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Some Ecological Aspects of Three *Dactylogyrus* Species (Monogenea) on Gills of Three Fish Species from Lesser Zab River, Kurdistan, Iraq

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Abstract: A total of 318 fishes, belonged to three species namely: *Capoeta trutta*, *Carassobarbus luteus* and *Cyprinion macrostomum*, were collected from Lesser Zab river, southeast of Koysinjaq city, east of Erbil province, Kurdistan region, Iraq, from April 2012 to the end of January 2013. The examination of gills revealed the infection of these fishes with three species of *Dactylogyrus* (*D. carassobarbi*, *D. elegantis* and *D. macrostomi*, respectively). The overall prevalence was 45% and the mean intensity was 7.17. No significant differences were noticed in the infection of male and female species of fishes with *Dactylogyrus* species. The infection of these monogeneans were higher in larger fishes. In general, *Dactylogyrus* infections showed pronounced seasonal variations. Such infections were high during summer and low during winter. The highest number of *Dactylogyrus* species were found on second left and right gill arch filaments of fishes.

Keyword: Fishes, *Dactylogyrus*, Seasonal variations, Lesser Zab River, Iraq.

Introduction

The first information on the genus *Dactylogyrus* from the Iraqi freshwater fishes was given by Ali et al. (1987), who recorded two species from river Tigris in Baghdad: *D. vastator* from *Cyprinion macrostomum* and *D. cornu* from *C. macrostomum*, *Luciobarbus xanthopterus* and *Acanthobrama centisquama*. A total of 94 species of *Dactylogyrus* become known from different species of fishes in Iraq. Among these species, 48 species were recorded in Kurdistan region, and most of them are found on gills of cyprinid fishes (Mhaisen, 2019).

The ecosystem of *Dactylogyrus* species is determined by two environments: micro-environment which is the direct environment (host body) and macro-environment which is the environment of the host (Dogiel, 1961).

Most species of monogeneans are restricted not only to a particular host but also to a particular part of the host body. The microhabitat of gill-living monogeneans has been investigated by some authors (Simková et al., 2001; Turgut et al., 2006).

Some previous ecological information about the monogeneans of Iraqi freshwater fishes were published. Information reported in such investigations included the seasonal changes of infection with host age, site of attachment, geographical distribution and correlation of infection with host sex (Al-Alusi, 1998; Al-Zubaidy, 1998; Abdullah, 2002; Abdullah & Mhaisen, 2006; Abdullah, 2007; Bashê & Abdullah, 2010; Bilal, 2016).

This work presents a study on the spatial distribution of three species of *Dactylogyrus* for specific parts of the gill apparatus of three fish species, in addition to study the relationship between these parasite species and their hosts.

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Materials and Methods

Study Area: Lesser Zab river is a largest tributary of the Tigris river (400 km). It is situated between 34º-36º North latitude and 43º-46º East longitude. In the present study, the fishes were collected from the southern part of the Lesser Zab river, which is called Kanibi river, passing through Kanibi village, far about 35 km to the southeast of Koysinjaq city and 105 km of Erbil city, Kurdistan region, north of Iraq (Al-Sahaff, 1976).

Sampling: Monthly or bimonthly samples of the fish specimens were taken by gill netting, cast netting, electrofishing and hook by local commercial fishermen, during the period from April 2012 until the end of January 2013.

The fishes were measured in the laboratory (total length), the gill arches from both sides were separated, kept moist in Petri dish and examined by dissecting microscope for detecting *Dactylogyrus* parasites. Gill arches from each side of the fishes were numbered I-IV from the anterior gill arch below the operculum to the posterior. The surface of each hemibranch was designated as outer and inner. The number of worms on each gill arch was recorded with their position (Turgut et al., 2006). Fishes were identified according to Coad (2010), and scientific names of fishes follow those provided by Froese & Pauly (2019).

During the study period, data on *Dactylogyrus* were categorized according to the sexes of hosts (sex was determined upon dissection) and seasons. Similarly, data were divided into three groups based on each host fish length.

