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THE ATTACHMENT APPARATUS AND COPULATORY ORGAN MORPHOMETRIC DIFFERENCES BETWEEN *DACTYLOGYRUS CRUCIFER* WAGENER, 1857 (MONOGENEA: DACTYLOGYRIDAE) FROM LAKE AND RIVER ENVIRONMENTS

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Investigation of morphological changes in organisms from different environments plays an important role in understanding an organism's phenotypic plasticity which in long-term strategy generates adaptive genetic changes. Therefore, it is expected that the main directions of the evolution of monogenean parasites are reflected primarily in the changes of the attachment apparatus and copulatory organs.

Morphometric parameters of the attachment apparatus and copulatory organ of *Dactylogyrus crucifer* were analysed to test for the existence of differences between *D. crucifer* from fishes inhabited lake and river environments. The main results indicate that there are differences in *D. crucifer* anchor length measurements, though those are not significant in hook measurements, dorsal connective and ventral connective bar, copulatory organ tube and total length. Thus, the differences in environments cause changes only in one part of the attachment apparatus. The differences between lake and river environments effect only anchor size of *D. crucifer*.

Key words: *Dactylogyrus crucifer*, morphometry, attachment apparatus.

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INTRODUCTION

The genus *Dactylogyrus* includes 900 species localized mainly on the gills of the Cypriniformes fish which inhabit many continents except for South America, Australia and Antarctica (Gibson et al. 1996, Герасев et al. 2008). Members of the genus *Dactylogyrus* usually parasitize a specific genus or species of fish and are highly host-specific (Бауер 1987). For many years, the morphology of the genus *Dactylogyrus* has been studied by different authors (Бауер 1987, Герасев 1981, 1989, 1990, 1991, Гусев 1983).

Dactylogyrus crucifer originates from the Monogeneans class – common ectoparasites with direct life cycles parasitizing mainly the gills and fins of fishes. The most important sign to determine the monogenean species are the structure and shape of the attachment apparatus and copulatory organ which may change depending on the size and the age of a host and the environmental factors of its habitat (Бауер 1987).

The aim of this study is to investigate the attachment apparatus and copulatory organ differences of measurements between *D. crucifer* individuals from lake and river environments. It is expected to detect differences in the *Dactylogyrus* morphology considering their specific environments.

MATERIALS AND METHODS

The research material consists of museum collection of the period from 1988 to 1996 the main part of which is the monogenaen collection prepared by emeritus Dr. biol. Karlis Vismanis. A total of 66 specimens of *D. crucifer* were measured*:* 45 from rivers and 21 from lakes. The main part of specimens originated from Zemgale lakes (n=18): Dzirnezers, Dūņu, Juglas, Kāla and Garmuižas. The main part of speciments collected from Vidzeme river (n=24) – Salaca, but others from Zemgale: Buļļupe, Lielupe and Daugava. There are no data about rivers and lakes temperature condition of habitats where collected parasites. The attachment apparatus and copulatory organs were measured according to Gussev (Гусев), 1983 (Fig.1).

14 morphometric variables of the attachment apparatus and two of the copulatory organ are used: ir – inner root length; or – outer root length; da – dorsoapical total length; va – ventroapical total length; mp – length of main part; pr – length of point recurved; DB – length and width of dorsal connective bar; VB – length and width of ventral connective bar; bl – blade length; ba – base length; hl – hooklet length; Hk – length of total hook; copulatory organ total length and copulatory organ tube length.

The attachment apparatus and copulatory organs were measured and photographed with Nicon 90i microscope by using the NIS-elements basic research software.

