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Research Article

Parasitic infections of some fish species in the Kirkuk waterbodies, Iraq

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Abstract: A total of 1218 fish samples were examined from the regions of Daquq and Altun Kupri, both riverine and farms, in the Kirkuk Governorate. The percentage of total infection with internal and external parasites was recorded in *Cyprinus carpio, Leuciscus vorax, Carasobarbus luteus, Alburnus caeruleus, Planiliza abu, Chondrostoma regium, Arabibarbus grypus, Cyprinion macrostomum, Luciobarbus barbulus, L. xanthopterus, Capoeta damascina* reached 15.599%. The infection with internal parasites of *Neoechinorhynchus hamann*, (Cestodes) was 3.776%, and the percentage of infection with external parasites (ciliates, spores, monogenesis, and fish lice) was recorded as 11.822%. The highest infection rate with spores was 8.702%.

Keywords: Parasitic infections, Water quality, Disease, Freshwater.
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Introduction

Freshwater fishes have high diversity and are widespread in different natural and artificial environments (Gil & Gil 2015; Song et al. 2018; Torris et al. 2018; Eagderi et al. 2022). Fishes have a great ability to resist diseases, but they may be exposed to the risk of bacterial, fungal, and parasitic diseases that affect their health, growth, and survival. These pathological factors can affect their feeding and body fluids causing various mechanical and chemical damages, and sometimes leading to their death (Matter et al. 2013).

Leaving these parasitic infections unchecked could act as a source of infection for humans and other vertebrates that consume fish (Tesfaye et al. 2018). This work aimed to diagnose ectoparasites and intestinal parasites infecting riverine fish and rearing ponds in the city of Kirkuk and compare these two systems as well as water and soil characteristics of the studied area i.e. the Little Zab River and Gay Daquq project, as well as fish farming ponds within the study areas.

Material and Methods

The study area is located in Kirkuk Governorate in the northern part of Iraq between the latitude 25-35 and longitude 23-44, bordering the Salah al-Din Governorate from the west, Sulaymaniyah Governorate from the east, and Erbil Governorate from the north. Sampling stations include (St. 1) Gay Daquq River represents the Ottoman Bridge area on the northeastern side of the Daquq district, 10km away, (St. 2) the Daquq Project, on the northwestern side of the Daquq district, at a distance of 2km, (St.3) Daquq basins, which depend on the river water at the outskirts of the city of Daquq, (St.4) the Daquq basins, which depend on well water on the outskirts of the city of Daquq, (St.5) the Little Zab River at Elton Bridge. It is located 1 km from the Elton Bridge, (St.6) Altun Bridge basins, which depend on the waters of the Zab River, are located 2km to the west of the city of Altun Bridge, and (St.7) the Elton Bridge basins, which depend on the waters of wells that are 10km from the city of Elton Bridge on the southwestern side.

Table 1. The number of infected fish samples and their proportions.

	title	Number	Ratio
1	The number of fish samples examined	1218	15.59%
2	The number of infected fish samples	190	
3	The number of infected fish samples with internal parasites	46	3.77%
4	The number of infected fish samples with external parasites	144	11.82%

Fish samples were collected from the Altun Kobri district, which is located 43km from Kirkuk Governorate on the road to Erbil. The samples were taken from the Little Zab River and the fish ponds near the Zab River, 2km away on the southwestern side of the Altun Kobri district, and the Daquq district, which is located 25km in the southeast side of the Kirkuk governorate and the ponds for breeding fish from the areas close to the project.

During the study period from February 2022 until November 2022. The number of the examined fish during the study period was 1218, caught using nets and angling with the help of fishermen in those areas. After collecting specimens, the live fish were transferred directly to the laboratory using a cork container containing a quantity of river or basin water. The dead fish were frozen until they were examined. The fish species were identified according to Coad (2010), Mouludi-Saleh et al. (2022), Froese & Pauly (2018), and Çiçek et al. (2023).

The fish were examined with the naked eye using a magnifying glass for external parasites on the skin, fins, and oral cavity. Then swabs were taken from these areas and placed on the slide glass and drops of calcerin on them to maintain the parasite softness a cover slip was placed on them to examine under a compound light microscope. The gills were isolated from the gill cavity and placed in a Petri dish and examined first using a dissecting microscope to search for large parasites, and then swabs were taken from them to examine under a compound light microscope. Afterward, the fish were dissected according to the method Lasee (2004) and Ahmad et al. (2014), by making a longitudinal incision starting from the exit hole and towards the front until the mouth opening to search for internal parasites. The internal cavity was examined first, then the internal organs (intestines, liver, and heart), and the isolated organ was placed in a petri dish and examined under a dissecting microscope to search for parasites. Then, swabs were taken from these organs, placed on glass slides, and examined under a compound light microscope.

