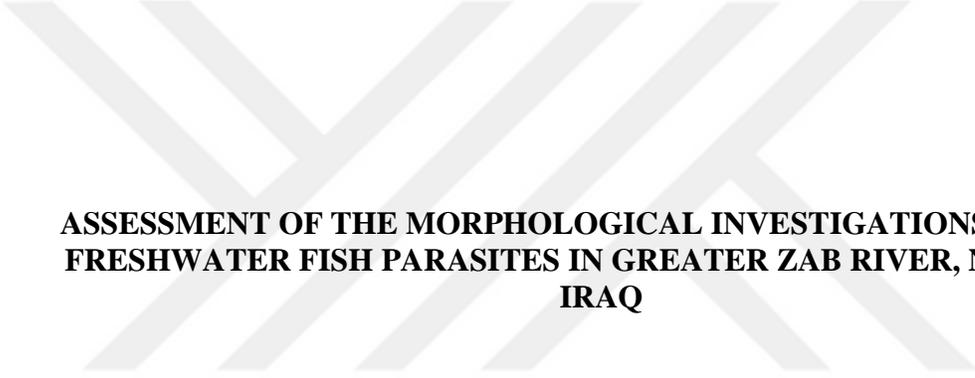


**REPUBLIC OF TURKEY
HARRAN UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES**

MASTER OF SCIENCE (MSc) THESIS



**ASSESSMENT OF THE MORPHOLOGICAL INVESTIGATIONS OF SOME
FRESHWATER FISH PARASITES IN GREATER ZAB RIVER, NORTH OF
IRAQ**

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DEPARTMENT OF BIOLOGY

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ABSTRACT

MSc Thesis

ASSESSMENT OF THE MORPHOLOGICAL INVESTIGATIONS OF SOME FRESHWATER FISH PARASITES IN GREATER ZAB RIVER, NORTH OF IRAQ

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A total of four fish species, which are *Capoeta trutta* (Heckel, 1843), *Luciobarbus kersin* (Heckel, 1843), *Mastacembelus mastacembelus* (Banks & Solander, 1794), and *Silurus glanis* Linnaeus, 1758 samples were collected and tested from Aski-Kalak region in Greater Zab River near Erbil city, north of Iraq, during from June 2018 to the end of March 2019. In the laboratory, those four species gathered in Aski-Kalak region in Greater Zab River were kept in a cool box with the river water in order to test and examine them carefully. Living parasite species that were found in the fish were examined and looked at under a compound light microscope, scanning electron microscope, and naked eye observation (as some of them are big and large worms). We recorded eight types of Protozoan parasites which are (*Myxobolus pfeifferi*, *Trichodina ranae*), Monogenea (*Dactylogyrus vastator*), Digenea (*Diplostomum spathaceum*), Cestoda (*Senga mastacembelus.*), Nematoda (*Procamallanus viviparus*), and Crustacea (*Argulus foliaceus*, *Lamproglana pulchella*). The numbers of fish types that we took differ from one another. In this research, no new parasitic species records were found, but few new hosts were found. We generally observed several parasites in different fish species, and the study was not limited to particular ones. For instance, from *Silurus triostegus*, we managed to examine 38 fish samples, while only 7 of them were found to be infected with *Myxobolus pfeifferi*, and 26 of them were found to be infected by another parasite species, after investigation the parasite was identified to be *Trichodina ranae*. Additionally, 3 of the host species were infected by *Diplostomum spathaceum*. Similarly, the same procedure was performed for the rest of the studied species, which are shown in (table 4.2.). The aim of this research is to know whether the new record of the parasitic fish infection increases or decreases when compared with other studies conducted prior to ours, considering the fact that this is the most recent research project conducted in this area of the north region of Iraq. As a conclusion, it is noticed that the parasitic infection rate is fluctuated from one fish to another and from one parasite to another, and from one research to another. However, generally the results are compatible to the ones obtained by previous researchers.

KEY WORDS: Parasites, fishes, morphology, great zab, north iraq.

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LIST OF SYMBOL AND ABBRIVATIONS

a	Anchor
ad	adhesive disc
Ap	anterior part
B	Blade
Bo	Bothria
Br	brandes's organ
C	Cytopharynx
cad	central of adhesive disc
Cb	connective bar
Ci	Cilia
Cl	Clamp
Co	copulatory organ
Cv	contractile vacuole
dad	dimeter of adhesive disc
Db	dorsal bar
Dd	dimeter of denticulate ring
dob	dimeter of body
Dv	digestive vacuole
Ed	epistomal disc

1. INTRODUCTION

Ichthyology is the branch of biology science that deals with the study of Fishes. They are groups of aquatic animals classified under cold-blooded vertebrates, their mode of breathing includes using gill slits in their pharynges. Fishes move in a forward propulsive fashion and they balance their motility via the use of pairs of fins found in their lateral side. There are some exceptions to this mode of motility, ranging from leaping and/or flying over the surface of the sea, to primitive locomotion on muddy lands. Having said so, there are several species of fish that can live outside of water for a long period of time using their accessory respiratory organs.

The term Fish includes any edible aquatic animal. Fishes are also known as the most diverse vertebrates, as they comprise about half of the sum of all vertebrates on earth. The evolutionary history of Fish dates back to 480 million years ago. Their habitat ranges from mountain flowing freshwater to the hadal depths of the ocean floor. Back in 2014, Fish Base reported 32,800 fish species, with 10,000 of them being freshwater fish. Although the majority of fish species are thought to be found and named, scientists find about 250 new species records annually. Hence, it is expected that fish are more than 40,000 species worldwide. 96% of which are considered to be bony fish belonging to Osteichthyes class and the remaining 4% are cartilaginous fish species belonging to Chondrichthyes class in the taxonomic group. All of these types of fish have their importance both to humans and to the environment.

In addition to its nutritional value, fish parts are also used traditional and circular economy. The full potential of fish products has not yet been explicitly addressed. The Institute of Natural Resources of Finland (LUKE) suggested various methods of exploiting fish parts.

Fish skin mainly contains a protein named collagen, which is widely used in skincare cosmetics and it can increase the elasticity and strength of the skin. Collagen is

also utilized to make gelatin for food production, such as gummy bears. Another use of fish skin is the process of making leather for handbags and shoes' production via special curing and tanning. Another bioactive polymer can be produced from fish scale which is chitosan due to the chitin content of the scales. This polymer has several applications that range from biomedicine, dietary supplements to agricultural uses. Examples of these applications include the use of chitosan for car paint coating.

In addition to the skin and meat, fishbone can be used as an excellent source of minerals. For instance, phosphorus, calcium aside from its abundant collagen content. These minerals are utilized in many industrial products, like the production of fertilizers. Hence, fish bones are considered as excellent raw materials for chemical production.

Although fish have many industrial, economical and food-related advantages both to humans and to the ecological food web. Consuming fishes can sometimes be dangerous. Some of the dangers are due to the consumption of heavy metals by the fish, leading to bioaccumulation in its body (Griffin et al 2018), this will then lead to biomagnification in the animal consuming that fish (Stefan et al 2018).

The other type of danger is due to the presence of parasite on or in the body of the fish. Such parasites can use the fish as intermediate hosts (Bakker et al 2017) or final host. In both cases, consuming such fish would add liability to the consumer. Consequently, this would cause dramatic health issues in the consumer. It is worth noting that parasites are naturally occurring and are not considered as a contaminant (Price and Tom, 2005) nor do they cause pollution to their habitat (Price and Tom, 2005). However, the degree of parasitic infection's severity in any organism depends on several factors, including number, size, shape and the range of activities by the parasite. This will then reflect the transmissibility of the parasite in the fish population.

Fish parasites depend on other factors to further spread among their hosts. These factors can be further subdivided into environmental and host species factors. The former

would include space-wise limitations in the water and the flow rate of the water, as well as the density of the fish population. The later would include host age, sex and genetic resistance to the parasitic infection (Dogiel, 1961).

As a survival mechanism, parasites must coexist with their hosts and tend to avoid killing them. However, it has been observed that when parasitic infection happens to fish in crowded areas like aquaria and fish farms, the infection causes rapid and gross mortalities (Paperna, 1980). In contrast to aquarium environments, natural water bodies tend to lack such phenomena except for human intervention, for example, anthropogenic water pollution has been reported to cause changes in the natural distribution of parasite communities (Barson, 2004). In 1968, Chew Valley Lake showed a diffusion in the number of cestode *Ligula intestinalis* larvae and this led to the dwindling of *Rutilus rutilus*'s population size as well as lack of their fingerlings (Wilson, 1971).

Fishing is a means of a recreational asset, and it is counted as a source of natural attraction. On top of that, fish observation (both natural and aquarium fish) is enjoyable for people of all ages (Hoffman, 1998). Thus, the fish significance is not limited to food quality and cuisine. Hence, it is crucial to consider enhancing the quality of fish farms and natural water bodies via decreasing sources of infestation and infection to the fish, this would add value and significance to fish and their products.

Fish parasite significance is directly proportional to their host's importance. Currently, overpopulation is related to food value including fish-derived food products. Also, fish meat contains a considerable amount of protein while containing little saturated fats, which further adds to the value of the animal product. To improve the pond farms' productivity, one would need to study fish parasites and the methods required to decrease their number. Barus et al., 2001 found out that fish parasites can be used indicators of heavy metal pollution in water. This has been observed to affect fish stocks in natural water bodies. Consequently, improvement of fish stocks in the natural water bodies would possibly enhance fish acclimation to new localities (Shul'man, 1961).

With regard to host-parasite interaction, some freshwater fishes are considered as intermediate hosts. They carry the infectious stages of the parasites. Examples would include trematodes, nematodes and cestodes. These parasites are pathogenic to fish-eating animals and humans as well. *Anisakis simplex*, *Clonorchis sinensis*, and *Diphyllbothrium latum* are examples of such cases (Roberts and Janovy, 2005).

Hoffman (1998) suggested a logical pattern to study fish parasites before initiating control and treatment of fish parasites, those patterns include: parasite identification, understanding their life history (ranging from simple to complicated), analyze the parasite's ecological requirements, pinpoint geographic range of the parasite on the map, determination of the mechanistic pathway leading to host's immunologic interaction with the parasite, as well as methods of treatment and study control.

The current study aims to investigate and identify parasites on/in several fish species which are (*Capoeta trutta*, *Luciobarbus kersin*, *Mastacembelus mastacembelus* and *Silurus glanis*) from Great Zab River in Northern Iraq. Then, we will compare the parasite fauna with the available literature in Iraqi published theses and articles. Then, report the possible new host and local records. The parasites that are studied in this investigation include: Protozoa, Trematoda (Monogenea and Digenea), Cestoda, Nematoda and Crustacea.

Fish parasites are as important as the host they infect. It is hence quite important to study fish parasites so as to increase the productivity of pond farms, and to further improve the valuable stocks for the commercial fisheries in the natural waters bodies. It is also important for the possibility of enhancing acclimatization of fish in new locations and sites (Shul'man, 1961). Additionally, some freshwater fishes only serve as intermediate hosts for the infective stages of some parasites, including human parasites (Roberts and Janovy, 2005).

Although consumed with fish, it has been observed that most fish parasites fail to

develop in humans. None of fish parasites are harmful to humans if cooked thoroughly with the fish. On the other hand, when raw fish is consumed, harboring the parasite, it will cause serious health issues, especially if the larval stage of the parasite is ingested (Patrick, 2008).

In Middle East, there is a high demand on such fishes. Also, some of these parasites (in their adult stages) have medical importance as they have the potential to infect humans (Abdullah, 2002). Based on those facts, the aim of this research was to investigate the parasites that infect the collected fish from Greater Zab River in northern Iraq region. Furthermore, the available information on the parasites infecting such fish is scarce, and this would be added to the reported Iraqi researches.

Hence, the main objectives of the current study include identification and classification of the parasites that are collected from the studied host fish in this research based on certain selected features. Also, in order to record the parasites' prevalence and intensity rates in those four types of host fishes that were sampled from Greater Zab river passing Aski-kalak district. Last but not the least, we will compare the parasite fauna with the ones that are reported in the available literature of Iraqi published works and to report possible new host and locality records. Despite the above mentioned reports.

2. LITERATURE REVIEW

As an ancient branch of science, fish parasitology has been extensively studied by scholars and researchers all over the world. Examples of early studies include Dogiel (1961) when he collected various information concerning ecological approaches of fish parasitic infectious diseases. A year later, Bykhovskaya-Pavlovskaya et al. (1962) published a system for classifying Soviet Union's freshwater fish parasites. This was the foundation for a more generic approach in fish infectious diseases and fish parasitology, in particular, leading to the Amlacher (1970)'s publication on fish diseases. In his publications, he addressed fungal viral, bacterial and fungal infections as well as its parasitic infections (Dujin, 1973).

Since 1973, a series of research projects have been conducted on fish parasites. Zaidi and Khan (1975) discovered a new *Zeylanema* barrage species in Taunsa Barrage, Pakistan, in which the parasite was found to inhabit *Mastacembelus armatus* intestine. In the same year, Mandal and Nair (1975) recorded two new blood-borne parasitic species of *Trypanosoma* named *Trypanosoma armeti* and *Trypanosoma pancali* infecting *Mastacembelus armatus* and *Mastacembelus pancalus* respectively. Their discovery was recorded in Champahati, West Bengal, India. Four years later, Kabata (1979) authored a book on Copepoda living on British fishes. A year after that, Paperna (1980) wrote about African fish parasites and its infectious diseases. As for Iraqi fish parasites, Mhaisen (1980) was the first to publish a list of Iraqi fresh water fish parasites. After that, Mokhayer (1981) recorded a nematode larvae belonging to *Contraecaecum* genera and isolated from *M. mastacembelus* from the Iranian Parishan Lake near Kazerun. In the same year in India, Agarwal and Kumar (1981) recorded a new genus and a new species of *Gangatrema chauhani*, an intestinal trematode parasite of *M. armatus*, from the Ganges River, Varanasi, India. This led to new records of other trematodes later on. Gupta and Puri (1984) found a digenetic trematode and named it (*Pleurogenes thapari*), they isolated it from the intestine of *M. armatus* too, and this was collected from Gomati River, in India. Later on that year, Pandey & Tewari (1984) recorded a new metacercaria species

belonging to *Prohemistomulum* genus and named it (*Prohemistomulum lucknowensis*). This was isolated from the muscles of *M. armatus* taken from Lucknow, India. A new cestode species, however, was recorded by Gupta and Parmar (1985) named *Senga indica* isolated from the same host (i.e. *M. armatus*) in the same river. Only two years later, Wahul (1987) marked the discovery of three new trypanosomatids belonging to the *Trypanosoma* genus, which were *T. aurangabadensis*, *T. murti*, and, *T. mastacembeli* from the same host (*M. armatus*) and the samples were collected from Kham River, Waluj, India. Later on in 1988, Agrawal and Agarwal (1988) recorded a new intestinal parasite in freshwater *M. armatus* called Digenea species, and named it *Dactylostomum harishii*, in Betwa River, Jhansi, India. In the same year, Chauhan (1988) discovered a two new cestode species, namely *Polyonchobothrium armatii* and *Senga nayari* from *M. Armatus* and *M. pancalus* intestine respectively, the research was carried out in two rain-fed rivers in Khoh and Nayar in India. Also, Gupta and Jaiswal (1988) found a new nematode species in *M. armatus*'s intestine in Lucknow River, India. Venkateshappa (1988) described *Ergasilus malnadensis* being isolated from the *M. armatus* gills studied in Chinnakatte Vanivalasapura, and Vanivilasa Sagar, India. Another nematode species, *Goezia moravecii*, was identified from in the intestine of *M. armatus* in Western Bangal, India. With regard to European fish parasites, Moravec (1994) described a number of nematodes parasitizing them. Also, in 1998, Jalili (1998) described Iraning fish parasites. In Turkey, Sarieyyupoglu and Saglam (1995) discovered five new species of *Dactylogyrus*, which are *D. ancylostylus*, *D. asper*, *D. extensus*, *D. minutus* and *D. Sphyrna*. These were isolated from *C. carpio* and collected at Keban Dam Lake. In North America, Hoffman (1998) described freshwater fishes in the country. This was followed by Hoole (2001)'s book on carp and other cyprinid fishes' infections.

