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Common Carp (*Cyprinus carpio*) parasites diversity and prevalence in Erbil aquacultures: gills, skin and intestinal infections

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ABSTRACT

This study was carried out to investigate the causative agents of the parasitic diseases affecting common carp (*Cyprinus carpio*) in aquacultures in the Erbil region. At first, all fish were visually examined, then, microscopic analysis of mucus, skin and fins scrapings and gastrointestinal contents were carried out, confirming that carps are infested by a large diversity of parasites, predominantly affected by *Dactylogyrus sp.*, followed by *Trichodina sp.*, and copepod parasites, with an infection rate of 25.2%, 17.2%, and 13.2%, respectively. On the other hand, the highest mortality was due to infestation by *Trichodina sp., Dactylogyrus sp., Ichthyophthirius sp.* and *Gyrodactylus sp.*, rating 40%, 35%, 29% and 28%, respectively. Several injuries and ulcerations were observed within gills, over fins and skin of infected fish. In conclusion, the results showed that carp fish from Erbil city are infested by several parasites causing pathological and mechanical injuries, which were associated with high mortality rates in carps.

Keywords

diversity, prevalence, carp, parasites

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Abbreviations

CC: common carp
C. carpio: Cyprinus carpio
PP: Potassium permanganate

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Introduction

Fish is an important food source for the world. Indeed, it is the human's single most important resource of high-quality protein, providing around 16% of animal protein [1,2]. Among numerous species of fishes, carps belong to the *Cyprinidae* family which is the biggest family of freshwater fishes, spreading widely around the world [3]. In Iraq, this fish is considered one of the most prized sources of protein. Due to their nutritive value, huge numbers of people, all over the country are developing carp aquacultures as a means of livelihood and/or income [4]. These observations suggest that a consistent source of fish is essential for the nutritional and financial health of a large segment of the worldwide population.

However, several disease agents (virus, bacteria and parasites) infect fishes [5], and a majority of freshwater fishes carry heavy parasitic infections, which deteriorate their food value [6]. The impact of parasites on fish health can be mechanical, or affecting the physiology and reproduction, or may even result in their death [7]. Various parasitic infections have been reported in the common carp (CC; *C. carpio*) [8, 9, 10]. Additionally, different types of parasitic infections have been recorded in this species in Iraq [8, 11, 12]. This parasitic fauna includes E*uglenozoan, Microsporidian, Ciliophorans, Myxozoans, Trematodes, Monogeneans, Cestodes, Nematodes, Acanthocephalans, Annelids, Molluscan,* and *Arthropods* [8, 11].

In addition, several areas of Iraq (Salah Al-Deen province, Babylon, Al-Diwaniyah, Kurdistan, and Najaf al-Ashraf) have been affected by carp infections due to parasitic agents [5, 8, 11, 1, 12]. Knowing that parasites can have harmful effects on carp populations or play a critical role in their mortality or growth retardation, leading to economic losses for the aquacultures, it has become important to carry out health monitoring on farmed fish in order to improve aquaculture systems and the food value of these fishes. Research on fish parasites and parasitic diseases that may reduce their growth and survival is imperative; therefore, the aim of this study was to find the parasitic disease agents that affect aquacultures of CC fish in Erbil city.

Results

Parasite diversity and prevalence

After examining 250 individual fish, several parasites were identified (Table 1). We identified *Ichthyophthirius sp., Trichodina sp., Dactylogyrus sp., Gyrodactylus sp., Bothriocephalus sp., Capillaria sp., crustaceans* (copepods), and leeches (Figures 1 and 2). Moreover, we observed other organisms on the gill—*Rotifera, Chlorophyta, Nematodes* and eggs of copepods. (Figure 2, C–G). This was the first identification of *Rotifera* (*Brachionus sp.*) in the gills of fish in Iraq.

Among all the identified parasites, the most predominant was *Dactylogyrus sp.*, with an overall prevalence of 25.2%, followed by *Trichodina sp.* and copepod parasites, with their global infection rates at 17.2% and 13.2%, respectively (Table 1). In the other taxa, the global prevalence is situated between 2% and 6% (Table 1). Surprisingly, the presence of *Capillaria sp.* infecting the gills was confirmed.

Four parasites (*Trichodina sp., Dactylogyrus sp., Ichthyophthirius sp.* and *Gyrodactylus sp.*) seemed to be associated with the highest mortality rates among the infected fish, 40%, 35%, 29% and 28%, respectively (Table 1). The remaining parasites were found in a small number of dead fish, with rates ranging between 10% and 18% (Table 1).

