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Identification of *Paradiplozoon* (Monogenea) parasitizing on gills of some fish at Euphrates River, Iraq

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Abstract: *During the period from March 2020 till the end of January 2021, a total of 219 specimens of Cyprinid fishes (19 Alburnus mossulensis, 13 Chondrostoma regium, 13 Cyprinion macrostomum, 57 Cyprinus carpio, 95 Leuciscus vorax, 22 Luciobarbus xanthopterus) were collected from Euphrates River passing through Al-Anbar province, Iraq. The gills of these fishes examined microscopically for monogenean parasites belonging to the family Diplozoidae. The present investigation revealed the existence of 11 species of the genus Paradiplozoon, included P. alburni (from gills of A. mossulensis), P. bliccae (from gills of each of L. vorax and L. xanthopterus), P. cyprini (from gills of C. carpio), and each of P. ergensi, P. homion, P. megan and P. minutum (from gills of L. vorax), P. rutili (from gills of each of A. mossulensis and L. vorax), P. iraqensis (from gills of each of C. macrostomum and L. xanthopterus), P. pavlovskii (from gills of each of A. mossulensis, C. regium, C. carpio, L. vorax and L. xanthopterus). In addition to record of P. zeller (from gills of L.vorax). In present study, P. alburni and P. zeller was reported for the first time in fishes of inland water of Iraq, therefore a description and morphometrics of these two parasites are presented herein. Also, six species of Paradiplozoon (P. bliccae, P. cyprini, P. homion, P. megan, P. minutum, P. iraqensis) are considered as the first record from the Euphrates River, Al-Anbar province, Iraq.*

Key words: *Euphrates river, Monogenea, Cyprinidae fish, Iraq*

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I. Introduction

The class Monogenea (Van Beneden, 1858) comprises diverse groups of parasitic flatworms, one of these groups of parasites belongs to the family Diplozoidae Palombi, 1949 that contains unique ectoparasite on gills of freshwater fishes in Europe, Asia and Africa, and generally considered as parasites of Cyprinid fishes (Pugachev et al., 2010; Shimazu et al., 2015).

Diplozoidae are parasites with a unique, direct life cycle, involving free-swimming larvae called oncomiracidium and a parasitic larval stage named diporpa, after that two diporpa come into contact and fuse together to develop as permanent cross-like copula in their adult life, and this body fusion is unique compared with the other monogenean families (Matějusová et al., 2001; Pečinková et al., 2007; Shimazu et al., 2015).

Monogeneans members belonging to the family Diplozoidae are blood- feeding parasites (Hodová et al., 2010). Infected gills appear pale and damaged and consequently the gill respiratory function is decreased (Al-Nasiri, 2003).

Adult diplozoids attached to the host by pair of central hooks and four pairs of clamps on each pair of the haptor (Pugachev et al., 2010; Matějusová et al., 2001). The sclerotized structures used as main morphological characters for species determination (Matějusová et al., 2004).

Where five genera *Diplozoon*, *Eudiplozoon*, *Inustiatus*, *Paradiplozoon* and *Sindiplozoon* are recognized in the family Diplozoidae, according to the shape of the posterior part of the body (Pugachev et al., 2010).

The Iraqi diplozoid fauna includes 18 species, including 15 species of *Paradiplozoon* and one species for each *Diplozoon* and *Eudiplozoon* (Al-Nasiri and Balbuena, 2016; Al-Nasiri, 2017).

However, more extensive surveys is needed to recognize more species of these parasites, and based on this, the present study aimed to inspect fishes from Euphrates River Al-Anbar Province, Iraq for more species of Diplozoidae family.

II. Materials And Methods

During the period from March 2020 till the end of January 2021, a total of 219 fish were collected, using gill nets in different mesh size, at the Euphrates River passing through Al-Anbar province. The fish of the present study included six species of cyprinids, 19 *Alburnus mossulensis* Heckel, 1843, 13 *Chondrostoma regium* (Heckel, 1843), 13 *Cyprinion macrostomum* Heckel, 1843, 57 *Cyprinus carpio* Linnaeus, 1758, 95 *Leuciscus vorax* (Heckel, 1843), 22 *Luciobarbus xanthopterus* Heckel, 1843. Host fish species identification was done according to Coad (2010) and Froese and Pauly (2020).

Fish were examined for the presence of monogenean parasites. Gills were removed from the head and placed into Petri dishes containing Tap water. Examination of gill filaments was performed using a dissecting microscope. Following their recovery, *Paradiplozoon* specimens were isolated from infected gills, fixed and stored in 70% ethanol. Parasite specimens were stained in Acetocarmine, before being dehydrated through a graded ethanol series, cleared with xylene and mounted with DPX media on glass slide .The morphological features of *Paradiplozoon*, especially the sclerites comprising the attachment clamp, were examined using a compound microscope. Diagnostic measurements were obtained using a microscopic micrometer. Drawings were made by using drawing tube. Identification of parasites species were done accordening to the parameters recorded at Pugachev et al. (2010). The ecological terms in parasitology (prevalence, intensity and mean intensity of infection) follow Bush et al. (1997).