The intestine was opened longitudinally and examined under a dissecting microscope to search for parasites on its walls or inside. The samples were preserved in vials containing 10% formalin. The contents of the intestines were examined by direct smear and acid-fast staining (Baron et al. 1994). Parasites were also diagnosed based on Yamaguti (1961), Bykhovskaya et al. (1964), and Al-Salmany & Al-Nasiri (2015), and a camera installed on the computer was used to prepare photographs of the parasites.

Collection of water and soil samples: Water and soil samples were taken from the seven studied stations using plastic bottles after washing them with river or basin water for water samples and sent to a laboratory for examination. The soil samples were taken in plastic bags and sent to a laboratory for examination of physical and chemical analyses. Water and soil parameters including temperature, turbidity, pH, electrical conductivity, hardness, alkalinity, and the concentrations of sodium, calcium, sulfur, potassium, and chloride were measured, respectively.

Results and Discussion

Out of 1218 fish examined, the number of infected samples was 190, with a total infection rate of 15.599%. The number of internal parasites was 46, with an infection rate of 3.776%, as well as the number of external parasites was 144, with an infection rate of 11.822% (Table 1). The results showed that the highest infection with internal and

Table 2. Percentage of infection with external and internal parasites, according to the type of fish.

Type of fishes	samples examined	Internal parasites: *Neoechinorhynchus hamann*	Internal parasites: *Caryophyllaeus Gmelin*	External parasites: *Ergasilus mosulensis*	External parasites: *Dactylogyrus Diesing*	External parasites: *Myxobolus Butschli*	External parasites: *Trichodina Ehrenberg*	infected samples	Ratio
Cyprinus carpio	204	1	6	2	3	3	1	16	7.84%
Leuciscus vorax	83	6	2	1	1	3		12	14.45%
Carasobarbus luteus	219	4	2	1	2	32		41	18.72%
Alburnus caeruleus	208	3	2		2	28		35	16.82%
Planiliza abu	98	11		1	4	9	5	30	30.92%
Chondrostoma regium	45	1	1		4	7	1	13	28.88%
Arabibarbus grypus	53	1			3			4	7.54%
Cyprinion macrostomum	136	1		1		6		8	5.79%
Luciobarbus barbulus	68		1		1	6	2	10	14.70%
Luciobarbus xanthopterus	72	1	2		2	8		13	18.05%
Capoeta damascina	33	1			1	5		8	24.24%
Total	1218	30	16	6	23	106	9	190	15.59%
		2.46%	1.31%	0.49%	1.88%	8.70%	0.73%		