Clinical signs

Results of the analysis of the different infected fishes revealed the presence of several clinical signs (Table 2). Indeed, we observed the appearance of necrotic areas, ulcerations and hemorrhage on the gills. On others body parts, we found *Protozoa and Monogeneas* parasites. We also observed carps infected with crustaceans, tapeworms, nematodes and leeches that caused inflammations and mechanical injuries (see Figure 3).

Treatment results

Formalin and potassium permanganate (PP) were effective treatments against a majority of the identified parasites reported in this study.

Discussion

Fishes are recognized as an excellent food source for humans and are preferred as the perfect diet because of the higher proportions of unsaturated fatty acids [17]. Thus, this makes fish the source of basic income for millions of people worldwide [2]. However, in the last few years, several parasitic species have been reported in fishes [9], especially in CC [1, 5]. Indeed, several studies around the globe have revealed cases of infection in carps with many parasites [5, 7, 10]. These parasitic infections can cause great mortality rates and morbidity among them, which may disrupt personal or national wealth systems [18].

In the present study, laboratory analyses were performed on a set of 250 fish collected from five farms rearing CC in Iraq. All the parasitic species found have been previously identified in CC [9]. Thus, we observed eight parasite taxa: *Ichthyophthirius sp., Trichodina sp., Dactylogyrus sp., Gyrodactylus sp., copepods, Bothriocephalus sp., Capillaria sp.* and leeches.

Table 1.
Frequency of isolated parasites

Group	Species	No. of infected fish (%)	Habitat	Frequency of infection in examined aquacultures	No. of fish deaths (%)
Protozoa	*Ichthyophthirius sp.*	28 (5.6)	Gill, skin	3–5	8 (29)
	Trichodina sp.	86 (17.2)	Gill, skin, fins	10–20	35 (40)
Monogenea	*Dactylogyrus sp.*	130 (25.2)	Gill	12–30	46 (35)
	Gyrodactylus sp.	32 (6.4)	Gill, skin	3–5	9 (28)
Crustacean	*Copepods*	66 (13.2)	Gill, skin, fins	9–14	7 (11)
Cestodes	*Bothriocephalus sp.*	22 (4.4)	Intestine	3–4	4 (18)
Nematodes	*Capillaria sp.*	18 (3.9)	Intestine, gills	3–5	3 (17)
Annelida	*Leeches*	10 (2)	Gills	2–3	1 (10)