Silurus triostegus and its parasites: In contrast to the above-mentioned fishes and their parasites, fewer research projects have been carried out on *Silurus triostegus* and its parasites, which is thought to be due to its limited geographical distribution of the fish. Another factor might be the mere interest of people to this type of fish. Thus, this review focuses on the internal and external parasites infecting the *Silurus genus* conducted over

the past two decades.

Mortezaei *et al.* (2002) found out an intestinal Nematode species, namely *Rhabdochona fortunatowi*, which infects *S. triostegus*. Their study included three stations in Khouzestan province in Khouzestan province-Iran, which are Hoor-Shadegan, Hoor-Al-Azim, and Karoon River. As for monogenetic trematode species, Galli *et al.* (2003) in Ticino River in Italy and Ondračková *et al.* (2004) in Central Europe rivers identified *Thaparocleidus vistulensis* and *Thaparocleidus magnus* from the *S. glanis* gills.

With regard to the dermatophyte parasites infesting fish skin and fins, Zhang & Wang (2005) discovered a new *Dermocystidium* sp. parasitizing *S. meridionalis* and isolated it from Ialing River in China. In the same year, Siylu (2005) found several parasitic species living on *S. glanis*, which are *Ancylo-discoides siluri*, the Monogenea *A. vistulensis*, the cestode *Siluritaenia siluri*, the trematode *Diplostomum* sp., a nematode *Eustrongylides excisus*, and a crustacean species named *Argulus foliaceus*. The research was conducted in Terkos Lake in Turkey. Afterwards, Galli *et al.* (2005) isolated a monogenic species named *Thaparocleidus vistulensis* that lives on *S. glanis*, they found this species in Po River, Northern Italy. This was followed by the extensive description of fish diseases and their parasites in Woo (2006)'s book.

Al-Samman *et al.* (2006) also studied fish parasites inhabiting their gills, and they found a new monogenetic trematode species and named it *Silurodiscoides vistulensis* that lived on *S. triostegus* and isolated it in the Lake Assad in Syria. Additionally, Öktenler *et al.* (2006) investigated fish ectoparasites and recorded a new gill louse, *Argulus foliaceus*, isolated from *S. triostegus* in Atatürk Dam Lake, Turkey. İnnal *et al.* (2007) studied intestinal parasites in *S. glanis* from Sariyan Dam Lake and Iznik Lake in Turkey, and found plerocercoides of *Ligula intestinalis* in *S. glanis*'s intestine. Also, Kirjušina and Vismanis (2007) reported a number of parasitic species ranging from protozoans to crustaceans. These parasites include, *I. multifiliis*, *Trichodina* sp., *Thaparocleidus siluri*, *Bucephalus polymorphus*, *D. spathaceum*, a digenic *Nicolla skrjabini*, *P. osculates*,

Aganonema sp., *Camallanus truncates*, *Eustrongylides* sp., *Cucullanus heterochrous*, *Raphidascaris acus*, *Acanthocephalus anguillae*, *A. lucii* and *Ergasilus sieboldin*, their project was conducted in Latvia.

Nagasawa *et al.* (2007) isolated a crustacean species, named *Lernaea cyprinacea* (both adult and larval states), from the gills of *S. asotus* in two rivers of Hiroshima Prefecture in Japan, which were Ashida and Kurose rivers. Pazooki *et al.* (2007) investigated eleven fish species in seven different stations in three rivers (Zangbar, Aras, and Ghotor) in Iran, they recorded a monogenetic trematode species identified as *Silurodiscoides siluri* on the *S. glanis* gills.

Laura *et al.* (2008) identified an intramuscular nematode larva of *Eustrongylidos* sp. in muscles, and coelom of *S. glanis* isolated from natural lakes in Romania. Moreover, Moravec *et al.* (2008) recognized a nematode species, *Philometra parasiluri*, inhabiting *S. asotus* isolated from Biwa Lake in Japan.

Berenice *et al.* (2009) identified three new species living on *Digenea* sp in Rio de Janeiro, Brazil, those were *Metamicrocotyla macracantha*, *Microcotyle pomatomid* and *Gotocotyla acanthura*. Maqbool and Ahmed (2014) identified a new species *Schizothorax plagiostomus* and the samples were isolated from *Trypanosoma* species in three different locations of Srinagar, J&K and India. Kareem Morsy *et al.* (2016) identified two new species, which were *Diclidophora merlangi* and *Loxuroides pricei* and isolated them from *L. sasikala*. The study was conducted in Egypt.

García-Varela *et al.* (2015) discovered four fish parasite species, which were *T. adulta*, *T. americana*, *T. elongata* and *T. brevis*, they parasitize *Tylodelphys azteca* n. sp, and they were isolated in Mexico. In the same year, McAllister *et al.* (2015) recorded *B. archeilognathi* parasitizing Oklahoma fish, the study was carried out in Arkansas non-hatchery fishes. A year later, Gabriela (2016) found a new fish parasite in India, and named it *Trichodina quelenii* that lives on *Gymnotus* sp. Also in India,

Saha (2017) recorded three new species which are *Trichodina Indiana n. sp.*, *Trichodina manjuae n. sp.* and *Trichodina vinodi n. sp.* and isolated from *Carassius auratus*.

Fadlallah (2017) identified six new parasites which are *Heterobothrium lineatus*, *Cichlidogyrus longicornis longicornis*, *Cichlidogyrus aegypticus*, *Quadriacanthus bagrae*, *Ancyrocephalus sp.* and *Protoancylo-discoides malapterurid* these were isolated in Nile River in Egypt.

Wee *et al.* (2017) isolated a new species and named it *Proctoeces choerodoni n.*, the study was conducted in Heron Island in the southern Great Barrier Reef.

Saha & Bandyopadhyay (2017) isolated two new species, which were *Dipartiella indiana n. sp.* and *Dipartiella carassii n. sp.* isolated from *Trichodinid ciliophorans* in India.

Roselene Nogueira Rodrigues *et al.* (2017) described a new fish parasite species, which was *Colossoma macropomum* isolated from *Trypanosoma sp.* in Amazon, Brazilian.

Abdel-Azeem Sh. Abdel-Baki *et al.* (2017) identified three new parasite species, which are named as *Trichodina maritinkae*, *T. centrostrigeata* and *T. frenata* and isolated from *Trypanosoma sp.* in Saudi Arabia.

Huston *et al.* (2018) discovered three new parasite species which are *Trigonocephalotrema euclidi*, sp. nov., *T. hipparchi*, sp. Nov. And *T. sohcahtoa*, sp. nov. And they parasitize fishes of *Naso Lacepedè* and *Zebrasoma Swainson*, their study locations were in Australia.

Aguilar-Aguilar *et al.* (2018) found three new parasite species, which were

Hargicola oligoplites, *Mazocraes* sp., and *Neohexostoma euthynni* and isolated them from *N. euthynni* in Costa Rica.

In Iraq, Herzog (1969) was the first to conduct an extensive research on fish parasites, who studied 16 species of fishes and collected them from different regions in Iraq. He identified six species of protozoans (namely, *Myxobolus oviformis*, *M. mülleri*, *Myxobolus* sp., *Myxosoma multiplicata*, *Ichthyophthirius multifiliis* and a Microsporidian of the Nosematidae family), a single trematode species (*Neodiplostomum* sp.), a cestode species (*Diphyllobothrium* sp.), an acanthocephalan species (*Neoechinorhynchus rutili*), a single leech species (*Piscicola* sp.), four nematode species (*Contracaecum* sp., *Goezia* sp. larva, *Philometra* sp. and *Dujardinascaris* sp.) and two crustacean species (*Ergasilus sieboldi* and *Argulus foliaceus*), among them the nematode larvae *Contracaecum* sp. was isolated from *S. triostegus* and his study was conducted in Tigris and Euphrates Rivers.

Also in Iraq, Shamsuddin *et al.* (1971) identified two protozoan species which were *Ichthyophthirius* sp. and *Trichodina domerguei* and another cestode species for each *Triaenophorus* sp., a Nematode (*Contracaecum* sp.) and a leech (*Piscicola* sp.) they isolated them from eight species of fishes and collected their samples from Tigris and Euphrates Rivers as well as Habbaniyah and Tharthar Lakes.

Fattohy (1975) surveyed six parasitic species of fishes and collected them from Tigris River in Mosul city. The study recorded three new species of both protozoans and nematodes and a single species for each monogenean, trematode and acanthocephalan as well as two crustacean species.

Rahemo (1976) recorded a microsporidian parasite species and named it *Unicauda lumae*, the sample was isolated from the liver of *Barbus grypus* in Tigris River in Mosul city.

In another collaborative study of Fattohy, i.e. Warsi and Fattohy (1976), they identified yet another new blood born parasitic flagellate species called *Trypanosoma acanthobramae*.

Habish (1977) studied mesentery and stomach surface of *S. triostegus* and in a search for a new parasite species, he recorded a nematode larvae called *Contracecum* spp., the sample was isolated from Shatt Al-Arab in Basrah city.

Al-Daraji (1986) studied five different fish species in a search for new parasites, the study was conducted in Al-Hammar marsh in Basrah city, and managed to record eleven parasitic isolated from *S. triostegus*. The parasites were *Trypanosoma* sp., *Myxobolus pfeifferi*, *Dactylogyrus* sp., *Orientocreadium pseudobagri*, *Asymphylogyrodora* sp., *Aspidogaster enneatis*, *Bothriocephalus* sp. *Khawia armeniaca*, *Contracecum* sp., *Ergasilus mosulensis* and *Ergasilus* sp.

Khalifa (1986) recorded intestinal cestode species, which were *Bothriocephalus gowkongensis* and *Proteocephalus turulosus* in *C. carpio* the samples were collected from several ponds near Baghdad City and Samaraa City.

Ali *et al.* (1986a) dedicated their studies to trematodes, first they recorded a monogenetic trematode called *Dactylogyrus cornu* inhabiting *S. triostegus*'s gills and isolated the sample. Then in the same year, Ali *et al.* (1986b) recorded a new digenetic trematode called *Apatemon pelluidus* infecting the *S. triostegus*'s liver surface project's sample data were collected from Diyala River, Southeast of Baghdad. This was the basis of two other research projects that they conducted a year later in the same river. Ali *et al.* (1987a) recorded *Trichodina domerguei* (a Protozoan species), *Apatemon pelluidus* (a Digenea species) and *Silurotaenia siluri* (a cestode) the samples were isolated from *S. triostegus*. Ali *et al.* (1987b) then recorded another five cestode species of the statistical analysis showed that these parasites were found in 27 (15%) of 179 freshwater fishes (Subject Category: Organism Groups).

Abdul-Ameer (1989) investigated twelve fish species to record new parasitic fauna, the samples were collected from Tigris River at Salah Al-Dien province, and he managed to record a protozoan species for each fish species which were *T. domerguei*, a monogenetic trematode (*Ancylodiscoides vistulensis*) and a nematode (*Contracaecum* sp.) this was isolated from *S. triostegus*.

Ali *et al.* (1988) then studied the skin and gills of *C. carpio* and they recorded six fish parasite species, which were *Apiosoma piscicola*, *Chilodonella cyprini*, *Ichthyophthirius multifiliis* and *Trichodina domerguei* (Protozoa) and *Ergasilus sieboldi* as well as *Lernaea cyprinacea* (Crustacea), the samples were collected from Suwairah and Latifiyah ponds near Baghdad City.

Mhaisen *et al.* (1988) managed to detect *Dactylogyrus achmerowi* inhabiting *C. carpio* gills the research samples were collected from Al- Wahda fish hatchery at Suwaira, south west of Baghdad city and Babylon fish farm in west Hilla city, this was the first record for this species in Iraq. Al-Daraji and Al-Salim (1990) then recorded a sporozoan parasite named *Myxobolus pfeifferi* and a monogenetic trematode *Dactylogyrus* sp., the samples were isolated from *S. triostegus* in Al-Hammar marsh. Afterwards, the same group of Al-Salim and Al-Daraji (1990) recorded a blood born flagellated parasitic species, which was *Trypanosoma arabica*, this samples were isolated in the heart of *S. triostegus* from Al-Hammar marsh, North West of Basrah province. On the other hand, ciliated protozoans in fish were first identified by Mhaisen *et al.* (1995), in which they recorded the ciliate *Trichodina domerguei* and isolated it from *S. triostegus*. Their samples were collected from Tigris River at Al-Rashidia in Iraq.

Al-Niaeemi (1997) identified sixteen parasitic species, these were categorized as follows. Four protozoan species (*Trypanosoma* sp., *Trichodina domerguei*, *Myxobolus iranicus* and *M. koi*), three monogenetic trematode species (*Ancylodiscoides vistulensis*, *Paradiplozoon pavlovskii* and diproa of *Diplozoon* sp.), two digenetic trematode species (*Orientocreadium siluri* and *Megamonostomella rashediansis*), two cestode species

(*Bothriocephalus ospariichthydis* and *Proteocephalus hemispherous*), one nematode species (*Contacaecum* sp.), three crustacean species (*Argulus japonicus*, *A. foliaceus* and *Ergasilus mosulensis*) and a single molluscan species (*Unio pictorum*). All of the above sixteen isolates were collected from *S. glanis* in Tigris River in Mosul city.

Rahemo and Al-Niaeemi (1998) recorded a digenetic intestinal trematode species, namely *Megamonostomella rashediansis* they isolated the sample from *S. glanis* in Tigris River, which passes through Mosul city.

Al-Dosary (1999) found two protozoan species, which were the flagellated *Trypanosoma* sp. and *Trichodina* sp. isolated from *S. triostegus* in Garmat Ali River in Basrah city. Abdul-Rahman (1999) recorded nineteen parasitic species two of which were monogenetic trematode species, a nematodes and an acanthocephalans, eight digenetic trematode species, one cestode species and four crustacean species, the samples were isolated from *S. triostegus* and collected from Garmat Ali River in Basrah city. In the same year, Adday *et al.* (1999) added a new host, *S. triostegus*, to Tigris River at Al-Zaafaraniya, south of Baghdad to study *Myxobolus koi* (a Sporozoan) and *Polyonchobothrium magnum* (a Cestoda). This was a different approach towards investigating anthropogenic host-parasite interaction in Iraq. Then Adday started studying parasites living in the gills of *S. triostegus* in 2001.

