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Assessment of Heavy Metal Pollution and Fish Parasites as Biological Indicators at Arabian Gulf off Dammam Coast, Saudi Arabia

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ABSTRACT

A new approach is chosen to visualize ecosystem health by using parasite bioindicators in Arabian Gulf off Dammam cost. Three hundred and sixty fish specimens belonging to three species of fish were examined parasitological for external and internal metazoan parasites. The seasonal prevalence of the detected parasites was differing from season to another. The highest rate occurred in summer and spring while, the lowest rate was in autumn and winter, respectively. The obtained data showed that Monogeneans prevalence showed highly significant positive correlations with Crustaceans, external parasites, Digeneans. Monogeneans and external parasites prevalence showed highly significant positive correlations with Zn and Se. While, external parasites and Digeneans showed significant positive correlations with Se only. On the other hand, Monogeneans there is antagonist action with Cr and Fe and Ni. Crustaceans showed highly significant positive correlations with Zn and Se. On the other hand, Crustaceans showed highly significant negative correlations with Cr, Fe and Ni. While, digeneans showed a significant negative correlation with Cr. On the same manner, external parasites showed highly significant negative correlations with Cr and Fe.

Key words: Fish, parasites, pollution, heavy metals

INTRODUCTION

Heavy metal pollution in coastal and marine environments have become a serious threat to the increasingly emphasized to both naturally marine ecosystems and humans who depend on marine resources for food and entertainment industry (Ozden, 2010; Kleinertz and Palm, 2015). They are introduced to coastal and marine environments through a variety of sources and activities including sewage and industrial effluents, coastal modifications and oil pollution (Sale *et al*., 2010; Irnawati *et al*., 2014). Most of the reviewed literature confirmed that heavy metal concentrations in marine organisms were generally within the permissible limits and pose no threat to public health (Kim *et al*., 2010; Tiimub and Afua, 2013).

Different organisms have been investigated to assess their potential as biological indicators of different types of pollution in aquatic environment (Garg *et al*., 2009). Where, the aquatic environment can be studied either directly by a regular monitoring of water quality parameters or indirectly by using bioindicators (Palm and Ruckert, 2009; Bayoumy and Abu-Taweel, 2012; Bayoumy *et al*., 2012), such as fish parasites. Definite fish parasite species have been identified as being highly sensitive either in their physiological response to aquatic contaminants or in their ability to accumulate particular toxins in a dose-time dependent manner (Madanire-Moyo *et al*., 2012; Perez-I-Garcia *et al*., 2015).

Water quality and season are the most important factors affecting the prevalence and prevalence of parasite (Marcogliese, 2005; Authman *et al*., 2008). Pollutants might promote parasitism increasingly in aquatic animals; especially fish (Khan and Billiard, 2007; Oros and Hanzelova, 2009). Metazoans, which are normally ectoparasites, are in constant contact with water, suggesting that poor water quality may adversely affect their diversity to a greater extent (Pietrock *et al*., 2008). Therefore, some approaches were carried out for the use of parasites as bio-indicators of environmental pollution.

Arabian Gulf is considered one of the highest areas affected that by human activity in the world (Basaham, 2012). Where, it is considered as a shallow, semi-enclosed basin that is subjected to intensive anthropogenic activities make it susceptible to heavy metal pollution (Naser, 2013). Hence, the present study carried out with the aim to determine and examine the pollutant levels of some heavy metals. Moreover, the relationship between metazoan parasites composition and heavy metal pollution in the Arabian Gulf.

MATERIALS AND METHODS

Study area, fish samples and parasitological examination: Fish were collected weekly for year starting at October 2013 from the Arabian Gulf, off Dammam, Saudi Arabia (26°26'N and 50°7'E). Three hundred and sixty fish specimens (30 fish/month and 10 fish from each species/month) were collected as fresh as possible and classified according to Heemstra and Randall (1993) as of *Epinephelus tauvina* (Forsskål) (greasy grouper, local name: Hamour), *Acanthopagrus bifasciatus* (Doublebar bream, local name: Faskar) and *Siganus rivulatus* (Rivulated rabbitfish, local name: Sigan). Skin, gills and intestines of each fish were freshly examined for external and internal metazoans parasites. They were detected and the prevalence of each type of parasite group was recorded.