The use of ecological terms is in accordance with Margolis et al. (1982). For testing differences in prevalence of infection and mean intensity of infection between fish sexes, length groups, the differences in parasite loading on the combined 4 left and 4 right gill arches, as well as seasonality, two tests (t- test and Complete randomized designs ANOVA) were conducted (Campbell, 1976). All statistical analyses were performed at the significance level of 0.05.

Results and Discussion

Variations of Infection with Host Sex

Males and females of *C. luteus*, *C. trutta* and *C. macrostomum* from Lesser Zab river showed no statistically significant differences in their infection rates with *D. carassobarbi*, *D. elegantis* and *D. macrostomi*, respectively ($t = -0.376$, $t = -1.734$ and $t = -0.653$ at $p < 0.05$, respectively) (Tables 1, 2 and 3). For this reason, data for both sexes of each fish species were pooled for further analysis.

The present results confirms observations noted by Chapman et al. (2000) on *Neodiplozoon polycotyleus* of *Barbus neumayeri* from an intermittent forest stream in western Uganda, by Abdullah & Mhaisen (2006) on *D. minutus* of *C. carpio* in Lesser Zab river, by Abdullah (2007) on *D. rectotrabus* from *Garra rufa* in Greater Zab river, by Vankara et al. (2011) on *Mastacembelocleidus heteranchoratus* of *Mastacembelus armatus* in Godavari river, India, by Zargar et al. (2012) on *Diplozoon kashmirensis* of *Carassius carassius* from Anchar and dam lake in India and by Bilal (2016) on *Paradiplozoon barbi* from *C. macrostomum*.

Table 1: Infection in both sexes of *C. luteus* with *D. carassobarbi* from Lesser Zab river.

Fish sex	No. fishes		Prevalence (%)	No. parasites	Mean intensity	Site of infection
	Examined	Infected				
Male	42	35	83	617	17.6	Gills
Female	32	27	84	505	18.7	
Both	74	62	83	1122	18.09	

Table 2: Infection in both sexes of *C. trutta* with *D. elegantis* from Lesser Zab river.

Fish sex	No. fishes		Prevalence (%)	No. parasites	Mean intensity	Site of infection
	Examined	Infected				
Male	66	24	36	66	2.78	Gills
Female	45	24	53	70	2.91	
Both	111	48	43.2	136	2.83	

Table 3: Infection in both sexes of *C. macrostomum* with *D. macrostomi* from Lesser Zab river.

Fish sex	No. fishes		Prevalence (%)	No. parasites	Mean intensity	Site of infection
	Examined	Infected				
Male	89	73	82.2	1138	15.5	Gills
Female	44	36	81.8	611	16.9	
Both	133	109	81.9	1749	16.04	

Living in the same habitat, the absence of the morphological differences, the similarity of the food and feeding habits between male and female fishes and their occupancy of the same habitat provide evidences on the similarity of the infection with parasites (Dogiel, 1961). Pickering & Christie (1980) suggested that factors such as mucus, color, hormonal status and the physiological state of fishes has a very important influence of infection of fishes of both sexes with monogenean parasites. However, some authors gave examples on the presence of such differences between males and females (Boungou et al., 2008; Allumma & Idowu, 2011; Akoll et al., 2012) due to differences in food behaviour and morphological differences between both sexes.

Variations of Infection with Host Length

Generally, the present results showed that the infection with *Dactylogyrus* occurred in all length groups of each fish species, but it increased with increase of fish length. The statistical analysis showed significant differences at level of 0.05 in prevalence and intensity of infection between the different groups of fish length. The high peak of infection (100%) was

recorded in the largest length group of *C. luteus* (more than 20 cm) with *D. carassobarbi* (Table 4). The high peak of infection (65.2%) was recorded in the largest length group of *C. trutta* (more than 24 cm) with *D. elegantis* (Table 5) and the high peak of infection (97%) was recorded in the largest length group of *C. macrostomum* (more than 20 cm) with *D. macrostomi* (Table 6).

Table 4: Changes of infection of length groups of *C. luteus* with *D. carassobarbi* from Lesser Zab river.

Fish length groups (cm)	No. fishes		Prevalence (%)	No. parasites	Mean intensity
	Examined	Infected			
<15	18	12	66	76	6.33±2.08
15-20	34	28	82	450	16.07±1.51
>20	22	22	100	596	27.09±1.88

LSD= 5.196.