III. Results

During the present investigation, a total of 219 freshwater fish specimen belonging to six species from family Cyprinidae were collected from Euphrates River passing through Al-Anbar province, Iraq. The study revealed the existence of 11 species of monogeneans belonging to the genus *Paradiplozoon*.

This is the first record of *Paradiplozoon alburni* and *Paradiplozoon zeller* in Iraq. The following is a brief description on the occurrence of these parasites together with a detailed morphological description and measurement of the two newly recorded *Paradiplozoon* species in Iraq.

3.1. *Paradiplozoon alburni* Khotenovsky, 1982 (Figures 1, 2)

This parasite was identified on the gills of *A. mossulensis* fish (Table 1) with a prevalence (and intensity) of total infection 15.78% (1 parasite/ fish). Where the highest prevalence infection was recorded in October with a value of 66.66%, and the highest intensity of infection in November with a value of 2 parasites/ fish. Whereas, the infection in November with a prevalence 12.5%. The lowest intensity of infection was in October with a value 1 parasite/ fish. No infection was recorded in the other months of the present study.

This species were not recorded previously from fishes of Iraq. Therefore, the registration of this parasite in the current study is considered the first record in Iraq. The following is a brief description with the measurements (in micrometers), for this species.

The total body length is 1400-3600, anterior part 800-2100, posterior part 400-1200. The posterior part has small folds, 16-23 folds. Size of clamps, I: 40- 70 × 70 -120; II: 40-80 ×80-150; III: 40-80 × 90-160; IV: 50-80 × 90-160. The anterior end of the median sclerite is almost square shaped and is connected to the clamp jaws by two short sclerites. Length of anchors is 20–22, handles 40-45. Diameter of suckers is 30-60 mm, pharynx 40-70. The intestine has few lateral projections in the posterior part of the body.

3.2. *Paradiplozoon bliccae* (Reichenbach-Klinke, 1961)

This parasite was diagnosed in the gills of *L. vorax* fish (Table 1) with a prevalence (and intensity) of total infection 1.05% (2 parasite/ fish).Where the infection was recorded in the month of November only, with a prevalence (and intensity) of infection 5.55% (2 parasite/ fish).

3.3. *Paradiplozoon cyprini* Khotenovsky, 1982

This parasite was isolated from the gills of *C. carpio* fish (Table 1) with a prevalence (and intensity) of total infection 1.75% (1 parasite/ fish). Where the infection was recorded in the month of September only, with a prevalence (and intensity) of infection 25.0% (1 parasite/ fish).

3.4. *Paradiplozoon ergensi* (Pejcoch, 1968)

This parasite were found on the gills of *L. vorax* fish (Table 1) with a prevalence (and intensity) of total infection 3.15% (1 parasite/ fish). Where the prevalence (and intensity) of infection was recorded in November, with a value 11.11% (1 parasite/ fish), and the prevalence (and intensity) of infection in December was 6.66% (1 parasite/ fish). No infection was recorded in the other months of the present study.

3.5. *Paradiplozoon homoion* (Bychowsky et Nagibina, 1959)

This parasite were diagnosed on the gills of *L. vorax* fish (Table 1) with a prevalence (and intensity) of total infection 10.52% (5 parasite/ fish).Where the prevalence (and intensity) of infection was recorded in September, with prevalence 30.43% (7 parasite/ fish), and in October with a value 21.42% (2 parasite/ fish). No infection was recorded in the other months of the present study.

3.6. *Paradiplozoon iraqensis* Al-Nasiri et Balbuena, 2016

This parasite was isolated from the gills of *C. macrostomum* fish (Table 2) with prevalence (and intensity) of total infection 7.69% (1 parasite/ fish). Where the infection was recorded in the month of September only with a prevalence (and intensity) of an infection of 20.0% (1 parasite/ fish), and no infection was recorded in the other months of the present study.

Also, it was isolated from gills of the *L. xanthopterus* fish (Table 2) with a prevalence (and intensity) of total infection 18.18% (5 parasites/ fish). Where the highest infection rate was recorded in October and December with a value of 33.33% for each of the above months, while the highest intensity infection was recorded in December with a value of 9 parasite/ fish, followed by intensity of infection in November with a value of 4 parasites/ fish. While the lowest prevalence of infection was recorded in November with a value of 22.22%, and the lowest intensity infection was recorded in October with a value of 3 parasites/ fish. No infection was recorded in the other months of the present study.

3.7. *Paradiplozoon megan* (Bychowsky et Nagibina, 1959)

This parasite was found in the gills of *L. vorax* fish (Table 2) with a prevalence (and intensity) of total infection 4.21% (9 parasite/ fish). The infection was recorded in the month of March only, with a prevalence (and intensity) of infection 30.76% (9 parasite/ fish).

3.8. *Paradiplozoon minutum* (Paperna, 1964)

This parasite was isolated from gills of *L. vorax* fish (Table 2) with a prevalence (and intensity) of total infection 12.63% (5 parasite/ fish). The infection was recorded in March, with a prevalence (and intensity) 38.46% (12 parasite/ fish), in November with a prevalence (intensity) 33.33% (2 parasite/ fish), in August with a value of 25% (2 parasites/ fish. No infection was recorded in the other months under study.