The obtained data was analysed by SPSS and Excel software using descriptive statistic tools, parametric and non-parametric tests. Prior to comparing *D. crucifer* populations from river and lake environments, the data was assessed for standard normal distribution using Kolmogorov–Smirnov test, and for the equality of variances using F-test and Levene's test. Depending on these tests results, the following tests were selected to compare the means of *D. crucifer* from lakes and rivers: Independent-Sample T-test for equal variances, Independent-Sample T-test with an approximate solution to the Behrens–Fisher problem for unequal variances, or Mann-Whitney

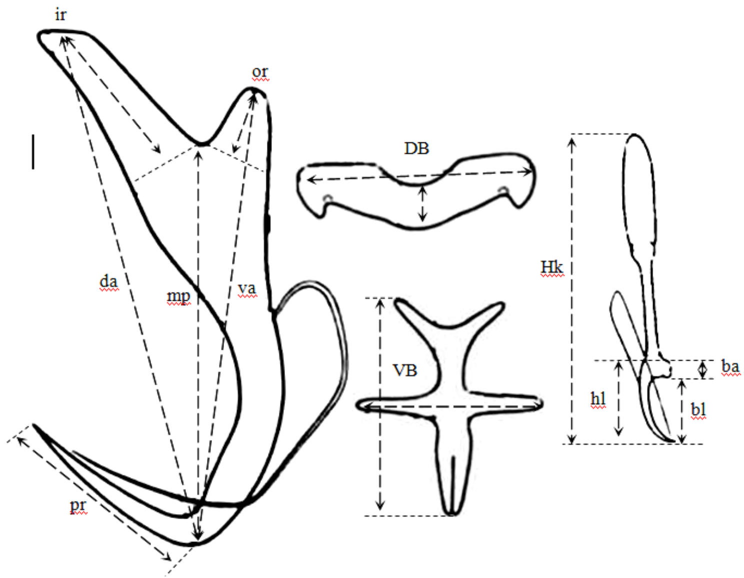

Fig. 1. Metric parameters of the *Dactylogyrus* attachment apparatus according to Gussev 1983.

Table 1. Descriptive Statistics for *D. crucifer*

	Dactylogyrus crucifer from rivers				*Dactylogyrus crucifer* from lakes			
	N	Mean		Variance	N	Mean		Variance
		statistic	std. error			statistic	std. error	
da	38	41.27	0.41	6.51	17	39.26	0.70	8.36
ir	38	14.60	0.27	2.70	17	13.71	0.30	1.53
va	38	35.54	0.38	5.60	17	33.37	0.38	2.48
or	38	4.08	0.19	1.41	17	3.49	0.22	0.80
mp	38	32.08	0.43	7.06	17	30.18	0.40	2.76
pr	38	14.69	0.27	2.84	16	12.70	0.47	3.50
bl	38	5.21	0.07	0.21	17	5.23	0.10	0.16
ba	38	1.78	0.05	0.10	17	1.79	0.06	0.07
hl	38	7.02	0.09	0.32	17	7.01	0.09	0.15
Hk	38	29.66	0.47	8.40	17	28.58	0.85	12.29
DB length	38	26.80	0.33	4.25	16	25.36	1.08	18.80
DB width	38	4.52	0.18	1.20	16	4.20	0.21	0.71
VB length	19	22.82	0.52	5.15	5	24.49	2.53	32.03
VB width	19	20.90	1.07	21.86	5	18.66	1.22	7.51
Copulatory total length	44	56.12	0.89	34.85	21	52.59	0.87	15.81
Copulatory tube length	43	70.09	1.12	53.55	20	68.02	1.31	34.58