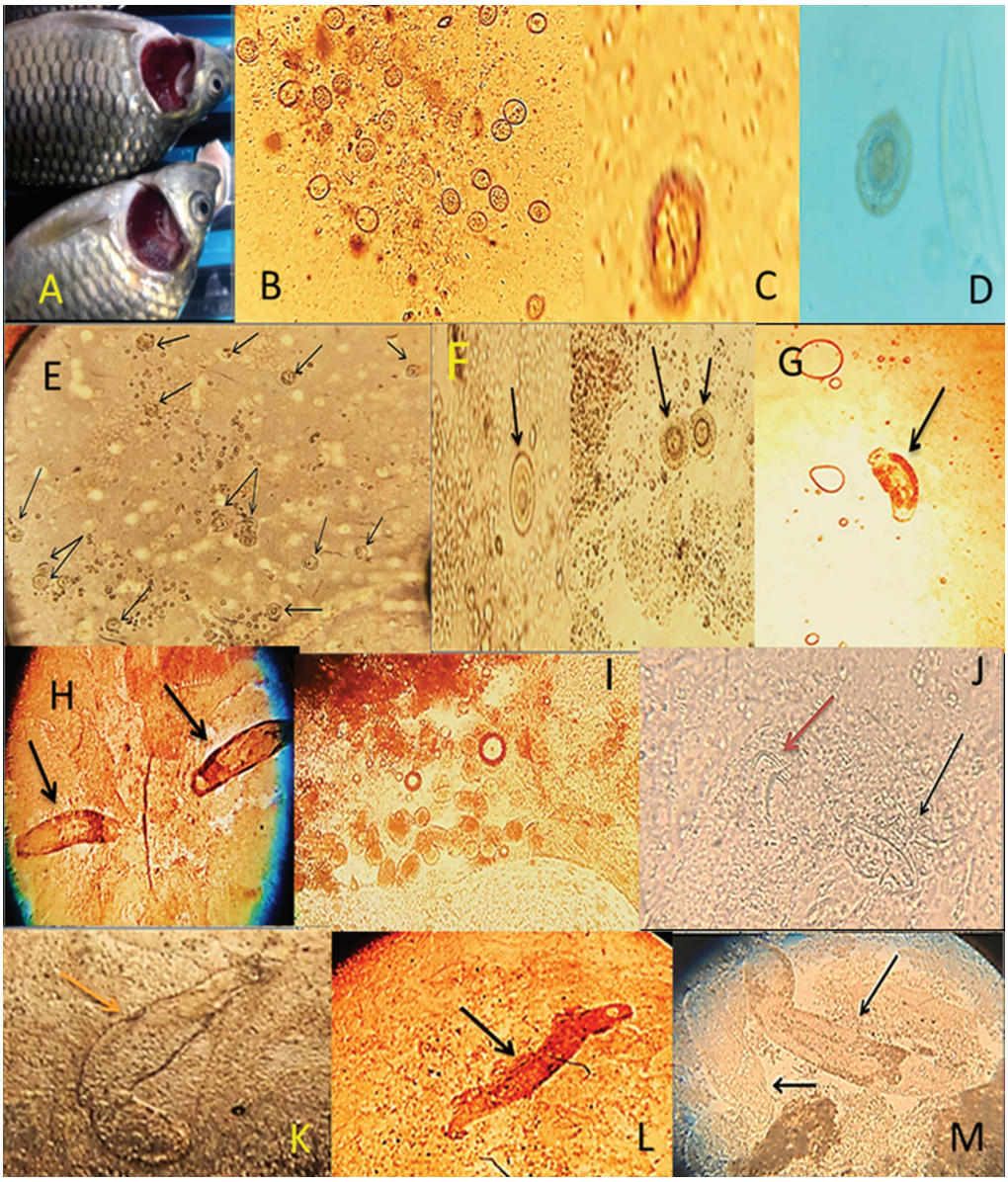

Figure 1
Detected Protozoa and Monogeneas parasites. A) Infected fish with *Ichthyophthirius*, B-C) *Ichthyophthirius sp.*, 400X and 1000X, E-F) *Trichodina sp.* shown by arrows, 400X, 1000X, G-I) *Dactylogyrus sp.*, arrows refer to the worm, 400X, J) *Dactylogyrus sp.*, black arrow refers to the haptor and red arrow to the hooks, 1000X), K-M) *Gyrodactylus sp.*, arrows refer to the worm, 400X.