3.9. *Paradiplozoon pavlovskii* (Bychowsky et Nagibina, 1959)

This parasite was diagnosed from the gills of *A. mossulensis* fish (Table 3) with a prevalence (and intensity) of total infection 10.52% (3 parasite/ fish). The infection was recorded in the month of September only with a prevalence (and intensity) of an infection 25.0% (3 parasites/ fish).

It was also isolated from gills of *C. regium* fish (Table 3) with a prevalence (and intensity) of total infection 7.69% (3 parasite/ fish). The infection was recorded in the month of October only with a prevalence (and intensity) of an infection 50.0% (3 parasite/ fish).

Also, this parasite was isolated from gills of *C. carpio* fish (Table 3) with a prevalence (and intensity) of total infection 1.75% (6 parasite/ fish). Where, the infection was recorded in the month of October only with a prevalence (and intensity) of 12.5% (6 parasites/ fish).

L. vorax was also infected with this parasite (Table 3) with a prevalence (and intensity) of total infection 16.84% (5 parasites/ fish). Where the highest prevalence of infection was recorded in July with a value 60.0%, and the highest infection intensity in the months of March and July with values 7 and 6 parasites/ fish (respectively), then followed by prevalence of infection in March and October with values 38.46%, 21.42% (respectively). The intensity of infection in October was 5 parasites/ fish. The prevalence (and intensity) of infection in September was 13.04% (3 parasites/ fish). Whereas, the prevalence (and intensity) of infection in November was 11.11% (4 parasites/ fish). No infection was recorded in the other months of the present study.

Furthermore, *P. pavlovskii* was recorded from gills of *L. xanthopterus* fish (Table 3) with a prevalence (and intensity) of total infection 9.09% (4 parasites/ fish), where the prevalence (and intensity) of infection was in September with a value 50.0% (6 parasites/ fish), and the prevalence and intensity of infection in July was 25.0% (2 parasites/ fish). No infection was recorded in the other months of the present study.

3.10. *Paradiplozoon rutili* (Gläser, 1967)

This parasite was identified from the gills of *A. mossulensis* fish (Table 4) with a prevalence (and intensity) of total infection 15.78% (4 parasite/ fish). Where the infection was recorded in the month of September only, with a prevalence (and intensity) of infection 37.5% (4 parasite/ fish).

It was also recorded from the gills of *L. vorax* fish (Table 4) with a prevalence (and intensity) of total infection 4.21% (5 parasite/ fish). The prevalence (and intensity) of infection was recorded in September, with a value of 13.04% (6 parasite/ fish), and the prevalence (and intensity) of infection in October was 7.14% (1 parasite/ fish). No infection was recorded in the other months of the present study.

3.11. *Paradiplozoon zeller* (Gyntovt, 1967) (Figure 3, 4)

This parasite was found on the gills of *L.vorax* fish only (Table 4) with a prevalence (and intensity) of total infection 2.10% (4 parasite/ fish).where infection was recorded in the month of September only with a prevalence (and intensity) of 8.69% (4 parasite/ fish).

This species was not previously recorded in Iraq, so, in present study, it was recorded for the first time in Iraq. The following is a brief description with its measurements (in micrometers).

The total body length is 1200-2900, anterior part 600-1900, posterior part 400-900. The posterior part has small folds, 10-14 folds. Size of clamps: I: 40- 70 × 40 -110; II: 40-70 ×80-140; III: 40-70 × 80-120; IV: 40-70 × 80-150. The anterior end of the median sclerite is broadened, fish tail shaped, and connected to the clamp jaws by two short sclerites. The lateral edges of the posterior end of the median sclerite are rounded. Length of anchors is 19-20, handles 36-47. Diameter of suckers is 40-50, pharynx 40-70. The intestine in the posterior part of the body has few lateral diverticula. Size of eggs is 210-220 x 80-90.

IV. Discussion

Diplozoids are considered as parasites of cyprinids fish but the host specificity are differs. This differ, possibly, are related to geographical origin (Matějusová et al., 2001). The appearance of diplozoids in Eurasia is registered to fish of Cyprinidae and families of Perciformes. All diplozoid species described in Europe are host-specific, except *P. homoion*, which has been recorded in more than 15 species of cyprinids fish (Al-Nasiri and Balbuena, 2016).

In iraq, diplozoids has been recorded in cyprinids and members of the Heteropeneustidae, Mastacembelidae, Mugilidae and Siluridae (Mhaisen and Abdul-Ameer, 2014).

