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Prevalence and Ecological Impact of Parasitic Infections in Farmed *Cyprinus carpio* and *Oreochromis niloticus* in Southern Iraq

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Abstract - Infestation of pathogenic infections or parasites in aquaculture is a great challenge to fish health, productivity and sustainability, and hence to the economic loss of the aquaculture sector. The purpose of the present study is to diagnose these pathogens in common carp and Nile tilapia because it is among the most common organisms in the southern environment of Iraq, which may be one of the factors of the disease infections spreading and also to observe the impacts of sustainable aquaculture management. The standard microscopic techniques were used to do a parasitic analysis. In the present research, it was revealed that the incidence rate was so high in the tilapia fish 35.8 relative to common carp 24.6. Infection was apportioned as follows of the parasitic population of the cope pods *Ergasilus mosulensis*, protozoa came next 17% in carp, 16% in tilapia and monogenes 31% in carp, and 29% in tilapia. The parasitic load of Nile tilapia that was evident even under the relatively stable conditions implies that fish can be a storage host, and this can influence integrated culture systems. The result also confirms health oriented and adaptive aquaculture activities that can facilitate the Sustainable Development Goal 14 (Life Underwater) such as selective breeding with emphasis on resistance, parasite surveillance, and restriction of few rules as regards the use of chemicals.

الانتشار والتأثير البيئي للإصابات الطفيلية في أسماك الكارب والبلطي المسترزعة بجنوب العراق

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المستخلص - تشكل الإصابة بالعدوى المسببة للأمراض أو الطفيليات في الاستزراع المائي تحديا كبيرا لصحة الأسماك وإنتاجيتها واستدامتها، وبالتالي الخسارة الاقتصادية لقطاع الاستزراع المائي. الغرض من هذه الدراسة هو تشخيص هذه مسببات الأمراض في الكارب الشائع والبلطي النيلي لأنه من أكثر الكائنات شيوعا في البيئة الجنوبية للعراق، والتي قد تكون أحد عوامل انتشار العدوى بالمرض وأيضا لمراقبة آثار الإدارة المستدامة للاستزراع المائي. تم استخدام التقنيات المجهرية القياسية لإجراء تحليل طفيلي. في هذا البحث، تبين أن معدل الإصابة كان مرتفعا جدا في أسماك البلطي 35.8 مقارنة بالكارب العادي 24.6 تم تقسيم العدوى على النحو التالي للمجموعة الطفيلية في قرون المواجهة *Ergasilus mosulensis* ، وجاءت الأوليات في المرتبة التالية 17 % في الكارب ، 16% في البلطي والجين الأحادي 31% في الكارب ، و29 % في البلطي. إن الحمل الطفيلي للبلطي النيلي الذي كان واضحا حتى في ظل الظروف المستقرة نسبيا يعني أن الأسماك يمكن أن تكون مضيفا للتخزين، وهذا يمكن أن يؤثر على أنظمة الاستزراع المتكاملة. وتؤكد النتيجة أيضا أنشطة تربية الأحياء المائية الموجهة نحو الصحة والتكيف التي يمكن أن تسهل هدف التنمية المستدامة 14 الحياة تحت الماء) مثل التربية الانتقائية مع التركيز على المقاومة ومراقبة الطفيليات وتقييد بعض القواعد فيما يتعلق باستخدام المواد الكيميائية.

الكلمات المفتاحية: سمك الكارب، التأثير البيئي ، سمك البلطي النيلي، العدوى الطفيلية

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Introduction

Monitoring of communities of parasites, particularly pathogenic forms located in selective fish farming practices, is one of the valuable mechanisms in assessing the dynamics of the marine ecosystem, as parasites are among the most sensitive indicators reflecting environmental changes. This practice is also part of the 14 th SDG, which aims at the conservation and sustainable use of resources and ecosystems of the marine environment. Previous investigations including Lafferty *et al*. 2015, present parasites as one class of biomarker that is potentially valuable in recognizing the changes associated with disturbance of ecosystems caused by pollution and degradation of habitats. International reports have expressed the necessity of management procedures in aquaculture, including the genetically engineered selection of cultured organisms to enhance adaptability and disease resistance as a means of reducing the use of chemical interventions which negatively affects aquatic food systems and contributes to antibiotic resistance as noted by (FAO, 2020).

