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Research Article

Seasonal dynamics and spatial distribution of *Dactylogyrus crucifer* Wagener, 1857 on the gills of roach (*Rutilus rutilus* L.) from Lake Sapanca, Turkey

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Abstract: This study determined the seasonal dynamics and spatial distribution of the monogenean parasite *Dactylogyrus crucifer* on the gills of roach *Rutilus rutilus* from Lake Sapanca, Turkey. A total of 183 specimens of roach between January and November 2005 were examined in monthly intervals. The highest mean intensity was recorded in March (227.1 ± 87.14) and the lowest in November (13.3 ± 8.2). Fifty three *R. rutilus* specimens were therefore investigated for spatial distribution of *D. crucifer* in March 2006. No significant differences in distribution were found according to any of the spatial determinants.

Key words: Roach, monogenean, seasonal occurrence, spatial distribution, Lake Sapanca

Sapanca Gölü (Türkiye)'nde Kızılgöz Balığı (*Rutilus rutilus* L.)'nın solungaçlarında *Dactylogyrus crucifer* Wagener, 1857 in mevsimsel dinamikleri ve mekansal dağılımı

Özet: Bu çalışmada, Sapanca Gölünde *Rutilus rutilus*'un solungaçlarındaki monogenean parazit *Dactylogyrus crucifer*'in mevsimsel dinamikleri ve mekansal dağılımı belirlendi. 2005 yılı Ocak ve Kasım ayları arasında toplam 183 kızılgöz balığı ile aylık olarak çalışılarak parazitin en yüksek ortalama yoğunluğu Mart'ta (227.1 ± 87.14) ve en düşük değeri Kasım'da (13.3 ± 8.2) bulundu. Bu nedenle 2006 yılı Mart ayında *D. crucifer*'in mekansal dağılımı araştırıldı. Mekansal dağılım yönünden hiçbir anlamlı fark bulunamadı.

Anahtar sözcükler: Kızılgöz, monogenean, mevsimsel varlık, mekansal dağılım, Sapanca Gölü

Introduction

The spatial distribution of gill parasites has been investigated by several authors (El Hafidi et al., 1998; Dzika, 1999; Chapman et al., 2000; Matejusova et al., 2002; Simkova et al., 2002; Gutierrez and Martorelli, 1999; Turgut et al., 2006). The microhabitats and coexistence of *Dactylogyrus* species of *Rutilus rutilus* have also been investigated (Koskivaara et al., 1992; Koskivaara and Valtonen, 1992; Bagge and Valtonen, 1999; Simkova et al., 2000, 2002). Various factors have

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been reported to affect parasite populations on gills. Seasons and water temperature affect the occurrence and abundance of monogenoids (Koskivaara et al., 1991; Simkova et al., 2001) and the trophic status of a lake determines the presence and abundance of certain parasites (Wisniewski, 1958). Physiological and immunological factors of the fish host may determine the degree of infection (Dobson and May, 1987). Some fish develop immunity against the *Dactylogyrus* species (Paperna, 1964). Site specificity in monogeneans may result from physico-chemical requirements (Chapman et al., 2000). Variations in water current over the gill surface, or which arch has the greatest area, can affect the hemibranch preference of monogenoids (Gutierrez and Martorelli, 1999).

The present study investigated the monogenean parasite *D. crucifer* on the gills of *R.rutilus* from Lake Sapanca to determine its seasonal occurrence and spatial distribution in monospecific infections.