According to Al-Nasiri and Balbuena (2016), 17 species of diplozoids have been reported from fishes of different region of Iraq. These include 15 species of *Paradiplozoon*, namely *P. amurense* (Akhmerov, 1974), *P. barbi* (Reichenbach-Klinke, 1951), *P. bliccae* (Reichenbach- Klinke, 1961), *P. cyprini* Khotenovsky, 1982, *P. ergensi* (Pejčoch, 1968), *P. homoion* (Bychowsky *et* Nagibina, 1959), *P. iraqensis* Al-Nasiri *et* Balbuena, 2016, *P. kasimii* (Rahemo, 1980), *P. leucisci* Khotenovsky, 1982, *P. megan* (Bychowsky *et* Nagibina, 1959), *P. pavlovskii* (Bychowsky *et* Nagibina, 1959), *P. rutili* (Glaeser, 1967), *P. skrjabini* (Akhmerov, 1974), *P. tadjikistanicum* (Gavrilova *et* Djalilov, 1965) and *P. vojteki* (Pejčoch, 1968)), one species of *Diplozoon*, namely *D. paradoxum* Nordmann, 1832, and one species of *Eudiplozoon*, *E. nipponicum* (Goto, 1891). Also, Al-Nasiri (2017) record *P. magnum* Lim *et* Khotenovsky, 1985 from cyprinids fish of Iraq to reach the number of Diplozoidae to 18 species.

As far, seven diplozoids that has been registered from fishes of Euphrates River, Iraq, These include 5 species of *Paradiplozoon*: *P. ergensi* was reported for the first time in Iraq from gills of *L. vorax* (reported as *A. vorax*) from Tigris river passing through Tikrit city, Salah Al-Din province (Al-Jubori and Al-Nasiri, 2014)., *P. kasimii* and *P. pavlovskii* were recorded for the first time in Iraq from gills of *L. vorax* (reported as *Aspius vorax*) from Mehaijeran creek, a side branch of Shatt Al-Arab river, Basrah province by Khamees in 1983 (Mhaisen and Abdul-Ameer, 2014) under the name *Diplozoon pavlovskii*, *P. rutili* was recorded for the first time in Iraq from gills of both *L. vorax* (reported as *A. vorax*) and *C. macrostomum* from Tigris river passing through Tikrit city, Salah Al-Din province (Al-Jubori and Al-Nasiri, 2014), *P. skrjabini* was recorded for the first time in Iraq from gills of from gills of *C. macrostomum* from Euphrates River by Al-Salmany and Al-Nasiri, 2015). Also, one species of *Diplozoon*, namely *D. paradoxum* was reported for the first time in Iraq from gills of *C. luteus* (reported as *B. luteus*) from Al-Husainia creek (Mhaisen and Abdul-Ameer, 2014), and one species of *Eudiplozoon*, *E. nipponicum* was reported for the first time in Iraq, as *Diplozoon nipponicum* from gills of *C. carpio* from manmade lake near Baghdad city (Al-Nasiri, 2003).

P. alburni was never reported from any fish species in Iraq previously. Therefore, the present recording is considered to be the first in Iraq. So, *A. mossulensis* in this study is considered as a first host for this parasite in Iraq. The description and measurement of the present specimen are in the range of those reported by Pugchev et al. (2010) about the description of this species of parasite.

P. bliccae was recorded for the first time in Iraq from the gills of the *C. macrostomum* and *C. carpio* (Al-Nasiri, 2009) from the Tigris River passing through Tikrit city, Salah Al-Din province. Later it was recorded from both of *C. macrostomum* and *Planiliza abu* (reported as *L. abu*) from Tigris River, Tikrit city (Al-Jubouri and Al-Nasiri, 2014). Therefore, this parasite possesses three fish host species are so far known in Iraq, and no further host was reported after that. So, *L. vorax* in this study is considered as a new host for this parasite in Iraq. This parasite was not previously recorded from the Euphrates River, Al-Anbar province, so the recording of this parasite in the present study is the first record at this region of Iraq. So, *L. vorax* in this study is considered as a first host for this parasite in Al-Anbar province.

`P. cyprini was found for the first time in Iraq from the gills of *Arabibarbus grypus* (reported as *Barbus grypus*) by Al-Nasiri and Mahaisen (2009) from the Tigris River passing through Tikrit city, Salah Al-Din province. Then it was recorded from the gills of *C. luteus* (reported as *B. luteus*) and gills of *C. macrostomum* from the Tigris River passing through Tikrit city by Al-Jubouri and Al-Nasiri (2014). Also, it was identified from the gills of *C. carpio* from two different environments, Ainkawa fish hatchery and Lesser Zab River near Alton Kupri, Erbil city, Kurdistan region, Iraq (Mama and Abdullah, 2012; Mhaisen and Abdul-Ameer, 2014). This parasite possesses seven fish host species are so far known in Iraq (Mhaisen et al., 2018).

This parasite was not previously recorded from the Euphrates River, Al-Anbar province, so the recording of this parasite in the present study is the first record at Euphrates River, Al-Anbar province. Also, *C. carpio* in this study is considered as a first host for this parasite in Al-Anbar province, Iraq.

P. ergensi was reborted for the first time in Iraq by Al-Jubouri and Al-Nasiri (2014) from gills of *L. vorax* (reported as *A. vorax*) from the Tigris River passing through Tikrit city, Salah Al-Din province. Four host species are so far known for this parasite in Iraq (Mhaisen et al., 2018).