This demonstrates the ever increasing global demand for the understanding between parasites and aquatic environments that will facilitate an approach to the environmental management aimed to be sustainable. This approach also aligns with Stentiford *et al.* 2017's suggestion of focusing on Environmental Monitoring and Host Genetic Resilience as Pathogen Control for the long Term of record and Chemotherapy. Such methods that promote non-chemically based approaches and increase the resistance to naturally occurring diseases of a target stock, alongside increasing efficiencies of production, also promote sustainable environmental health and resilience in the biosphere; which are the core of SDG 14. All these findings also incorporate parasitology to the models of One Health to illustrate the relationships between the growing sustainable aquaculture and the conservation of aquatic ecosystems (Naylor *et al.,* 2021). Fish constitute a major source of high-quality protein, vitamins, and minerals and is an important component of World Food Security. It is currently estimated that fish and shellfish, constitute around 25% of the food of animal protein eaten globally (FAO, 2022) .One of the many biotic and abiotic factors that affect the health of fish are parasitic infections, which are of major importance.

The effect of parasites on the environment and the economy of both domestic and wild fish is tremendous. The presence of parasites and parasitic infections, on the other hand, is one of the most important constraints of fish aquaculture, due to the negative impacts these infections have on fish growth, increased death rates and financial returns (Lafferty and Kuris, 2012; Coral, 2016).

Although the impact of fish parasites is of global importance, very little information is available on the parasites of fish in Iraqi waters and their abundance. Some information has been documented in the literature on fish parasites in Iraq; however, this is very limited, and further studies are necessary to understand the ecological phenomena of parasite-host relationships, and their variation in time. For the purpose of making a comparative ecological study of parasitic infection, it is planned to sample two species of freshwater fish, from three different sites, in all of the four seasons, in the Basra Governorate. The current study aims to investigate the seasonal dimensions of infestation so as to aid in the development of control measures and health management of parasites, hence contributing to the sustainability of aquaculture in the region.

Materials and Methods:

A total of 305 fish samples, including two freshwater species in the period between January and December 2024, three different sites in Basra Governorate in southern Iraq, were sampled to collect it in the *Cyprinus carpio* Linnaeus, 1758 Cyprinidae and *Oreochromis niloticus* Linnaeus, 1758 Cichlidae. They were the district of Qurna fish farm, the city location and the area of al-Mashab. In fishing, gill nets and cast nets of different mesh sizes were employed by the local fishermen. It was taxonomically defined later; following the classification given by (Coad, 2010; Froese and Pauly, 2016). Every fish sample was transported in ice-filled cold boxes with the local water to alleviate stress. The recently killed specimens were viewed under the microscope. Microscopy of wet swatches of the skin, fins, and gills was done to determine external parasitic infection. The gills were peeled using compound microscopes 100 x magnification and dissection 40 x magnification using a petri dish with a physiological saline solution to clearly observe. Microglass pipettes were used to isolate the active parasites which were then prepared under optical microscopy as in (Scholz *et al*., 1998). The parasites were identified based on morphological features based on the established taxonomic sources such as (Yamaguti, 1961)12 to document and analyze them. High-resolution photographs of the parasites were captured using a digital camera attached to a computer. The samples were stored in 70% ethanol to preserve them over the long term and prepare permanent slices using the accepted protocols concerning tissues (Bykhovskaya *et al*., 1962). The suggested normative terms were used to identify and analyze prevalence and infection criteria (Salmani and Nasiri, 2015).

Statistical Analysis: The prevalence of parasites was estimated for each site and season using the formula:(%)The prevalence (%)= Number of infected fishTotal number examined×100. The prevalence among localities and seasons was compared by means of the Chi-square test of independence with 2×2 contingency tables (infected x non-infected). For species, site and season effects on infection probability, we used a binary logistic model to estimate odds ratios (OR) with 95 % of confidence intervals. Analyses Statistics were carried out using SPSS (v. 26) or R software (v.4.3), considering $P < 0.05$ as the significant level for analysis of results.

Results:

Fish Specimen Distribution

The specimens sampled and analyzed were 305 fish samples of three sites in Basrah Province (199 *Cyprinus carpio* and 106 *Oreochromis niloticus*). The numbers were 96 (49) *C. carpio* in Al-Qurna, 64 (32) in Al-Medeina and 39 (19) in Al-Mashab. Conversely, *O. niloticus* had a numerical abundance that was found to be more in Al-Mashab than in Al-Qurna and Al-Medeina (12-11%). Nevertheless, in the three places, *C. carpio* was evenly distributed (Table 1). Despite the fact that *C. carpio* can exploit a variety of habitats due to the fact that the different environment habitats can provide. The differences between the fish abundance of *O. niloticus* are possibly indicative that the fish is better adapted to the environment conditions at the Al-Mashab.