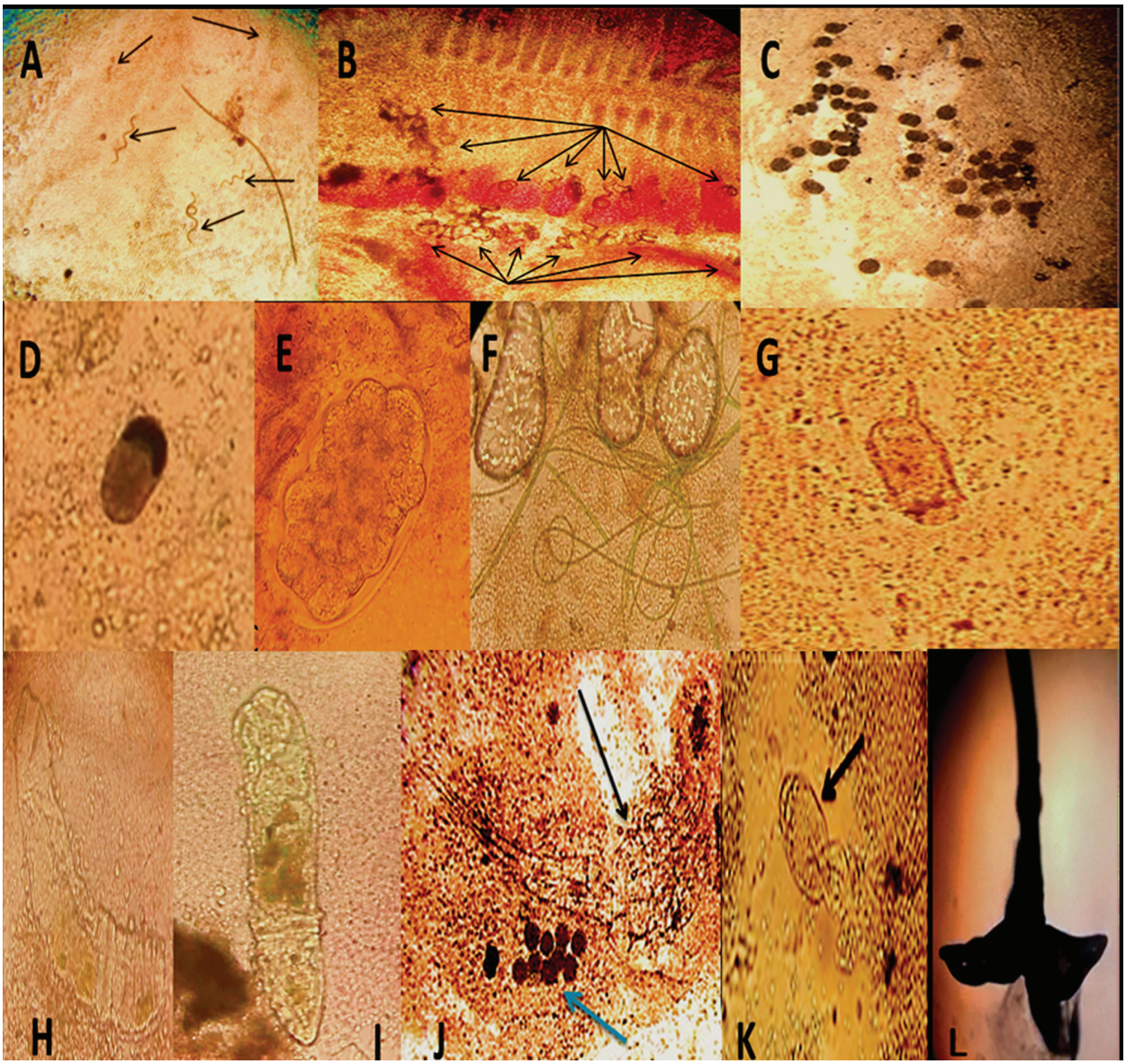

Figure 2
Detected Nemadodae, Crustacean and other organisms on fish gills. A-B) Nemadodae, capillaria worms from gill, arrows refer to the worm, 400X, C-E) Egg types detected on gills, C: Copypod, D and E: Nemadodae, 400X, F) *Chlorophyta* (green algae), G) R*otifera Brachionus sp.*, detected on gills, 400X, H-I) Leeches isolated from gills, 40X, J-L) Crustacean samples detected on gills and skin, black arrows refer to the crustacean, the blue arrow refers to the eggs. 40X, L) *Lernaea* anchor.

The most prevalent were protozoa and Monogeans (Table 1).

Regarding the protozoa group, two genera were found in the carps involved in our study: I*chthyophthirius sp.* and *Trichodina sp.* These parasites have been previously reported in Iraq [12, 19]. Among both protozoa, the most represented was *Trichodina sp.*, with 17.2% of carps infected with this parasite. This was found in the gills, skins, and fins. This observation is consistent with the results of previous studies. Indeed, Al-Marjan and Abdullah, 2009 found this parasite in the skin, fins, and gills of *C. carpio* from the Ainkawa fish hatchery in Erbil province [19]. The infection level detected in our study was less compared to previous studies [20]. Concerning the *Trichodina sp.*, we think that this identified species could most likely be *Trichodina reticulata* or *Trichodina nobilis*, which have been observed in carps from Iraq [20, 4]. However, the *Ichthyophthirius* genus parasites were found in the gills and skins, with a prevalence of 29%. This parasite is recognized by colonizing areas known in this geographical region, and has been reported in several areas of Iraq, infecting many fish species including *C. carpio* [12, 7, 19]. The second ciliated parasite belonging to the *Ichthyophthirius* genus could be the *Ichthyophthirius multifiliis* species.