Water samples collection and preparation: Three water samples were collected each month from studying area at depth 1.5 m under water. Water samples were collected in acid-treated sampling bottles at all sampling sites. Heavy metals concentrations in water were determined by atomic absorption spectroscopy using a GBC model Avanta S, (GBC Scientific Equipment Pty. ltd.). The heavy metals examined in this study were nickel, lead, chromium, zinc, copper, selenium, cadmium, cobalt, manganese and iron. Sample preparation and analysis were carried out according to method described by American Public Health Association standard methods (APHA., 1998).

Statistical analyses: Basic descriptive statistics were performed to calculate means. One-way analysis of variance (ANOVA) and Duncan's multiple range test (Duncan, 1955) were used to access whether Mean±SE (Standard Errors) varied significantly between seasons. After completion of the above, means were analyzed for the development of Pearson's correlation matrix (2-tailed) of different variables. All statistical analyses were performed using a computer program of SPSS Inc. (version 17.0 for Windows) at the 0.05 level of significance.

RESULTS

The present study reports the results of a preliminary survey on external and internal metazoan parasites of three fish species, caught from off Dammam in the Arabian Gulf. The highest prevalence of infestation was by Monogenea (monog.) and Crustacea (Crs.) (56 and 49.25%), respectively. The lowest ones of infestation were 27.17% by Digenea (Dig.) while, mixed infestation (external) Monogenea and Crustacea was 42.33% (Table 1). Duncan's multiple range test indicated that there are highly significant ($p<0.01$) differences in infestation percentages of Monogenea, Crustacea, external and Digenea, between different seasons (Fig. 1). On the other hand, temperature showed significant ($p<0.05$) difference between different seasons (Table 2).

Duncan's multiple range test indicated that all heavy metals concentrations showed highly significant ($p<0.01$) seasonally differences with the exception of copper which showed significant ($p<0.05$) difference (Table 3).

Table 1: Parasite prevalence and temperature

Months	Monogeneans	Crustaceans	External	Digeneans	Temperature
Jan	40	23.0	20.0	13.0	20.4
Feb	33	20.0	16.0	6.0	23.3
Mar	50	40.0	30.0	20.0	27.5
Apr	56	46.0	43.0	26.0	32.3
May	53	63.0	50.0	16.0	35.5
Jun	73	70.0	60.0	30.0	36.3
Jul	80	80.0	56.0	36.0	36.5
Aug	76	73.0	70.0	50.0	34.0
Sep	63	50.0	53.0	40.0	32.7
Oct	56	60.0	50.0	46.0	30.0
Nov	46	36.0	30.0	27.0	25.0
Dec	46	30.0	30.0	16.0	28.5
G. mean	56	49.25	42.33	27.17	30.17

G. Mean: Grand mean

Table 2: Duncan's multiple range test between parasite prevalence and temperature

	Monogeneans	Crustaceans	External	Digeneans	Temperature
Seasons	(Mean±SE)				
Winter	39.667 ± 3.756^{a}	24.333 ± 2.963^{a}	22.000 ± 4.163^{a}	11.667 ± 2.963^{a}	24.067 ± 2.369^{a}
Spring	53.000 ± 1.732^{b}	49.667 ± 6.888^{b}	41.000 ± 5.859^{b}	20.667 ± 2.906^{a}	31.767 ± 2.325^{b}
Summer	76.333 ± 2.028^{c}	74.333 ± 2.963^{c}	62.000 ± 4.163^{c}	38.667 ± 5.925^{b}	35.600 ± 0.802^{b}
Autumn	55.000 ± 4.933^{b}	48.667 ± 6.960^{b}	44.333 ± 7.219^{bc}	37.667 ± 5.608^{b}	29.233 ± 2.256^{ab}
G. mean	56.000±4.214	49.250±5.795	42.333±4.881	27.167±3.967	30.167±1.535
F-value	20.202	14.698	8.873	8.355	5.585
Sig.	(0.000)**	(0.001)**	(0.006)**	(0.008)**	(0.023)*

