Biological and Applied Environmental Research

Vol. 5(1): 141-151, 2021

https://doi.org/10.51304/baer.2021.5.1.141

ISSN: 2002-6153
Biol. Appl. Environ. Res.
www.baerj.com
editor@baerj.com

Myxosporeans (Phylum Myxozoa) Parasitic on Some Fishes from Hamrin Lake in Diyala Province, Iraq

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Abstract: Between January and December 2019, a total of 368 fish specimens were collected from Hamrin lake in Diyala province, Iraq. These fishes belonged to 16 species: *Acanthobrama marmid*, *Alburnus caeruleus*, *A. sellal*, *Arabibarbus grypus*, *Carasobarbus luteus*, *Carassius auratus*, *Chondrostoma regium*, *Cyprinion kais*, *C. macrostomum*, *Cyprinus carpio*, *Garra rufa*, *Leuciscus vorax*, *Luciobarbus xanthopterus*, *Mastacembelus mastacembelus*, *Mystus pelusius* and *Planiliza abu.* The result of inspection showed that these fishes were infected with 25 species of parasites belonging to the class Myxosporea. These included one species each of *Chloromyxum* and *Unicauda*, two species each of *Myxidium* and *Thelohanellus* and 19 species of *Myxobolus*. Among these parasites, *Myxobolus pfeifferi* infected the highest number of hosts (ten host species), followed by *M. drjagini* and *M. oviformis* (nine host species each), while five parasite species infected one host species each. Among these fishes, *C. luteus* was infected with the highest number of parasite species (18 species), followed by *C. carpio* (13 species). *Myxobolus. hemibarbi* was recorded in the present study for the first time in Iraq. The description and measurements of this parasite is presented. In addition, a total of 35 new host records in Iraq were reported for 18 species of these parasites.

Keywords: Myxosporea, Myxozoa, Fishes, Hamrin lake, Iraq

Introduction

The parasites are a major part of world biodiversity (Poulin & Morand, 2004). The myxosporeans and monogeneans are recognized among the most common parasites of numerous fish species (Özer et al., 2015). The myxozoans are parasites that affect a great variety of tissues (Klinger & Floyd, 1998). They infect fins, skin, gills, operculum, buccal cavity, nasal chamber, eye ball, gall bladder, liver, spleen, kidneys, heart and wall of the alimentary canal of freshwater fishes (Kaur, 2014).

The taxonomy of myxozoans is still based on the structure of the spore stages; number of shell valves, spore shape and position of the polar capsules (Feist & Longshaw, 2006). According to the introduction of the checklists of the genus *Myxobolus*, Mhaisen & Al-Jawda (2020) gave a detailed account on evolution of the phylum Myxozoa.

Received Oct. 28, 2020, accepted Dec. 30, 2020

In Iraq, Herzog (1969) recorded the first occurrence of three myxosporeans from fishes of Iraq. After that numerous works were done in which more species of the phylum Myxozoa were recorded. The latest article by Mhaisen & Al-Jawda (2020) indicated that a total of 97 *Myxobolus* species, four *Chloromyxum* spp., one *Henneguya* species, one *Kudoa* species, six *Myxidium* species, two *Myxobilatus* species, four *Thelohanellus* species and one *Unicauda* species are so far known from fishes of Iraq. The present article aimed to report on additional records of some myxosporean parasites of fishes of Iraq from Hamrin lake in Diyala province. Previously only one report (Balasem et al., 2000) was published on the parasitic fauna of fishes of this lake.

Materials and Methods

The sampled fishes were collected from the south part of Hamrin lake at Diyala province**,** during the period from January to December 2019. The description of this lake was demonstrated by Balasem et al. (2000). As well demonstrated by Al-Jawda & Asmar (2014), these fishes were captured by gill nets of different mesh sizes as well as cast nets. Fishes were brought to the laboratory with containers filled with ice. These fishes were identified according to Coad (2010). Total length and weight was recorded for each fish. Smears from the skin, gills and buccal cavity were examined under a compound microscope. On dissection of fishes, muscles and all internal organs were examined according to Amlacher (1970).