Balaseem *et al.* (2000) recorded two new species parasitizing *S. triostegus* which were *Ancylodiscoides siluri* and *Botheriacephalus* sp., their samples were collected from Hemrin Dam Lake in Diyala province. This was followed by Adday (2001)'s work in which he recorded *Ergasilus ogawai* in *S. triostegus*'s gills for the first time the study was conducted in Garmat Ali River in Basrah city.

Balaseem *et al.* (2001) studied eight fish species within which *S. triostegus* was one of them, their study was conducted in Diyala River and managed to isolate a ciliated protozoan species, namely *Trichodina domerguei* from the host.

Rahemo & Al-Niaeemi (2001) isolated a new intestinal cestode parasite, namely *Proteocephalus hemisphaerus*. The sample was recovered from the *S. glanis* and the data collection was carried out in the Tigris River, passing through Mosul city. Two years later, De Chambrier *et al.* (2003) recorded a new cestode species named *Postgangesia inarmata* and isolated it from *S. glanis* in Tigris River in Mosul city.

Jori (2006) carried out an extensive study on *S. triostegus*'s parasites and collected the samples in Al-Hammar marshes in Basrah city, and the study output was a record of forty parasite species which were:-

Table 2.1. summarizes the parasite species, their categories and their count in the samples being studies.

Parasite species	Category
1. <i>Trypanosoma Arabica</i>	(Protozoa)
2. <i>Trypanosoma</i> sp.	(Protozoa)
3. <i>Glugea plecoglossi</i>	(Protozoa)
4. <i>Myxobolus mesopotamiae</i>	(Protozoa)
5. <i>M. pfeifferi</i>	(Protozoa)
6. <i>Myxobolus</i> sp.	(Protozoa)
7. <i>Henneguya tachysuri</i>	(Protozoa)
8. <i>Ichthyophthirius multifiliis</i>	(Protozoa)
9. <i>Trichodina domerguei</i>	(Protozoa)
10. <i>T. nigra</i>	(Protozoa)
11. <i>T. prowazeki</i>	(Protozoa)
12. <i>T. reticulata</i> and <i>Trichodina</i> sp.	(Protozoa)
13. <i>Gyrodactylus vimbi</i>	(Monogenea)
14. <i>Gyrodactylus</i> sp.	(Monogenea)
15. <i>Dactylogyrus calbasi</i>	(Monogenea)
16. <i>Paradactylogyrus bati</i>	(Monogenea)
17. <i>Hamatopweduncularia arii</i>	(Monogenea)
18. <i>Ancylodiscoides parasiluri</i>	(Monogenea)
19. <i>Haliotrema</i> sp.	(Monogenea)
20. <i>Cleidodiscus</i> sp. and <i>Bychowskylla qharui</i>	(Monogenea)

21. <i>Proctoeces maculates</i>	(Digenea)
22. <i>Asymphyiodora</i> sp.	(Digenea)
23. <i>Orientocreadium batrachoides</i>	(Digenea)
24. <i>O. pseudobagri</i>	(Digenea)
25. <i>Hemiurus sigani</i>	(Digenea)
26. <i>Monodharmis philippinensis</i>	(Digenea)
27. <i>Ascocotyle coleostoma</i> and <i>Clinostomum complanatum</i>	(Digenea)
28. <i>Polyoncobothrium clarias</i>	(Cestoda)
29. <i>Contraecaecum</i> sp.	(Cestoda)
30. <i>Camallanus kirandensis</i>	(Cestoda)
31. <i>Echinocephalus</i> sp. and <i>Rhabdochona garuai</i>	(Nematoda)
32. <i>Neoechinorhynchus iraqensis</i>	(Acanthocephala)
33. <i>Bomolochus</i> sp.	(Crustacea)
34. <i>Ergasilus mosulensis</i>	(Crustacea)
35. <i>E. rostralis</i>	(Crustacea)
36. <i>E. pararostralis</i>	(Crustacea)
37. <i>Dermoergasilus varicoleus</i>	(Crustacea)
38. <i>Paraergasilus inflatus</i>	(Crustacea)
39. <i>Alicalgus</i> sp. and <i>Lernanthropus trifoliatus</i>	(Crustacea)
40. <i>Unio pictorum</i>	(Mollusca)

Rahemo and Mohammad (2006) recorded a cestode intestinal parasite named *Silurotaenia siluri* from *S. triostegus* in Tigris River in Mosul city. A year later, Al-Saadi (2007) identified five new fish parasite species including *Trichodina domerguei* (Protozoa), *Dactylogyrus extensus* and *Diplozoon barbi* (Monogenea) and *Ergasilus barbi* and *Ergasilus sieboldi* (Crustacea) isolated from *C. carpio* in Al-Husainia creek in Karbala province. A year later, Al-Sa'adi (2007) studied twenty four parasitic fauna species of fish, and collected the samples from Euphrates River at Al-Musaib city. Afterwards, he recorded six monogenetic trematode species, which were *Dactylogyrus extensus*, *Gyrodactylus elegans*, *G. markewitschi*, *Diplozoon paradoxum*, *Eudiplozoon nipponium* and *Paradiplozoon homoion* as well as two new digenetic trematode species, namely *Aspidogaster limacoides* and *Asymphyiodora macracetabulum*) from *C. carpio*.

These were followed by Al-Nasiri's collaborative works in 2009 on *C. carpio* parasites.

First, Al-Nasiri and Mhaisen (2009a) isolated a protozoan *Trichodina cottidarum* species, and a Monogenea species (*Dactylogyruis vastator*) the samples were collected from the *C. carpio*'s gill surface. Later on, Al-Nasiri (2009) identified three other monogenetic trematode species, which were *Diplozoon barbi*, *Paradiplozoon bliccae* and *P. pavlovskii* on the *C. carpio*'s gills. Sample collection of both of his works were carried out in different locations of Tigris river spanning PW, the river through Tikreet city in Salah Al-Deen province.

Al-Mahi and Al-Mayali (2015) published a meta-analysis by extracting data from the previous works carried out by Al-Mahi (2014) the extracted features included the measurements taken from eight heavy metals in one cestode and a nematode species from both *A. grypus* (reported as *B. grypus*) and *P. Abu* (reported as *L. abu*) the study was conducted in several locations in Al-Diwaniyah province. The parasite names were not mentioned in their published works. However, in the present study the names will be considered as *Schyzocotyle acheilognathi* and *Contracaecum sp.*, respectively. A year later, Al-Mahi published yet another article with Al-Mayali in 2016, the data was also extracted from the base article of Al-Mahi (2014). In which, they recorded three helminths (a cestode, a nematode, and an acanthocephalan to be precise), the samples were isolated from *A. grypus* (mentioned as *B. grypus*) as well as a nematode and an acanthocephalan isolated from *P. abu* (reported as *L. abu*). In addition, they demonstrated some histopathological changes caused by such parasites excluding pivot determination of such changes for each parasite species.

Mohammad (2016) carried out an intensive investigation of the parasites in redbelly tilapia *Coptodon zillii* (reported as *Tilapia zillii*) from Al-Dalmaj marsh of Al-Diwaniyah province as well as from locations in the Central marshes in Thi-Qar province. According to his obtained results, there were parasitic infection in the studied fish of Al-Dalmaj marsh. However, he recorded two parasite species from *C. zillii* of Thi-Qar province.

In 2018, Shakir conducted two exploratory investigations in Al-Diwaniyah province. First, Shakir (2018) investigated *Coptodon zillii* and *P. abu* for possible parasitic infections from two stations in Al-Diwaniyah province (Al-Saniyah own and Al-Diwaniyah city center) and two other stations in Al-Muthanna province. He managed to detect parasitic infections in both fish species from both provinces with two *ciliophorans* and two *myzozoans*. Afterwards, Shakir and Al-Asadiy (2018) published an extracted article from Shakir (2018) and analyzed the the record of two *ciliophorans* and two *myzozoans* from both *C. Zillii* and *P. abufrom* waters of both Al-Diwaniyah and Al-Muthanna provinces, and other proviencens.

Mhasien and Ameer (2019) published a specified checklist for the monogenea *Dactylogyrus* species for fishes in Iraq. In their checklist, there are eighty two candidate species of this genus on forty fish species. All of which can infect freshwater fishes, excluding *Dactylogyrus vastator* that was also identified to have infected two marine fish species while entering fresh waters. Furthermore, , it has been observed that *Dactylogyrus* has a wide distribution range when it comes to multiple host infectivity, as the parasite can infect a minimum of nine up to a maximum range of fourty three common carp species (*Cyprinus carpio*).

In a more recent publication, Mhaisen *et al.* (2019) made yet another parasite checklist al-diwanayah province fishes, in Iraq. This list of parasitic fauna involved a euglenozoan, two myzozoan species, six ciliophorans, three myxozoans, three trematodes, nine monogeneans, four cestodes, six nematodes, three acanthocephalans and six crustaceans. Also, another group of parasites have been observed to infect the fish species. Among them, a trematode, a monogenean, along with two cestode species and a nematode have been observed at their larval stages, while the other recorded infections were either at their adult stage or were trophozoites. Among the inspected fishes, the fish species with the highest vulnerability rate to the studied parasites was *Carasobarbus luteus* as it was infected with the highest number of parasite species (with a total of twenty parasite species), this was followed by *Planiliza abu* (with a total of seventeen species)

and *Cyprinus carpio* (with a total of seventeen sixteen species). However, two fish species were recorded with the lowest number of parasitic infections, these were *Ctenopharyngodon idella* and *Hypophthalmichthys molitrix*. Each of which was infected with only three species of the studied parasites. This might mean that the last two fish species are more resistant to the studied parasites...

In Northern Iraq the first research project that aimed at studying fish parasites was carried out by Rasheed and Hussain (1988) who investigated seven fish species from Greater Zab River, and found a parasite protozoan species *per se* (*M. pfeifferi*), a monogenean (*D. cornu*), a trematode (*Diplostomum* sp.), a cestode species (*Caryophyllaeus fennica*) and an acanthocephalan (*Neoechinorhynchus rutili*) and three crustacean species (*Ergasilus sieboldi*, *Ergasilus* sp. and *Lamproglena pulchella*).

Ali (1989) conducted an extensive survey on eleven species of fishes on a search for possible parasitic infections and he collected the samples from Greater Zab River. As a result, he recorded thirteen parasite species. one of which was a protozoan species , two monogeneans species , two trematode species , one nematode species for each one of them, a cestode and an acanthocephalan, as well as four crustacean species and one leech species.

Rasheed *et al.* (1989) investigated four fish species to record new parasites. They collected the samples from Lesser Zab River, and recorded three parasite species including *Myxobolus pfeifferi*, *Neoechinorhynchus rutili* as well as *Ergasilus sieboldi*. A decade later, Abdullah (1998) identified five species of *Myxobolus* (*M. cyprinicola*, *M. macrocapsularis*, *M. parvus*, *M. rotundus* and *M. sandrae*) the samples were isolated from a total of four fish species and they were collected from Dokan Lake. Furthermore, Abdullah (2002) conducted an elaborate study on the parasites of twenty eight fish species, in which they belonged to seven families from Lesser Zab and Greater Zab Rivers, and he recorded sixty eight parasite species including nineteen protozoan species, thirty monogenean species, four trematodes, six cestodes, three nematode larvae, two

acanthocephalans, three crustaceans, and one clam larva. Among these species, he wrote a descriptive analysis of a new acanthocephalan species (i.e. *Pomphorhynchus spindletruncatus*) that parasitizes *B. xanthopterus* and *A. vorax* intestine. He also recorded twenty parasite species for the first time in Iraq. Afterwards, he published a number of research articles based on his PhD thesis (Amin *et al.*, 2003a; Abdullah and Mhaisen, 2004; 2005a; b; 2006; 2011a; b).

Amin *et al.* (2003b) identified a new acanthocephalan species named (*Neoechinorhynchus zabensis*) isolated from *Capoeta damascina* and *C. trutta*, and their study was conducted in Lesser Zab and Greater Zab Rivers near Erbil city.

Abdullah and Rasheed worked on two projects in 2004 in Dokan Lake. In their first publication, Abdullah and Rasheed (2004a) isolated ten ectoparasite species that were collected from Dokan Lake fishes, these ectoparasites included one protozoan species (*Myxobolus poljanski*), four monogenean species (*Dactylogyrus affinis*, *D. carpathicus*, *D. charbinensis* and *Diplozoon pavlovskii*), a single trematode species (*Clinostomum complanatum*) and four crustacean parasites (*Ergasilus barbi*, *Lamproglena pulchella*, *Pseudolamprogleana annulata* and *Lerneae cypriniacea*). In their later project, Abdullah and Rasheed (2004b) published a record of nine other endoparasite species that were collected from Dokan Lake fishes. Specifications of the parasite species included five cestode species. Two of which were plerocercoid cestodes (*Ligula intestinalis*, *Diphyllobothrium latum*), and the last three were adult cestodes (*Caryophyllaeus fimbriceps*, *Bothriocephalus achielognathi*, *Proteocephalus coregoni*). Also, two nematode species in their larval species (*Anisakis* sp., *Contracaecum* spp.) as well as two adult acanthocephalans (*Neoechinorhynchus rutili* and *Pomphorhynchus laevis*). Later on in the same year, Kritsky *et al.* (2004) recorded *Mastacembelocleidus heteranchorus* (a monogenean fish parasite) and the specimens were isolated from *M. mastacembelus* gills. The research project was conducted in Greater Zab River at Iski Kalak town.

After Kritsky *et al.* (2004)'s work, Abdullah (2005) conducted several surveys for a

duration of seven successive years. He first studied seventeen different fish species for possible parasites Greater Zab River Lake, and recorded two protozoan species (*I. multifiliis* and *T. domerguei*), nine monogenean species (*Dactylogyrus barbuli*, *D. extensus*, *D. hypophthalmichthys*, *D. pavlovskyi*, *D. vastaor*, *D. vistulae*, *Dogielius planus*, *Gyrodactylus elegans* and *G. paralatus*), three cestode species in their adult stage (*Bothriocephalus achielognathi*, *Khawia sinensis* and *Paracaryophyllaeus gotoi*), one nematode species in its larval stage (*Contraecum* sp.) as well as four crustacean species (*Lamproglena pulchella*, *Pseudolamproglena annulata*, *L. cyprinacea* and *Tracheliastes polycolpus*). Two years later, Abdullah (2007) isolated *Dactylogyrus rectotrabus* from *Garra rufa*'s gills for the first time and the research project was conducted in Greater Zab River in north of Iraq. Afterwards Abdullah (2008) isolated the monogenean *Dactylogyrus fallax* from *Chalcalburnus mossulensis*'s gills and the samples were collected from Greater Zab River, this record was the first of its kind at that time in Iraq.