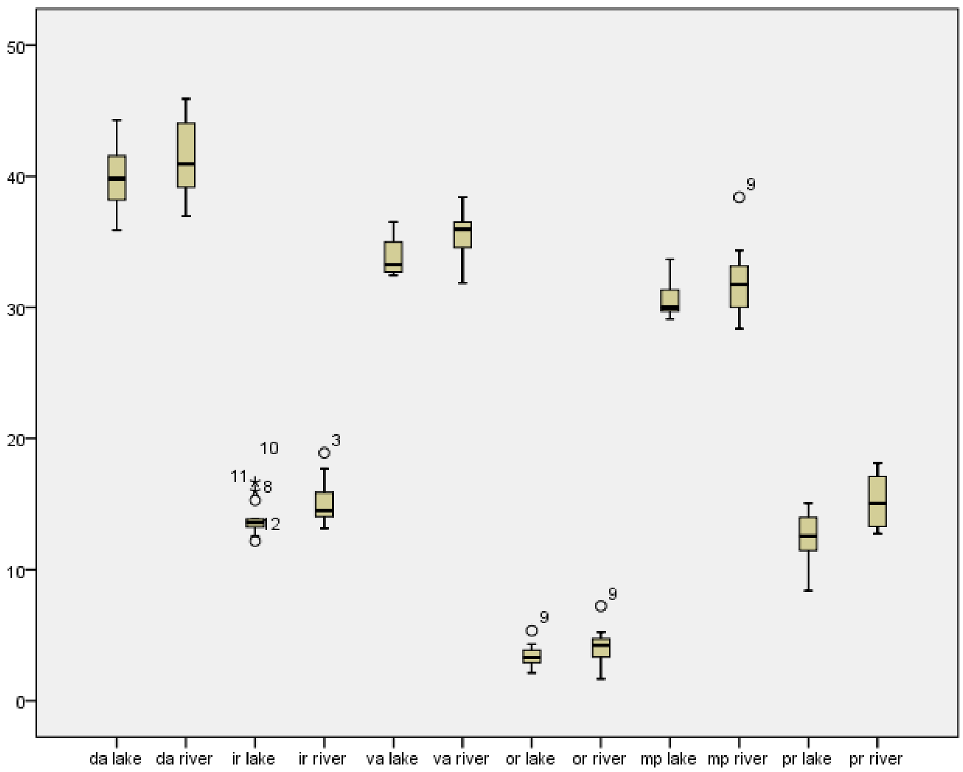

Fig. 2. The anchor measurements for lake and river environments.

U-test. All statistical analyses were performed at the significance level of $\alpha=0,05$.

RESULTS

There were obtained different results of measurements for separate parts of attachment apparatus and copulatory organ. The four parts of anchor measurements demonstrated a significant difference for means: the dorsoapical total length $P<0.05$, $df=53$, $t=-2.6$; the ventroapical total length $P<0.000$, $df=44.8$, $t=-4.02$; the length of main part $P<0.05$, $df=46.9$, $t=-3.21$; the length of point recurved $P<0.000$, $df=52$, $t=-3.83$. For two parts of anchor tests results indicate that the inner root length $P=0.051$, $df= 53$ $t=-1.99$; and the outer root length $P=0.072$, $df=53$, $t=-1.84$. It indicates that the size of anchor is higher in river than in lake environments (Table 1 and Fig. 2).
No differences were detected between the sample from lake and river environments for all hook measurements, dorsal connective and ventral connective bar; copulatory organ tube and total length ($P>0.05$).

DISCUSSION

The tests results have shown that there are significant differences in anchor means of *D. crucifer* from rivers and lakes: in dorsoapical, ventroapical, main part length and length of point recurved. But the tests results for anchor inner root and outer root length means are close to reject null hypothesis and accept the fact that the means differ. Thus, it can be concluded that there is a significant difference in anchor length of *D. crucifer* from river and lake environments. According to Бауер и др. (1987) the attachment apparatus and copulatory organ differ in size and shape in different environments. These differences occur only in some structures, such as haptor, connective bar, copulatory organ, etc. The size of the anchors is the most variable, but the size of the marginal hooks is more stable, that is associated with the order of the appearance of these structures in ontogeny (Dmitrieva & Dimitrovs 2002).