Parasite classification was based on Bykhovskaya-Pavlovskaya et al. (1962), Shulman (1984) and Hoffman (1998). The prevalence of infection was computed according to Margolis et al. (1982). Index-catalog of parasites and disease agents of fishes of Iraqi (Mhaisen, 2020) was followed to specify number of previous host records for each parasite species to reduce the reference list for each parasite species. The scientific names, together with their orders and families, and the full authority of the valid fish host species are according to Fricke et al. (2020), as shown in the following systematic account.

Class Actinopteri
Order Cypriniformes
Family Cyprinidae
Arabibarbus grypus (Heckel, 1843)
Carasobarbus luteus (Heckel, 1843)
Carassius auratus (Linnaeus, 1758)
Cyprinion kais Heckel, 1843
Cyprinion macrostomum Heckel, 1843
Cyprinus carpio Linnaeus, 1758
Garra rufa (Heckel, 1843)
Luciobarbus xanthopterus Heckel, 1843
Family Leuciscidae
Acanthobrama marmid Heckel, 1843
Alburnus caeruleus Heckel, 1843
Alburnus sellal Heckel, 1843

Chondrostoma regium (Heckel, 1843)
Leuciscus vorax (Heckel, 1843)
Order Siluriformes
Family Bagridae
Mystus pelusius (Solander, 1794)
Order Synbranchiformes
Family Mastacembelidae
Mastacembelus mastacembelus (Banks & Solander, 1794)
Order Mugiliformes
Family Mugilidae
Planiliza abu (Heckel, 1843)

Results and Discussion

During the present study, a total of 368 fish specimens were captured. The parasitological investigation of these fishes revealed the occurrence of 25 species of parasites belonging to the class Myxosporea. The following is a brief account on the occurrence of these parasites which are alphabetically arranged under their genera. For each parasite species, its first record in Iraq will be indicated as well as the total number of its host species so far recorded from fishes of Iraq and any new host record will be declared depending on Mhaisen (2020) without mentioning this reference each time to economise space.

Chloromyxum bychoviskii Shulman 1962 was revealed from *A. marmid*, *A. grypus*, *C. luteus*, *C. auratus*, *C. regium*, *C. kais*, *G. rufa* and *L. vorax*. The first paper to document this parasite from fishes of Iraq was from unspecified host by Mansor et al. (2012) who reported no authority for this parasite. No more hosts are so far known for this parasite in Iraq. So, the eight hosts of the present study represent new host records for this parasite in Iraq.

Myxidium pfeifferi Auerbach, 1908 was recorded from *A. marmid*, *A. grypus*, *C. luteus*, *C. auratus* and *C. carpio*. Balasem et al. (1997) reported this parasite in Iraq from *B. sharpeyi* (= *M. sharpeyi*) from Al-Qadisiya dam lake, northwest of Baghdad and then, it was nominated from five other host species which included *A. grypus* and *C. luteus*, and hence *A. marmid*, *C. auratus* and *C. carpio* of the present study represent new host records for this parasite in Iraq.

Myxidium rhodei Léger, 1905 was isolated from *C. luteus* and *C. carpio*. In Iraq, the first mention of this parasite was from *B. sharpeyi* (= *M. sharpeyi*) from Al-Qadisiya dam lake, northwest of Baghdad by Balasem et al. (1997). It has been subsequently reported from ten other fish species which included *C. luteus* and *C. carpio*.

Myxobolus bramae Reuss, 1906 was detected from *C. luteus* and *L. xanthopterus*. The first record concerning this parasite in Iraq was from *B. xanthopterus* (= *L. xanthopterus*) from Al-Qadisiya dam lake, northwest of Baghdad by Asmar et al. (1999), then it was recorded from eight other host species which included both *C. luteus* and *L. xanthopterus*.

Myxobolus cyprini Doflein, 1898 was isolated from *C. luteus*. The first report from Iraq was from unspecified host by Mansor et al. (2012) who reported no authority for this parasite. So, *C. luteus* of the present study represents a new host record for this parasite in Iraq.