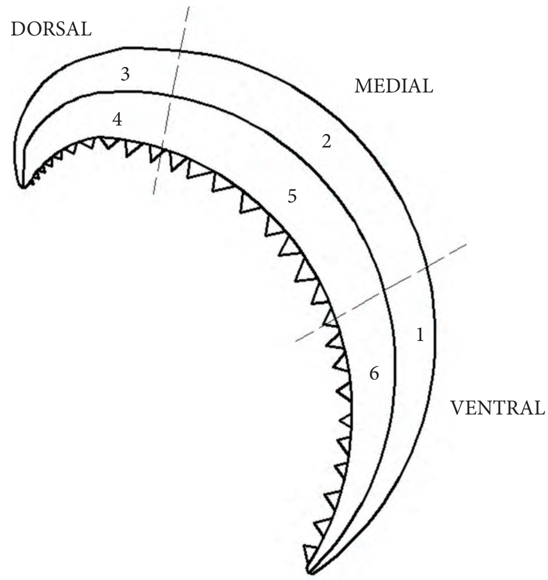

Figure. Numbering of left branchial arch. 1, 2, 3 distal parts, 4, 5, 6 proximal parts.

Materials and methods

A total of 183 *R. rutilus* were collected from the oligotrophic Lake Sapanca using gill nets once per month between January and November 2005 and examined for the occurrence of *D. crucifer*. Fish were transported to the laboratory alive in the lake water and killed immediately prior to examination. Their length and sex were recorded. The gill arches were removed fresh from the left and right side. All soft parts of a gill arch were isolated and all Dactylogyrid specimens were counted and identified using sclerotised parts of the parasites and the reproductive organs as per Gussev (Gussev, 1985).

In March 2006, the month in which the intensity of infection was found to be highest, 53 *R. rutilus* specimens (total length 19.0-28.0 cm) were examined for the spatial distribution of *D. crucifer* in monospecific infections. Parasites from the left and right gill arches were collected after fixation of the arches in 4% formalin solution. Each gill arch was placed in a Petri dish filled with distilled water. The left and right gill arches were numbered as I to IV, with gill arch I being nearest to the operculum. The 2 hemibranches of each gill arch were designated anterior and posterior. Each hemibranch was divided into 6 sectors, with proximal and distal parts being divided into dorsal, medial, and ventral areas (Figure).

The parasites were collected from each sector separately and the species of each identified on the basis of chitinized parts (haptor, copulatory organ). Microhabitats on the gill arch were classified in accordance with the following: El Hafidi et al. (1998) and Dzika (1999). The prevalence and mean intensities of the parasite species were determined according to Bush et al. (1997). The distribution of *D. crucifer* was analyzed by nonparametric statistics tests, Kruskal Wallis ANOVA Test, and followed by Mann Whitney U tests to determine the parasite population differences between the gill arches and between the segments.

Results

Of the 183 roach specimens (total length range: 17.0-36.0 cm; mean 23.42 ± 3.60) collected between January and November 2005, 149 were found to be infected with *D. crucifer* (prevalence 81.4%). During this period 14,549 specimens of *D. crucifer* were examined. The mean intensity and mean abundance of infection was detected as 95.8 ± 62.7 and 90.0 ± 66.2, respectively. Statistical data of the collected fish are shown in Table 1. The mean intensities in male and female fish were found to be 75.90 ± 66.65 and 83.97 ± 76.58, respectively, and there were no

Table 1. Number of uninfected and infected fish, prevalence, range, and mean intensity of *Dactylogyrus crucifer* on the gills of *Rutilus rutilus.*

Months	Uninfected fish number	Infected fish number		Prevalence of infection (%)	Intensity of infection min-max	Mean intensity of infection ± SD
		male	female			
Jan	14	7	4	44.0	5-48	26.2 ± 10.05
Feb	10	5	4	47.3	12-40	24.2 ± 10.97
Mar		2	7	100.0	123-387	227.1 ± 87.14
Apr	5	7	6	72.2	36-170	113.3 ± 39.78
May		6	9	100.0	30-152	100.7 ± 45.34
Jun		8	5	100.0	73-236	128.8 ± 48.64
Jul		8	10	100.0	31-102	68.4 ± 19.51
Aug		9	8	100.0	41-208	92.3 ± 41.45
Sep		6	11	100.0	29-213	109.3 ± 54.02
Oct		6	11	100.0	33-195	149.7 ± 55.74
Nov	5	5	5	66.6	1-27	13.3 ± 7.78

significant differences of infection between male and female fish (P > 0.05). Although *D. crucifer* were the dominant parasite, *D. sphyrna* and *D. vistulae* were observed in May, June, and July only, but they were low in number and therefore not taken into account.

