and ad.)	5	1.8	1.7	1-2	0.01
Raphidascaris acus	6	0.8	2	2	0.02
Acanthocephalus lucii	108	12.4	2.3	1-12	0.3
Piscicola geometra	3	0.8	1	1	0.008
Ergasilus sieboldi	3	0.5	1.5	1-2	0.008
Caligus lacustris (ch. III, IV and ad.)	11	2.7	1.1	1-2	0.03
Unionidae gen sp. (glochidia)	105	0.5	52.5	1-104	0.3
Total	22202	83.8	71.4	1-465	59.8

Table 18. Parasitic fauna of ruffe from the Vistula Lagoon

Parasite	No. of parasites	Prev. [%]	Mean int.	R. int.	Dens.
Glugea acerinae	177	0.6	88.5	75-102	0.5
Dactylogyrus amphibothrium	168	23.6	2.2	1-4	0.5
Diplostomum spp. (met.)	103	8.8	3.6	1-34	0.3
Tylodelphys clavata (met.)	17	0.6	8.5	1-16	0.05
Ichthyocotylurus platycephalus (met.)	66	2.1	9.4	1-38	0.2
Ichthyocotylurus variegatus (met.)	1	0.3	1	1	0.003
Eubothrium crassum (pl.)	4	1.2	1	1	0.01
Proteocephalus filicollis	36	5.8	1.9	1-4	0.1
Schulmanella petruschewskii	6	0.6	3	2-4	0.02
Eustrongylides mergorum (III st.)	77	22.1	1.1	1-2	0.2
Anguillicola crassus (III st.)	320	11.8	8.2	1-159	1
Hysterothylacium aduncum (IV st.)	1	0.3	1	1	0.003
Ergasilus sieboldi	5	0.9	1.7	1-3	0.02
Caligus lacustris (ad.)	4	0.9	1.3	1-2	0.01
Unionidae gen sp. (glochidia)	5	0.9	1.7	1-2	0.02
Total	984	58.2	5.1	1-159	3

Table. 19. Parasites of cyprinid and percid fishes found in the Polish and Russian part (Kaliningrad Lagoon) of the Vistula Lagoon

Parasite	Polish part of the Vistula Lagoon		Russian part of the Vistula Lagoon	
	hosts	references	host	references
Pleistophora sp.	Ru	Własow et al. 1997		
Myxidium rhodei			R, Rd, W	Evdokimova et al. 1994, Zaostrovceva 1996
Myxidium sp.			B, R	Evdokimova et al. 1989
Sphaerospora sp.	Ru	Własow et al. 1997		
Chloromyxum sp.			B	Evdokimova et al. 1989
Myxosoma dujardini	Rd	Wegener 1909		
Myxobolus bramae			B, R, W	Evdokimova et al. 1994, Zaostrovceva 1996
M. cycloides (=*muelleri*)	B, Bl, R, Rd, V, W, (G, Bi)**	Wegener 1909		
M. dispar			B, R, Rd, W	Evdokimova et al. 1994, Zaostrovceva 1996
M. elegans			B, R	Evdokimova et al. 1994, Zaostrovceva 1996
M. exiguus	B	Wegener 1909		
M. macrocapsularis			B, R, W	Evdokimova et al. 1994, Zaostrovceva 1996
M. muelleri	Ru, (B, R)*, G**	Wegener 1909, Własow et al. 1996, 1997	B, R, Rd, W	Evdokimova et al. 1994, Zaostrovceva 1996
M. mulleriformis			R, Rd	Evdokimova et al. 1994, Zaostrovceva 1996
M. musculi			B, R, Rd, W	Evdokimova et al. 1994, Zaostrovceva 1996
M. oviformis	B, V, W	Wegener 1909		
M. pseudodispar			B, R, Rd, W	Evdokimova et al. 1994, Zaostrovceva 1996
M. rutili			R, Rd	Evdokimova et al. 1994, Zaostrovceva 1996
Myxobolus sp.	P, Ru,	Wegener 1909, Własow et al. 1997	B, R, Za	Evdokimova et al. 1989
Henneguya creplini	Ru	Wegener 1909	P	Evdokimova et al. 1994
H. minuta	P	Wegener 1909		
H. texta	P	Wegener 1909		
Henneguya sp.	P	Własow et al. 1997		
Ichthyophthirius multifilis	Bl, R, W	Wegener 1909		
Cyclochaeta (= *Trichodina*) *domerguei*	C, P, R, Rd, Ru, T, W, Z, Za, (Be, Cc, G, L, We)**	Wegener 1909		
Trichodina urinaria	P, Ru, Ru*	Własow et al. 1996, 1997		
Trichodina sp.	Ru, (B, Ru Za)*	Własow et al. 1996, 1997	Za	Evdokimova et al. 1989, 1994
Dactylogyrus alatus	Bl	Wegener 1909		
D. amphibothrium	Ru	Wegener 1909		