Myxobolus cyprinicola Reuss, 1906 was recorded from *A. grypus*, *C. regium*, *C. macrostomum*, *C. carpio*, *L. xanthopterus* and *P. abu*. This parasite was recorded for the first time in Iraq from *C. carpio* from Dokan lake by Abdullah (1997). After that, it was reported from 13 other host species which included the six above-named host species of the present study.

Myxobolus dispar Thélohan, 1895 was detected from *C. luteus*, *C. carpio*, *L. xanthopterus* and *P. abu*. Abdul-Ameer (1989) reported this spore for the first time in Iraq from *C. regium* from Tigris river at Salah Al-Dien province. Then, it was recorded from 12 other host species which included *C. luteus*, *C. carpio*, *L. xanthopterus* and *P. abu*.

Myxobolus dogieli Bykhovskaya-Pavlovskaya & Bykhovski, 1940 was isolated from *L. xanthopterus* and *P. abu*. Abdul-Ameer (1989) declared its first record in Iraq from *P. abu* (as *L. abu*) from Tigris river at Salah Al-Dien province. Then, it was reported from eight other host species which included *L. xanthopterus* and *P. abu* of the present study.

Myxobolus drjagini (Akhmerov, 1954) Landsberg & Lom, 1991 was revealed from *A. grypus*, *C. luteus*, *C. auratus*, *C. regium*, *C. carpio*, *G. rufa*, *L. xanthopterus*, *M. mastacembelus* and *P. abu*. The first report in Iraq was from *C. luteus* (reported as *B. luteus*) from the northern sector of the main drainage at Al-Mahmoodia city by Balasem et al. (2002). Later on, it was reported from nine other host species which did not include *C. auratus*, *C. carpio*, *G. rufa* and *M. mastacembelus* and hence *C. auratus*, *C. carpio*, *G. rufa* and *M. mastacembelus* of the present study represent new host records for this parasite in Iraq.

Myxobolus ellipsoides Thélohan, 1892 was recorded from *A. grypus*. The first report from Iraq was from *C. macrostomum* by Al-Jadoaa (2002). After that, it was reported from three other host species which did not include *A. grypus* and hence *A. grypus* of the present study represents a new host record for this parasite in Iraq.

Myxobolus hemibarbi Dogiel & Achmerov 1960 was recorded from *C. luteus*. This parasite was not previously reported from Iraqi fishes. It was reported herein as a new record of *Myxobolus* for the parasitic fauna of Iraqi fishes, and hence *C. luteus* is considered as the first host for *M. hemibarbi* in Iraq. Spores (Figure 1) are pyriform with narrow and pointed anterior end. Pyriform polar capsules are quite large. Small sporoplasm is pushed to the posterior end of the spore. Length of spores 12-14 μm, width 10-11 μm, thickness 8 μm, length of polar capsules 8-10 μm and their diameter 3.5-4.5 μm. The description of this spore was similar to those previously reported in Shulman (1984) with slight differences in the measurements between each specimen.

Myxobolus koi Kudo, 1919 was isolated from *C. luteus* and *C. carpio*. Al-Niaeemi (1997) reported this spore for the first time in Iraq from *Silurus glanis*.

Later on, it was reported from five other host species which included *C. luteus* but not *C. carpio*. So, *C. carpio* of the present study represents a new host record for this parasite in Iraq.

Myxobolus kubanicus Bykhovskaya-Pavlovskaya & Bykhovski, 1940 was detected from *A. caeruleus*, *C. luteus* and *C. regium*. The first report in Iraq was from *A. grypus*, *C. luteus*, *L. barbulus* (as *B. barbulus*) and *L. xanthopterus* by Atwan (2016). After that, it was reported only from *M. sharpeyi* by Sheyaa (2019) and hence, both *A. caeruleus* and *C. regium* represent new host records in Iraq for this parasite. The specific name was misspelled as *kubanicum* instead of *kubanicus* by both Atwan (2016) and Sheyaa (2019).