Concerning *Monogenea*, two parasites were identified as *Gyrodactylus sp.* and *Dactylogyrus sp.* Our results showed that the most common parasite was *Dactylogyrus sp.*, with a rate of 25.5% within the

Table 2.
Common signs noted in infected fish

Type of Parasites	Common signs noted in infected fishes	Type of Treatment	Effectivity of the Treatment
Ichthyophthirius sp.	Lesions and necrotic area, white spots, paleness of gills	Formalin, potassium permanganate	100%, 95%
Trichodina sp.	Irritant area, gill filament fusion, congestion, ulceration and lesions on skin and gills, gill whitening	Formalin	100% repeated three times
Dactylogyrus sp.	Extreme amount of mucous, hemorrhage, gill necrosis, gill whitening and congestion	Salt baths, formalin	80%, 95%
Gyrodactylus sp.	Hemorrhage, ulceration, body inflammation, mechanical injury	Common salt 3%, potassium permanganate	70% for 3 days, 80%
Crustacean	Ulceration, inflammation, mechanical injury	Fenbendazole	80% for 3 days
Cestodes, Nematodes	Inflammation, redness, paleness, gill mechanical damage, congestion	Malathion	100%
Leeches	Inflammation, redness, paleness, gill mechanical damage, congestion	Malathion	100%

Monogean and other identified parasite taxa in this study. This species is more prevalent than the *Gyrodactylus sp.* (6.4%). The *Dactylogyrus* genus has been known as a parasite of various freshwater fishes, although most commonly found in the *C. carpio* in Iraq [1, 18]. However, many species of these two parasitic genus of *Gyrodactylus* and *Dactylogyrus* are known to infect many fish species [4]. Observation of both these monogenic parasites in farms can be seriously problematic, due to fact that their presence has been associated with the death of fish in carp farms [17]. This observation could explain the observed high death rates of 35% and 28% (Table 1), respectively, for *Dactylogyrus sp.* and *Gyrodactylus sp. Dactylogyrus* was found on the gill while *Gyrodactylus sp.* was found on both the gill and skin. This could be because parasites of the *Dactylogyrus* genus are oviparous and infect mainly the gills of their hosts, while the *Gyrodactylus* members are viviparous and infect the skin of their host fish [21].

Our results showed the presence of the crustaceans, in particular, copepods parasites in CC located in different areas of the carp body: skin, gills and fins. The infection rate was 13.2%. Thus, our results support previous studies which reported the presence of this taxa in carp in Iraq [12, 4]. Several species of crustacean are known to infect fish farms in Iraq [11], however, only one species—*Argulus foliaceus*, was observed on the skin of three carp species, including the *C. carpio* [22]. Moreover, the presence of this copepod was associated with 11% of carp deaths.

Only one Cestode was identified in the intestine of the carps (*Bothriocephalus sp.*). The intestine as a habitat is preferred by the Cestodes; indeed, most tapeworms dwell in the intestine of their hosts, attached by suckers, hooks or other holdfast organs [23]. These are widespread parasites which develop into mature adults in the intestine of homeothermic animals. This parasite genus is behind the most important fish-borne zoonoses caused by a Cestodes parasite [24]. In our study, we found that the carps were infected at a 4.4% rate, this infection rate was associated with 18% deaths observed in CC.

The last group identified in the *C. carpio* ectoparasites in our study was leeches (*Annelida, Hirudinea*), with a 2% infestation rate. The literature mentions several species that affect different freshwater fishes in Iraq [25, 26]. Indeed, in Iraq, six taxa of leeches have been so far documented [25]. These ectoparasite was reported first in Iraq from the skin of fish species in ponds near Baghdad [27]. However, our results showed them in the gills of the carps. Moreover, this parasitic group has been associated with around 10% of carp deaths. This observation is supporting by some studies which have reported leaches as the cause of death in fishes [27, 28, 29].

Finally, we state that these parasites can quite often negatively impact the health and mortality of CC [18]. Indeed, during our study, we observed different signs in the infected fish. For example, we observed necrotic areas, ulcerations, and hemorrhaging on the gills and other body parts infected with both Protozoa and Monogeneas, while inflammation and mechanical injury were more frequently observed in fishes infected with crustaceans, tapeworms, nematodes and leeches. Our results support previous studies [7, 30], which reported important harmful effects of parasites on their hosts. Thus, the lesions or different signs observed in the fish could be due to the different mechanical pathways used by the parasites to better

colonize or attach to their host, which has mechanical and/or physiological consequences and production of enzymes and other substances that reduce the weight and growth and reproduction rates [30, 31]. Thus, it is important to carry out monitoring of fish systems in aquacultures, in order to better control parasitic infections and avoid loss of fish. The surveillance of CC from the Erbil aquacultures has allowed us to use some products (formalin, PP, and fenbendazole) for treatment against different observed parasites, and these products have proven to be very effective against the majority of the identified parasites. However, additional studies must focus on identifying fish parasites and their burdens and evaluating the pathological impact of parasites, such as *Capillaria* isolated from fish gills.