D. anchoratus	Cc**	Wegener 1909		
D. auriculatus	B	Prost 1959		
D. caballeri	R	Prost 1959		
D. cornu	W	Wegener 1909, Prost 1959		
D. crucifer	R	Prost 1959		
D. difformis	Rd, W	Wegener 1909, Prost 1959		
D. extensus			B, R, W	Evdokimova et al. 1994
D. falcatus	B, W	Wegener 1909, Prost 1959		
D. fallax	R, Rd, W	Wegener 1909, Prost 1959		
D. fraternus	Bl	Wegener 1909		
D. intermedius	Cc**	Wegener 1909		
D. minor	Bl	Wegener 1909		
D. nanus	R	Prost 1959		
D. parvus	Bl	Wegener 1909, Prost 1959		
D. similis	R	Prost 1959		
D. sphyrna	R, V, W	Wegener 1909, Prost 1959		
D. wunderi	B	Prost 1959		
D. zandti	B	Prost 1959		
Dactylogyrus sp.	W	Wegener 1909	B, R	Evdokimova et al. 1989
Ancyrocephalus cruciatus	We**	Wegener 1909		
A. paradoxus	Za	Wegener 1909	Za	Evdokimova et al. 1994
Ancyrocephalus sp.			Za	Evdokimova et al. 1989
Paradiplozoon homoion homoion			B, W	Evdokimova et al. 1994
P. rutili			R	Evdokimova et al. 1994
Paradiplozoon sp.	B*	Własow et al. 1996		
Diplozoon paradoxum	B, Bl, R, Rd, V, W, G**	Wegener 1909, Prost 1959	B, R	Evdokimova et al. 1994
Diplozoon sp.			B, R	Evdokimova et al. 1989
Monogenea n. d.	Ru	Własow et al. 1996		
Sanguinicola inermis	Ru	Wegener 1909		
Bucephalus polymorphus, met	B, Bl, Ru, W	Wegener 1909		
Ichthyocotylurus sp.	P, Ru, (Ru, Za)*	Własow et al. 1996, 1997	B, Za	Evdokimova et al. 1989
Tetracotyle sp.	P, Ru, Za, L**	Wegener 1909		
Diplostomum helveticum			P	Evdokimova et al. 1989, 1994
Diplostomum spathaceum			P, R, Za	Evdokimova et al. 1994
Diplostomum sp.	B, P, R, Ru, (B, P, R, Ru)*	Własow et al. 1996, 1997	B, P, R, Za	Evdokimova et al. 1989
Tylodelphys clavata	B, P, R, Ru, (P, Ru)*	Własow et al. 1996, 1997		
Tylodelphys sp.			B, P, R	Evdokimova et al. 1989
Trematoda n. d.			B	Evdokimova et al. 1989

Caryophyllaeus laticeps			B	Evdokimova et al. 1989 and 1994
C. brachycolis			B	Evdokimova et al. 1994
C. fimbriceps			B	Evdokimova et al. 1994
Khawia baltica			B	Evdokimova et al. 1994
Ligula intestinalis	B*	Własow et al. 1996	B	Evdokimova et al. 1994
Triaenophorus nodulosus	P	Własow et al. 1996	P, Za	Evdokimova et al. 1994
Proteocephalus sp.	Ru	Własow et al. 1997		
Camallanus lacustris	P, Za	Własow et al. 1997	P, Za	Evdokimova et al. 1989, 1994
Camallanus sp.			B, P	Evdokimova et al. 1989
Philometra kotlani	B*	Własow et al. 1996		
Contracaecum sp.			P	Evdokimova et al. 1989
Rhaphidascaris acus			P, Za	Evdokimova et al. 1989, 1994
Anguillicola crassus	P, Ru, Za, (B, Ru, W)*	Własow et al. 1996, 1997		
Nematoda n. d.			R	Evdokimova et al. 1989
Acanthocephalus anguillae			P	Evdokimova et al. 1989
Acanthocephalus luci			P	Evdokimova et al. 1989, 1994
Pseudoechinorhynchus borealis			P, Za	Evdokimova et al. 1994
Pomphorhynchus laevis			P	Evdokimova et al. 1989
Acanthocephala n. d.			B	Evdokimova et al. 1989
Piscicola geometra	P	Wegener 1909		
Ergasilus sieboldi	B, Bl, P, R, Ru, W, Za, Cc**	Wegener 1909, Grabda 1962		
Caligus lacustris	B	Grabda 1956, 1962, Grabda and Grabda 1959		
Achtheres percarum	Za	Grabda 1962, Grabda and Grabda 1959	Za	Evdokimova et al. 1994
A. sandrae (=percarum)	Za	Wegener 1909		
Achtheres sp.			Za	Evdokimova et al. 1989
Tracheliastes maculatus	B	Grabda 1956, Grabda and Grabda 1959		
Argulus foliaceus	W	Wegener 1909		
Anodonta spp. (glochidia)	C, Ru	Wegener 1909		
Unio spp. (glochidia)	Bl, P, R, Rd, W, G**	Wegener 1909		
Glochidia n. d.	(R, Ru)*	Własow et al. 1996		

B – Carp bream, Be – Belica, Bi – Bitterling, Bl – Bleak, C – Common carp, Cc – Crucian carp, G – Gudgeon, L – Stone loach, P – European perch, R – Roach, Rd – Rudd, Ru – Ruffe, T – Tench, V – Baltic vimba, W – White bream, We – Weatherfish, Za – Zander, Z – Ziege

*parasites found in fish regurgitated by cormorants, **not studied at present

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