Myxobolus macrocapsularis Reuss, 1906 was recorded from *A. grypus*, *C. luteus* and *C. auratus*. Abdullah (1997) recorded this spore for the first time in Iraq from *L. barbulus* (as *B. barbulus*). Later on, it was reported from seven other host species which included *A. grypus* and *C. luteus* but not *C. auratus*. So, *C. auratus* of the present study represents a new host record for this parasite in Iraq.

Myxobolus muelleri Bütschli, 1882 was revealed from *P. abu*. The first report in Iraq was from *L. xanthopterus* (as *B. xanthopterus*) by Herzog (1969). After that, it was reported from 11 other host species which included *P. abu*. The authority of this parasite was spelled as *mülleri* by some references and as *müelleri* by others, while some stated no authority.

Myxobolus orientalis Shulman, 1962 was isolated from both *C. luteus* and *C. auratus*. Al-Nasiri (2008) reported this spore for the first time in Iraq from *A. grypus* (as *B. grypus*). Later on, it was reported from only one host species which was *C. luteus*. So, *C. auratus* of the present study represents a new host record for this parasite in Iraq.

Myxobolus oviformis Thélohan, 1892 was recorded from *A. grypus*, *C. luteus*, *C. auratus*, *C. kais*, *C. macrostomum*, *C. carpio*, *G. rufa*, *L. xanthopterus* and *P. abu*. Herzog (1969) gave the first record of this parasite in Iraq from *A. grypus* (as *B. grypus*), *L. vorax* (as *A. vorax*), *L. esocinus* (as *B. esocinus*) and *M. sharpeyi* (as *B. sharpeyi*). After that, it was reported from 18 other host species which did not include *C. kais* and *G. rufa*, and hence, both *C. kais* and *G. rufa* of the present study represent new host records in Iraq for this parasite.

Myxobolus parvus Shulman, 1962 was recorded from *C. luteus*, *C. regium*, *C. kais*, *C. macrostomum*, *C. carpio* and *P. abu*. Abdullah (1997) recorded this parasite for the first time in Iraq from *C. carpio*. Later on, it was reported from nine other host species which did not include *C. kais* and *C. macrostomum*, and hence, both *C. kais* and *C. macrostomum* of the present study represent new host records in Iraq for this parasite.

Myxobolus pfeifferi Thélohan, 1895 was recorded from *A. sellal*, *A. grypus*, *C. luteus*, *C. auratus*, *C. regium*, *C. kais*, *C. carpio*, *L. xanthopterus*, *M. pelusius* and *P. abu*. Its first report from Iraq was from *A. marmid* by Fattohy (1975). After that, it was reported from 34 other fish species in Iraq, inclusive of the all above-named host species of the present study.

Myxobolus poljanski Shulman, 1962 was recorded from *C. luteus*, *C. carpio* and *L. xanthopterus*. The first report from Iraq was from *A. grypus* (as *B. grypus*) by Abdullah (1990). Later on, it was reported from six other host species which did not include *C. carpio*. So, *C. carpio* of the present study represents a new host record in Iraq for this parasite.

Myxobolus schulmani Donec, 1962 was recorded from *C. auratus*. Al-Nasiri (2008) gave the first record of this parasite in Iraq from *A. grypus* (as *B. grypus*), who mentioned no authority for this parasite. After that, it was reported from two other host species which did not include *C. auratus*, and hence, *C. auratus* of the present study represents a new host record for this spore in Iraq.

Myxobolus sphaericus (Fujita, 1924) Landsberg & Lom, 1991 was recorded from *A. grypus*, *C. luteus*, *C. kais*, *C. carpio*, *L. xanthopterus* and *P. abu*. The first report in Iraq was from *C. regium* by Abdul-Ameer (1989) who spelled its name as *Myxobolus sphaerica*. Later on, it was reported from 12 other hosts which did not include *C. kais* and *C. carpio*. So, both *C. kais* and *C. carpio* of the present study represent new host records in Iraq for this parasite.