Afterwards, Bilal and Abdullah (2008) recorded four parasitic protozoa and crustacean species in an extensive survey their sample isolates came from eight species of cyprinid fishes and the study location was Bahdinan River The recorded protozoan species were (*Trypanosoma* sp., *Plistophora longifilis*, *Myxobolus pfeifferi* and *M. shadgani*). As for the crustacean species, they were (*Ergasilus barbi*, *E. sieboldi*, *Lamproglena pulchella* and *Pseudolamproglena annulata*). Additionally, Abdullah (2009) managed to record another four monogenean species belonging to the *Dactylogyrus* genus, *Dactylogyrus alatus* on *Chalcalburnus mossulensis*, *D. cyprinioni* on *C. macrostomum*, *D. macracanthus* on *Leuciscus Lepidus* and *D. microcirrus* on *Capoeta trutta* from Darbandikhan Lake. This was also a first-time record in Iraq for the studied genus. Afterwards, Bilal and Abdullah (2009a) isolated yet another six *Dactylogyrus* species inhabiting the gills of five species of cyprinid fishes. Namely, they were *D. barbuli* on *B. barbulus*, *D. deziensoids* on *B. barbulus* and *B. kersin*, *D. deziensis* on *B. barbulus* and *B. kersin*, *D. macrostomi* on *C. macrostomum*, *D. pavlovskyi* on *B. grypus*, and *D. vistulae* on *Luciscus lepidus*. Furthermore, Bilal and Abdullah (2009b)

recorded several helminthes parasitizing eight cyprinid fish species the samples of these two successive projects were collected from Bahdinan River, and the reported parasite species were (*Clinostomum complanatum*, *Diplostomum spathaceum*, *Bothriocephalus acheilognathi*, *Caryophyllaeus fimbriceps*, *Rhabdochona chodukini*, *R. gnedini*, *R. tigræ* and *Neoechinorhynchus zabensis*).

A year later, Bashě and Abdullah (2010) recorded sixteen parasitic species belonging to *Mastacembelus mastacembelus* that includes two protozoan species (*Trypanosoma* sp. and *Trichodina pediculus*), one monogenean species (*Mastacembelocleidus heteranchorus*), six trematode species (*Allocreadium transversale*, *Asymphylogora macracetabulum*, *Pseudochetosoma salmonicola*, *Clinostomum complanatum*, *Diplostomum flexicaudum* and *D. spathaceum*), two cestode species (*Polyonchobothrium magnum* and *Ligula intestinalis*), two nematode species (*Agamospirura* sp. and *Procamallanus viviparus*), a leech species, a crustacean and an arachnoide (*Cystobranthus mammillatus*, *Argulus foliaceus* and *Arrenurus* sp. respectively). Additionally, Abdullah and Shwani (2010) isolated another list of ten ectoparasites isolated from *Silurus triostegus* and collected from Greater Zab River. The parasites were divided into three groups, seven protozoan species (*Myxobolus poljanski*, *Chilodonella cyprini*, *Tetrahymena pyriformis*, *Ichthyophthirius multifiliis*, *Trichodina ranae*, *Scyphidia arctica* and *Apiosoma robusta*), one monogenean species (*Ancylo-discoides vistulensis*) and two crustacean species (*Ergasilus mosulensis* and *E. sieboldi*).

Then, Shwan and Abdullah (2010) managed to record ten other endoparasite species that parasitize *S. triostigus* from Greater Zab River. The record included five trematode species (*Azygia robusta*, *Orientocreadium siluri*, *Megamonostomella rashediansis*, and *Diplostomum flexicaudum* And *D. spathaceum*), three cestode species (*Proteocephalus osculatus*, *Neogryporhynchus cheilancristrotus* and *Polyoncobothrium clarias*) and two nematode species (*Procamallanus viviparus* and *Contracaecum* sp.). In yet another collaborative work, Shwani *et al.* (2010) recorded two new *Trichodina* species (*T.*

erbilensis and *T. kurdistani*) that parasitize *Silurus triostigus* these samples were also collected from Greater Zab River.

Last but not the least, Bilal and Abdullah (2012) isolated the intestinal nematode parasite called *Procamallanus siluri* from *Silurus glanis* the samples were isolated from Greater Zab River, too. Mama (2012) recorded four protozoan species. This included *Trichodina acuta*, *T. nobilis*, *T. reticulata* and *Apiosoma amoebae* and nine monogenean species, which were (*D. achmerowi*, *D. anchoratus*, *D. baueri*, *D. deziensioides*, *D. extensus*, *D. inexpectatus*, *D. minutus*, *D. molnari*, *D. sahuensis*) and a single crustacean species (*Lernaea cyprinacea*) that parasitize on *C. carpio*, the samples were collected from Ainkawa Fish Hatchery in Erbil City.

Also, Mama (2012) recorded another sixteen parasites species that were isolated from *Cyprinus carpio* collected from Lesser Zab River, two of these species were protozoan (*Ichthyophthirius multifiliis* and *Trichodina reticulata*), eleven of them were monogenean species (*Dactylogyrus achmerowi*, *D. anchoratus*, *D. baueri*, *D. deziensioides*, *D. inexpectatus*, *D. minutus*, *D. molnari*, *Gyrodactylus baikalensis*, *G. elegans*, *G. gobioninum* and *G. vicinus*), a species trematode (*Diplostomum spathaceum*), a cestode species (*Bothriocephalus acheilognathi*) and a crustacean parasite (*Lernaea cyprinacea*).

Moravec *et al.* (2012) recorded a new intestinal nematode species called *Rhabdochona (Globochona) kurdistanensis* from *Luciobarbus kersin* in Greater Zab River. The research was conducted in the in Darbandikhan Lake, however only two reports are available.

Muhamad *et al.* (2013) surveyed several freshwater fishes for possible parasitic fauna from greaterzab river, north of Iraq, The study results showed the existence of eight parasite species, which were one protozoan species (*Trichodina mutabilis*), three monogenean species (*Dactylogyrus barbuli*, *Gyrodactylus kherulensis* and

Paradiplozoon cyprini), metacercaria *Diplostomum spathaceum*, two cestodes species (*Bothriocephalus acheilognathi* and *Proteocephalus osculatus*) and one crustacean species (*Pseudolamproglena annulata*). In their study, *S. triostegus* was considered as a new host for *T. mutabilis* and *G. kherulensis*. Also, *B. kersin* as a host for *D. barbuli* and *C. macrostomum* for *P. cyprini* in Iraq.

Abdullah (2012) surveyed some fish parasites from Darbandikhan Lake in North of Iraq. The study results showed the existence of forty five parasitic species, which were seven protozoan species, twenty nine monogenean species, two trematode species, one cestode species and a nematode, two acanthocephalan species and three crustacean species. Eleven of these species were recorded for the first time, they were categorized into two subgroups. Seven of which were (*Myxobolus amurensis*, *Dactylogyrus dyki*, *D. persis*, *D. mascomai*, *D. suchengtaii*, *Gyrodactylus molnari* and *Paradiplozoon leucisci*) and the other four species were (*Dactylogyrus barbiodies*, *D. formosus*, *D. lenkorani* and *Gyrodactylus sprostonae*). However, the last four were recorded in northern Iraq, only. In addition, for some of those parasites, some fish species (*B. grypus*, *C. auratus*, *C. luteus*, *C. trutta*, *C. umbla*, *L. esocinus*, *M. mastacembelus*, *S. lepidus*, *S. triostegus*) were recorded as new hosts being observed for the first time.

Afterwards, Abdullah and Mama (2012) recorded four *Paradiplozoon* species and isolated them from *C. carpio*. Their samples were collected from Ankawa Fish Hatchery in Erbil City. A year later, Mama and Abdullah (2013) recorded *Ichthyophthirius multifiliis*, *Trichodina acuta*, *Trichodina nobilis*, *Trichodina reticulate*, and *Apiosoma amoebae*. On different body locations of the host including the skin, fins and gills of *C. carpio*. These samples were also collected from Ainkawa Fish Hatchery in Erbil City.

Bilal (2016) studied the effects of sex and age relationship with the seasonal distribution and site selection of *Luciobarbus kersin* (Osteichthyes: Cyprinidae) on the parasitic nematode *Rhabdochona kurdistanensis* from Greater Zab River, and the study showed found out that host sex has no significant effect on the distribution. However,

acute seasonal distribution changes were recorded.

Abdul-Rahman (2014) evaluated the effects of using *Spirulina* spp. (an algal species) as food supplement on growth, and performance of common carp fingerlings. This study was conducted in order to study the effect of adding different levels of the algae (i.e *Spirulina* spp.) in fish laboratory of Animal Production Department, Faculty of Agricultural sciences of Sulaimani University, Sulaimani, North of Iraq and it was published International Journal of Fisheries and Aquatic Studies .

Mhaisen *et al.* (2015f) observed twenty-four parasite species and they inspected four parasites throughout July 2006 until the end of June 2007. The study results showed that the crustacean parasites (*Ergasilus mosulensis*) were isolated from *Glyptothorax steindachneri*, *E. peregrinus* from three fish species (*Carasobarbus luteus*, *G. steindachneri* and *Liza abu*), *E. sieboldi* from *L. abu* and *Lamproglena pulchella* from *Leuciscus vorax*. Additionally, twelve new host records in Iraq were reported for two parasitic crustacean species and a mollusk larva. Among the studied fishes, the frequency of ectoparasitic species changed dramatically in a population of sixteen fish species from a minimum of one parasite species to a maximum of three parasite species as observed in the case of both *G. steindachneri* and *L.abu*,

Mhaisen *et al.* (2015e) studied and recorded twenty four parasite species and they inspected four parasites in 2007. All the collected fish samples were externally studied for the presence of ectoparasites and then they were dissected and microscopically examined in search for the possible presence of internal parasites in different body parts including their musculature, body cavity, and internal organs. In this research, twelve fish species were examined for intestinal parasite occurrence. Four of which were, nematode species and two of them were found to be acanthocephalan species. These collected nematode species were *Contracaecum* spp. that were isolated from nine fish species (namely *Alburnus orontis*, *Arabibarbus grypus*, *Carasobarbus luteus*, *Coptodon zillii*, *Leuciscus vorax*, *Luciobarbus xanthopterus*, *Mastacembelus mastacembelus*, *Mystus pelusius* and

Silurus triostegus), as well as *Camallanus lacustris* that was isolated from three fish species (namely *A. orontis*, *Glyptothorax steindachneri* and *M. pelusius*), *Philometra* sp. isolated from *Alburnus sellal* and *Rhabdochona denudata* collected from both *A. grypus* and *L. xanthopterus*. The acanthocephalan parasite species were *Neoechinorhynchus iraqensis* and *Paulisentis fractus* that were isolated from *Liza abu*. All these helminthes species were in their adult stages except for *Contraecaecum* spp. which was observed to be present in its third instar larval stage only. Furthermore, another list of seven new host records were observed in Iraq and they were reported as four of these nematode species.

Bilal *et al.* (2016) performed a comparative analysis for the intestinal helminths parasitizing some fishes that were collected from Greater Zab River and Lesser Zab River, Erbil-North Iraq. Six of these species were (*Barbus grypus*, *Carabarbuis luteus*, *Luciobarbus esocinus*, *L. kersin*, *Mastacembelus mastacembelus* and *Silurus glanis*) were collected from Greater Zab and Lesser Zab rivers, north of Iraq. These fish species were examined for the presence of nematodes and/or cestodes parasitizing them then compared to the helminthes parasitizing the previous mentioned fish along these two rivers. The study showed the occurrence of three cestode species namely, *Khawia armeniaca*, *Postgangesia inarmata* and *Senga* sp. in Greater Zab river and two cestode species, *Khawia armeniaca* and *Postgangesia inarmata* in Lesser Zab river.

Al-Moussawi (2017) observed the morphological features of *Contraecaecum rudolphii* (Hartwich, 1964 (Nematoda: Anisakidae)) as it was evident in the scanning electron microscope (SEM) examination. The study showed detailed morphological description of the adult stage (both male and female) of *Contraecaecum rudolphii* (Hartwich, 1964). The study samples were collected from the different heart regions, namely proventriculus and ventriculus of the cormorant species (*Phalacrocorax carbo*) (Linnaeus, 1758) in Iraq by utilizing (SEM). The results also showed the cephalic structures the nematode extremity, labium, inter labium, as well as the papillae in the dorsal labium.

Finally, in their recent publication, Mhaisen *et al.* (2017) surveyed fish parasites of

North of Iraq. Their results showed a total of one hundred eighty eight parasite species that are known to parasitize thirty three freshwater fish species (twenty seven of which are cyprinids and six of them were non-cyprinid species) the samples were collected from different water bodies in Northern Iraq. The studied parasitic fauna included a single euglenozoan, a microsporidian, twenty one ciliophorans, nineteen myxozoans, eleven trematodes, eighty two monogeneans, nineteen cestodes, sixteen nematodes, five acanthocephalan species, two annelid parasites, a single Molluscan and ten arthropod species. The most commonly occurred genus among them was the nematode, which was the *Contracaecum* because it was found to have infected twenty one host species, this was followed by the trematode metacercaria named *Diplostomum spathaceum* (infection sixteen host species) and then ciliophoran *Ichthyophthirius multifiliis* (infecting fifteen host species) while the rest hundred and three parasite species only infected one fish species each.

On the other hand, the parasite species number infecting the studied host species fluctuated from a maximum of fifty seven species in *Cyprinus carpio*, followed by a moderate number of *Cyprinion macrostomum* (by thirty five parasite species) and *Silurus triostegus* (infected twenty nine parasite species) to a minimum number of parasite of one species, these include *Barbus rajanorum*, *Ctenopharyngodon idella*, *Glyptothorax cavia* and *Luciobarbus subquincunciatus*. This also reveals the diversity of fish's host-parasite interaction and resistance.

3. MATERIAL and METHODS

3.1. Description of Study sites

The location of the Greater Zab River is east to the Tigris River at the north of Iraq. Its geographic coordinates on the map are between 36°-37° north latitudes and 43°-44° east longitude (Fig.3.1). The river originates from a mountain area of Urmea in Iran and Wan Lake in Turkey, it is then directed to the western south and near to Amedi. Afterwards, it transcends through Iraqi border and extends through a number of mountain and hills of varied elevations. The Greater Zab River length from its sink to the point where it pours into the Tigris River in Guer sub district is measured to be 392km.

With regard to its width in the study region, it was between 5-7 m wide, and its length was about 4-5 km, with the deepest measured point of 5.5 m. The bottom and the shores of the River were sandy or sandy-loam and in some places were only loam. Additionally, some aquatic plants were sought to spread on the shores of the River, such as *Typha* sp. and *Phragmites* sp., also some Pteridophytes pinus shrubs, as well as various types of Algae. In the place of specimen collection, various types of invertebrate animals were observed. For instance, snails, calms, crustacean and aquatic insects. Additionally, some other types of helminthes such as turbilaria and free-living nematodes were sought. Although many types of vertebrates were observed, including Amphibia like toads and frogs, Reptilians like turtles, and some aquatic birds like gulls, cormorants, grosses and storks. Some domestic mammals in the villagers' vicinity were also observed. For instance, sheep, goats, cows, dogs and some hyena and foxes.

The mean river depth and width in the studied site was about 3m and 60m respectively, and the current velocity of the river was about 1.2 m/s (Sosa, 1960). The research project was carried out in the river part that passes through Aski-Kalak districts, 40 km to the west of Erbil city and Gwer district, 56 Km to the west of Erbil. During the study period, the range of air temperature ranged between -2 -48 °C and the average

precipitation was between 400-600 mm but it is reported that it also reached 1000 mm in some years, its latitude was 450-600 m above the sea's level (Phillips, 1967).