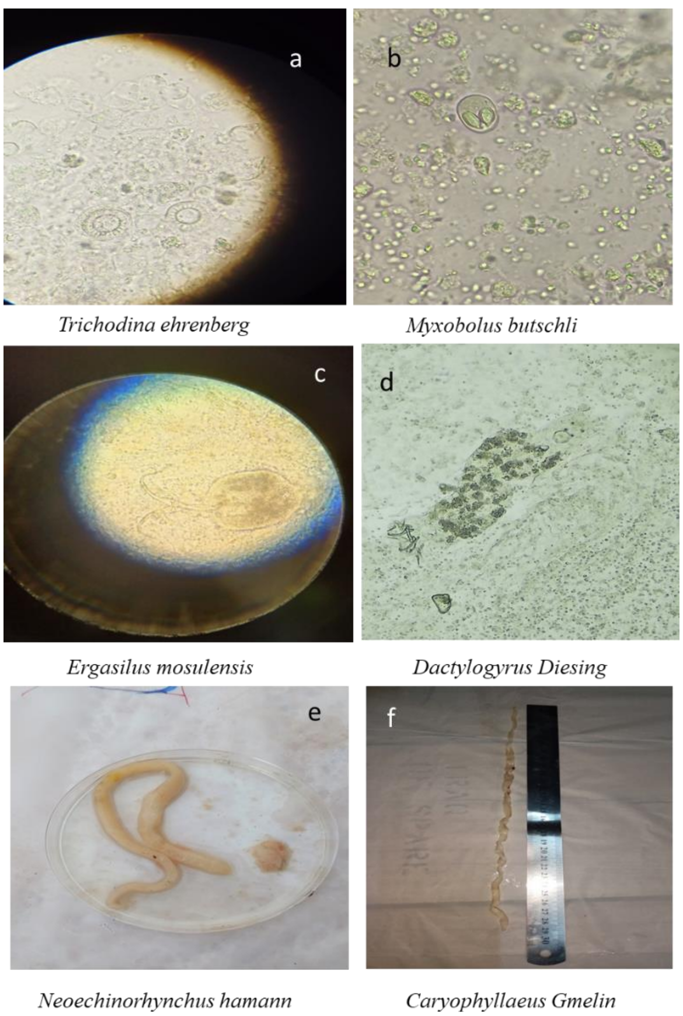

Fig.1. The collected parasites during study period.

external parasites was in *Planiliza abu*, at a rate of 30.927%, and the lowest infection rate was recorded in *Cyprinion macrostomum*, at a rate of 5.797% (Table 2), and this is consistent with the study of Mohammed et al. (2012) and Al-Salmany & Al-Nasiri (2015).

The current study showed the rate of infection with mucous Sporozoites (Table 2, Fig. 1a), i.e. among the ectoparasites that had infected the skin and gills, was the highest rate (8.702%) compared to other parasites with Ciliates (Fig. 1b), Monogenetic worms (Fig. 1c), *Ergasilus mosulensis* (Fig. 1d), with a rate of 0.738%, 1.888% and 0.492%, respectively. The highest rate of infection was found in *Carasobarbus luteus* and *Alburnus caeruleus* with a rate of 18.721% and 16.826%, respectively. The highest rate of infection for *Neoechinorhynchus hamann* (Fig. 1e), was 2.463%. Likewise, the highest rate of infection was in *P. abu*, with a rate of 30.927%. As for Cestoda (Fig. 1f), the rate of infection was 1.313%, and this agrees with the findings of Shulman (1984), Singh & Kaur (2014) and Shuaib & Osman (2015).

The highest infection rate was in July, 29.189%, followed by September and August, with similar

Table 3. The number of fish examined, the number of cases of infection with various parasites, and the percentage of total infection during the months of the study.

Study months	The number of fish samples examined	The number of infected fish samples	Ratio
Febraury	63	2	3.17%
March	59	2	3.38%
April	74	7	9.45%
May	141	7	4.96%
June	219	12	5.47%
July	185	54	29.18%
August	218	49	22.47%
September	164	42	25.60%
October	95	15	15.78%
Total	1218	190	15.59%

Table 4. The number of samples examined and infected during the months of the year according to the study areas.

Months	Infected fish samples	fish samples examined	Elton Kupri						Daquq								Ratio
			St7		St6		St5		St4		St3		St2		St1		
			infection	examine	infection	examine	infection	examine	infection	examine	infection	examine	infection	examine	infection	examine	
February	2	63		3		4	1	28		2		4		12	1	10	3.17%
March	2	59		2		3		23		2		2	2	15		12	3.38%
April	7	74		3		4	2	30		5		6		13	5	13	9.45%
May	7	141		3		4	4	80		6		6	2	27	1	15	4.96%
June	12	219	1	4		3	3	134		6	1	2	3	46	4	24	5.47%
July	54	185		2	2	2	33	78	1	5	1	4	12	63	5	31	29.18%
August	49	218		2	3	4	27	89	1	5	1	6	13	63	5	49	22.47%
September	42	164		2		4	33	111	1	6	1	5	5	24	2	12	25.60%
October	15	95		2	1	3	11	46		3		3	1	15	2	23	15.78%
Total	190	1218	1	23	6	31	114	619	3	40	4	38	37	278	25	189	15.59%
			4.34%		19.35%		18.41%		7.5%		10.52%		13.30%		13.22%		

rates of 25.609% and 22.477%, respectively (Table 3). October showed an infection rate of 15.789%, and February and March had the lowest rates of 3.174%, and 3.389%, respectively, and this indicates that the infection of these types of parasites occurred through the fish devouring the intermediate hosts (crustaceans). Therefore, the increase in the feeding activity of fish usually occurs at the beginning of the summer and the end of spring, and this is consistent with the findings of Karawan et al. (2012), Singh & Kaur (2014), Soylu (2014) and Mansour (2019) with an increase in the number of intermediate hosts, as they are active and multiply in periods of high temperatures. These results agree with the study of Karawan et al. (2012) and AL-Doury (2020) in the Shatt Al-Arab that infection with parasites was high from May to October and decreased in November, February, and even April. This is accompanied by periods of low temperatures, as well as a decrease in the intermediate hosts (snails and crustaceans) and a decrease in feeding activity for fish.