The first record of *P. homoion* in Iraq was from gills of *L. xanthopterus* (reported as *B. xanthopterus*) from Al-Husainia creek (Mhaisen and Abdul-Ameer, 2014). Also, it was reported from gills of *C. macrostomum* from Lesser Zab River (Mhaisen and Abdul-Ameer, 2014), from gills of *C. carpio, L. vorax* (reported as *A. vorax*) and *L. xanthopterus* (reported as *B. xanthopterus*) from the Euphrates River at Al-Musaib city (Mhaisen and Abdul-Ameer, 2014), and from gills of *C. regium* from the Kamirah location on the Tigris River north of Baghdad province (Hameed, 2019). As above, five host species are so far known for this parasite in Iraq (refs.). This parasite was not previously recorded from the Euphrates River, Al-Anbar province. So the recording of this parasite in the present study is the first record of it from the Euphrates River, Al-Anbar province, and *L. vorax* in this study is considered as a first host for this parasite in Al-Anbar province, Iraq.

P. iraqensis was recorded for the first time in Iraq from the gills of the *C. macrostomum* from the Tigris River in Tikrit by Al-Nasiri and Balbuena (2016), then it was recorded from the fish of *P. abu* from Lake Hamrin in Diyala province, Iraq (Al-Jawda and Ali, 2020). So far, two fish host species are known for *P. iraqensis* in Iraq, and no further host was reported after that. Also, *L. xanthopterus* in this study is considered as a new host for this parasite in Iraq. This parasite was not previously recorded from the Euphrates River, Al-Anbar province, so the recording of this parasite in the present study is the first record from fishes of Euphrates River, Al-Anbar province, and *C. macrostomum, L. xanthopterus* in this study is considered as a first two hosts for this parasite in Al-Anbar province, Iraq.

The first identified of *P. megan* in Iraq was from gills of *L.vorax* (reported as *A. vorax*) and *L. xanthopterus* (reported as *B. xanthopterus*) from Al-Husainia creek (Mhaisen and Abdul-Ameer, 2014). Also, it was recorded from the gills of *C. luteus* from the Euphrates River, the city of Al-Musaib (Mhaisen and Abdul-Ameer, 2014). As above, this parasite possesses, so far, three species of host fish in Iraq. This parasite was not previously recorded from the Euphrates River, Al-Anbar province, so the recording of this parasite in the present study is the first record of it from this River, and *L. vorax* in this study is considered as a first host for this parasite in Al-Anbar province, Iraq.

P. minutum was recorded for the first time in Iraq by Hameed (2019) from the gills of *C. regium* fish, from the Kamirah location on the Tigris River north of Baghdad province. It was not recorded later from any other fish species in the inland water of Iraq. Thus, *L. vorax* in the present study is considered a new host for this parasite in Iraq. Also, this parasite was not recorded from the Euphrates River, Al-Anbar province, the recording of this parasite in the present study is the first record from Euphrates River, and *L. vorax* is considered as a first host for this parasite in Al-Anbar province, Iraq.

P. pavlovskii was recorded for the first time in Iraq from gills of *L. vorax* (reported as *Aspius vorax*) from Mehaijeran creek, a side branch of Shatt Al-Arab River, Basrah province by Khamees in 1983 (Mhaisen and Abdul-Ameer, 2014) under the name *Diplozoon pavlovskii*. Also, it was reported as *D. pavlovskii* from gills of both *C. luteus* (reported as *B. luteus*) and *C. regium* from Tigris River in Salah Al-Din province by Abdul-Ameer in 1989 (Mhaisen and Abdul-Ameer, 2014), and as *P. pavlovskii* from *C. macrostomum* from Tigris River in Salah Al-Din province by Al-Nasiri (2009) and by Al-Jubori and Al-Nasiri (2014), and from *C. carpio* from Tigris River by Al-Nasiri (2009). So far, *P. pavlovskii* and its synonym (*D. pavlovskii*) have 13 host species in Iraq (Mhaisen et al., 2018), not including *A. mossulensis*. Thus, this fish is now a new host for this parasite in Iraq.

The first record of *P. rutili* in Iraq was by Al-Jubori and Al-Nasiri (2014) from gills of both *C. macrostomum* and *L.vorax* (reported as *A. vorax*) from the Tigris River. At recently, no more hosts are known for *P. rutili* in Iraq. So, *A. mossulensis* in this study is considered as a new host for this parasite in Iraq.

P. zeller was never reported from any fish species in Iraq before. Therefore, the present recording is considered to be the first one in Iraq. Also, *L. vorax* in present study is considered as a first host for this parasite in Iraq. The descriptions and measurements of the present specimen are nearly similar to those reported by Pugchev et al. (2010) about the description of this species of parasite.

V. Conclusion

Through the investigations about Monogenea parasitizing on fish of Euphrates River that had little attention, two species of *Paradiplozoon* are identified as new record on fishes of Iraq. Therefore, the search for fish parasites in a new areas of inland water of Iraq, leads to discover other species that not previously recorded, and this will be leads to increase in the number of discovered species of fish parasites in Iraq.