A strong positive correlation was observed between parasites' activity and temperature degrees. The rationale behind this correlation is the fact that microbial reproduction is enhanced in that temperature (Al-Marjan and Abdullah, 2008). In addition, temperature level is inversely proportional to the dissolved oxygen levels. Thus, it was observed that decreasing temperature lead to an increase of dissolved oxygen levels in the water. Consequently, it had a direct effect on the parasites' life cycle by minimizing their generation time, this was mainly observed in some crustaceans and some protozoans. . Also, this lead to a dramatic increase in the parasite number as described by Lafferty and Kuris (2014). The study was conducted in a river that passes through regions with varying heights, and there are some villages on its way, namely Maramosi, Doratiasae, Sawa, Beachey and Bekhma near the Bekhma dump.

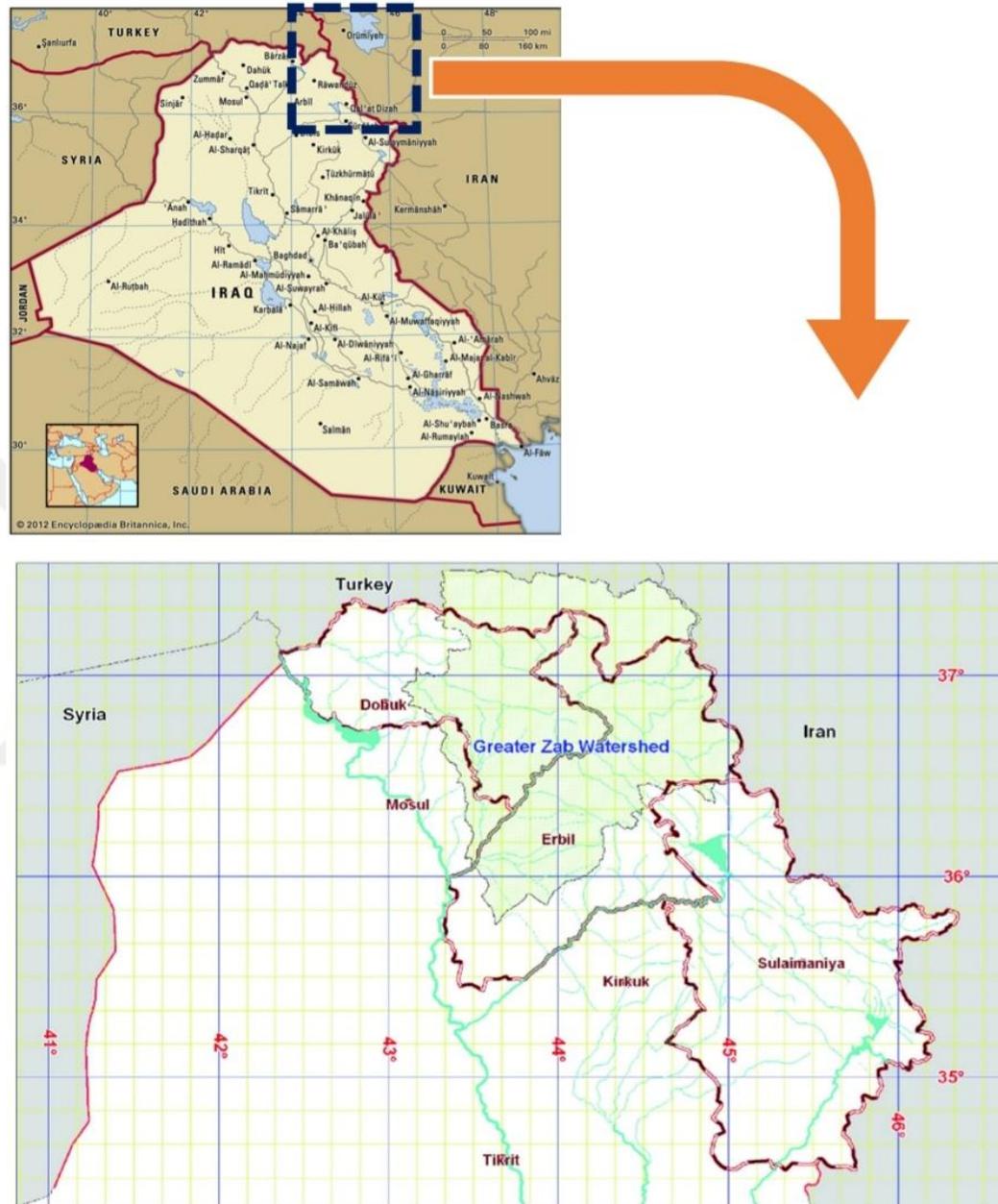


Figure 3.1. A. Map of Iraq showing northern region (map info v.9). B. map of northern region showing greater zab river in aski-kalak, show the points of sample collections.

3.2. Collection and Examination of fishes

The fish samples from Zab River Aski-kalak region in Northern Iraq were collected from fishermen. They used using ast nets, gill nets and electrofishing every other week,

from June 2018 until the end of March 2019.

A cool box was used to transfer some of the containing river water and then transferred to the laboratory in the Department of Biology, College of Education, and University of Salahaddin. Then, they were examined within 48 hours after their capture. Although, some of the specimens were directly deep-frozen and held for one week to examine this was based on the procedures mentioned in (Brown *et al.*, 1986; Nepszy, 1988). Fishes were identified according to Beckman (1962), and the fish nomenclature was taken from Froese and Pauly (2017).

Laboratory-based measurements including total length and standard length as well as external and internal parasitic examinations were carried out. Skin, fin and buccal cavity smears were also prepared via a slight scraping and then examined. Gills were separated from both sides, and kept moist in a Petri dish and then investigated under a dissection on a microscope. This was followed by a preparation of the gill-filament wet mount and then it was followed by light microscope examination. Finally, the eyes were microscopically examined. This was carried out by pulling the eyes out and putting them on Petri dishes with a physiological solution, the eyes were then dissected and examined microscopically.

Fish opening was started ventrally. This was then followed by a thorough search for parasites and/or cysts in organs like stomach, spleen, liver, kidneys, heart, muscles, swim bladder, gonads, and the body cavity. The GIT (gastrointestinal tract) was opened from the rectum up to the esophagus and the opening slit was a longitudinal section for thorough examination (Amlacher, 1970; Barson, 2004).

3.3. Fixation, Preservation and staining of parasites

3.3.1. Protozoa

In order to study the protozoan species, a direct method was used for identification

of most of the samples, without using any techniques, instead a mucus smear was prepared from different body regions such as skin scrap, fins and gills, and this was put on a microscopic slide and then spread carefully with a cover slip for examination. Then, important measurement were considered for each protozoan species.

In cases were trichodinids were found, smears would have been prepared and then the slides were fixed via the use of absolute methyl alcohol for a duration of about 1-2 minutes. This step was then followed by Giemsa's staining with a 1:10 dilution for a duration of 30-40 minutes, then it was washed and dried again and then the sample was mounted using Canada balsam (Amlacher, 1970).

Using Lom (1958)'s methods and terminology, micronucleus and macronucleus were measured for their positioning within the samples, as well as taking measurements of adhesive disc and tentacle components.

3.3.2. Monogenetic trematodes

Gills were put in a Petri dish. A small amount of tap water added to the gill. Gill filament pieces was tiered using a needle. As for the helminthes (after leaving the gills), a small pipette was used to remove them from the water and then placed on a slide, with a very small drop of water. A cover slip was then used with glycerin-gelatin. The worms were then covered by a piece of melted glycerin- gelatin and a cover slip. It is worth mentioning that the A cover slip was carefully covered using a blotting paper, and the worms were cautiously thickened in glycerin- gelatin by following the methods described in (Vidal-Martinez et al., 2001; Kritsky et al., 2004).

3.3.3. Digenetic trematodes

Certain body parts of the infected fishes were removed and studied, such as the stomach, the intestine and the eyes in search for digenetic trematodes' metacercariae and adults, then the samples were fixed in 4% hot formalin (in 60Co), after that the samples

were stained with acetocarmine, and dehydrated in a gradient of ethanol concentrations, finally the samples were cleared in xylene and mounted in Canada balsam (Soylu, 2005).

3.3.4. Cestoda

Intestinal tapeworms were swirled in saline water or tap water in order to relax them and then they were fixed in 4% a hot formalin solution. The solvent was then substituted by 70% ethanol before staining. Acetocarmine was used as a staining solution, and a gradient of ethanol concentrations was used as a dehydrating solution, and finally they were cleared in xylene and mounted with D.P.X. or Canada balsam (Scholz, 1989).

3.4.5. Nematoda

A 4% hot formalin was used to fix the nematode specimens for a period of two minutes, then they were conserved in 70% ethanol, and a glycerine solution or lactophenol was used to clear them, mounted in jelly glycerin and examined under compound microscope as described in (Chai et al., 1986). In some female samples, a fine needle was used to rupture them in order to study the egg shape and also to take the egg dimensions.

3.3.6. Crustacea

A 5% formalin was used to kill and fix crustaceans by putting them in the solution for a duration of one hour and then the sample was transferred to a solution of 80% alcohol (Kim, 2004). Specimens were then cleared using 85% lactic acid as described in (Lin & Ho, 1998).

3.4. Photos and Measurements

Canon EOS 700D Compact Digital Camera was used to take the photos. Also, Camera Lucida (Drawing tube) was used to draw the figures. Then, an Olympus ocular micrometer was used to take measurements of parasites.

3.5. Parasite Identification

After detection of the parasitic samples, they were identified according based on their morphology. The identification step was carried out by consulting the following keys: Bykhovskaya-Pavlovskaya et al. (1962), Yamaguti (1963), Shul'man (1966), Gussev (1985) and Hoffman (1998).

3.6. Criteria of Infection

The ecological terminology (prevalence and mean intensity of infection) were used in this thesis are based on the terminology of Margolis et al. (1982);

Prevalence of Infection: The percentage of host species infected with any given parasite species / Number of hosts examined.

Mean Intensity of Infection: Mean number of individuals of a given parasite species divided by the number of infected hosts in a sample.

4. RESULTS and DISCUSSION

A total of 147 fishes, which belonged to 4 distinct freshwater fish species (Fig. 4.1), were collected from in greater Zab Rive- Aski-kalak region in Northern Iraq. (Table2.1.). The study presented the occurrence of eight freshwater fish parasite species that occur in the River. These included two protozoan species, one monogenetic trematode species, one digenetic trematode species, a cestode, and a nematodes, and two crustacean species (Table4.1.).

The parasites distribution and their location on/or in the fish host body are summarized in Table(4.2). Also, the prevalence rate and average infection intensity are described in the same table. The following includes a thorough description and important measurements of the studied parasites.

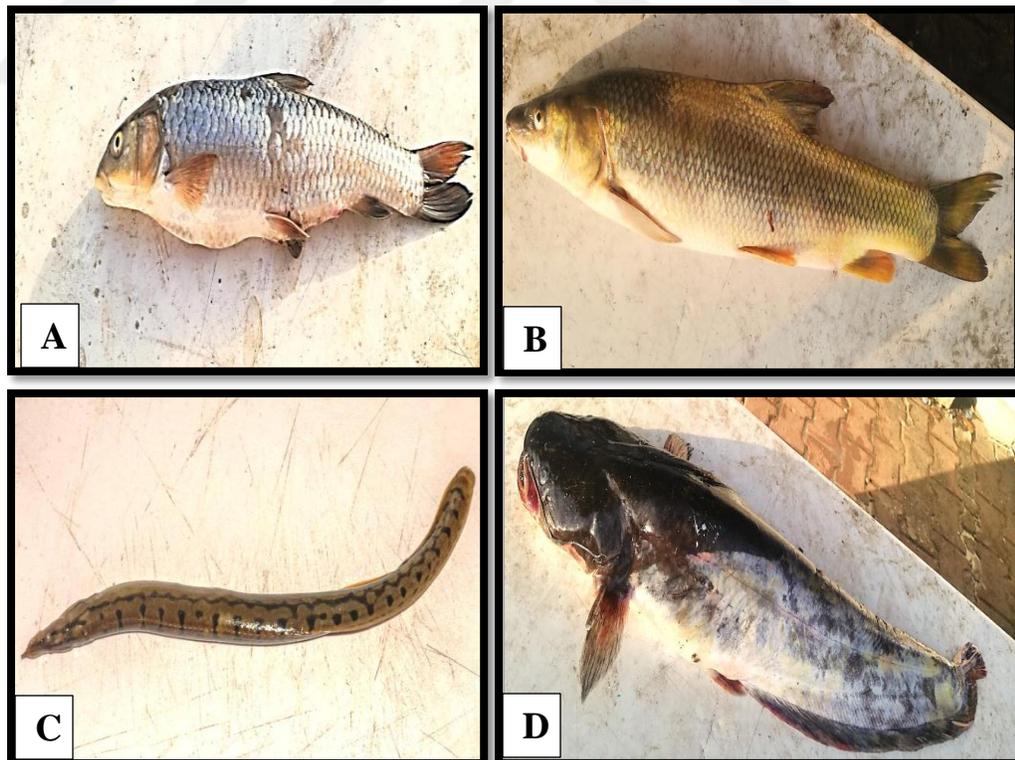


Figure 4.1. Types of fish collected from Aski-kalak region Greater Zab River. A) *Capoeta trutta* (Heckel, 1843). B) *Luciobarbus kersin* (Heckel, 1843). C) *Mastacembelus mastacembelus* (Banks & Solander, 1794) D) *Silurus glanis* Linnaeus, 1758

Table 4.1. Scientific and common names of collected fishes collected from aski-kalak region greater zab river, and their numbers.

Scientific name	Common name	Number
<i>Capoeta trutta</i> (Heckel, 1843)	Trout barb (Kara baligi)	33
<i>Luciobarbus kersin</i> (Heckel, 1843)	Shassan (Kersin baligi)	47
<i>Mastacembelus mastacembelus</i> (Banks & Solander, 1794)	Mar masi (Dikenli yılanbalığı) Marmarej	29
<i>Silurus glanis Linnaeus</i> , 1758	Jurey (Yayin baligi)	38

Table 4.2. Parasite species recorded in aski-kalak region greater zab river according to their classification status.

<p>1.A Kingdom Protista Subkingdom Protozoa Phylum Myxozoa Class Myxosporea Order Bivalvulida Family Myxobolidae <i>Myxobolus pfeifferi</i> Thèlohan, 1895</p> <p>1.B Kingdom: Protista Subkingdom: Protozoa Phylum: Ciliophora Class: Ciliata Order: Peritricha Family: Urceolariidae <i>Trichodina ranae da Cunha</i>, 1950</p> <p>Kingdom: Animalia Phylum: Platyhelminthes Class: Monogenea Subclass: Monopisthocothlea Order: Dactylogyrida Family: Dactylogyridae <i>Dactylogyrus vastator</i> Nybelin, 1924</p>
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Kingdom Animalia
Phylum Platyhelminthes
Class: Trematoda
Subclass: Digenea
Order: Strigeidida
Family: Diplostomatidae
Diplostomum spathaceum (Rud., 1819)

Kingdom Animalia
Phylum Platyhelminthes
Class Cestoidea
Order Pseudophyllidea
Family Bothriocephalidae
Senga mastacembeli, rahemo, Bilal , Abdullah et (1996)

Kingdom : Animalia
Phylum : Nematelminthes
Class : Nematoda
Order: Spirurida
Family: Camallanidae
Procamallanus viviparus, Ali, 1956

Kingdom Animalia
Phylum Arthropoda
Class Crustaceae
Order Branchiura
Family Argulidae
Argulus foliaceus (Linnaeus, 1758)

Phylum Arthropoda
Class Crustacea
Order Copepoda
Family Dichelesthidae
Lamproglena pulchella von Nordmann, 1832

Table 4.3. The distribution of parasites in different sites of fish hosts from aski-kalak region greater zab river.