Table 4 shows that the percentage of infection in the fish of the Elton Kobri River area and the ponds (fish farms) is highest, about 18.416% in the Zab River passing through the Elton Kopri city and 19.354% in the fish ponds (fish farms) in the Elton Kopri region. In the Daquq region, the infection rate in the Daquq and Gay Daquq water project was 13.309%, and the ponds (fish farms) were about 10.526%.

Table 5. The factors of the water samples during the study period.

factors	2022/2/21							2022/4/27							2022/7/21							2022/10/21						
	St1	St2	St3	St4	St5	St6	St7	St1	St2	St3	St4	St5	St6	St7	St1	St2	St3	St4	St5	St6	St7	St1	St2	St3	St4	St5	St6	St7
temperature	14	13	13	14	12	12	13	20	22	21	22	22	23	22	26	27	26	27	27	27	28	21	20	20	21	18	18	19
turbidity	5.48	125	60.1	49.0	24.8	56.8	23.9	19	54	8.9	11	114	101	29.5	60	40	46	24.5	37	170	75	13	2.4	14.3	18	9.5	288	159
Ph	7.6	7.8	7.2	7.3	7.5	7.42	7.8	74	76	7.2	7.3	7.4	7.5	7.6	7.2	6.9	7.4	7.2	7.3	7.3	7.2	7	6.8	7.2	7.1	7.3	7.2	7
EU	899	846	470	410	336	364	671	1979	761	582	439	354	494	743	756	997	398	462	370	361	486	824	527	557	809	426	488	430
Alkalinity	164	168	148	147	144	142	188	220	166	156	146	144	160	180	164	198	122	128	116	120	127	168	180	132	169	120	124	125
hardness Caco3	448	402	196	186	168	172	280	648	410	198	187	166	186	324	340	597	170	208	188	185	220	384	420	191	346	190	196	218
ca	79	84	52	51	44	40	58	120	80	58	52	43	49	68	70	105	40	45	42	40	54	67	75	50	86	50	46	53
Mg+	60	47	16	14	14	17	33	85	51	13	14	14	15	37	40	64	17	23	20	20	20	52	56	16	32	16	18	20
cl	52	48	17	14	12	13	28	70	40	19	15	13	19	34	35	38	20	22	19	16	24	40	32	22	35	21	19	24
So4	210	192	38	36	25	27	140	150	150	122	87	36	70	150	110	140	48	76	28	36	66	118	136	52	48	34	40	62
D.S	632	588	284	258	246	250	410	1410	466	296	248	250	284	468	426	570	282	256	268	260	310	476	268	290	480	266	275	258
Na	30	25	10	9	9	8	44	48	22	12	9	8	9	40	20	18	10	14	10	8	15	22	14	15	18	13	12	12
K	4	3.2	1.7	1.4	1.4	1.2	1.9	4	3.7	1.5	1.3	1.4	1.3	1.7	3.5	4.0	1.4	2.3	2	1.2	2.7	4	2.7	3	5	2.2	14	2

This is consistent with the findings of Al-Ayash (2011), Hashim (2014) and Al-Obaidy (2019). The reason for this is that the natural geography that surrounds the Little Zab and its passage through several areas as well as the throwing of industrial and sanitary waste, sewage, and heavy water into the Zab River, which led to an increase in the proportion of parasites of two types, external and internal, on river fish and pond fish (Al-Jubory 2017; Sulaeman & Hassan 2017). The water temperature is one of the important and essential factors for the density of water that is directly related to the percentage of

Table 6. The factors of the soil samples during the study period.

