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Research Article

Evaluation of seasonal changes in parasitic infestations of fish species of aquatic ecosystems in Kirkuk Governorate, Iraq

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Abstract: Fish samples (1218 specimens) were examined, both those collected from rivers and ponds, from the Daquq and Altun Kobri, Kirkuk Governorate from February 2022 to the end of October 2022. The results showed changes in some physical and chemical characteristics of water and soil during the study period. The air temperature ranged from 2-46, and 12-28°C for water temperature, while pH was 6.8-7.8, turbidity 2.4-288 FTU, EC 336-1979 µS/cm, the total base 120-120, total hardness 170-648 ppm, sulfates 25-210 mg/l and dissolved solids 246-1410 mg/l. The percentage of total infection in the total animal parasites was about 15.599%, where the distribution was as follows: infection with internal parasites (*Neoechinorhynchus hamann*, Castoda) 3.776%. The percentage of infection with ectoparasites (Ciliates, Spores, Monospores, and *Ergasilus mosulensis*) was 11.822%, and the highest percentage of infection with mucous sporozoites was 8.702%.

Keywords: Parasitic infestations, Freshwater fish, Ecosystems.

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Introduction

Freshwater fish is represented by its widespread and ease of access due to widespread distribution within different natural and artificial environments. This is of great importance as a basic food resource as well as its economic importance, which is characterized by the provision of the fishing sector and related industries to about 61 million jobs around the world (Osman 2001). It also represents an essential part of healthy food, as its meat is one of the important components of nutrition necessary to prevent heart disease. Its benefits are represented in providing a healthy and natural source of energy and high-quality nutritional components such as proteins, vitamins (D, A, E, and B12), and essential mineral elements (selenium, Manganese, and copper) and being a source of long-chain fatty acids (Schmidt & Larry 2000; Lasee 2004).

The diseases that affect fish are divided into two parts. The first includes fungal, viral, bacterial, and parasitic diseases, and the second includes diseases other than genetic and environmental diseases and food deficiency diseases (Urquhart et al. 1996). Parasitic diseases in fish have attracted the attention of researchers because they are the most widespread diseases and are the main source of pathogens that cause secondary infections such as viruses, bacteria, and fungi, which in turn lead to extensive economic losses (Baron et al. 1994; Radkhah & Eagderi 2022).

Some parasites cause mechanical damage and various chemical damage to their host, as well as obstructing several different physiological activities such as respiration, reproduction, digestion, and growth. Parasites sometimes contribute to the transmission of infection with parasites and other disease factors from one fish to another (Bykhovskaya et al. 1994).

Infection with fish parasites depends on the geographical location of the environment in which the fish live, the season of the year, the type and depth of the bottom, animals and plants around the environment, etc. These parasites are affected by the physiological, morphological, and vital characteristics of the host such as the host's food, and its digestive secretions. The type and speed of movement, the ability of the fish to form immunity, the age and gender of the host, the time of its reproduction, and activity, presence, gathering, and emigration (Yamaguti 1961). This study aimed to evaluate seasonal changes in parasitic infestations of fish species in aquatic ecosystems in Kirkuk Governorate, Iraq.

Materials and Methods

Study area: The study area is located in Kirkuk Governorate in the northern part of Iraq between latitude 25-35 with longitude 23-44, and it is bordered by Salah al-Din Governorate from the west, Sulaymaniyah Governorate from the east, and Erbil Governorate from the north (Amin 2011).

Sampling stations: 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 drainage, which depends 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 located 1km from the Elton Bridge, St. 6: the Altun Bridge drainage, which depends on the waters of the Zab River, is located 2km to the west of the Altun Bridge city, 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. Fish samples were collected from the areas of 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, between latitude 34.540 and longitude 41.9911, and the Daquq district, which is located 25km on the southeast side of the Kirkuk governorate. The ponds for breeding fish were from the areas close to the project during the study period from the beginning of February 2022 until November 2022.