Parasites	Hosts	No. of fishes		Prevalence (%)	Mean intensity	Site of infection
		Examined	Infected			
Protozoa						
<i>Myxobolus pfeifferi</i>	<i>Silurus glanis</i>	38	7	18.42	5.42	Gills
<i>Trichodina ranae</i>	<i>Silurus glanis</i>	38	26	68.42	14.84	Skin & Fins
Monogenea						
<i>Dactylogyrus vastator</i>	<i>Mastacembelus mastacembelus</i>	29	2	6.89	3.5	Gills
Digenea						
<i>Diplostomum spathaceum</i>	<i>Capoeta trutta</i>	33	1	3.03	2	Eye lens
	<i>Luciobarbus kersin</i>	47	1	2.12	4	Eye lens
	<i>Silurus glanis</i>	38	3	7.89	2.33	Eye lens
Cestoda						
<i>Senga mastacembelus.</i>	<i>Mastacembelus mastacembelus.</i>	29	18	62.06	5.11	Intestine
Nematoda						
<i>Procamallanus viviparous</i>	<i>Silurus glanis</i>	38	19	50	5.57	Stomach & Intestine
Crustacea						
<i>Argulus foliaceus</i>	<i>Mastacembelus mastacembelus.</i>	29	1	3.44	1	Skin
<i>Lamproglana pulchella</i>	<i>Capoeta trutta</i>	33	6	18.18	1.83	Gills
	<i>Luciobarbus kersin</i>	47	10	21.27	1.91	Gills

Protozoa:

Two protozoan species were recorded in the current study. They were: -

***Myxobolus pfeifferi* Thélohan, 1895**

Sporocysts of this myxosporidian were obtained from the gills of *Silurus glanis* with

a prevalence of 18.42% (Table4.3.).

The sporocyst shape (i.e. the vegetative form) was oval to fusiform, its diameter range measured 0.9-2.5mm in length and 0.55-0.65mm in width. Spores were elongated to ovoid, 10-12 μ m long, and 9-11 μ m wide and 7.5-8.5 μ m in thickness. Polar capsules were perform and approximately of an equal size, which ranged between 5.01-8.30 μ m long. The large iodophilous vacuole size was about 4.5-5.3 μ m long the lie in the posterior half of the spore.(fig4.1).

Fattohy (1975) was the first one to record this parasite in Iraq, by on *A. marmid*'s gills and the samples were collected from Tigris River in Mosul city. Later on, it was reported that 36 other freshwater fish hosts were parasitized by this species in Iraq including *V. umbla* (Mhaisen, 2019). This research surveyed *Myxobolus pfeifferi*, one can deduce that seven out of thirty eight studied fishes were infected by the parasite .The samples were collected from the fish gills (Table4.3.). However, the current research did not discover new types of parasites in. The only discovery in this project was new hosts like *Silurus triostegus*.

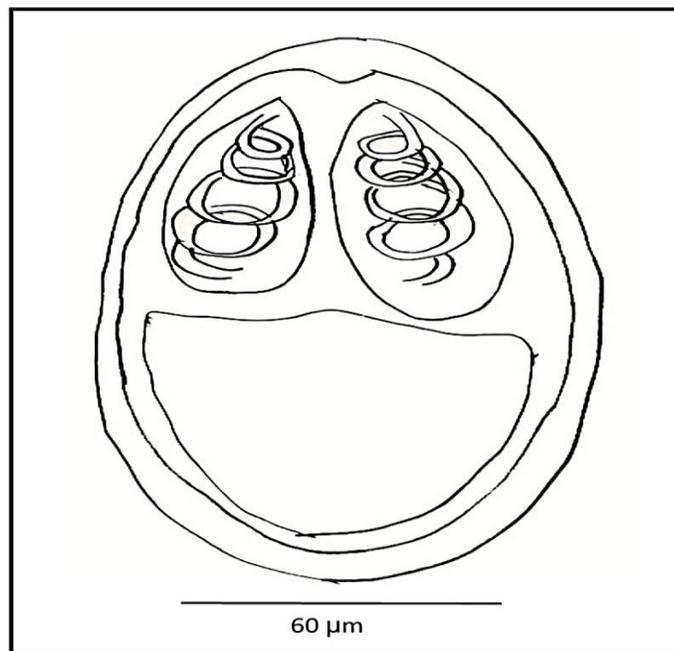


Figure 4.2. Lucida drawing of *Myxobolus pfeifferi*

***Trichodina ranae* da Cunha, 1950**

Skin and fins on the fish was investigated for possible occurrence of this ciliated parasite (i.e. *Silurus glanis*), it was observed that the samples' infection rate was medium to high, with a prevalence of infection of 68.42 % (Table4.3.). The range size of *Trichodina* was 45-56 μ m (50.84 ± 0.70) in diameter. Adhesive disc was concave and ranges between 33-40 μ m (37.14 ± 0.62) in diameter that is surrounded by a finely striated border membrane 2-5 μ m (2.97 ± 0.34) in width. Denticulate ring 21-26 μ m (24.18 ± 0.29) in diameter. Central area of adhesive disc medium was observed to be slightly light stained when it was treated with silver and it measures ranged between 10-14 μ m (13.26 ± 0.31) in diameter, it was also recorded that it contained a group of whitish granules. The number of denticles ranged between 29-32 (30.77 ± 0.15) denticles. Also, the number of radial pins per denticle ranged between 6-9 μ m (7.46 ± 0.27). Span of denticle is 11-15 μ m (11.82 ± 0.35) and length of denticle is 4-6 μ m (5.38 ± 0.19). The blade of the denticle sickle-shaped and curved filling almost all y+1 space 4-7 μ m (5.62 ± 0.31) in length, the central part of denticle cylindrical and tubular the preceding denticles are interlocked to each other, which extends slightly more than halfway to y-1 axis 2-5 μ m (3.71 ± 0.22) wide, the ray backwardly bent 5-8 μ m (5.92 ± 0.19) length, cylindrical, straight, and finger-like with variable thickness but having no apophysis rays and no central grooves were apparent. The variations in denticles are well developed (Fig.4.3.) (Table4.3.). Figure4.2 shows the measurements of the structures identified in this species.

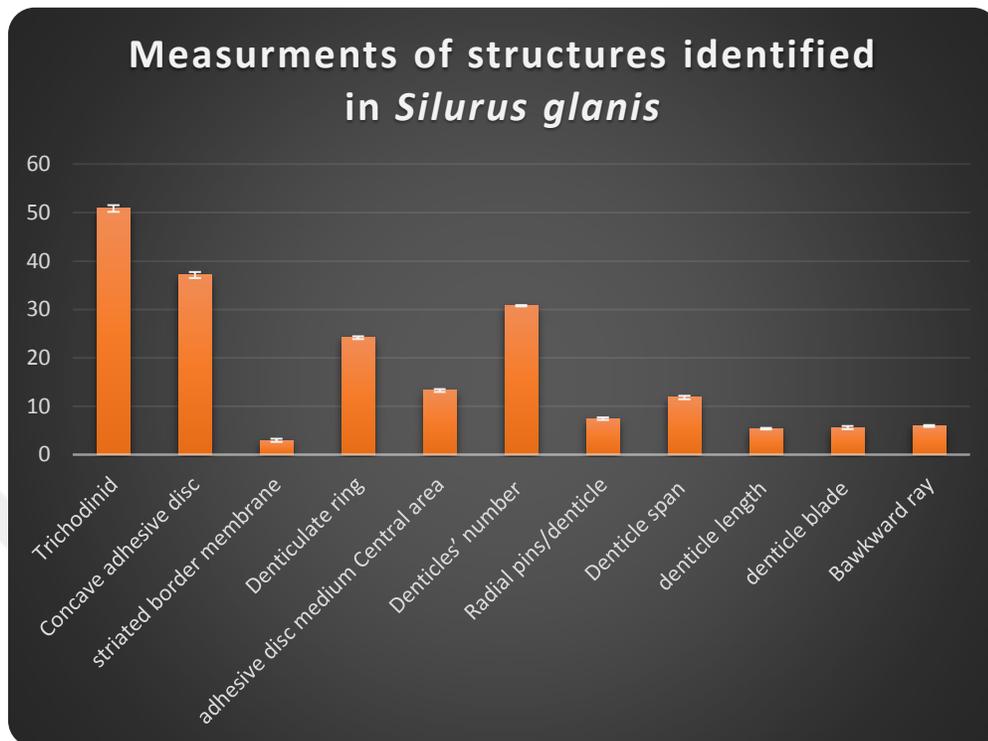


Figure 4.3. Measurements of the structures identified in silurus glanis. the measurements are Mean +/- SEM.

The description and measurements of the currently studied specimens are quite similar to those described by Asmat (2005), which were isolated in the urinary bladder of the Grenouille frog in Portugal by da Cunha in 1950, this was the first time they identified those structures. As conceivable issue, there is a difference of the host species range parasitized by *Trichodina*, while Woo (2006) verified that the most abundant *Trichodina* species exhibited low host and organ specificity (skin, fins, gills and urinary bladder of fishes and amphibians). On the other hand, others considerably have more host specificity. Trichodinids are cosmopolitan, they are probably distributed via transcontinental introductions of fish. Commonly known species such as those that are found on most fish families in Europe, Asia, America and Africa. According to the confirmation of Professor Dr. Ghazi S. M. Asmat, this *Trichodina sp.* specimen in the current study is identified as *T. ranae*. It was the first record of this species in north of Iraq and it was reported from skin and fins of *S. triostegus* and the samples were collected from Greater Zab river (Shwani, 2009; Abdullah & Shwani, 2010). Also, in Iraq, Shwani

(2009) recorded this species for the first time. . *S. triostegus* is the only known *T. ranae* host in Iraq.

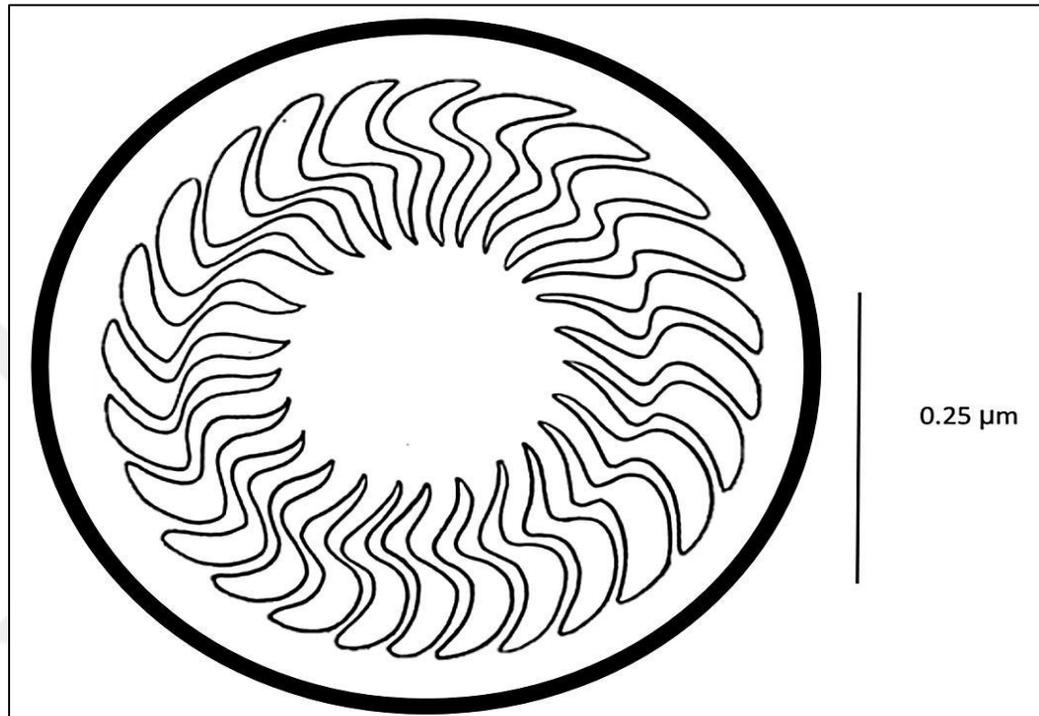


Figure 4.4. Lucida drawing of *Trichodina ranae*

Monogenetic Trematodes

Dactylogyrus vastator Nybelin, 1924

This parasite was recorded in the present study from the gills of *Mastacembelus mastacembelus* from greater Zab Rive Aski-kalak region fish hatchery with a prevalence of 6.89% (Table4.3.).

They are considerably large worms. Their body length reaches up to 1.30 mm and width 0.30 mm. The hook lets' length range between 0.032-0.045 mm. Total length of median hooks 0.040-0.051 mm, inner root 0.022-0.034 mm and outer root 0.008-0.017 mm. The total length of connecting bar 0.006-0.011 X 0.042-0.049 mm, the bar slightly thickened at ends. The copulatory tube has a small posterior projection, the length of

copulatory organ 0.051-0.072 mm. (Fig.4.4).

D. vastator has been recorded for the first time in Iraq from *Cyprinion macrostomus* from Tigris River at Baghdad city (Ali *et al.*, 1987). After that, the parasite was reported from 32 fish hosts that includes *C. carpio* (Mhaisen, 2012). In Northern Iraq, the same parasite was reported again in a publication that investigated ten different species of fishes, all of which were parasitized by the parasite. The samples were collected from Greater Zab River and Darbandikhan Lake (Ali, 1989; Abdullah, 2005), respectively.

In Iraq, 82 *Dactylogyrus* species (except *D. molnari*) were previously recorded from various fish species, 40 of these species were recorded in Northern Iraq, the location of most of them are found to be on the gills of Cyprinid fishes (Mhaisen & Abdul-Ameer, 2019).

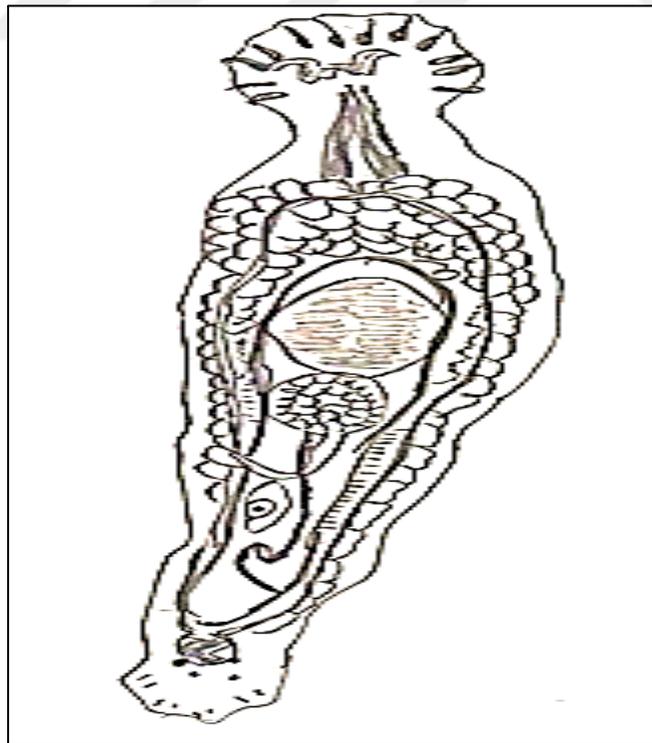


Figure 4.5. Lucida drawing of *Dactylogyrus vastato*

Digenetic Trematodes

Diplostomum spathaceum (Rud, 1819)

In their study, this metacercaria was isolated from the eye lens of three fish species, namely they were *Capoeta trutta*, *Luciobarbus kersin* and *Silurus glanis* with a prevalence rate of 3.03%, 2.12% and 7.89% respectively (Table 4.3.).