Carp fish in and around Erbil city were found to carry heavy parasitic infections, causing pathological and mechanical injuries in fish. These effects were associated with high mortality rates in fish. *Dactylogyrus sp.* was the most prevalent parasite affecting the *C. carpio*. The unexpected presence of the *Capillaria sp.* was observed for the first time infecting the gills. This result has not been recorded in any earlier studies in Iraq.

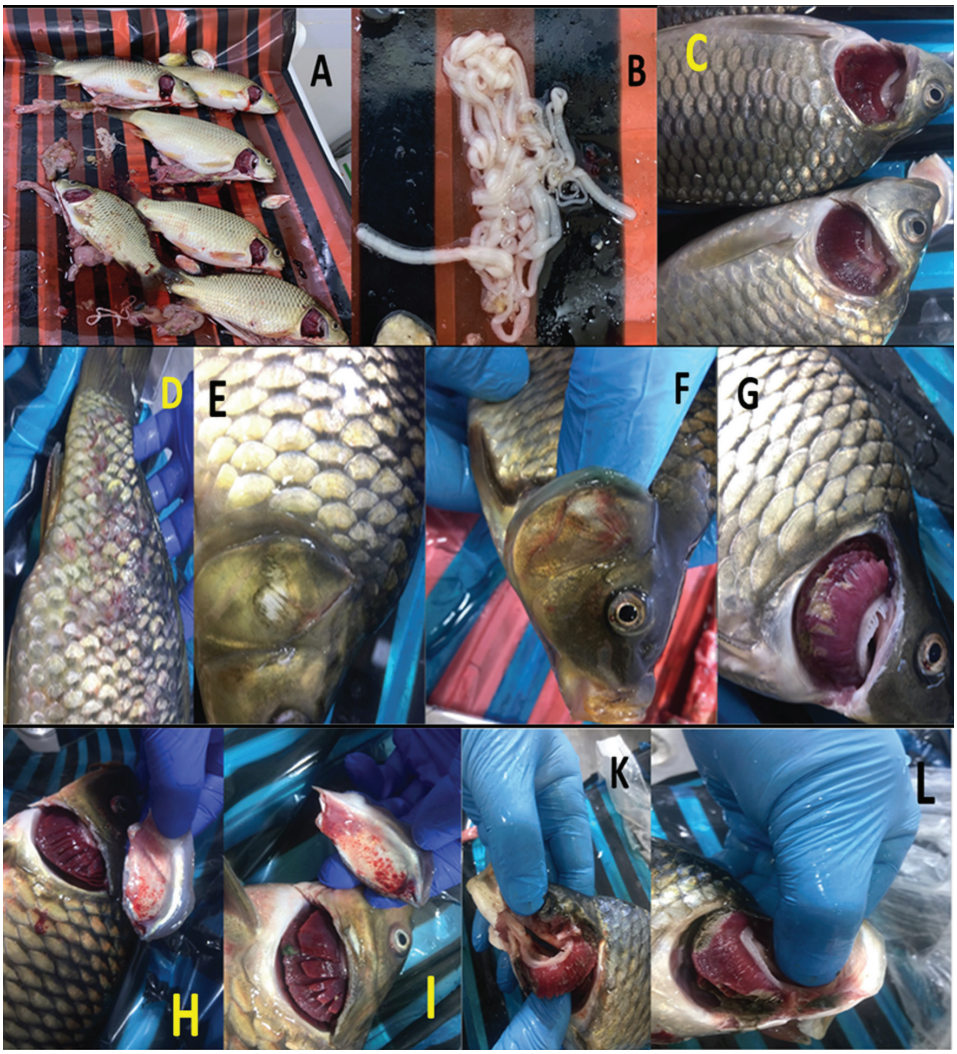

Figure 3
Clinical signs observed in infected fish. A-B) worm samples isolated from intestine, C) Pale whitened gills, D-G) Necrosis, mechanical injury, increased mucus decayed tissues, H-L) hemorrhage, necrosis, ulceration of infected gills

Materials & Methods

Samples collection

Research on the parasites was conducted from March to July 2018 on common carp fish from five farms, located around Erbil, North Iraq. Fish were collected using a bag net. All animals collected alive were kept in big, clean containers and transported to the laboratory for analyses. Identification of the fish was done using the Coad's list [13]. A total of 250 fish were collected for examination (average of 50 Carp per farm). Behavioral parameters such as sluggish movement, aggregation of fishes near oxygen sources, breathing difficulties, anorexia, lethargy, noting of dead fishes in early morning were recorded for each farm.