Table 5: Changes of infection of length groups of *C. trutta* with *D. elegantis* from Lesser Zab river.

Fish length groups (cm)	No. fishes		Prevalence (%)	No. parasites	Mean intensity
	Examined	Infected			
< 18	41	11	26.8	22	2.0±0.23
18-24	47	22	46.8	56	2.54±0.21
>24	23	15	65.2	58	3.86±0.31

LSD= 0.7104.

Table 6: Changes of infection of length groups of *C. macrostomum* with *D. macrostomi* from Lesser Zab river.

Fish length groups (cm)	No. fishes		Prevalence (%)	No. parasites	Mean intensity
	Examined	Infected			
< 14	35	25	71.4	274	10.9±1.41
14 -20	60	47	78.3	801	17.04±1.08
>20	38	37	97	674	18.2±1.35

LSD= 3.613.

Attributed to these parasites are small worms in size that have a series of hooks that attach to the gill filaments of fishes. Consequently, they showed a kind of agreement between sizes of hooks and gill filaments, whereas blood pushes power in these filaments affects the

fixation of these worms. The interpretation was given by Amlacher (1970) and Duijn (1973) that the small fishes are more susceptible to infection with the parasites in comparison with large fishes. The prevalence and intensity of *Dactylogyrus* are often higher on older rather than younger fishes. In some cases, this may simply reflect the greater surface area of gills available for the establishment of the parasites, an increase in water flow over the gills in older fishes and larger individuals having higher physical (ventilation volume) and chemical (mucus) stimuli which increase gill attractiveness by providing more food (Koskivaara, 1992; Özer & Öztürk, 2005).

Similar trends of fluctuations in prevalence were noted in the case of *Dactylogyrus* spp. from three species of *Tilapia* (*T. nilotica*, *T. zillii* and *T. galilae*) in lake Manzalah, Egypt (Ramadan, 1991), *D. cornu* from *Vimba vimba tenella* in the Sinop region of Turkey (Özer & Öztürk, 2005), *D. rectotrabus* from *G. rufa* in Greater Zab river (Abdullah, 2007) and *Mastacembelocleidus heteranchoratus* from *Mastacembelus armatus* in Godavari river, India (Vankara et al., 2011). However, the present study did not agree with the observations noted by Chapman et al. (2000), which quantified the prevalence and intensity of *N. polycotyleus* on the gills *B. neumayeri* from an intermittent forest stream in western Uganda, and did not agree with Abdullah & Mhaisen (2006) who demonstrated that the infection with *D. minutus* decreased with increase of the length of *C. carpio* as well as with Raissy et al. (2013) who noticed no significant differences in the infection rate of *Dactylogyrus lenkorani* and *Gyrodactylus* sp. among different lengths of *Capoeta capoeta* and *C. damascina* from Kaaj river, Chaharmahal va Bakhtiari province, Iran.

In general, to put the above findings into perspective, four patterns of parasite abundance versus host length are recognized: (1) abundance increasing with host length, (2) abundance independence of host length, (3) abundance of maximal middle host length and (4) abundance of decreasing with host length (Dogiel, 1961).

Seasonal Variations in Infection

A survey of prevalence and mean intensity of all the three monogenean infections in their host species in different seasons in the present study are given in Tables 7, 8 and 9. It is apparent that these parasites occurred on their hosts throughout the whole year (all seasons). The infection of *D. carassobarbi* in *C. luteus* showed significant differences among seasons at the level of 0.05. The mean intensity of infection was higher during summer (30) and lower during winter (6.1) as in Table 7.

Similar trends in the fluctuation in prevalence were noted with the other two worms in the present study, where the infection of *D. elegantis* and *D. macrostomum* on *C. trutta* and *C. macrostomum*, respectively, showed significant differences at the level of 0.05. The mean intensity of infection was the highest during summer (3.2 and 17.2, respectively) as indicated in Tables 8 and 9, respectively, while the lowest mean intensity was during winter (2.1 and 9.4, respectively).