The number of fish examined during the study period reached 1235 fish. The methods of fishing were gill-nets and angling with the help of fishermen. After sampling, 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. Fish species were identified according to Coad (2010), Mouludi-Saleh et al. (2022), and Çiçek et al. (2023), and scientific names of fish were used based on Froese & Pauly (2018).

The fishes were examined with the naked eye using a magnifying glass to search for external parasites that reside in the skin, fins, and oral cavity. Then swabs were taken from these areas and placed on a slide glass slide. Drops of calcerin were added to it to maintain the softness of the parasite and a cover slip was placed on it. Then, it was examined under a microscope (Compound 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, then smears were taken from them and examined under a compound light microscope. The fish were dissected according to 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 of the body was examined first, and then the internal organs (intestines, liver, and heart) were isolated.

Each 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 a glass slide and examined under a microscope. The intestine was opened longitudinally and examined under a dissecting microscope to search for parasites on its walls or inside. Samples were preserved in vials containing formalin at a concentration of 10%. The contents of the intestines were examined by direct smear and acid-fast staining (Al-Salmany & Al-Nasiri 2015). Parasites were also diagnosed based on the method mentioned in AL-Kanena & Al-Abadan (2015). A camera installed on the computer was used to prepare photographs of the parasites.

Collect water and soil samples: Water and soil samples were taken from the seven study stations using plastic bottles after washing them with water from the river for water samples and sent to a laboratory. As for soil samples, they were taken in plastic bags and sent to a laboratory for physical and chemical analyses, including temperature, turbidity, pH, electrical conductivity, hardness, alkalinity, the concentrations of sodium, calcium, sulfur, potassium, and chloride.

Physical and chemical tests:

Water temperature: Water temperature was measured using a mercury thermometer with a gradient of 0.1 degrees Celsius, by immersing the tip containing mercury directly in the water and waiting for 3 minutes until the reading stabilized.

Turbidity: The turbidity was checked by a turbidity meter of the type Hana LP2000 of Portuguese origin. The device records the standard solutions in (N.T.U) naphthalene unit as a turbidity unit.

Electrical conductivity: A Multi-Parameter analyzer (WTW Cand 720 inolab Germany) was used to measure the electrical conductivity of the sample after calibrating the device in distilled water and measuring the results in microsiemens/cm.

Salinity: Salinity was measured using a multimeter (WTWand720 inolab Germany) and recorded as mg/L.

Total dissolved solids (TDS): The measurement of solids was checked by a multimeter (WTW Cand 720 inolab Germany) after calibration with distilled water, and the readings were measured in mg/l.

pH: The PH was measured using a pH meter (ADWA A1000 Romania originated) after calibration of the device using standard buffer solutions, and the sample was placed in a glass vial, and the sensitive electrode was placed for a while until the reading stabilized.

Total alkalinity: The total alkalinity was examined according to Mudeed et al. (2020) by taking 50ml of the samples and adding 3 drops of methyl orange indicator and pulverizing with sulfuric acid at a concentration of (N 0.02) until the color changed from yellow to reddish pink.

Total hardness: The total hardness was examined according to Mudeed et al. (2020), as 50ml of the sample was taken and 1 ml of a buffered ammonia solution was added to it. This amount is sufficient to make the PH reach 10, and then 4 drops of Eriochrome Black T index were added, so the color becomes violet and fuzzy with Standard Na2EDTA solution with a titer of (N 0.01) until the color turns from violet to blue.

Ca hardness: Calcium hardness was recorded according to the method Mudeed et al. (2020), by taking 50ml of the samples and adding 2ml of NaOH at a concentration of (2.5) to raise the pH more than 10, adding 0.2g of index (Murixide) and pulverizing the mixture with Na2EDTA with a concentration of (N 0.01), until it changes color from pink to blue.

Hardness of Mg hardness: The hardness of magnesium was taken in an arithmetic way according to Mansour (2019), by the difference between the total hardness and the calcium hardness as found in the following equation and measured in mg magnesium carbonate/liter unit.