In the 53 roach specimens investigated in March 2006, to determine the spatial distribution of *D. crucifer*, a total of 4514 *D. crucifer* individuals were recorded. The total numbers in each sector of each branchial arch are given in Table 2. The mean intensity of the parasites was 98.8.

An evaluation of the Kruskal Wallis test found no significant differences in distribution according to any of the spatial determinants. As a result, Mann Whitney U tests revealed no meaningful result. However, most of the differences in spatial distribution were considerable. Of the *D. crucifer*, 56.2% were in the anterior hemibranches and 48.8%

Table 2. Total numbers of *Dactylogyrus crucifer* in each sector of each branchial arch of *Rutilus rutilus* (n = 53).

		Sector of Branchial Arch						
ARCH		1	2	3	4	5	6	TOTAL
I	L	45	159	83	144	151	91	673
	R	38	91	38	129	121	83	500
II	L	105	98	106	76	151	128	664
	R	128	151	91	38	113	90	611
III	L	91	136	83	151	212	98	771
	R	53	106	76	91	144	68	538
IV	L	106	114	53	45	83	30	431
	R	61	68	38	23	98	38	326
TOTAL		627	923	568	697	1073	626	4514

in the posterior (P = 0.114 >0.05) and 56.2% were in the left gill arches and 43.8 % in the right (P = 0.149 >0.05). According to gill arch number, 16.8% were in gill arch IV and around 28% in average in the other 3 (P = 0.177 > 0.05). One difference, which was almost significant, was between the dorsal, medial, and ventral segments, where 44.2% were in the medial segment and around 28% in average were in the others (P = 0.084 > 0.05). This was reflected by the numbers in the sectors; 20.4% and 23.8% in (medial) sectors 2 and 5, respectively, and around 14% in average in the rest (P = 0.013 > 0.05). However, the difference between the numbers of *D. crucifer* in the proximal and distal parts was small; 53.1% and 46.9%, respectively, (P = 0.386 > 0.05), Table 3.

Discussion

Few studies on the distribution of monogenean species of the inland water fish of Turkey have been conducted. Özer and Öztürk (2005) studied *Dactylogyrus cornu* on the vimba (*Vimba vimba tanella*) in the Sinop region of Turkey. Soylu (2007) studied the seasonal occurence and site selection of *Paradiplozoon homoion* on the gills of *Pseudophoxinus antalyae*. The metazoan parasites of *R. rutilus* in Lake Sapanca have been previously investigated and *D. crucifer, D. sphyrna, D. vistulae, Diplostomum* sp, *Tylodelphys clavata*, *Palaeorchis incognitis, Aspidogaster limacoides*, glochidia of mollusks, and *Piscicola geometra* were recorded by Karabiber (2006). In the present study, 3 *Dactylogyrus* species, *D. crucifer*, *D. sphyrna,* and *D. vistulae,* were found on roach from the oligothrophic Lake Sapanca, although only *D. crucifer* prevailed throughout the year. Kogteva (1957) found *D. crucifer* on the gills of rudd *Scardinius erythrophthalmus*, roach *R. rutilus*, and white bream *Blicca bjoerkna* from the USSR. As well as *R. rutilus*, both *S. erythrophthalmus* and *B. bjoerkna* are present in Lake Sapanca, but *D. crucifer* has previously been reported only on the gills of *R. rutilus* (Soylu, 1991). In the present study *D. sphyrna* and *D. vistulae* were found in limited numbers in May, June, and July.

