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Research Article

SEX AND AGE OF FLOUNDER *PLATICHTHYS FLESUS* (L.) AND PARASITIC INFECTION IN THE GULF OF GDAŃSK

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Abstract

Flounder *Platichthys flesus* (L.) (1509 specimens) was sampled randomly between April 1998 and March 2000 in the Gulf of Gdańsk. The sex, age, and parasites were determined. The prevalence, intensity, mean intensity, and relative density of the infection of the detected parasites were calculated according to host sex and age. Susceptibility to infection was related to host age. Each parasite species had its own host sex preferences. The results indicated that host age and sex could play a major role in the determination of parasitic infection in flounder.

INTRODUCTION

The parasite fauna of flounder *Platichthys flesus* (L.) in the Baltic Sea is a mixture of marine and freshwater species. Most of the parasites observed are not specific for the flounder or flatfishes. The parasite fauna of flounder from the Gulf of Gdańsk and adjacent areas was studied by Sulgostowska *et al.* (1987), Fagerholm and Køie (1994), Rokicki and Morozińska (1994), and Køie (1999).

Although plentiful information is currently available regarding the various aspects of the biology of flounder and its parasites, the relationship between the sex and age of this fish and its parasitic fauna has been studied infrequently in the Baltic Sea. A wide variety of environmental and host-dependent factors can influence the prevalence, intensity, mean intensity, and relative density of parasitic infection. Many difficulties face the researcher when ranking the importance of biotic and abiotic factors with regard to their influence on the prevalence and intensity of parasites. Little information exists on the correlation between the ecological parameters of parasite species and host sex and age. Only a few researchers have addressed parasitic infection in relation to flounder age in the Gulf of Gdańsk (Mulicki 1947, Ziółkowska *et al.* 2000).

Therefore, the objective of this study was to investigate the parasitic fauna in an attempt to determine the correlation between ecological parameters such as prevalence, intensity, mean intensity, and relative density with host sex and age.

MATERIALS AND METHODS

Platichthys flesus (1509 specimens) was collected randomly from the nets of local commercial fishermen from April 1998 to March 2000. The mean monthly sample size was 66 specimens. The sex of each specimen was determined by examining the gonads, and the age of the specimens was determined by examining the otoliths (Bucke 1994). Each gender was divided into age classes, as follows: class I (2 years); class II (3 years); class III (4 years); class IV (5 years); class V (6 years).

The minimum and maximum ages of the specimens were 2 and 6 years, respectively with a mean of 2.83 ± 0.65 (SD). The majority of the specimens belonged to classes 2 and 3.

The external organs (skin, gills, eyes) of each specimen were examined for the occurrence of ectoparasites and/or signs of parasites. The internal organs of post-mortem fish were examined for the occurrence of endoparasites and/or signs of parasites according to Brown (1987), Moravec (1994), Valtonen and

Crompton (1990), and Bucke (1994). The parasites were identified morphologically and classified according to the criteria of Anderson (1992), Berland (1970), Lom (1995), Malmberg (1970), and Moravec (1994).

The number of individuals of each parasite in each host and their total number from all infected hosts were determined. The prevalence, intensity, mean intensity, and relative density (mean abundance) of the parasitic infection for all detected parasite species were calculated according to Margolis *et al.* (1982). With *T. borealis*, the density was reported as categories (parasite numbers per microscopic field, under magnification of 10 x). Intensity, mean intensity, and relative density were not determined for *G. anomala*, *T. borealis*, or *Lampetra* sp.

The correlation between the prevalence of parasitic infection and host sex and age were calculated using Log likelihood statistics (-2Log L R). The correlation between parasitic infection, mean intensity, and relative density (mean abundance) of parasitic infection and sex and age were calculated using Snedcor's F statistic test (Piegorsh and Bailer 1997).

RESULTS

The ecto- and endoparasite species and genera detected (and/or signs of them) included the following: *Trichodina borealis* (Dogiel 1940); *Diplostomum* sp. *metacercariae*, most probably *Diplostomum spathaceum* (Rudolphi 1819); *Hysterothylacium aduncum* (Rudolphi 1802); *Cucullanus heterochrous* (Rudolphi 1802); *Dichelyne minutus* (Rudolphi 1819); *Echinorhynchus gadi* (Zoega in Müller 1776); *Pomphorhynchus laevis* (Zoega in Müller 1776). The following species were found sporadically (very low level of infection): *Glugea anomala* (Moniez 1887); *Gyrodactylus unicopula* (Glukhova 1955); *Gyrodactylus flesi* (Malmberg 1957); *Diplostomum mergi* (Dubois 1932); *Bothriocephalus scorpii* (Müller 1776) larvae; *Raphidascaris acus* (Bloch 1779); *Lampetra* sp. Therefore, they were considered very rare or incidental parasite species (Tab 1).