The commonness of infection of parasites.

The general prevalence of the infection in all of the sites was 24.6, with parasitic infections obtained in 49 out of the 199 *C. carpio* specimens examined. The prevalence rate of *C. carpio* was different in each study site; it was 17.7, 32.8 and 28.2 in Al-Qurna, Al-Medeina and Al-Mashab, respectively. *O. niloticus* was found to be more infected with a prevalence of 35.8 overall with parasitic infections being found in 38 of the 106 specimens. The *O. niloticus* infection was found in 25% in Qurna, 39% in the city and 36.6% in Mashab (Table 2). Finally, a parasitic infection of *C. carpio* was more common in more *O. niloticus* collected at the study sites and in the urban site in particular. *C. carpio* had a lower global prevalence and more overall prevalence by location variation.

The occurrence of various parasites species.

The distribution of the various groups of parasites, zoospores (*Myxobolus musculi*), crustacean parasites (*Ergasilus mosulensis*), and monogeneans (*Dactylogyrus extensis*) depended on the sites (Table 3). Al-Mashab recorded the highest infection rate of *C. carpio* (30%), then Al Medeina (28%), and Al-Qurna (17%). This means that the level of prevalence was significantly lower at Al-Qurna, but at Al-Mashab it was more severe. Al-Medeina and Al-Mashab recorded more rates of protozoan and crustacean parasites infections of *O. niloticus* than in Al-Qurna.

The parasite infection rates of Medina and Al-Mishab were 17 and 35 percent respectively, in the two parasite groups.

The increased impact of environmental factors in aquaculture site or aquatic environmente, coincidind with the availability of host and the impact of water quality ,has contributed tp higher levels.

Parasite Infections It is seasonally affected

Table 4 and Table 5 showed seasonal patterns of parasitic infections in the two fish species. *C. carpio* had the highest infection prevalence (17) in the summer months both at Al-Qurna and Al-Medeina. The 6% rate in Al-Medeina over the winter can suggest that these differences are primarily caused by the fact that parasites reproduce better in the summer when the temperatures are higher. Seasonal changes in prevalence of the infection are influenced by temperatures and environmental conditions that increase the survival and reproduction of parasites. *O. niloticus* was highest (33) in the summer and at Al-Medeina and spring months at Al-Mashab. The seasonal effects are also supported by the observation that the prevalence of *O. niloticus* was the lowest in summer in the winter at Al-Qurna and Al-Medeina. Everything said and done, these results indicate that the parasitic infection of freshwater fish species is highly dependent on the season. This table presents the frequency of parasitic infection in *O. niloticus* and *C. carpio* in three locations. All in all, the infection rate of *O. niloticus* is higher than that of *C. carpio* (35.8% vs. 24.6%). Al Medeina recorded the highest rates of infection on both the species of the study sites.

In *C. carpio*, summer was the period when the prevalence of infections was greatest (16) at the Al-Qurna and Al-Medeina locations. The lowest PR (5 percent) was registered in winter months, which was experienced at both the Al-Medeina and Al-Mashab sites. The dynamic seasonality reveals that the major determinant for parasite prevalence is a number of affecting environmental factors, such as temperature, water quality and host immunity. The infection prevalence of *Cyprinus carpio* and *Oreochromis niloticus* did not differ significantly among the three localities according to Chi-square test ($\chi^2 = 4.12$, df = 2, P = 0.127 and $\chi^2 = 3.79$, df = 2, P = 0.150). Nevertheless, the overall prevalence was significantly different between both species ($\chi^2 = 3.95$, df = 1, P = 0.047), where *O. niloticus* had also a higher prevalence (35.8%) in comparison with C. carpio (24.6%).

Logistic regression indicated that there was no significant predictor of infection except for species. *O. niloticus* had the greater probability of being infected (OR = 1.7) and no effect was observed to that concerning locality (P \> 0.05).

The highest values of seasonal variation in infection prevalence were observed in summer (16%) and spring (13%), and the lowest for winter (5%) and autumn (9.5%). However, season differences were not significant according to a chi-square inspection ($\chi^2 = 4.91$, df = 3, P = 0.178) for these four seasons meaning that the parasite prevalence data did not vary substantially with season.

Table 1. lists all of the *C. carpio* and *O. niloticus* that were examined in the three distinct locations.