Here, it is reliable to mention that the infection with these parasites were increased during summer and spring because they reproduce during these seasons, when they deposit eggs directly into the water, the motile ciliated larvae hatch out and after a short free-swimming period, they settle on the fishes, on which they reach their stage of sexual maturity (Kennedy, 1975).

Table 7: Seasonal fluctuations of infection of *C. luteus* with *D. carassobari* from Lesser Zab river.

Seasons	No. fishes		Prevalence (%)	No. parasites	Mean intensity
	Examined	Infected			
Spring	15	13	86	208	16±2.13
Summer	23	21	91	642	30±1.72
Autumn	18	15	83	192	12.8±1.94
Winter	18	13	72	80	6.1±1.94

LSD= 5.47911.

Table 8: Seasonal fluctuations of infection of *C. trutta* with *D. elegantis* from Lesser Zab river.

Seasons	No. fishes		Prevalence (%)	No. parasites	Mean intensity
	Examined	Infected			
Spring	28	12	42.8	34	2.8±0.30
Summer	30	19	63.3	62	3.2±0.29
Autumn	26	10	38.4	25	2.5±0.31
Winter	27	7	25.9	15	2.1±0.31

LSD= 0.849955.

Table 9: Seasonal fluctuations of infection of *C. macrostomum* with *D. macrostomi* from Lesser Zab river.

Seasons	No. fishes		Prevalence (%)	No. parasites	Mean intensity
	Examined	Infected			
Spring	33	28	84.8	473	16.8±1.38
Summer	49	48	97.9	830	17.2±1.13
Autumn	28	23	82.1	352	15.3±1.50
Winter	23	10	43.4	94	9.4±1.65

LSD= 4.0002.

Similar trends in fluctuations in percentage incidence were noted in case of *Microcotyle donavini* from *Liza abu* in Alus region, upper Euphrates river, Anbar (Al-Alusi, 1998). The present results also agree with Mo (1992, 1997) who indicated that the infection of *Salmo salar* with *Gyroductylus salaris* and *G. derjavini* was high during summer in the river Batnfjordslva, Norway. Chapman et al. (2000) indicated that the infection of *B. neumayeri* with *N. polycotyleus* was high during summer in western Uganda. Stojanvoski et al. (2004) noticed the greatest prevalence and intensity of infection with monogenean parasites on some cyprinid fishes in lake Prespa (Macedonia) during summer. Abdullah & Mhaisen (2006) indicated that the infection of *C. carpio* from Lesser Zab river in north of Iraq with *D. vastator* was high during summer and spring. Abdullah (2007) noticed high infection of *G.*

rufa from Greater Zab river in Kurdistan region of Iraq with *D. rectotrabus* during spring and summer. Koyun & Altunel (2011) showed that the prevalence of infection and mean intensity level of *Carassius carassius* from Enne dam lake in Turkey with *Dactylogyrus anchoratus* and *Gyrodactylus katharineri* were higher during spring and summer. Koyun (2012) noticed that *Capoeta umbla* in Murat river in Turkey was highly infected with *Dactylogyrus lenkorani* during summer. Raissy et al. (2013) observed that the infection rate of *Capoeta capoeta* and *C. damascina* from Kaaj river, Iran with *Dactylogyrus lenkorani* and *Gyrodactylus* sp. were high during summer and autumn.

The findings of this study also confirm the suggestion by Granath & Esch (1983) that seasonal changes in abundance of fish parasites are influenced by a variety of factors including temperature and food consumption.

Distribution of Monogeneans and Sites of their Attachments on Gill Arches

The distribution of monogenean parasites on each gill arch filaments for each fish species was determined in the present study. The statistical analysis showed no significant differences in distribution of *D. carassobarbi*, *D. elegantis* and *D. macrostomum* on left and right set of gill arch filaments of their hosts (t= 0.046, 1.281 and 0.046 at P< 0.05, respectively), but in general, there were significant differences between individual gill arch filaments for *C. luteus*, *C. trutta* and *C. macrostomum* as LSD= 0.379, 0.220 and 0.563, respectively for the right set of gill arch filaments and LSD= 0.356, 0.223 and 0.693, respectively for the left set of gill arch filaments. The highest number of parasites were found on the second and the first arches of both sides of each fish species and the lowest on the fourth gill arch filaments (Tables 10, 11 and 12).