Examination

Initially, all the fish were visually examined. The aim of this step was to observe the worms, larva and other big parasites as well as all signs and symptoms on the gills and bodies of each fish, and the death rates were also recorded. Secondly, the microscopic (wet smear) analyzes were conducted on the mucus. The skin and the fins were gently scraped, and the scraped materials were placed on a clean microscopic slide and examined with a compound light microscope. For the gills, the bony arches were omitted and little filaments were cut and placed with saline on a slide, were covered by a coverslip on the slide and examined microscopically. The moving worms were obviously noted and photographed with a mobile camera.

Finally, we conducted internal examination of the fish. For this analysis, the body wall was cut from the ventral side, the intestinal parts were opened and examined for gastrointestinal parasite investigation, especially for Cestodes and Nematode worms. The detection and counting of intestinal parasitic eggs, larvae and cysts was performed using a compound microscope (objective 10X). We used the 40X and 100X objectives to take pictures. Identification of the parasites was based on stages morphology, as previously described in studies and guides [14,15,16]. Some locally available treatments were employed for the infected fish on the aquacultures and the mortality reduction was recorded.

Authors' Contributions

Experiment design: HM, NF, TM. Samples collection: HM, NF. Preparation of samples: NF, TM. Slides examination: HM NF. Analyzed the data: HM, NF, TM, LB. Research equipment (reagents, materials and analysis tools: HM, NF, TM. Wrote the paper: HM, LB.

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Competing Interests

The authors declare no conflict of interest.

References

1. Abdullah SMA. Additional Records of Dactylogyrus (Monogenea) from Some Cyprinid Fishes from Darbandikhan Lake, Iraq. J.J.B.S. 2009; 2(4):145–150.

2. Tidwell JH, Allan, GL. Fish as food: aquaculture's contribution. Ecological and economic impacts and contributions of fish farming and capture fisheries". EMBO Rep. 2001; 2(11):958–963.

3. Nelson JS, Grande TC, Wilson MVH. Fishes of the World. (5th Edi). John Wiley and Sons, publisher. Hoboken, New Jersey. 2016. ISBN: 9871118342336.

4. Al-Nasiri FS, Mhaisen FT. Parasites of Fishes Collected from Tigris River, Salah Al-Deen Province, Iraq. I.H.J.P.A.S. 2009; 22(2):1–8.

5. Mhaisen FT, Abdul-Ameer KN, Hamdan ZK. Checklists of Parasites of Fishes of Salah Al-Din Province, Iraq. B. A. E. R. 2018; 2(2):180–218.

6. Mofasshali MS, Abul Bashar MD, Alam MM, Alam GM, Moumita D, Mazlan AG, et al. Parasites of Three Indian Minor Carps of Rajshahi, Bangladesh". A.J.A.V.A. 2012; 7(7):613–62.

7. Hamzah JA, Abdulkarim MF, Khaled M. Diagnosis of parasitic diseases of fish cages (Cyprinus carpio) in the Al Furat River Bridge of Mussayab in Babylon province". Kufa J. Vet. Sci. 2017; 8(1): 90–93.

8. Mhaisen FT, Al-Rubaie AL. Review Article. "Checklists of Parasites of Farm Fishes of Babylon Province, Iraq". Kufa J. Vet. Sci. 2017; 8 (1):1–15.

9. Nematollahi A, Ahmadi A, Mohammadpour H, Ebrahimi M. External parasite infection of common carp (Cyprinus carpio) and big head (Hypophthalmichthys nobilis) in fish farms of Mashhad, northeast of Iran. J. Para. Dis. 2012; 37(1):131–133.

10. Roohi D, Asl AD, Pourkazemi M, Shams S. Occurrence of Dactylogyrid and Gyrodactylid Monogenea on common carp, Cyprinus carpio, in the Southern Caspian Sea Basin". J. Para. Inter. 2019; 73, 101977.

11. Mhaisen FT, Al-Mayali HMH, Al-Abodi HRJ. Checklists of parasites of fishes of Al-Diwaniyah province, Iraq. Bull. Iraq. Nat. Hist. Mus. 2019; 15(3):293–318.