Means with the same letter at the same column are not significantly different ($p>0.05$), SE: Standard error, G. mean: Grand mean, f-value: ANOVA's f-test, Sig.: Significance level, *Significant ($p<0.05$). **Highly significant ($p<0.01$)

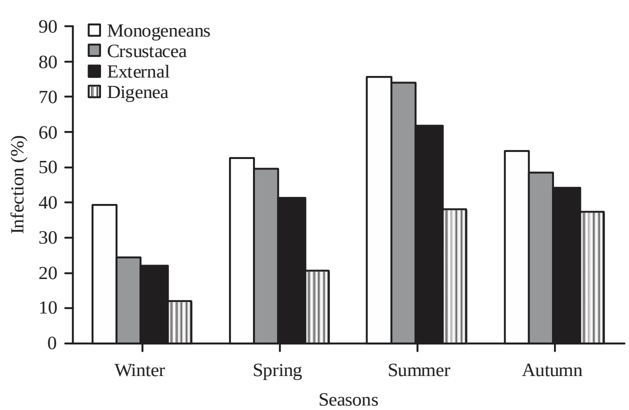

Fig. 1: Seasonal prevalence of the detected parasites

Table 3: Duncan's multiple range test between heavy metals concentrations

Seasons	Ni	Pb	Cr	Zn	Cu
	(ppm)				
Winter	0.964±0.051[b]	0.988±0.099[b]	0.564±0.052[c]	0.413±0.059[a]	0.300±0.022[c]
Spring	0.833±0.149[b]	0.673±0.047[a]	0.248±0.051[b]	0.846±0.106[b]	0.182±0.017[a]
Summer	0.426±0.030[a]	1.215±0.079[b]	0.078±0.005[a]	1.312±0.118[c]	0.229±0.031[ab]
Autumn	0.894±0.055[b]	0.992±0.134[b]	0.323±0.052[b]	0.672±0.056[b]	0.219±0.026[a]
G. Avg.	0.779±0.054	0.967±0.056	0.303±0.036	0.810±0.070	0.232±0.014
F-value	8.137	5.480	20.487	18.125	3.967
Sig.	(0.000)**	(0.004)**	(0.000)**	(0.000)**	(0.016)*
Months	**Se**	**Cd**	**Co**	**Mn**	**Fe**
	(ppm)				
Winter	0.038±0.002[a]	0.120±0.017[a]	0.565±0.119[a]	0.264±0.043[a]	2.223±0.141[c]
Spring	0.155±0.066[ab]	0.261±0.049[b]	1.785±0.099[c]	1.246±0.124[b]	1.150±0.078[b]
Summer	0.394±0.095[c]	0.329±0.057[b]	0.908±0.148[b]	1.127±0.090[b]	0.690±0.055[a]
Autumn	0.246±0.023[bc]	0.077±0.013[a]	0.508±0.047[a]	0.254±0.088[a]	1.428±0.114[b]
G. mean	0.208±0.036	0.197±0.025	0.942±0.101	0.723±0.090	1.373±0.106
F-value	6.545	9.189	28.926	35.123	39.464
Sig.	(0.001)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**

Means with the same letter at the same column are not significantly different (p>0.05), SE: Standard error. G. mean: Grand mean, f-value: ANOVA's f-test, Sig.: Significance level. *Significant (p<0.05), **Highly significant (p<0.01), values are given as Mean±SE