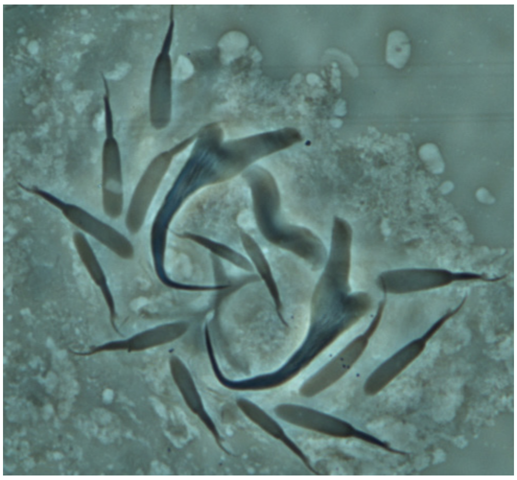

Fig. 3. The attacment aparatus of *Dactylogyrus crucifer* from roach gills (Kala Lake) phase contrast with 40x magnification, Nicon 90i microscope (original picture).

The *Gyrodactylus* monogeneans hamuli and genital hooks showed considerable geographical variability from several localities in the Atlantic and Indo-Pacific Oceans (Rohde & Watson 1985a, b, Rohde 1987, 1989). The Jackson & Tinsley (1995) research results revealed that environmentally induced morphometric variation have a significant but small effect on sclerite measurements. However, Rohde (1991) reported that difference morphometry correlated with host size is much less than it correlated with geographic locality. Malmbers (1970) discussed the morphological differences in the North American and Eurasian freshwater *Gyrodactylus* fauna for 29 species.

One of contributing factor of attachment apparatus can be water temperature condition that differs between lake and river environments. For several species of *Gyrodactylus* are reported that the range of variation in the size and shape of attachment apparatus depend on water temperature variation. For example, Ergens (1976, 1991) described range of the metrical variability of the hard parts of opisthaptor of *Gyrodactylus leucisci* Žitňan, 1964 of two local population and suggested connection with regular and periodical temperature changes of the environement. Ergens & Gelnar (1985) reported that temperature effect attachment apparatus and at the same time Gelnar (1991) by gradually increasing temperature from 12 to 18°C observed *Gyrodactylus gobiensis* Gläser, 1974 disappearance from the bodies of infected *Gobio gobio* L., while the decrease in water temperature from 18 to 12°C resulted in an increase in the parasite amount. Mo (1991a, b, c, d) explored size and shape of attachment apparatus of *Gyrodactylus salaris* Malmberg, 1957 from Atlantic salmon *Salmo salar* L. in laboratory experiments at different water temperature (1.5°C to 20.0°C) and note that the opisthaptoral hard parts were largest at the lowest water temperatures and decreased in size with increasing water temperature. There is negative correlation between water temperature and attachment apparatus morphometry. Therefore, Geets et al., (1999) suggest to take into account variation in size caused by differences in water temperature, when identifying gyrodactylid species. However, Jackson & Tinsley, (1995) demonstrate little qualitative variability in the morphology of sclerites from *Gyrdicotylus gallieni* Vercammen-Grandjean, 1960 exposed to different temperature and did not produce any trend in morphometric variation.

Dzika et al. (2009) suggest that differences in haptor size may be due to the necessity of a more secure parasite attachment to the host with a more active way of life. Supposedly water flow is a contributing factor for the attachment apparatus development. Жарикова (1986) concludes that the *Dactylogyrus* larva cannot attach to the fish gills when water flow is high.

However, another contributing factor why anchor size differs can be due to host specificity (Гусев & Кулёмина 1971, Герасев 1981). It has been established that there is a correlation between host body size and size of the haptors and other haptoral structures. Perera (1992) studied the effect of host size on large hamuli length of *Kuhnia scombri* from Eden, New South Wales and reported about significant but not strong correlation between host length and large hamuli length of worm. Šimkova et al. (2001) hypothesized that worm need to develop large attachment organs to remain attached on large gills and confirmed that specialists with large attachment apparatus are found on larger host. Karaivanova et al. (2003) indicate the presence of positive relationship between host body size and two morphometric parameters of anchors of the haptor of *D. extensus* on carp in natural reservoirs.

Because, geographic locality influence is neglected, presumably temperature and water flow of lake and rivers environments are contributing factors to *D. crucifer* attachment apparatus morphometry.

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