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Table 1. Prevalence (intensity) of infection with *paradiplozoon alburni*, *P. bliccae*, *P. cyprini*, *P. ergensi* and *P. homoion* on gills of fish in present study.

Parasite and Host / month	*P. alburni*			*P. bliccae*			*P. cyprini*			*P. ergensi*			*P. homoion*		
	A. mossulensis			*L. vorax*			*C. carpio*			*L. vorax*			*L. vorax*		
	number of examined fish	number of infected fish	prevalence (intensity) of infection (%)	number of examined fish	number of infected fish	prevalence (intensity) of infection (%)	number of examined fish	Number of Infected fish	prevalence (intensity) of infection (%)	number of examined fish	Number of Infected fish	prevalence (intensity) of infection (%)	number of examined fish	Number of Infected fish	prevalence (intensity) of infection (%)
March 2020	0	0	0	13	0	0	6	0	0	13	0	0	13	0	0
July 2020	0	0	0	5	0	0	1	0	0	5	0	0	5	0	0
August 2020	0	0	0	4	0	0	18	0	0	4	0	0	4	0	0
September 2020	8	0	0	23	0	0	4	1	25.0 (1)	23	0	0	23	7	30.43 (7)
October 2020	3	2	66.66 (1)	14	0	0	8	0	0	14	0	0	14	3	21.42 (2)
November 2020	8	1	12.5 (2)	18	1	5.55 (2)	7	0	0	18	2	11.11 (1)	18	0	0
December 2020	0	0	0	15	0	0	8	0	0	15	1	6.66 (1)	15	0	0
January 2021	0	0	0	3	0	0	5	0	0	3	0	0	3	0	0
Total / average	19	3	15.78 (1)	95	1	1.05 (2)	57	1	1.75 (1)	95	3	3.15 (1)	95	10	10.52 (5)

Table 2. Prevalence (intensity) of infection with *paradiplozoon iraqensis*, *P. megan*, and *P. minutum* on gills of fish in present study.

Parasite and Host / month	*P. iraqensis*						*P. megan*			*P. minutum*		
	C. macrostomum			*L. xanthopterus*			*L. vorax*			*L. vorax*		
	number of examined fish	number of infected fish	prevalence (intensity) of infection (%)	number of examined fish	number of infected fish	prevalence (intensity) of infection (%)	number of examined fish	Number of Infected fish	prevalence (intensity) of infection (%)	number of examined fish	Number of Infected fish	prevalence (intensity) of infection (%)
March 2020	0	0	0	0	0	0	13	4	30.76 (9)	13	5	38.46 (12)
July 2020	3	0	0	4	0	0	5	0	0	5	0	0
August 2020	3	0	0	0	0	0	4	0	0	4	1	25.0 (2)
September 2020	5	1	20.0 (1)	2	0	0	23	0	0	23	0	0
October 2020	0	0	0	3	1	33.33 (3)	14	0	0	14	0	0
November 2020	0	0	0	9	2	22.22 (4)	18	0	0	18	6	33.33 (2)
December 2020	0	0	0	3	1	33.33 (9)	15	0	0	15	0	0
January 2021	2	0	0	1	0	0	3	0	0	3	0	0
Total / average	13	31	7.69 (1)	22	4	18.18 (5)	95	4	4.21 (9)	95	12	12.63 (5)

Table 3. Prevalence (intensity) of infection with *paradiplozoon pavlovskii* on gills of fish in present study.

Parasite and Host / month	*P. pavlovskii*														
	A. mossulensis			*C. regium*			*C. carpio*			*L. vorax*			*L. xanthopterus*		
	number of examined fish	number of infected fish	prevalence (intensity) of infection (%)	number of examined fish	number of infected fish	prevalence (intensity) of infection (%)	number of examined fish	Number of Infected fish	prevalence (intensity) of infection (%)	number of examined fish	Number of Infected fish	prevalence (intensity) of infection (%)	number of examined fish	Number of Infected fish	prevalence (intensity) of infection (%)
March 2020	0	0	0	0	0	0	6	0	0	13	5	38.46 (7)	0	0	0
July 2020	0	0	0	5	0	0	1	0	0	5	3	60.0 (6)	4	1	25.0 (2)
August 2020	0	0	0	3	0	0	18	0	0	4	0	0	0	0	0
September 2020	8	2	25.0 (3)	3	0	0	4	0	0	23	3	13.04 (3)	2	1	50.0 (6)
October 2020	3	0	0	2	1	50.0 (3)	8	1	12.5 (6)	14	3	21.42 (5)	3	0	0
November 2020	8	0	0	0	0	0	7	0	0	18	2	11.11 (4)	9	0	0
December 2020	0	0	0	0	0	0	8	0	0	15	0	0	3	0	0
January 2021	0	0	0	0	0	0	5	0	0	3	0	0	1	0	0
Total / average	19	2	10.52 (3)	13	1	7.69 (3)	57	1	1.75 (6)	95	16	16.48 (5)	22	2	9.09 (4)

Table 4. Prevalence (intensity) of infection with *paradiplozoon rutili* and *P. zeller* on gills of fish in present study.