Most species of monogeneans are restricted not only to a particular host (host specificity) but also to particular part (site or organ specificity) of the host body. Wootten (1974) for *D. amphibothrium* and Gutiérrrez & Martorelli (1994) for *Demidospermus valenciennesi* reported a preference for either the left or right set of gills. The present results showed that there were no significant differences between right and left sets of gill arch filaments in infection of each of the three host species with their particular parasites. This result confirms observations noted by Özer & Öztürk (2005) on *Dactylogyrus cornu* from *Vimba vimba tenella* in the Sinop region in Turkey, by Abdullah (2007) on *D. rectotrabus* from *G. rufa* in Greater Zab river, north of Iraq, Tombi et al. (2010) on *D. insolitus* from *Barbus marolli* in the Floulou water course in Nkolfoulu locality, Cameron, Central Africa and Bilal (2016) on *Paradiplozoon barbi* from *Cyprinion macrostomum*.

Table 10: Changes of the infection between left and right set of gill arch filaments of *C. luteus* with *D. carassobari* from Lesser Zab river

Left set of gill arch filaments			Right set of gill arch filaments		
No. gill Arch	No. gill arch infected	No. parasites	No. gill arch	No. gill arch infected	No. parasites
First	52	156	First	56	159
Second	62	256	Second	60	236
Third	42	103	Third	58	120
Fourth	26	44	Fourth	32	48

LSD= 0.563 for the left set and LSD= 0.693 for the right set.

Table 11: Changes of the infection between left and right set of gill arch filaments of *C. trutta* with *D. elegantis* from Lesser Zab river.

Left set of gill arch filaments			Right set of gill arch filaments		
No. gill arch	No. gill arch infected	No. parasites	No. gill arch	No. gill arch infected	No. parasites
First	16	17	First	18	18
Second	29	36	Second	29	43
Third	9	9	Third	11	11
Fourth	0	0	Fourth	2	2

LSD= 0.223 for the left set and LSD= 0.220 for the right set.

Table 12: Changes of the infection between left and right set of gill arch filaments of *C. macrostomum* with *D. macrostomi* from Lesser Zab river.

Left set of gill arch filaments			Right set of gill arch filaments		
No. gill arch	No. gill arch infected	No. parasites	No. gill arch	No. gill arch infected	No. parasites
First	100	271	First	99	259
Second	102	315	Second	104	359
Third	89	183	Third	97	209
Fourth	83	82	Fourth	71	71

LSD= 0.356 for the left set and LSD= 0.379 for the right set.

On the other hand, the higher number of the monogeneans were found on the second gill arch filaments of both sides in the results of the present study. These results agree with Chapman et al. (2000), which noted highest number of *Neodiplozoon polycotyeus* on second gill arch of *B. neumayeri* from an intermittent forest stream in western Uganda and with Özer & Öztürk (2005) on *Dactylogyrus cornu* from *Vimba vimba tenella* in the Sinop region in Turkey. Also, the results confirm observations noted by Abdullah (2007) on *D. rectotrabus* from *G. rufa* in Greater Zab river, Tombi et al. (2010) on *D. insolitus* from *Barbus marolli* in the Floulou water course in Nkolfoulu locality, Cameron of Central Africa and Bilal (2016) on *Paradiplozoon barbi* from *C. macrostomum* from Greater Zab river.

Differences between the distribution of monogenean species and site specificity on the gill arches have also been suggested to be influenced by hydrostatic pressure of the branchial pump, coughing action and water current over the gill surface during the respiratory cycle (Wootten, 1974; Özer & Öztürk, 2005).

Gutiérrez & Martorelli (1994) attributed differences in the occurrence of monogeneans on lamellae of fish gill arches to variations in water current on the gill surface or to greater area of certain arches. The results obtained in this study indicated that the greatest number of monogenean species (*D. carassobarbi*, *D. elegantis* and *D. macrostomi*) occurred on the filaments of the second gill arch of both sides, could be explained by the reasons mentioned above.

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