12. Mhaisen FT, Al-Rubaie AL. Checklists of fish parasites of Al-Najaf Al-Ashraf Province, Iraq. Al-Kufa Univ. J. Biol. Special Second International Scientific Conference for the Life Sciences Faculty of Education for Women. University of Kufa. 2016: 86–95.

13. Coad BW. Fishes of the Tigris-Euphrates basin: A critical check-list. Syllogeus. Can. Mus. Nat. 1991; 68-49.

14. Schram FR, Von Vaupel kleint JC, Charmantier-Daures M, Forest J. Treatise on zoology- anatomy, taxonomy, biology. The Crustacea. Complementary to the volumes translated from the French of the Traité De Zoologie. founded by grassé pp. volume 9. part B. Koninklijke Brill NV. Leiden. Boston. 2012.

15. Arai HP, Smith JW. Guide to the Parasites of Fishes of Canada Part V: Nematoda. Magnolia Press Auckland, New Zealand. Zootaxa 4185. 2016; 1: 001–274.

16. Meyers T, Burton T, Bentz C, Ferguson J, Stewart D, Starkey N. Diseases of wild and cultured fishes in Alaska. Alaska Department of Fish and Game Fish Pathology Laboratories. 2019.

17. Seema J. Current status of ichthyofaunal diversity of various water sources of western Uttar Pradesh, India. Int. J. Fish. Aquat. Stud. 2017; 5(2):473–478.

18. Mama KS, Abdullah SMA. Parasitic infections of the common carp Cyprinus carpio from lesser Zab river in Kurdistan region, Iraq. 1st Annual International Interdisciplinary Conference, AIIC. Azores, Portugal. 2013; 24–26.

19. Al-Marjan KSN, Abdullah SMA. Some ectoparasites of the common carp (Cyprinus carpio) in Ainkawa fish hatchery, Erbil province. Second Kurdistan conference on biological science. Journal of Dohok University.2009; 12(1):102–107.

20. Jori MM. Parasitic study on the Asian catfish Silurus triostegus (Heckel, 1843) from Al-Hammar marshes, Basrah, Iraq. M. Sc. Thesis, Coll. Educ., Univ. Basrah. 2006. pp 192.

21. Arora DR, Arora B. Medical Parasitology. (2nd ed.) New Delhi. Bangalore India. CBS Publishers and Distributors. 2009; 220–21.

22. Al-Zubaidy AB. Studies on the parasitic fauna of carps in Al-Furat fish farm, Babylon province, Iraq". Ph. D. Thesis, Collage of Science, University of Babylon. 1998; pp141. (In Arabic).

23. Scholz T, Kuchta R. Fish-borne, zoonotic Cestodes (Diphyllobothrium and relatives) in cold climates: A never-ending story of neglected and(re)-emergent parasites. Food Waterborne Parasito. 2016; 4: 23–38.

24. Al-Saadi AAJ, Mhaisen FT, Hasan R. Endoparasites of seven fish species from Al-Hussainia creek, Karbala province, mid Iraq. B. J. A. S. 2010; 23(2). (special issue).

25. Khalifa KA. Leeches on freshwater farmed fishes in Iraq. J.W.D. 1985; 21(3): 312–313.

26. Ali AH, Mhaisen FT, Khamees NR. Checklists of nematodes of freshwater and marine fishes of Basrah province, Iraq". Mesopot. J. Mar. Sci. 2014; 29(2):71–96.

27. Khan H. Study in diseases of fish: infestation of fish with leeches and fish lice. Proc. Ind. Acad Sci. 1943; 17: 171–175.

28. Gouda AH. The effect of peritrich ciliates on some freshwater leeches from Assiut, Egypt. J. Inver. Pathol. 2006; 93(3):143–149.

29. Fournie JW. Parasitic Diseases of Aquarium Fishes. Gulf Coast Research Laboratory, Ocean Springs, MS. IAAAM. 1986. MAIN : Rehabilitation Efforts : Parasitic Diseases.1986.

30. Britton JR, Pegg J, Williams CF. Pathological and Ecological Host Consequences of Infection by an Introduced Fish Parasite. PLoS One. 2011; 6(10):1–8. e26365.

31. Stewart DB, Bernier LMJ. Common parasites, diseases and injuries of freshwater fishes in the Northwest Territories and Nunavut". Arctic Biological Consultants, Winnipeg, Department of Fisheries and Oceans, Central and Arctic Region. 1999.

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