Locality	***C. carpio* (N)**	***O. niloticus* (N)**	**Total Fish (N)**	**Total Prevalence *C. carpio* (%)**	**Total Prevalence *O. niloticus* (%)**
Al-Qurna	96	12	108	49	11
Al-Medina	64	23	87	32	22
Al-Mashab	39	71	110	19	67
Total	199	106	305	100	100

Table 2. Total Prevalence of *C. carpio* and *O. niloticus* Infections in the Three Collection Sites

Locality	***C. carpio* Examined (N)**	***C. carpio* (N)**	***C. carpio* Prevalence (%)**	***O. niloticus* Examined (N)**	***O. niloticus* Infected (N)**	***O. niloticus Prevalence* (%)**
Al-Qurna	96	17	17.7	12	3	25.0
Al-Medina	64	21	32.8	23	9	39.0
Al-Mashab	39	11	28.2	71	26	36.6
Total	199	49	24.6	106	38	35.8

Table 3. Prevalence of Infection by Different Parasite Groups in *C. carpio* and *O. niloticus* from Three Different Localities

Parasite Group	***C. carpio* - Al-Qurna (%)**	***O. niloticus* - Al-Qurna (%)**	***C. carpio* - Al-Medina (%)**	***O. niloticus* - Al-Medina (%)**	***C. carpio* - Al-Mashab (%)**	***O. niloticus* - Al-Mashab (%)**	**Total Prevalence - *C. carpio* (%)**	**Total Prevalence - *O. niloticus* (%)**
Protozoan	7.29	8.3	17	17	13	17	17	16
Monogenoidae	14.58	16	28	35	21	30	31	29
Crustacean	15.62	16	30	35	23	35	33	33

Table 4. Seasonal Variation in the Prevalence of Infection by Three Groups of Parasites in *C. carpio* from the Three Collection Sites

Season	Al-Qurna Site	Al-Medeina Site	Al-Mashab Site	Total Prevalence (%)
Winter	11 (1) 9.0%	8 (0) 0.0%	3 (0) 0.0%	22 (1) **5.0%**
Spring	33 (5) 15.0%	17 (2) 12.0%	11 (1) 9.0%	61 (8) **13.0%**
Summer	35 (6) 17.0%	23 (4) 17.0%	16 (2) 13.0%	74 (12) **16.0%**
Autumn	17 (2) 11.7%	16 (1) 6.0%	9 (1) 11.0%	42 (4) **9.5%**

Table 5. Seasonal Variation in the Prevalence of Infection in the Three Parasite Groups of *O. niloticus*

Season	Locality	No. of Examined Fish	No. of Infected Fish	Prevalence (%)
Winter	Al-Qurna	0	0	0
	Al-Medina	3	0	0
	Al-Mashab	8	1	13
Total	-	11	1	9
Spring	Al-Qurna	2	0	0
	Al-Medina	7	2	28
	Al-Mashab	30	10	33
Total	-	39	12	30
Summer	Al-Qurna	4	0	0
	Al-Medina	9	3	33
	Al-Mashab	22	7	32
Total	-	35	10	28
Autumn	Al-Qurna	6	1	16
	Al-Medina	4	1	25
	Al-Mashab	11	3	27
Total	-	21	5	24

Discussion:

The study findings reveal that the presence and distribution of fish parasites in Basrah region are influenced by the presence of host species, the environment and seasonal variations. The paper makes clear the relationship between the hosts and the parasites in freshwater habitats and underlines the impact of the regional ecologic conditions on the epidemiology of fish parasites in the mentioned environments. Geographic location played a major role in the prevalence of infection with more infections in Al-Medina and Al-Mashab compared to Al-Qurna. The variations in the geographic distribution of a parasite underscore the significance of local environmental conditions (temperature, host density and/or water quality) that may modify the dynamics of transmission and restrict the optimum ecological setting of the distribution of the observed parasites.

Other studies have found that the effect of environmental factors, which differ significantly among geographical locations, can be significant in determining the distribution and abundance of fish parasites (Eiras *et al*., 2006; Margolis *et al*., 2016).