Pearson correlation matrix between parasites, temperature and heavy metals concentrations: A Pearson correlation analysis was conducted to determine significant relationships among the detected kinds of infestation, temperature and heavy metals concentrations. It was found that, Monogeneans showed highly significant positive correlations with crustaceans, external parasites, digeneans, temperature and Zn (r = 0.932, 0.927, 0.775, 0.859 and 0.818, p<0.01, respectively) and a significant positive correlation with Se (r = 0.576, p<0.05) (i.e., the Monogeneans infestation increases with increasing these infestation, temperature and metals). On the other hand, Monogeneans showed highly significant negative correlations with Cr and Fe (r = -0.891 and -0.797, p<0.01, respectively) and a significant negative correlation with Ni (r = -0.611, p<0.05) (i.e., the Monogenean infestation decreases with increasing these metals). Crustaceans showed highly significant positive correlations with external parasites, digenea, temperature and Zn (r = 0.940, 0.728, 0.905 and 0.883, p<0.01, respectively) and a significant positive correlation with Se (r = 0.687, p<0.05) (i.e., Crustaceans infestation increases with increasing these infestation, temperature and metals). On the other hand, Crustaceans showed highly significant negative correlations with Cr and Fe (r = -0.899 and -0.584, p<0.01, respectively) and a significant negative correlation with Ni (r = -0.663, p<0.05) (i.e., Crustaceans infestation decreases with increasing these metals). External parasites showed highly significant positive correlations with digeneans, temperature and Zn (r = 0.821, 0.895 and 0.759, p<0.01, respectively) and a significant positive correlation with Se (r = 0.673, p<0.05) (i.e., External infestation increases with increasing Digeneans infestation, temperature and Zn). On the other hand, external parasites showed highly significant negative correlations with Cr and Fe (r = -0.920 and -0.795, p<0.01, respectively) (i.e., External infestation decreases with increasing these metals). Digeneans showed a significant positive correlation with Se (r = 0.634, p<0.05) and a significant negative correlation with Cr (r = -0.625, p<0.05) (i.e., Digeneans infestation increases with increasing Se and decreases with increasing Cr) (Table 4).

Winter: A Pearson correlation analysis was conducted to determine significant relationships among the detected kinds of infestation, temperature and heavy metals concentrations during winter. It was found that, Crustacea showed highly significant and significant positive correlations

Table 4: Pearson correlation matrix between parasites, temperature and heavy metals concentrations. Heavy metals (ppm)

Parameters	Monog	Crs	Ext	Dig	Temp	Ni	Pb	Cr	Zn	Cu	Se	Cd	Co	Mn	Fe
Monog.	1.000														
Crs.	0.932**	1.000													
Ext.	0.927**	0.940**	1.000												
Di.	0.775**	0.728**	0.821**	1.000											
Temp.	0.859**	0.905**	0.895**	0.560	1.000										
Ni	-0.545	-0.457	-0.373	-0.040	-0.421	1.000									
Pb	-0.828**	-0.868**	-0.847**	-0.818**	-0.737**	-0.125	1.000								
Cr	-0.239	-0.116	-0.220	-0.589*	0.038	0.589**	-0.167	1.000							
Zn	0.443	0.517	0.535	0.739**	0.329	-0.718**	0.329*	-0.797**	1.000						
Cu	-0.573	-0.541	-0.574	-0.589*	-0.605*	0.256	0.190	0.414*	-0.335*	1.000					
Se	-0.626*	-0.687*	-0.603*	-0.731**	-0.475	-0.514**	0.154	-0.519**	0.416*	-0.484**	1.000				
Cd	-0.120	-0.202	-0.050	0.332	-0.197	-0.563**	0.272	-0.569**	0.651**	-0.059	0.139	1.000			
Co	0.512	0.529	0.556	0.796**	0.341	0.042	-0.252	-0.208	0.284	-0.285	-0.264	0.456**	1.000		
Mn	0.864**	0.805**	0.796**	0.776**	0.623*	-0.453**	-0.199	-0.478**	0.529**	-0.384*	0.101	0.481**	0.705**	1.000	
Fe	-0.612*	-0.624*	-0.660*	-0.800**	-0.539	0.544**	-0.162	0.767**	-0.777**	0.572**	-0.461**	-0.591**	-0.456**	-0.649**	1.000