Table 1

Prevalence and mean intensity of infection of species found sporadically (very low infection)

Parasite	no. of infected fish	no. of parasites(*)	prevalence (%)	mean intensity
Glugea anomala	14	44 (29♀ 15♂)	0.93	3.14
Gyrodactylus unicopula	10	16 (10♀ 6♂)	0.66	1.60
Gyrodactylus flesi	1	1 (♀)	0.07	1
Diplostomum mergi	8	45 (21♀ 24♂)	0.53	5.63
Bothriocephalus scorpii	9	10 (7♀ 3♂)	0.6	1.11
Raphidascaris acus	10	12 (3♀ 9♂)	0.66	1.20
Lampetra sp.	13	30 (21♀ 9♂)	0.86	2.31

* Number of parasites found in female and male hosts; ♀♂ - host sex

Neither *Trichodina borealis*, due to its stable (100%) prevalence, or incidental parasites are shown in Figures 1 or 2. Apart from *T. borealis*, the most prevalent parasite species in both females and males were *C. heterochrous* (49.97%), *H. aduncum* (45.13%), and *D. minutus* (31.88%), and females were more heavily infected with these species, with the exception of *H. aduncum* (Fig. 1A). The mean intensity for *Diplostomum* sp. and *D. minutus* in females was higher than in males (Fig 1B). The highest density in both female and male hosts was observed in *Diplostomum* sp., *D. minutus*, *H. aduncum*, and *P. laevis*. However, the infection of *D. minutus* in females was slightly more frequent (Fig. 1C). Females were more heavily infected with Acanthocephala than were males. Although there were small differences between the sexes regarding infection susceptibility to these two nematodes, the prevalence of *C. heterochrous*, the mean intensity of *H. aduncum*, and the relative density of *H. aduncum* and *C. heterochrous* were only insignificantly correlated with host sex. Incidental parasites were recorded primarily in the most frequent age class II; the exception to this rule was *R. acus*, which was noted equally in age classes I and II.

The samples from the oldest age classes were too small to allow statistical analysis (IV – fourteen fish; V - two fish). All of the parasites were detected in the three classes, except *G. flesi*, which was found only in one age class III host. *T. borealis*, *H. aduncum*, *C. heterochrous*, *E. gadi*, and *P. laevis* were found even in the extreme classes. The prevalence of *G. anomala*, *Diplostomum* sp., *D. mergi*, *H. aduncum*, and *Lampetra* sp. was lower in older fish, which contrasted with the prevalence of *G. unicopula*, *B. scorpii*, *E. gadi*, and *P. laevis.* The prevalence of *C. heterochrous* and *D. minutus* was the highest in age class II. Other species have different age preferences (Fig. 2A). The mean intensity of *Diplostomum* sp. decreased in comparison with that of *D. minutus*. The mean intensity of other parasite species varied irregularly (Fig. 2B). Similar relationships were noted regarding relative density; that of *Diplostomum* sp. decreased while that of *D. minutus* and *C. heterochrous* increased in older fish (Fig. 2C).

The majority of fish belonged to the most infected age classes I and II. Most of the detected flounder parasite species were noted in hosts from age classes II and III.

Statistical analysis indicated that the prevalence, mean intensity, and relative density were correlated with host age in some parasite species. The prevalence of *C. heterochrous* and *D. minutus* was inversely proportional to fish age. There was a positive correlation between *P. laevis* prevalence and host age. The correlation between mean intensity and host age for *E. gadi* and *C. heterochrous* is direct, as opposed to *D. minutus*, where the correlation is