These experiments indicate that the parasites under observation would be more prevalent in an ideal situation. The most common parasites were crustacean parasites especially Ergasilus mosulensis. More studies are required to determine whether crustacean parasites may be used as a pointer of the environmental conditions in aquatic life since the parasites that were found were the only ones used in the study. Crustacean parasites are suitable bioindicators to measure the ecological health of freshwater ecosystems since they are widespread. This is because the abundance of this parasite gives researchers with important information concerning stressor factors of the environment which could cause an effect on fish populations. Previously, crustacean parasites have been popularly used as an environmental bioindicator of environmental changes, such as pollution and habitat modification, which has a significant impact on parasite dynamics and fish population health (Gendron *et al*., 2021; Diane *et al.*, 2016).

It was discovered that the prevalence of parasite infections had other seasonal effects. Spring and the summer had higher rates of infections due to temperature variations and some parasites reproductive cycles.

Parasite abundance and transmission are positively associated with each other since at high temperatures both the parasite and the host are more active. It is the enhanced parasite reproduction through the enhanced feeding activities of fish in warmer months that has resulted in the incidence seasonal patterns such as those reported in other examples have agreed that parasites were more prevalent in warmer months (Johnson *et al*., 2019; Bauer *et al*., 2018).

The rate of infection is low during winter, which might be due to a reduced activity of both the parassite and the host species at lower temperatures. Conversely, the reduced infection rates in winter seasons could be as a result of reduction of the activities of parasites and their hosts.

This research contributes to past research concerning parasite transmission that it was demonstrated to be necessary in spreading the parasite to a new host in *Oreochromis niloticus* (tilapia) (Sarkar *et al*., 2020). The highest prevalence infection rate was observed in *Oreochromis niloticus* where the overall rate of infection was 35.8. The second-highest (24.6%) belonged to *cyprinus carpio*. Rather, the parasitization of this species was less than 24.6.

This gives ecological support to the hypothesis that the adaptability of *Oreochromis niloticus* enables the transmission of parasites to a wide variety of fish species which are the most efficient hosts of parasites transmission.

The crustacean parasites, especially *Ergasilus mosulensis* were the most common external parasites in this study with an infection rate of 33%. By comparison, protozoan parasites (*Myxobolus musculi*) and monogenean parasites (*Dactylogyrus extensus*) had lower rates of infection (16% and 29), respectively. These results provide reason to believe that crustacean parasites could serve as important indicators of the quality of the aquatic environment, and further research is justified to determine how it can be sustained and affect the dynamics of fish populations.

The results suggest that the crustacean parasites may be important indicators of aquatic environment quality, justifying further research to determine their sustainability and impact on fish population dynamics. Freshwater fish with monogenetic trematodes were also found to be more frequently infecte during the spring and summer months, as noted by Al-Salmani *et al*., 2015; Hussein ,2017).

It was observed that a seasonal tendency in the highest prevalence rate of parasites (Abd El-Gawad, 2004) was linked to increased reproduction rate that relates to the warmer period of the water temperature that parasites are more active in feeding. Conversely, the infection rate was the lowest in the fall season (Al-Sahlani *et al*., 2024).

In contrast, the protozoan infections would rise during the winter, we have discovered that 40 did not rise, and that both external protozoan peak infection rates were higher in the spring. As with the infections reported in winter reported by (Hussein, 2017; Al-Murgan, 2016)summer months were also the most infected crustaceans (El-Moghazy, 2008; Basem *et al*., 2024).

Otherwise, these differences in studies can be attributed to differences in the sample sizes, the environmental conditions, fish species of interest, and the level of water quality/pollution. The variation of the infection rates and season dynamics as witnessed in different studies highlights the complexity of the parasite ecology. They emphasize the importance of ecological and environmental conditions, including host responses, water quality and temperature changes in the prevalence of parasites. Temperature, specifically, has a considerable influence on the life cycles and reproduction modes of parasites that consequently influences the prevalence of the latter throughout the seasons. To study findings, *Oreochromis niloticus* may have a significant potential as a primary vector of parasitic fish in the wild. Given that tilapia has a high potential of being infected with the parasite, we should further explore the interrelation between the environmental factors and the prevalence of the parasite. The comprehensive information about the factors that affect the health and chances of survival of fish (in the aspect of the sustainability of FPEs) affect our work greatly. To sum up, the study can be important in terms of our knowledge about interactions between fish parasites and freshwater hosts and gives important critical insights on the ecology of fish parasites and helps to comprehend their dynamics. There is a need to have constant risk evaluation of fish parasite prevalence and seasonality to ensure the health of the fish as well as the health of freshwater ecosystems. As per this study, it is necessary to be able to control the health of fish and freshwater ecosystems across various seasonal and environmental conditions to sustain population health and the sustainability of the overall fish population.

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