Table 3. Distribution of *Dactylogyrus crucifer* on the gill apparatus of *Rutilus rutilus*, single species infections.

	P Kruskal-Wallis	No of *D.crucifer*	% of *D.crucifer*
Left side	P = 0.149 > 0.05	2539	56.2
Right side		1975	43.8
Gill arch I	P = 0.177 > 0.05	1173	26.0
Gill arch II		1275	28.2
Gill arch III		1309	29.0
Gill arch IV		757	16.8
Dorsal segment	P = 0.084 > 0.05	1265	28.0
Medial segment		1996	44.2
Ventral segment		1253	27.8
Proximal part	P = 0.386 > 0.05	2396	53.1
Distal part		2118	46.9
Sector 1	P = 0.013 > 0.05	627	13.9
Sector 2		923	20.4
Sector 3		568	12.6
Sector 4		697	15.4
Sector 5		1073	23.8
Sector 6		626	13.9
Anterior hemibranch	P = 0.114 > 0.05	2536	56.2
Posterior hemibranch		1978	48.8

Koskivaara and Valtonen (1992) found *D. crucifer*, *D. nanus*, *D. suecicus*, *D. microcanthus*, *D. similis*, *D. cabollario*, *D. fallax*, *D. sphyrna,* and *D. vistulae* on roach from 3 small and interconnected but limnologically different lakes in central Finland. They reported finding all these dactylogyrids except for *D. vistulae* on roach in the oligothrophic Lake Peurunka. They claimed that *D. crucifer*, *D. nanus,* and *D. suecicus* are mainly found in large numbers in oligothrophic lakes. They identified *D. sphyrna* and *D. vistulae* as a satellite species originating from less common cyprinid species found in the same area (Koskivaara et al., 1991).

Ten dactylogyrid species from roach in the Morava river basin in the Czech Republic were reported by Kadlec et al. (2003). Simkova et al. (2001) found 6 dactylogyrid species on the same host individual and recorded *D. crucifer*, *D. nanus*, *D. rutilii,* and *D. suecicus* as common dactylogyrids on the gills of roach . However, on the roach in the present study from Lake Sapanca, the dactylogyrid diversity was far less rich.

The maximum mean intensity of *D. crucifer* on the gills of *R. rutilus* in Lake Sapanca was found in March. We found no significant difference in left-right preference. Similarly, others have found no significant differences in monogenean numbers between left and right gill arches of host fish (El Hafidi et al., 1998; Dzika, 1999). *Pseudodactylogyrus anguillae*, however, has been reported to prefer the left side of European eel, whereas *P. bini* was found mostly on the right side (Buchmann, 1988).

Parasites have been reported to prefer sheltered parts of the gill. Wooten (1974), studying ruffle respiratory currents, reports significantly higher water flowrates over the middle 2 gills, the ventral segments, and the distal parts of the gill filaments, but no significant difference in flowrates over anterior and posterior gill hemibranches. Oncomiracidia attach to the outside surface of the gill filaments and may migrate to the area of the arch sheltered from the direct effect of respiratory current (Paling, 1968). A great volume of water in the gill ventilating current passes over the 2nd and 3rd gill arches, spreading the cercariae onto the anterior gills, after which they actively select the preferred habitat (Madhavi, 1986). The findings of the present study were consistent with these reports, in that the greatest tendency, although not significant, was for the *D. crucifer* to prefer the more sheltered proximal parts.

This study found that in *R. rutilus, D. crucifer* was more abundant on the medial segments, anterior hemibranches, and on left side than on other microhabitats of the gills, although the differences were not very distinct. It also found that *D. crucifer* settled on almost all the sectors and that it was the dominant parasite species throughout the year, which means that there were no interspecific interactions. Ramasamy et al. (1985) suggest that the microhabitat extension can also occur in cases of high parasite density and intraspecific competition for space. This intraspecific competition was evident in the present study where *D. crucifer* was high in density and spread over almost all the gill arches and sectors.

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