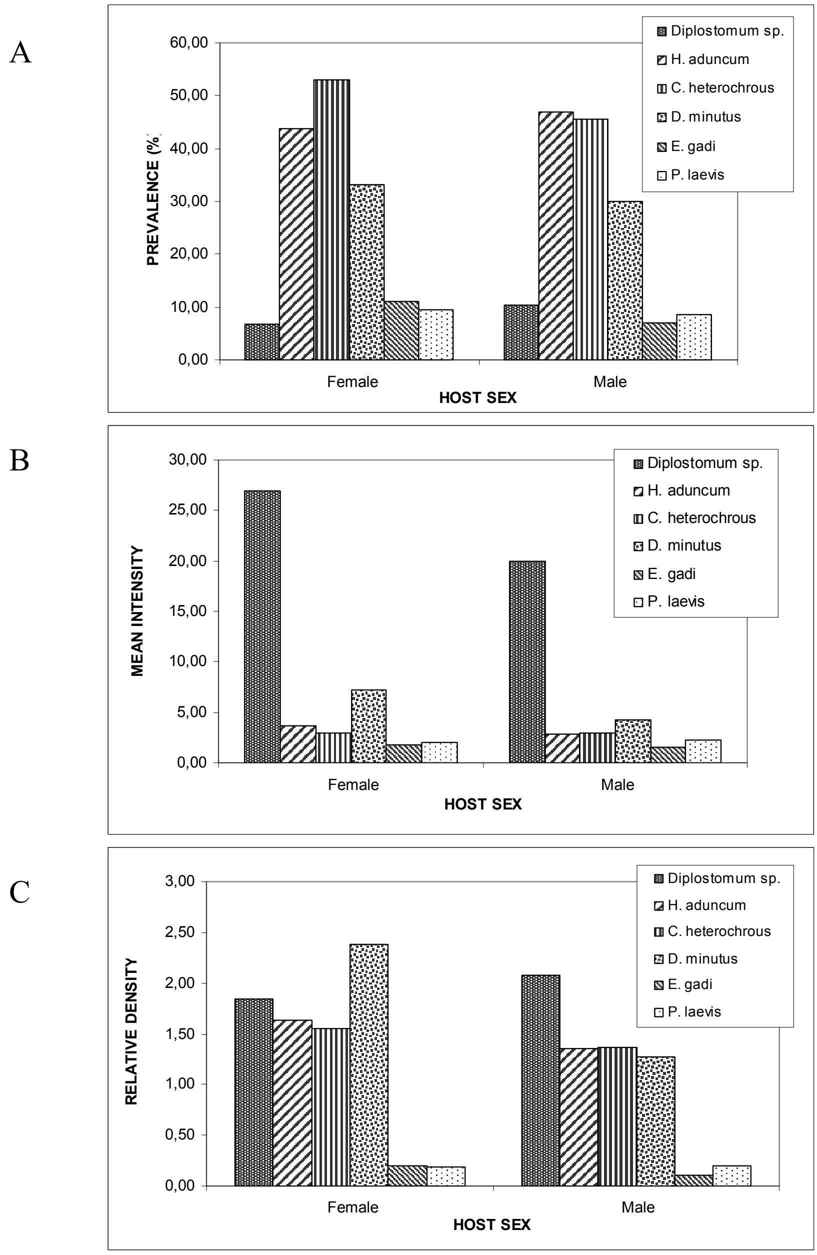

Fig. 1. Values of prevalence (A), mean intensity (B), and relative density (C) of infection according to host sex.