Parasite and Host / month	*P. rutili*						*P. zeller*		
	A. mossulensis			*L. vorax*			*L. vorax*		
	number of examined fish	number of infected fish	Prevalence (intensity) of infection (%)	number of examined fish	number of infected fish	Prevalence (intensity) of infection (%)	number of examined fish	Number Of infected fish	Prevalence (intensity) of infection (%)
March 2020	0	0	0	13	0	0	13	0	0
July 2020	0	0	0	5	0	0	5	0	0

August 2020	0	0	0	4	0	0	4	0	0
September 2020	8	3	37.5 (4)	23	3	13.04 (6)	23	2	8.69 (4)
October 2020	3	0	0	14	1	7.14 (1)	14	0	0
November 2020	8	0	0	18	0	0	18	0	0
December 2020	0	0	0	15	0	0	15	0	0
January 2021	0	0	0	3	0	0	3	0	0
Total / average	19	3	15.78 (4)	95	4	4.21 (5)	95	2	2.10 (4)

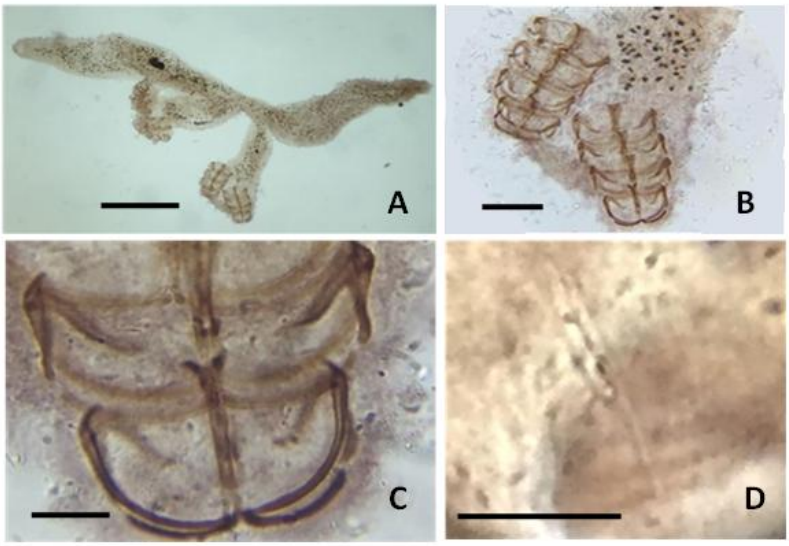

Figure 1. *Paradiplozoon alburni*; photomicrographic of: whole worm (**A**), posterior end (**B**), clamp (**C**), anchor (**D**); *Scale bar*: A= 500, B= 60, C= 20, D=20 µm.

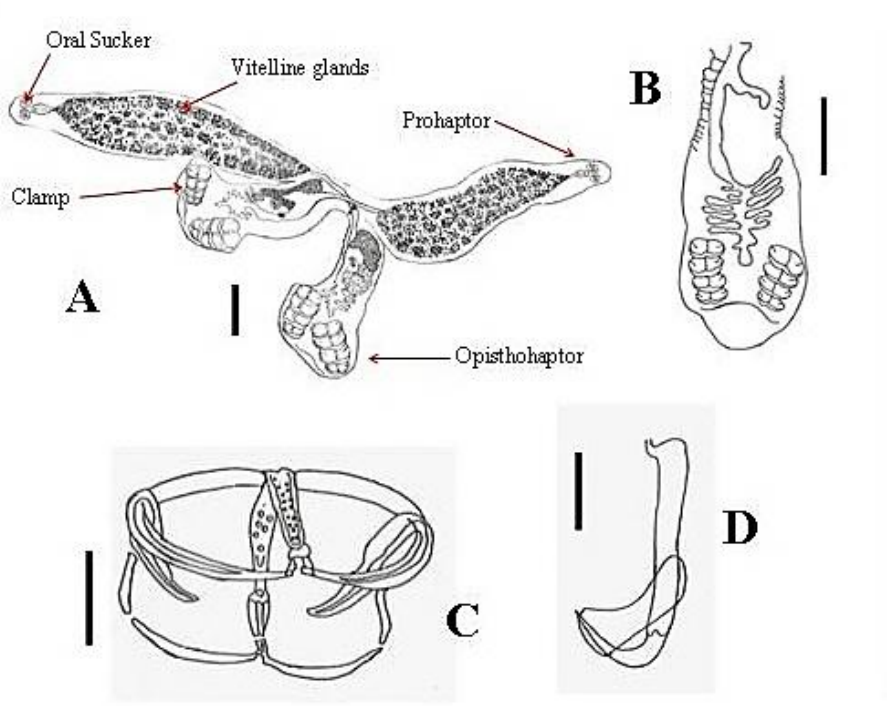

Figure 2. *Paradiplozoon alburni*; linedrawing of: whole worm (**A**), posterior end (**B**), clamp (**C**), anchor (**D**); *Scale bar*: A= 300, B= 200, C= 30, D=6 µm.