Chloride measurement: Chloride was recorded according to Mohur's method in Mudeed et al. (2020) by taking 50ml of sample water, and adding some drops of potassium dichromate reagent K2CrO4 to it, rubbing with standard silver nitrate $AgNO_3$ with a concentration of (N 0.025) until the color changed from yellow to fleshy red.

Measurement of sulfate: Sulfur was measured according to what is in Karawan et al. (2012) using a spectrophotometer, where 100ml of sample water was taken and 5ml of the conditioned substance was added to it with shaking using a Magnetic Stirrer, then barium chloride $BaCl_2$ was added to it and shaken for one minute, then it was measured in a spectrophotometer (UV) taking into account the work of (Blank), so that the results are accurate, and compare the results with the measurement curve, and the results worked with the unit mg/liter and at a wavelength of 420nm.

1Measurement of sodium: The sodium ion concentration was measured using a Corning Flame Photometer M410 manufactured by Corning Diaganostics Scientific Instruments, Halsted, Essex, England.

Measurement of potassium: The potassium ion concentration was measured using a BWB XP Flame Photometer manufactured by BWB Technologies Newbury, Berks, U.

Results and Discussion

Physical and chemical factors: Water temperature is one of the important and essential factors for the density of water that is directly related to the percentage of salinity that determines the distribution of organisms in water bodies (APHA, 2017). 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 percentage of pH in the summer in October is 6.8, and the highest in February is 7.8 (Table 1).

The results of the study showed that the turbidity varied between the lowest percentages 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. The water flow sweeps away dust and suspended matter (APHA 2005). The electrical conductivity results showed the highest value of 1978 in the first station, which represents the Gay Daquq River in April, and the lowest percentage in February, 336 in the fifth station, which represents the water of the Little Zab River in the Altun Kobri area. In the first station, the percentages of salts and dissolved substances were the highest, including chlorine, sodium, calcium, and magnesium (Table 1). Thus, these factors have a role in increasing the conductivity in this station (Froese & Pauly 2018).

The pH values in the soil samples are close to the pH values in the water samples (Table 2), where it was the lowest in July at 7.02 in the first station and the highest in October at 8.04 in the sixth station. The organic matter, which affects the pH values, and the electrical conductivity were highest in the first station, on October 1189, and the lowest in the sixth station on April 5.779. This is due to the increase of dissolved salts of calcium, potassium, chloride, and sulfate in this station (Talabani 2022).

Parasitic infection: Table 3 shows the fish species and parasites collected during the study period. In addition, the pictures of the collected parasites are shown in Figure 1. The number of infected samples was 190, with a total infection rate of 15.599% (Table 3). The highest infection rate was 29.198% in July, followed by September and August, with rates of 25.609 and 22.477%, respectively. The month of October recorded an infection rate of 15.789%, while February and March recorded the lowest infection rates at 3.174 and 3.389%, respectively. The percentage of total infection with internal parasites (*Neoechinorhynchus hamann*, Castoda) was 3.776%. The percentage of infection with ectoparasites (Ciliates, Spores, Monospores, and *Ergasilus mosulensis*) was 11.822% and the highest percentage of infection with mucous sporozoites was 8.702%.

The feeding activity of fish usually occurs at the beginning of the summer months and the end of spring (AL-Doury 2020), and an increase in the number of intermediate hosts occurs, as they are active and reproduce during periods of high temperatures. This also agrees with the findings of Al-Obaidy (2019) on Al-Khashni fish in the Shatt Al-Arab. The infection of parasites was high from May to October and decreased in November, February, and even April. Table 4 shows that the percentage of infection in the fish of the Elton Kobri River and the ponds (fish farms) is highest, about 18.416% in the Zab River passing through the Elton Kopri city and 4.347% in the fish ponds (fish farms) in the Elton

Table 1. The environmental factors of the water samples during the studied period.