Thelohanellus catlae Chakràwarty & Basu, 1958 was recorded from *C. auratus* and *C. carpio*. Abdul-Ameer (1989) recorded this parasite for the first time in Iraq from *C. macrostomum*. After that, it was reported from four other host species which did not include *C. carpio*, and hence, *C. carpio* of the present study represents a new host record for this parasite in Iraq.

Thelohanellus dogieli Achmerov, 1955 was recorded from *C. macrostomum* and *C. carpio*. Bdair (2018) gave the first record of this parasite in Iraq from *C. carpio*. Later on, it was reported from only one host species which was *C. auratus*. So, *C. macrostomum* of the present study represents a new host record for this parasite in Iraq.

Unicauda lumae Rahemo, 1976 was recorded from *C. luteus* and *C. regium*. Rahemo (1976) gave the first record of this spore in Iraq, as species de novo, from *A. grypus* (as *B. grypus*) from Tigris river at Mosul city. After that, it was reported from three other host species which did not include *C. luteus* and *C. regium*. So, both *C. luteus* and *C. regium* of the present study represent new host records for this parasite in Iraq.

Table 1: Myxosporean species with their site of infection and percentage incidence.

Parasite species	Host species	Site of infection*	% Incidence
Chloromyxum bychoviskii	*A. marmid***	G	75
	*A. grypus***	G	40
	*C. luteus***	G	35.2
	*C. auratus***	G	17
	*C. regium***	G	52.1
	*C. kais***	G	25
	*G. rufa***	G	5
	*L. vorax***	G	25
Myxidium pfeifferi	*A. marmid***	K	11.1

	A. grypus	K	20
	C. luteus	S, K	14.7
	*C. auratus***	K, L, H	4.2
	*C. carpio***	K	3.8
M. rhodei	*C. luteus*	K	14.7
	C. carpio	K	7.6
Myxobolus bramae	*C. luteus*	K, S, L, G	26.4
	L. xanthopterus	H, K	6.2
M. cyprini	*C. luteus***	L, K	2.9
M. cyprinicola	*A. grypus*	S, K	40
	C. regium	S, G	13
	C. macrostomum	S	25
	C. carpio	K, H	1.9
	L. xanthopterus	K, L	12.5
	P. abu	K, H, L, S, O, G, Sk	67
M. dispar	*C. luteus*	K	2.9
	C. carpio	K	1.9
	L. xanthopterus	L	6.25
	P. abu	K, G, S, H	6.1
M. dogieli	*L. xanthopterus*	K, L, S	6.25
	P. abu	K, L, S, G	3
M. drjagini	*A. grypus*	S	20
	C. luteus	S, K	14.7
	*C. auratus***	K	2.1
	C. regium	Sk, K, L	8.6
	*C. carpio***	G	1.9
	*G. rufa***	K	5
	L. xanthopterus	K	6.25
	*M. mastacembelus***	H, K, G	50
	P. abu	K, L, S, T, G, H	10.3
M. ellipsoides	*A. grypus***	K, L, H	40
*M. hemibarbi****	*C. luteus***	G	5.8
M. koi	*C. luteus*	S	2.9
	*C. carpio***	G, H, S, K	1.9
M. kubanicus	*A. caeruleus***	G	33.3
	C. luteus	G, S, K, L, H	8.8
	*C. regium***	S, K, L, H	4.3
M. macrocapsularis	*A. grypus*	G, H, K	40
	C. luteus	G, H, K, S, L	32.3
	*C. auratus***	G	2.1
M. muelleri	*P. abu*	K, L, G	1
M. orientalis	*C. luteus*	K, S, G, H	20
	*C. auratus***	K, G	2.1
M. oviformis	*A. grypus*	S, K, L	40
	C. luteus	G, S, K, L, H, Sk	23.5
	C. auratus	G, K, S	4.2
	*C. kais***	K, L, Sk	50