Date/factor		temperature	Ec	Ph	Na	K	Ca	SO4	Cl
2022/2/21	St1	13	0.10	7.65	35.123	99.218	57.202	479.584	72.704
	St2	13	0.12	7.80	15.523	173.631	40.905	342.702	6.262
	St3	16	0.34	7.73	42.336	74.413	89.170	648.295	33.867
	St4	13	0.06	7.22	48.675	233.240	70.579	1164.073	21.104
	St5	12	1.06	7.92	16.128	86.816	63.647	591.867	3.266
	St6	12	1.69	7.83	62.899	173.631	43.863	441.331	30.161
	St7	13	1.40	7.61	38.761	220.331	42.686	332.201	24.956
2022/4/27	St1	35	1.585	7.07	295.680	136.425	485.409	1140.915	742.887
	St2	36	0.793	7.62	63.078	148.827	418.924	1033.627	97.000
	St3	37	0.168	7.70	11.424	99.218	59.687	350.624	4.345
	St4	33	0.138	7.82	165.760	74.413	33.737	172.957	14.448
	St5	32	0.138	7.88	16.128	74.413	49.118	369.322	11.502
	St6	32	0.198	7.84	5.779	86.816	41.535	220.439	9.617
	St7	33	0.693	7.62	37.094	148.827	222.925	769.047	56.999
2022/7/21	St1	45	1.758	7.02	269.360	186.034	130.278	852.023	3132.697
	St2	43	0.157	7.50	7.840	124.022	28.126	383.833	155.312
	St3	42	0.253	7.65	16.486	124.022	47.567	479.845	136.355
	St4	46	0.761	7.27	127.321	111.620	193.382	555.589	1484.716
	St5	43	0.420	7.40	15.590	124.022	54.919	525.687	186.854
	St6	45	2.003	7.36	1322.496	124.022	128.560	683.835	3385.422
	St7	42	1.653	7.30	376.768	111.6203	127.797	497.402	2685.965
2022/10/21	St1	27	3.75	7.42	1189.328	719.331	479.591	4462.201	16549.035
	St2	26	0.15	8.04	15.680	136.425	29.108	617.084	150.342
	St3	26	0.22	7.88	24.192	260.447	56.164	855.543	369.981
	St4	24	0.72	7.76	67.961	403.073	227.708	1429.427	1192.658
	St5	24	0.26	7.57	10.349	198.436	59.506	1097.048	138.663
	St6	25	0.04	8.05	6.272	99.218	15.080	199.826	113.067
	St7	26	0.07	7.99	6.899	99.218	17.731	231.799	99.400

salinity (AL-Nasiri & Mhaisen 2009) and this factor has an important role in the processes of photosynthesis in water and the decomposition of organic matter, which affects the pH values. The lowest PH in the summer was recorded in October as 6.8, and the highest in February was 7.8 (Table 5).

The results of the study showed that the turbidity varied between the lowest percentage of 2.4 in the second station, which represents the waters of the Daquq project, to the highest percentage of 288 in the sixth station in the Elton Kupri fish ponds that depend on the waters of the Zab River. And the water velocity sweeps away suspended matter with them (Smith 2004). The results of the EC showed the highest value of 1978 in the first station, which represents the Gay Daquq River in April, and the lowest rate of 336 in the fifth station, which represents the water of the Little Zab River in the Altun Bridge area. The reason is because of the first station's higher proportions of salts and dissolved substances in this station are at the highest levels, including chlorine, sodium, calcium, and magnesium. Thus, these factors have a role in increasing the conductivity (Marwa et al. 2020)

The results of the study showed that the pH in the soil samples was close to the pH values of the water samples, where it was the lowest in Jul at 7.02 in the first station, and the highest in October, at 8.04 in the sixth station. This is because the organic matter affects the PH values, as well as the EC at its highest rate in the first station and in October at 1189, and the lowest in the sixth station and in April at 5.779. This is due to the increase in the proportions of dissolved salts of calcium, potassium, chloride, and sulfate in this station (Weiner 2000).

Conclusions

1-Types of ectoparasites were isolated from different phyla: *Trichodina ehrenberg*, *Myxobolus butschli*, *Dactylogyrus diesing*, *Ergasilidae mosulensis*.

2-Some types of internal parasites were isolated, including *Caryophyllaeus gmelin*, *Camallanus lacustris*, *Neoechinorhynchus hamaum*.

3-By studying the environmental factors of physical and chemical properties, it was found that the Elton Bridge area, which includes the Little Zab River and the fish ponds close to it, is more suitable for the presence of fish parasites, compared to the Daquq project and the fish ponds near it.

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