Date/factors		temperature	turbidity	Ph	EU	Alkalinity	hardness Caco3	ca	Mg+	cl	So4	D.S	Na	K
2022.02.21	St1	14	5.48	7.6	899	164	448	79	60	52	210	632	30	4
	St2	13	125	7.8	846	168	402	84	47	48	192	588	25	3.2
	St3	13	6.01	7.2	470	148	196	52	16	17	38	284	10	1.7
	St4	14	49	7.3	410	147	186	51	14	14	36	258	9	1.4
	St5	12	24.8	7.5	336	144	168	44	14	12	25	246	9	1.4
	St6	12	56.8	7.42	364	142	172	40	17	13	27	250	8	1.2
	St7	13	23.9	7.8	671	188	280	58	33	28	140	410	44	1.9
2022.04.27	St1	20	19	74	1979	220	648	120	85	70	150	1410	48	4
	St2	22	54	76	761	166	410	80	51	40	150	466	22	3.7
	St3	21	8.9	7.2	582	156	198	58	13	19	122	296	12	1.5
	St4	22	11	7.3	439	146	187	52	14	15	87	248	9	1.3
	St5	22	114	7.4	354	144	166	43	14	13	36	250	8	1.4
	St6	23	101	7.5	494	160	186	49	15	19	70	284	9	1.3
	St7	22	29.5	7.6	743	180	324	68	37	34	150	468	40	1.7
2022.07.21	St1	26	60	7.2	756	164	340	70	40	35	110	426	20	3.5
	St2	27	40	6.9	997	198	597	105	64	38	140	570	18	4.0
	St3	26	46	7.4	398	122	170	40	17	20	48	282	10	1.4
	St4	27	24.5	7.2	462	128	208	45	23	22	76	256	14	2.3
	St5	27	37	7.3	370	116	188	42	20	19	28	268	10	2
	St6	27	170	7.3	361	120	185	40	20	16	36	260	8	1.2
	St7	28	75	7.2	486	127	220	54	20	24	66	310	15	2.7
2022.10.21	St1	21	13	7	824	168	384	67	52	40	118	476	22	4
	St2	20	2.4	6.8	527	180	420	75	56	32	136	268	14	2.7
	St3	20	14.3	7.2	557	132	191	50	16	22	52	290	15	3
	St4	21	18	7.1	809	169	346	86	32	35	48	480	18	5
	St5	18	9.5	7.3	426	120	190	50	16	21	34	266	13	2.2
	St6	18	288	7.2	488	124	196	46	18	19	40	275	12	14
	St7	19	159	7	430	125	218	53	20	24	62	258	12	2

Table 2. The environmental factors of the soil samples during the studied 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