With regard to their body, their body is broad, leafy shaped, encysted white color and they are mobile species. The anterior part is bluntly rounded end of body with an angular lappet protrusions. The species also possesses distinct lateral Pseudo suckers. Brandes organ is rounded. Body length ranges between 0.52-0.73mm, with a width range of 0.22-0.24mm. Ventral sucker diameter was 0.024mm, oral sucker 0.010mm and length of lateral sucker 0.014mm. Intestinal caeca is not branched, 0.37 x 0.2mm (Fig.4.5).

The first record of *D. spathaceum* in Iraq was carried out by Abdullah (1990) he investigated the eye lens of three species including *B. luteus*, *C. macrostomum* and *C. carpio* from Dokan Lake. According to Mhaisen (2004), the host sample number was 24 fishes and they were recognized as *D. spathaceum* in Iraq including *C. regium* and *C. macrostomum*.

Other *Diplostomum* species were recorded from freshwater fishes of Iraq for the first time and it included three species, namely *D. indistinctum*, *D. pungiti* and *D. yogenum* from *B. esocinus* they were isolated in Tigris River in Mosul city (Al-Alousi *et al.*, 1988), *D. commutatum* and *D. phoxini* was isolated from *A. vorax* and *M. pelusius* sample collection was carried out in Tigris River in Baghdad city (Al-Moussawi, 1997) and *D. paraspathaceum* from *C. carpio* and *Ctenopharyngodon idella* in a fish farm in Al-Eskandaryia region, Babylon province (Muhammed, 2000). Furthermore, metacercariae of *Diplostomum* (un specified species) were recorded from 36 fish species in Iraq (Mhaisen, 2019) including those host species from *C. regium* isolated in Greater Zab River (Rasheed and Hussain, 1988) and those from *B. barbulus*, *B. esocinus*, *C.*

macrotomum, *L. cephalus*, *L. spurius* and *V. umbla* that were isolated from the Greater Zab River.

Also (Ali, 1989), conducted a research on *Diplostomum spathaceum*, it can be concluded that (1, 1, 3) of the fishes were infected by parasite out of (33, 47, 38). The eye lens of these fish are prone for such parasitic infections (Table4.3.). Although the present study recorded new host fish species (i.e *Capoeta trutta*, *Luciobarbus kersin* and *Silurus triostegus*), the present study did not discover new parasitic species.

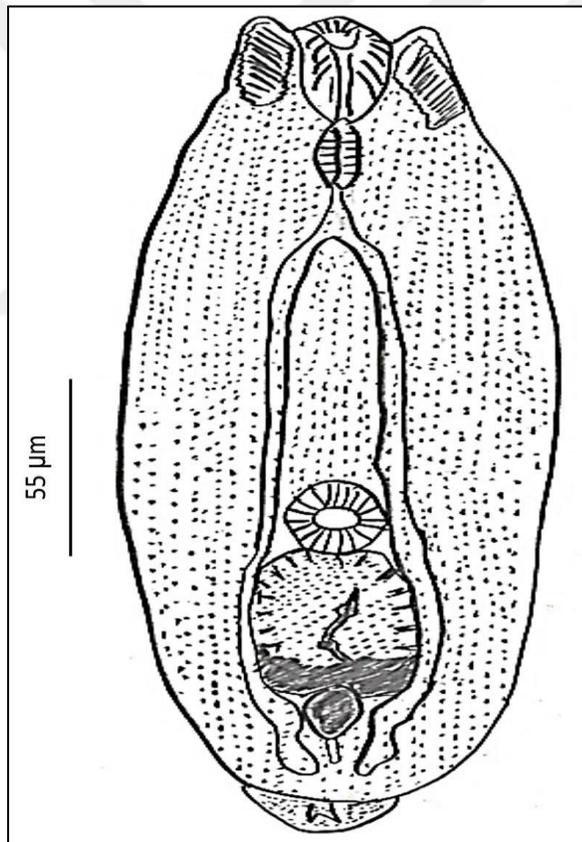


Figure 4.6. Lucida drawing of *Diplostomum spathaceum*

Cestoda

Senga sp.

The current study recorded this intestinal parasite species from *Mastacembelus mastacembelus* and the samples were collected from greater Zab Rive Aski-kalak region with a prevalence rate of: 62.06% (Table4.3.).

In France, the *Senga* genus was established with the *S. besnardi* species that was isolated from Siamese fighting fish, and *Betta splendens* in a Vincennes aquarium (Dollfus, 1934). Also, intestinal cestodes belonging to *Senga* genus are found to parasitizing freshwater bony fishes (Schmidt, 1986). The species belonging to the genus *Senga* are capable of hooking themselves on scolex that are arranged in two semicircles. Bothria which are well developed and shallow, apical disc located dorsally and ventrally, they lack prominent neck. (Fig.4.6). they have an incomplete metamerism. Their proglottids are acraspedote, and wider than their length except when gravid. Genital pores are virtually median and located dorsally. Two lateral fields' medullary testes, Females have compact ovary, median, posterior. cortical vitelline follicles, continuous around proglottid's margins. The uterus loops forward, there is a ventral opening in the uterine via a median pore close to the anterior margin of proglottid. Eggs operculate (Khalil *et al.*, 1994).

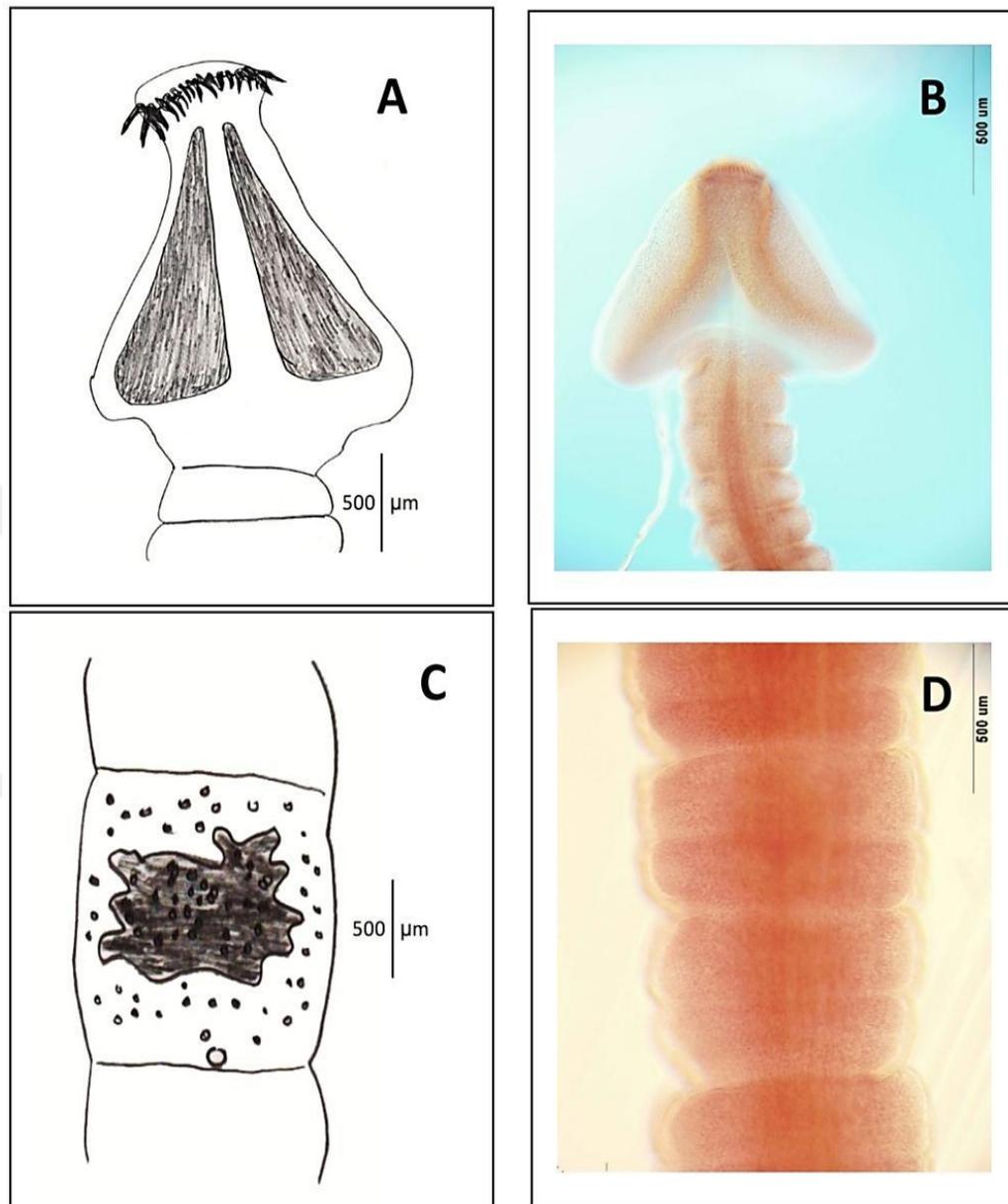


Figure 4.7. Lucida drawings of *Senga sp.* A – Scolex. C – Gravid proglotid
 Photomicrographs of *Senga sp* B – Scolex D– Gravid proglotid

Currently, molecular based identification has been carried out. However, due to time constraints this step has not been finalized in Scientific Academy of Czech Rep. Institute of Parasitology.(Fig4.7).

The intestinal parasite, *S. mastacembei*, which was recorded in Iraq by Rahemo (1996) was found to parasitize the *M. simach* species and it was isolated from Tigris River in Mosul city, it showed a homonymy with *S. mastacembei* distribution as described by Gupta and Sinha (1980) their samples were isolated from *M. armatus* in India and described by Kuchta and Scholz (2007) both are names are used as synonyms to *S. malayana*. Kuchta and Scholz (2007) mentioned 16 unique species of *Senga* namely they were (*S. bagariusi*, *S. besnardi*, *S. filiformis*, *S. gangesi*, *S. gordoni*, *S. lucknowensis*, *S. magnum*, *S. malayana*, *S. ophiocephali*, *S. ophiocephalina*, *S. pahangensis*, *S. pathankotensis*, *S. pycnomera*, *S. scleropagis*, *S. taunsaensis* and *S. visakhapatanamensis*) 38 species of which were described in many publications around the globe.

It is also worth mentioning that Bashě and Abdullah (2010) described the intestinal parasite *Polyonchobothrium magnum* isolated from the same host (*M. mastacemelus*) and the same locality (Greater Zab River) with many similar characteristic features and hooks known to have been arranged in two semicircles, while those hooks of *Polyonchobothrium* spp. are known to have been arranged in four quadrants (Khalil *et al.*, 1994).

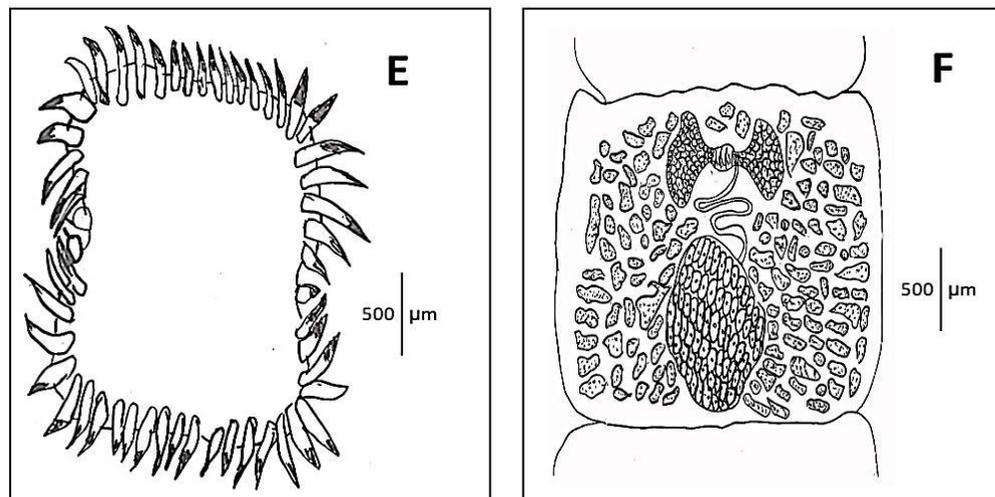


Figure 4.8. Lucida drawings of *Senga* sp E - Rosellum F - Mature proglotid
Abbreviations r = rostellum

Nematoda

Procamallanus viviparus Ali, 1956

This parasitic species was isolated from two internal organs (namely stomach and intestine) in *Silurus glanis* with a prevalence rate of 50% (Table 4.3.). The worms have a fine and elongated body with a considerably large and chitinous barrel-like buccal capsule, their color is orange to yellowish, they carry four cervical papillae positioned anteriorly. The buccal capsule leads to esophagus, which is composed of two parts, the anterior part is short and heavily muscled and while the posterior one is long and granulated. The size of the female is usually twice longer than males, reaching a double of the size of the male length and measuring up to 5-6mm in length and 0.19mm in diameter. The female is not-egg laying (i.e. viviparous), inside the female's uterus there is a numerous observable small sized larva. Also, the buccal capsule measures up to 0.07 x 0.12mm. As for the male, it is 3.7-4.2mm and the diameter is between 0.3-0.16mm with the large one measuring up to 0.14mm, however the smaller one measures up to 0.05mm. The mouth leads into a cylindrically shaped buccal capsule, measuring up to 0.08 x 0.06mm (Fig.4.8).

P.viviparous was first recorded in Iraq while studying the *Mystus halpensis* stomach, the sample was isolated from Tigris River in Baghdad city (Ali *et al.*, 1987c). After that, Nawab Al-Deen (1994) found it in *Mastacembelus simach* and this samples was isolated from Tigris River in Mosul city as a new host record for the studied parasite. However, in Northern Iraq, *P. viviparous* was first recorded from a samples of *Mastacembelus mastacembelus* and the sample was isolated from Greater Zab River at Isk Kalak town (Bashê, 2008). Then, the parasite was recorded in six other fish hosts except for *G. kurdistanicus* (Mhaisen, 2016). Nine of these fish species have been known as nematode hosts in Iraq (Mhaisen, 2019). In north Region of Iraq, it was first recorded in two species (namely *M. mastacembelus* and *S. triostegus*), the samples were collected from the stomach and intestine of the fishes, and the fishes were collected from Greater Zab river (Bashê and Abdullah, 2010; Shwani and Abdullah, 2010 respectively).

As for the current research conducted on *Procamallanus viviparus*, one can conclude that 19 of the fishes were infected by a parasite out of 38 parasite species. The site of the infection of this type of fish is Stomach & Intestine (Table4.3.). It is worth mentioning that the present study did not discover any new species record for this parasite. However, a new host was identified that was *trioctegus Silurus*. Thus, this fish represents new host for this parasite in Iraq.