	C. macrostomum	H, G	25
	C. carpio	G	3.8
	*G. rufa***	K	5
	L. xanthopterus	K, G	18.7
	P. abu	S, K, L, H, Sk	8.2
M. parvus	*C. luteus*	L, K, G	8.8
	C. regium	G, S	4.3
	*C. kais***	H	25
	*C. macrostomum***	G, L, S, H, K	50
	C. carpio	K	1.9
	P. abu	G, L, S, H, K, O, Sk	25.7
M. pfeifferi	*A. sellal*	G, L, K	7.1
	A. grypus	G, L, K, S, Sk	40
	C. luteus	K, G, S, L, Sk	41.1
	C. auratus	K, G, S, Sk, H	6.3
	C. regium	G, L	8.6
	C. kais	Sk	25
	C. carpio	L, Sk	3.8
	L. xanthopterus	K, G, L, H	12.5
	M. pelusius	K, S	5.5
	P. abu	G, L, S, H, K, O, Sk	15.4
M. poljanski	*C. luteus*	S, K	2.9
	*C. carpio***	K	1.9
	L. xanthopterus	K	6.2
M. schulmani	*C. auratus***	G	2.1
M. sphaericus	*A. grypus*	K	20
	C. luteus	G, L, S, K, Sk	5.8
	*C. kais***	L, K	25
	*C. carpio***	Sk, K, G	3.8
	L. xanthopterus	K	6.2
	P. abu	G, L, S, K, Sk, H	34
Thelohanellus catlae	*C. auratus*	K	2.1
	*C. carpio***	K	7.6
T. dogieli	*C. macrostomum***	S	25
	C. carpio	K, S, H	7.6
Unicauda lumae	*C. luteus***	G	2.9
	*C. regium***	G	4.3

* Site of infection: G= Gills, H= Heart, K= Kidneys, L= Liver, O= Ovaries, Sk= Skin, S= Spleen, T= Testes.

** New host record in Iraq.

*** New parasite record in Iraq.

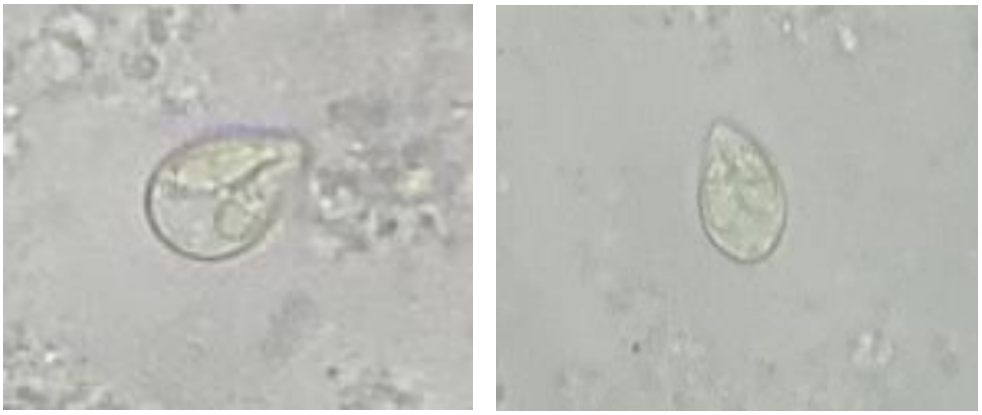

Figure 1: Spore of *Myxobolus hemibarbi* from gills of *C. luteus* (1000x).

To sum up on the myxosporean infections of fishes of the present study, *Myxobolus pfeifferi* was the prevalent parasite among these fishes as it was recorded here from ten fish host species, followed by *M. drjagini* and *M. oviformis* which were reported from nine fish species each, while two hosts were recorded for one myxosporean each. Dealing with the host specificity, it seems from table 1 that five species (*M. cyprini*, *M. ellipsoides*, *M. hemibarbi*, *M. muelleri* and *M. schulmani*) occurred in only one host species each. *C. luteus* was infected with the highest number of myxosporeans (18 species). Few myxosporeans were recorded as external parasites, but most of them were found as internal parasites.

Acknowledgement
Thanks are due to Prof. Dr. Furhan T. Mhaisen for providing us with the necessary information concerning the previous records of members of class Myxosporea of fishes of Iraq and for his revision of the manuscript.

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