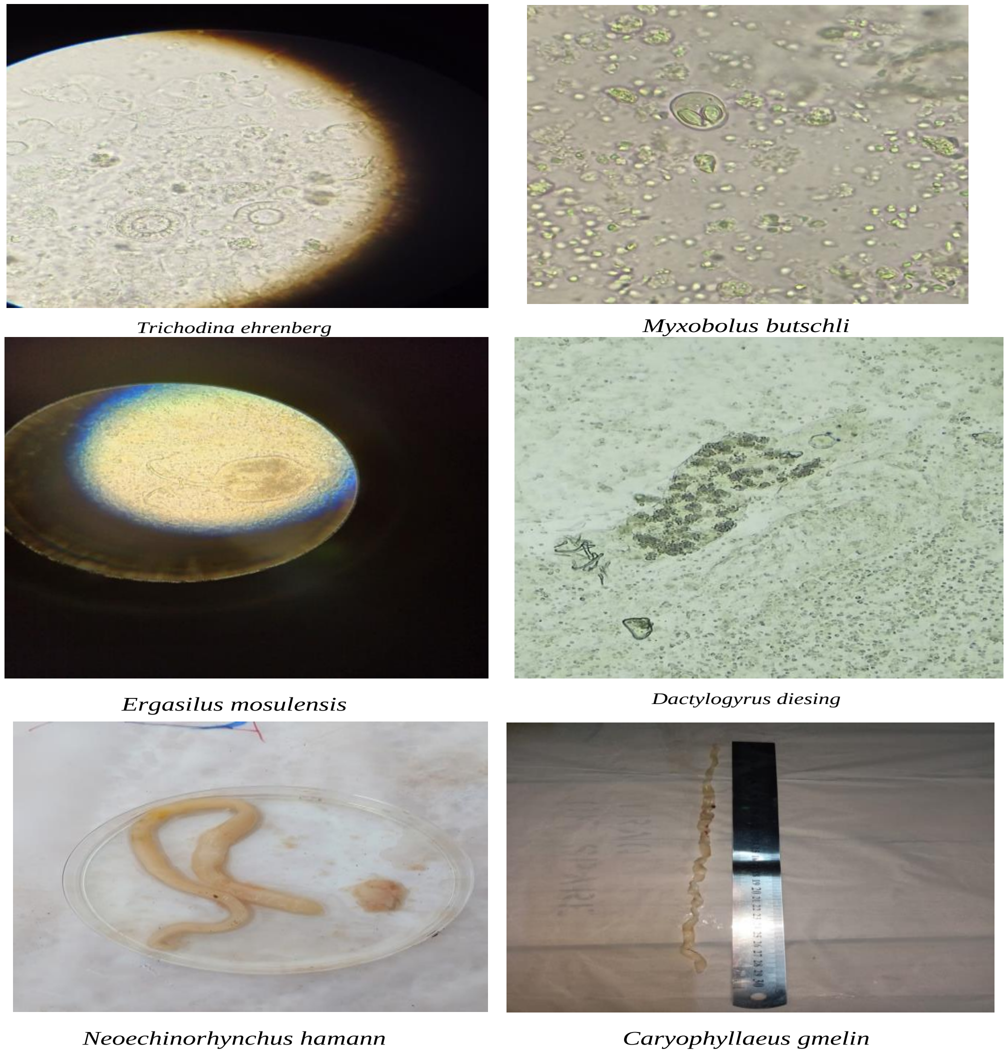

Fig.1. The picture of the collected parasites are shown in this study.

Kopri region. In the Daquq region, the infection rate in the Daquq and Gay Daquq water projects was 13.227%, and the ponds (fish farms) were 7.5%. This finding is consistent with Al-Ayash (2011) and the reason for that is that the nature of the geography that surrounds the Little Zab and its passage through several regions, as well as the throwing of industrial and sanitary waste, sewage waters to the Zab River, which led to an increase of parasites both external and internal (Hashim 2014; Al-Jubory 2014; Sulaeman & Hassan 2017).

Table 4 also shows that the percentage of infection in the Elton Kobri River area and the ponds is 16.169% in the Zab River passing through the Elton Kopri city and 9.259% in the fish ponds in the Elton Kopri region. In the Daquq region, the infection rate in the Daquq and Gay Daquq water was 12.633%, and in the ponds 7.692%. This is consistent with the findings of Al-Ayash (2011).

The effect of environmental factors on parasitic infestation: The results showed that an increase in water temperature leads to an increase in the infection of parasites in fish, especially external parasites. The infection rate was 10.881%, especially in July and August when the air temperature was 46℃ and the water temperature was 28℃. Also, the total hardness values increased in July. The decrease in PH and sulfur in July has a role in increasing parasitic infections in fish.

Table 3. Percentage of infection with external and internal parasites, according to the type of fish.

Type of fishes	samples examined	internal parasites		external parasites				infected samples	Ratio
		Neoechinorhynchus hamann	*Caryophyllaeus gmelin*	*Ergasilus mosulensis*	*Dactylogyrus diesing*	*Myxobolus butschli*	*Trichodina erenberg*		
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 2.46%	16 1.31%	6 0.49%	23 1.88%	106 8.70%	9 0.73%	190	15.59%

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

Study 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	
Febraury	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%		

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