A

B

C

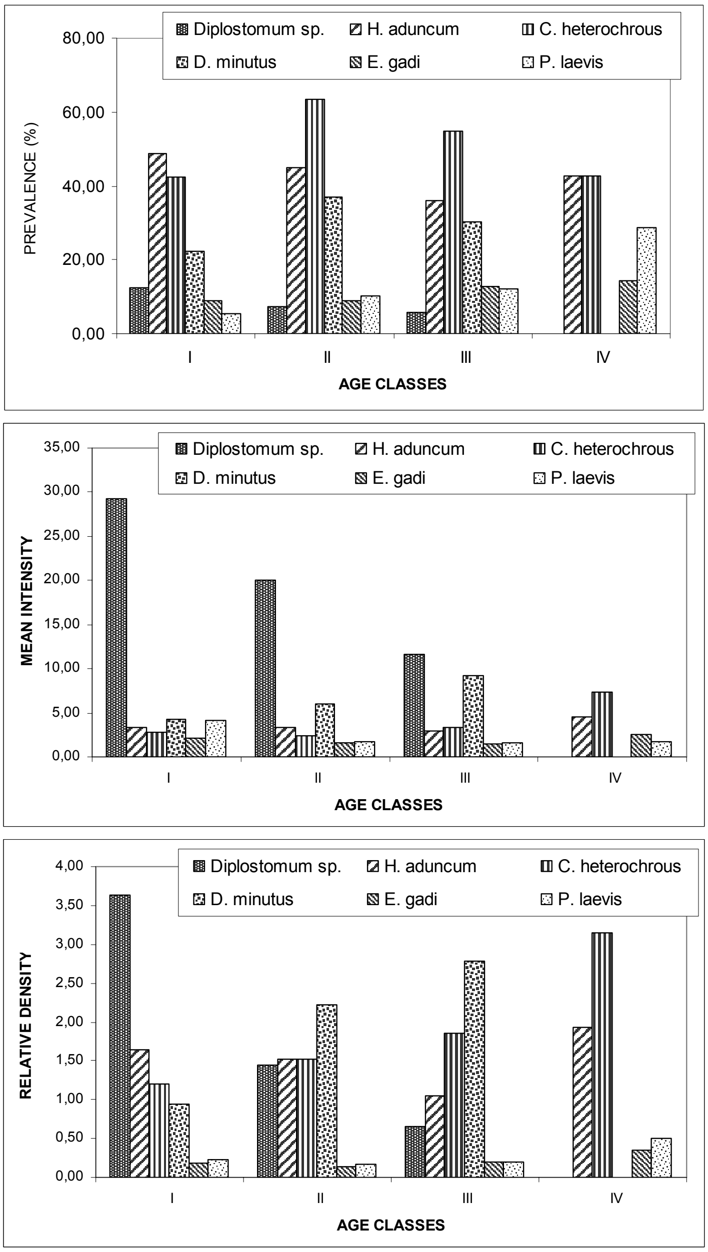

Fig. 2. Values of prevalence (A), mean intensity (B), and relative density (C) of infection according to host age.

negative. The relative density of *E. gadi*, *D. minutus*, and *C. heterochrous* is positively correlated with flounder age, while for *Diplostomum* sp. this correlation is inversely proportional. Finally, the results indicate that each parasite species infected mainly hosts of specific age characteristics (Fig. 2A, B, C).

DISCUSSION

This paper does not discuss at length the following incidental parasite species: *Glugea anomala*, *Gyrodactylus unicopula*, *Gyrodactylus flesi*, *Diplostomum mergi*, *Bothriocephalus scorpii*, *Raphidascaris acus*, and *Lampetra* sp.

In biological and ecological studies, especially in the field of parasitology, an acceptable overall view of the parasite fauna can only be obtained if the monthly fish sample size is at least 12 - 15 specimens (Bylund *et al.* 1979). Thus, the total number of specimens used in the present study is reasonably representative of the whole population of the host species.

The data from the Gulf of Gdańsk indicated a little difference in the susceptibility to infection depending on host sex, but the differences in the values of prevalence, intensity, mean intensity, and relative density of infection were statistically insignificant (Fig. 1).

In the case of Acanthocephala, the present data were similar to results obtained by Valtonen and Crompton (1990). They reported that the females of thirty-one examined fish species, including *Platichthys flesus* from the Bothnian Bay in the Baltic Sea, were usually more heavily infected than males. Hine and Kennedy (1974) reported that the incidence of *P. laevis* infection in dace (*Leuciscus leuciscus*), chub (*L. cephalus*), and grayling (*Thymallus thymallus*) in the River Avon depended on fish sex. They concluded that intensity is higher in older females due to feeding variations, but that the difference was insignificant. This conclusion is drawn from the opinion that the cause of heavier infections in older fish stem from the association between testosterone and the immune system (Zuk and McKean 1996). These authors also suggested that sex differences in disease have evolved just as sex differences in morphology and behavior, and that they result from selection acting differently on males and females. Additionally, susceptibility to parasites and behavior-influenced exposure can vary depending on season or year. Many vertebrates exhibit increased activity or altered feeding patterns during the breeding season. Another factor which determines diet preference is host age and size.

In the present study, the parasite samples collected from females significantly outnumbered those from males, but the prevalence of infection of

H. aduncum and *Diplostomum* sp. were higher in males (Fig 1A). The high intensity, prevalence, and relative density of *Diplostomum* sp. infection in young fish is probably related to the fact that juveniles live in the shallow coastal waters and estuaries of the Gulf of Gdańsk that are the natural environments of snails – the intermediate host of *Diplostomum* sp. The infection of this parasite is progressive; the *metacercariae* accumulate in fish lenses and are associated with cataracts or blindness caused by opacity of the eye lens (Whyte *et al.* 1991). Thus, it is probable that by infecting the vision system this parasite reduces the survival rate of its host. Flounder that are infected with eye flukes are probably more susceptible to predatory attacks, which can limit the number of infected individuals in a studied population (Fig 2 A, B, C).