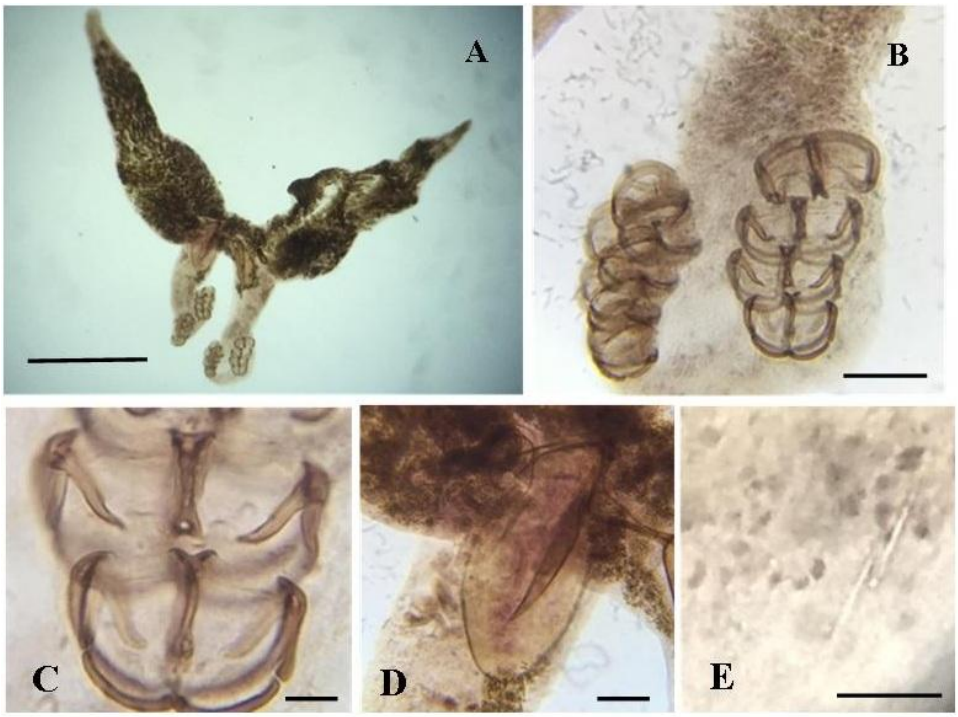

Figure 3. *Paradiplozoon zeller*; photomicrographic of: whole worm (**A**), posterior end (**B**), clamp (**C**), ovum (**D),** anchor (**E**); *Scale bar*: A= 500, B= 60, C= 20, D=40, E= 10 µm.

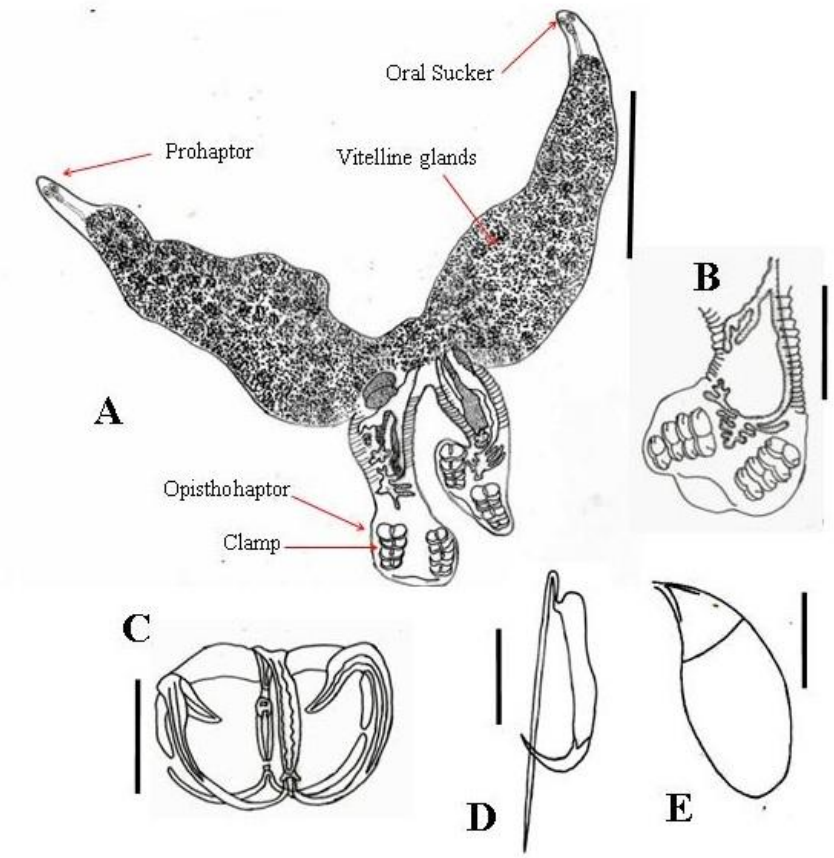

Figure 4. *Paradiplozoon zeller*; linedrawing of: whole worm (**A**), posterior end (**B**), clamp (**C**), anchor (**D**); *Scale bar*: A= 500, B= 300, C= 50, D=10, E= 60 µm.