With regard to the laboratory diagnosis, many methods were attempted to find new parasites in this fish. Also, many other fish species were investigated for a possible occurrence of new parasite. Additionally, intensive microscopic image analysis was carried out to further enhance the analysis and investigation of new parasite records. However, all the observed parasites have already been recorded by other scholars previously.

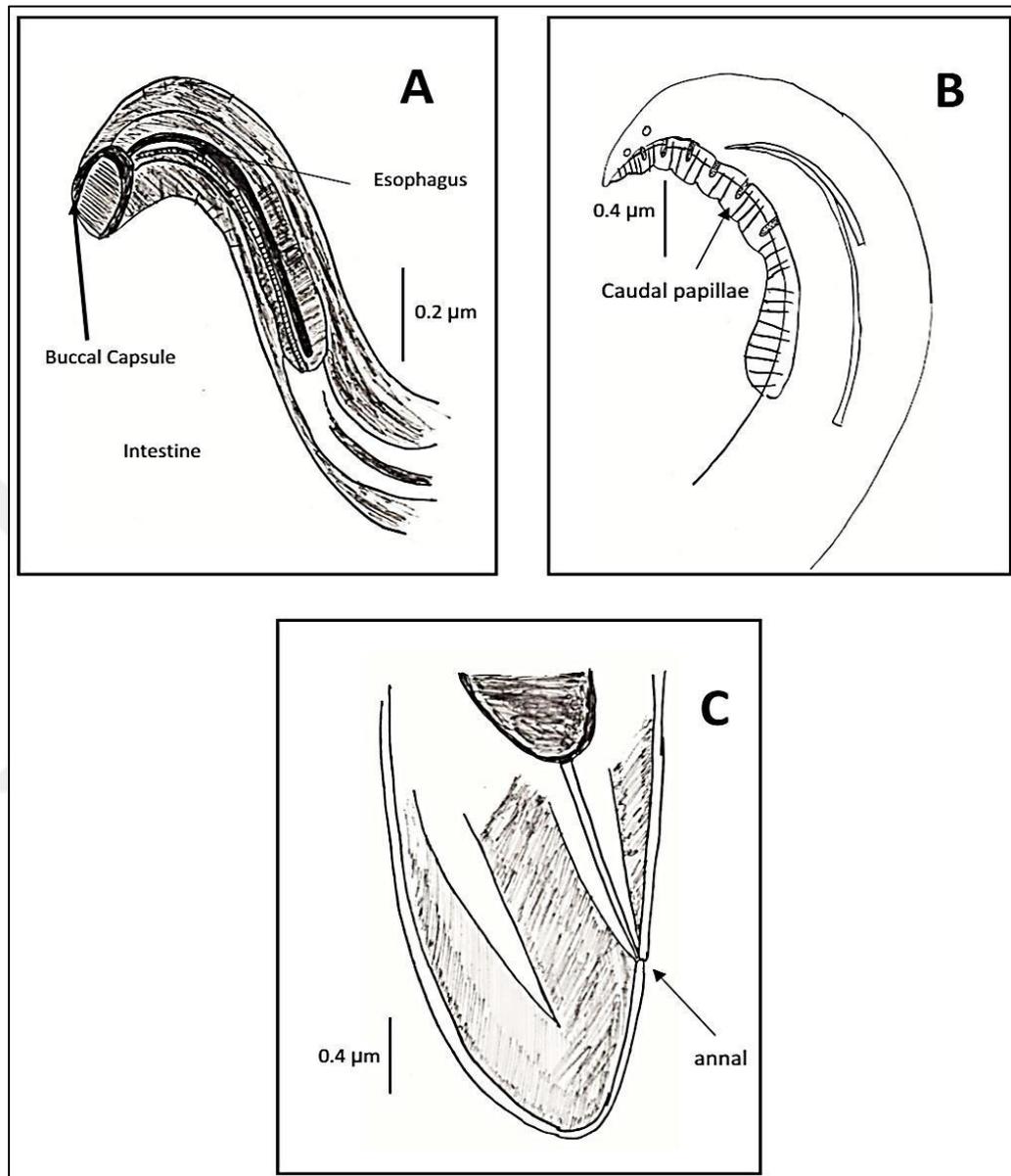


Figure 4.9. Lucida drawing of *Procamallanus viviparous*: A. Camera Lucida drawing of the anterior End. B. Posterior end of adult male. C. Posterior end of adult female.

Crustacea

Argulus foliaceus (Linnaeus, 1758)

This parasite was isolated from the skin and fins of *M.mastacembelus* with a prevalence rate of 3.44% (Table4.3.). The body structure is oval, with a body length ranging between 4-6 mm, and this species is cephalothorax meaning that its head merges

with the first thoracic segment. A broad carapace covers the cephalothorax that extends posteriorly into two large lobes. An attachment organ is formed from a modification of the first antenna, which then terminates in a number of highly curved hooks. Maxillae are modified as powerful sectorial organs that are ventrally visible. The species has four pairs of biramous swimming feet, with two complex faceted eyes (Fig.4.9).

Bomolochidae family has two genera parasitizing both marine and freshwater fishes. One of these genera is *Argulus*. Khamees *et al.* (2015) enlisted the crustacean species parasitizing the fish's found in Basrah province, Iraq based on Ahyong *et al.* (2011). , the overall Crustacean classification has been on a constant change, probably due to the abundance of molecular data. . On the other hand, Boxshall has placed the order Poecilostomatoida as a synonym for Cyclopoida based on the established changes in WoRMS (2017), this analysis was driven from a single gene tree (the gene 18S) and he believes that this change is a weak evidence. The present classification in WoRMS (2017) for the Crustacea sheds lights on the proposed changes in two detailed research projects (Regier *et al.*, 2010; Oakley *et al.*, 2012).

Argulus foliaceus (Linnaeus, 1758) Jurine, 1806 was reported from *C. luteus*'s gills (reported as *B. luteus*) by Al-Waaly (2005). This crustacean species was recorded from the skin of the two species, namely *C. luteus* (reported as *B. luteus*) and *C. carpio* for the first time in Iraq and the samples were isolated from Al-Habbaniyah Lake by Herzog (1969). After that, the parasite was isolated from ten other fish species in Iraq, except for *M. mastacembelus* (Mhaisen, 2008). Therefore, *M. mastacembelus* is considered as a new host for the parasite. In Northern Iraq, *A. foliaceus* was isolated and recorded from *C. carpio*'s skin and fins and the samples were collected from Ankawa fish hatchery, in Erbil province (Al-Marjan, 2007). Also, the genus *Argulus* has two other known species that were reported in Iraqi fishes : *A. japonicus* was isolated from the *Silurus glanis* gills and they isolated the samples from Tigris River in Mosul city (Al-Niaeemi, 1997) and *A. coregoni* in *B. xanthopterus* in a man-made lake at Al-Amiryia region, Baghdad (Al-Nasiri, 2000).

A. foliaceus is known as a common fish louse in several farm fish species as well as in some inland water bodies in Iraq, and it has so far 16 identified fish host species (Mhaisen, 2018). According to WoRMS (2018), this parasitic species belongs to the Ichthyostraca class with the same order and family names as mentioned previously.

Argulus sp. was isolated from two fish species, which are *C. carpio* and *H. molitrix* in a study conducted by Abd and Abdul Wahab (2011). So far, a number of previously unidentified *Argulus* species were recorded from three host fish species in Iraq. In addition, three other identified species were recorded belonging to this genus that was conducted by (Mhaisen, 2018). Therefore, *M. mastacembelus* is considered as a new host for this parasite, in Northern Iraq.

There are several signs of pathogenicity due to *Argulus* infection in the host fishes, which include skin lesions and skin damage (dermatitis), most of these lesions could become prone to secondary bacterial infection. The dermatitis is due to the damaging effect of the suckers and proboscis. Another significant pathological effect of this parasite is Anemia that is caused by feeding on the host. In addition to its pathogenic effects, *Argulus* is also known to be a vector of certain viruses, such as *Rhabdovirus carpio* (Tam, 2005).



Figure 4.10. Photomicrograph of *Argulus foliaceus*. (20x).

***Lamproglena pulchella* Nordmann, 1832**

The gills of *Capoeta trutta* were investigated and as a result many specimens of this crustacean were discovered. A prevalence of 18.18%. It was also found on the *Luciobarbus kersin* gills with a prevalence of (21.27%), (Table4.3.).

Upon measuring, body length ranged about 3.1-3.5mm. The cephalous shape is quadrate, and thorax consists of five segments and the abdomen has only three segment, the first abdominal segment is wider compared to the other two segments while the last one is narrower and terminated by two short structures (Fig. 4.10).

L. pulchella was recorded on two host species, namely *C. regium* and *V. trutta* for the first time in Iraq, and isolated from Tigris River (Rahemo, 1977). Then, the species was reported from sixteen different host fish species, five of which were observed in the present study, excluding *B. kersin* and *C. macrostomum* (Mhaisen, 2006). Thus, the first parasite record this was reported from *C. damascina*'s gills (reported as *B. belayewi*) from *C. umbla* (reported as *V. umbla*) from Greater Zab river (Ali, 1989), and *L. vorax*'s gills

(reported as *A. vorax*) by Al-Jubori (2013). So far, *L. pulchella* has been reported to have twenty-one fish host species in Iraq.

In this project, which was conducted on *Lamproglena pulchella*, it can be concluded that (1,6) of the fishes were infected by parasite out of (33,47) in both fishes (*Capoeta trutta*, *Luciobarbus kersin*). Also, it is observed that the parasite only infects the fish gills (Table4.3.).

Although, the present study did not discover any new parasite species, new hosts were found for the studied parasites such as *Luciobarbus kersin*. Thus, this fish represents a new host for the studied parasite in Iraq. A number of laboratory diagnostic procedures were tried in order to find new parasite species and record them. However, as it is evident from the results, there were no new parasite species records.

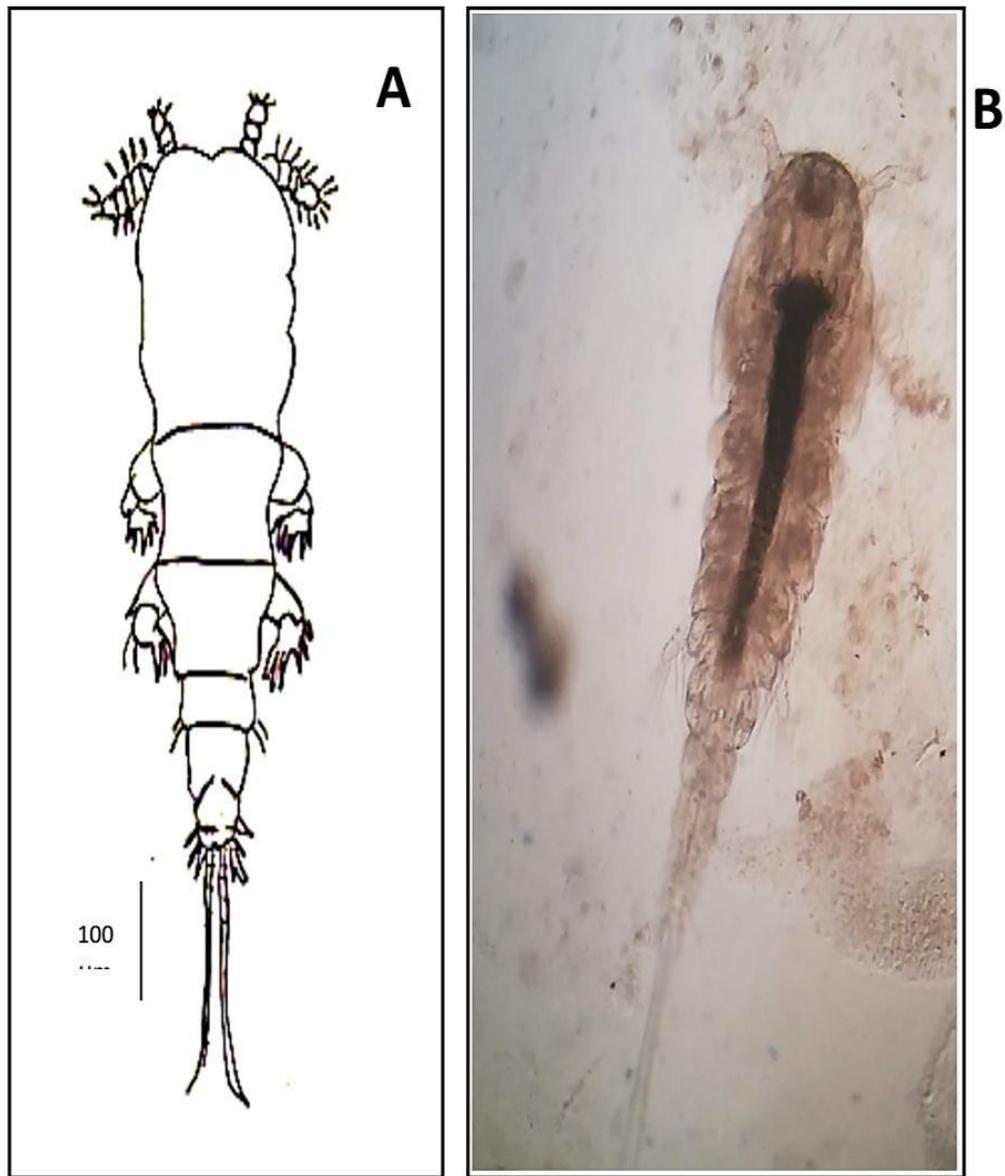


Figure 4.11. A. Lucida drawing of *Crustacean lamorglena* B. Photomicrograph of *Crustacean Lamorglena*

5. CONCLUSION and RECOMMENDATIONS

5.1. Conclusion

Based on the results of the present study, the following conclusions are drawn:

1. Via an external experiment that was made for four different kind of fish in the Great Zab River that flows into Aski-Kalak region, minimum of eight different species of the ecto parasitic group (external parasites) were found which indicates of the richness of this group of parasites.
2. A new host of for *Myxobolus pfeifferi* is observed to be *Silurus glanis*
3. Trichodina ranae was the highest rate of infection in *Silurus glanis* which was 68.42%; while the lowest rate read *Diplostomum spathaceum*, which was (2.12%) in *Luciobarbus kersin*.
4. *Silurus glanis* is more likely to be infected by separate group of ectoparasites, because of their simplicity in life cycle and their ability to transfer from one host to another easily.

5.2. Recommendation

1. Due to our country has good source of water bodies and aquaculture. Thus, it is recommended to perform the survey of parasite of the fishes.
2. We should develop the study of parasites in order to identify the weak stage in which measurement of controlling can be applied.
3. Because of the significance of the fish, it is required to perform studies on treatment and control fish parasites.
4. to the group of the parliament in North-Iraq monitoring and guiding the fisher man in order to control and avoid any diseases which can cause a health problem due to parasite in fishes.
5. The connection between agricultural and health sector in our region is quite important and necessary while the disease spread due to parasite in fishes, these two sector should

contribute together and stop the fishing and selling. In addition, the health sector should alert the people in order to avoid eating fish.

6. Government should try to encourage people in order to establish the non-profit organization specifically for fish, and this organization should really care about the development of fishes and the parasite inside them.

7. The water organization and environmental keeper should really try to clean our ponds and water in everywhere in order to obtain a healthy food for people and provide clean environment for fishes so that they do not infect the parasite.



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