The prevalence and intensity of *H. aduncum* infections recorded in this study were similar to those reported in the Baltic gobies studied by Zander *et al.* (1993). The intermediate hosts were mainly planktonic copepods, amphipods, and polychaetes (Anderson 1994), and all the fish age classes could eat intermediate hosts of different sizes. While the intensity and relative density of *C. heterochrous* and *D. minutus* increased, prevalence decreased. This pattern of change linked to age attests to the progressive character of the infections. Alternatively, older fish with well-developed immune systems become more resistant to new infections. The balance between these processes might reduce the prevalence of infection. Another reason might be that some parasite species have a direct, or monoxenous, life cycle, *e.g.*, neither *T. borealis* nor *Gyrodactylus* sp. have intermediate hosts. The high intensity of *Trichodina* sp. infections might result from the high concentration of fish in the sampling area. Other parasites apparently have an indirect, or heteroxenous, life cycle with one or more intermediate host. Paratenic hosts might also play a role in some cases.

Ziółkowska *et al.* (2000) reported a correlation between the prevalence and intensity of *P. laevis* infection and the age of their host - flounder from the Gulf of Gdańsk. These authors also found that susceptibility to infection increased in fish from age class V. Munro *et al.* (1989) reported a similar relationship between *P. laevis* and flounder in the tidal River Thames. The incidence of parasites in the River Avon is independent of fish age, and the higher intensity in older individuals was due to feeding differences (Hine and Kennedy 1974); this conflicts with the results of the current study (Fig. 2B).

Ostrowski (1997) studied the food of flounder in the southern Baltic. He observed variation in food composition relative to the area and the depth of catch, which corresponded to the qualitative and quantitative distribution of bottom-dwelling fauna and also depended on fish size. Aarnio *et al.* (1996) investigated the ontogenic shift, dependent on the size of the fish, in the food preferences of juvenile flounder and turbot *Scophthalmus maximus* (L.) from the northern Baltic Sea. These authors concluded that small flounder mainly consumed meiofauna-dominating taxa (*e.g.*, Harpacticoida) but large fish consumed macrofauna-dominating taxa (*e.g.*, Oligochaeta). Aarnio and Bonsdorff (1997) found experimentally that benthic prey organisms (*e.g.*, Ostracoda) can resist digestion and survive the gut passage of juvenile flounder *P. flesus* from the Baltic Sea. This could also explain the low prevalence of parasites in young fish revealed in this study. In the present study, an upward tendency was observed in the case of older fish, in contrast to Janiszewska (1938), who reported irregular fluctuations in the prevalence of *P. laevis*. These differences can be described as dependent on the season and on the numbers and composition of benthic species and their behavior (Aarnio *et al.* 1996, Ostrowski 1997). The prevalence of infection with age is increased by the higher probability of being exposed to the intermediate host of *P. laevis.* Kennedy (1996) described a similar dependence: the highest prevalence occurred in the larger size categories of flounder and continued to rise until the fish were eight years old. Mulicki (1947), who reported that the percentage of infected fish rises in proportion to their length, described the same relationship. This picture of the distribution of the mean intensity and the prevalence of *P. laevis* is probably connected with the feeding habits of *P. flesus*. The diet of fish younger than one year old consisted mainly of *Baccilariophyceae* (Mulicki 1947) and *Calanoida* (Kostrzewska-Szlakowska and Szlakowski 1990) but not *Gammaridae.* The highest prevalence of infected *Gammarus* spp. was reported in specimens 6 – 10 mm in length (Hine and Kennedy 1974), and these are rather too large for the smallest flounder to consume. Fish of medium age (3 – 4) are the least fastidious in their choice of food. In spite of this, a high percentage of uninfected fish was found in each age class of fish examined from the same area. There is a considerable possibility that infection is directly connected with individual food preferences, and indirectly with the varying proportion of gammarids in the flounder diet. Therefore, in the case of older fish, the observed intensity is probably lower than in younger fish even though Mulicki (1947) reported that gammarids are an important component of the flounder diet. It could be concluded that as *Gammaridae* plays a significant role in the life cycle of *P. laevis*, the prevalence and intensity of infection are dependent upon feeding on them.

There are differences between the parasite fauna of females and males and old and young hosts. The possibility that the immune system in mature fish is responsible for the decreasing intensity of *D. minutus* infection in older hosts cannot be excluded (Fig. 2B). In older fish the prevalence and relative density of *P. laevis* and *E. gadi* are increased by the ontogenic shift in food preferences, but the well-developed immune system could decrease the intensity of infection.

There is a correlation between parasite prevalence, intensity, mean intensity, and relative density and host sex and age in the Gulf of Gdańsk. The current results indicate that each parasite species parasitized a host with specific characteristics depending directly on food preferences. The second factor determining parasitic infections is probably the development of the immune system, but this correlation is indirect, depending on sex hormones and breeding behavior.

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