Monog: Monogenea, Crst: Crustacea, Ext: External, Dig. Digenea, Temp: Temperature, *Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed)

with external parasites and Cd (r = 1.000, p<0.01 and r = 1.000, p<0.05, respectively) (i.e., the Crustacea infestation increases with increasing external infestation and Cd concentration). On the other hand, Crustacea showed significant negative correlations with Pb, Cr, Co and Fe (r = -0.999, -0.999, -0.997 and -0.999, p<0.05, respectively) (i.e., the Crustacean infestation decreases with increasing these metals). External parasites showed highly significant positive correlation with Cd (r = 1.000, p<0.01) (i.e., the external infestation increases with increasing Cd concentration). On the other hand, external parasites showed significant negative correlations with Pb, Cr and Fe (r = -1.000, -1.000 and -0.999, p<0.05, respectively) (i.e., the external infestation decreases with increasing these metals).

Spring: A Pearson correlation analysis was conducted to determine significant relationships among the detected kinds of infestation, temperature and heavy metals concentrations during spring. It was found that, Monogenea showed highly significant positive correlation with Cr (r = 1.000, p<0.01) (i.e., the Monogenea infestation increases with increasing Cr concentration). External parasites showed significant positive correlations with temperature and Zn (r = 0.998 and 1.000, p<0.05, respectively) (i.e. the external infestation increases with increasing temp and Cr concentration). On the other hand, external infestation showed highly significant negative correlation with Co (r = -1.000, p<0.01) (i.e. the external infestation decreases with increasing Co concentration). Digenea showed significant negative correlation with Se (r = -1.000, p<0.05) (i.e., the Digenea infestation decreases with increasing Se concentration).

Summer: A Pearson correlation analysis was conducted to determine significant relationships among the detected kinds of infestation, temperature and heavy metals concentrations during summer. It was found that, Digenea showed highly significant positive correlation with Cd (r = 1.000, p<0.01) (i.e. the Digenea infestation increases with increasing Cd concentration).

Autumn: A Pearson correlation analysis was conducted to determine significant relationships among the detected kinds of infestations, temperature and heavy metals concentrations during autumn. It was found that, Monogenea showed significant positive correlation with temperature (r = 0.998, p<0.05) (i.e., the Monogenea infestation increases with increasing temperature). Crustacea showed significant negative correlation with Cr (r = -0.999, p<0.05) (i.e., the Crustacea infestation decreases with increasing Cr concentration). Digenea showed highly significant positive correlation with Pb (r = 1.000, p<0.01) (i.e., the Digenea infestation increases with increasing

Pb concentration). On the other hand, Digenea showed significant negative correlation with Cr (r = -0.997, $p<0.05$) (i.e., the Digenea infestation decreases with increasing Cr concentration) (Table 5).

Table 5: Pearson correlation matrix between parasites, temperature and heavy metals concentrations

Seasons	Monog	Crs	Ext	Dig	Temp	Ni	Pb	Cr	Zn	Cu	Se	Cd	Co	Mn	Fe
Winter															
Monog.	1.000														
Crs.	0.963	1.000													
Ext.	0.959	1.000**	1.000												
Di.	0.983	0.899	0.892	1.000											
Temp.	0.599	0.791	0.801	0.443	1.000										
Ni	-0.350	-0.086	-0.071	-0.514	0.541	1.000									
Pb	-0.952	-0.999*	-1.000*	-0.880	-0.816	0.766*	1.000								
Cr	-0.954	-0.999*	-1.000*	-0.884	-0.811	0.240	0.013	1.000							
Zn	-0.992	-0.990	-0.987	-0.952	-0.696	-0.598	-0.771*	-0.276	1.000						
Cu	-0.482	-0.700	-0.711	-0.315	-0.990	0.002	0.237	-0.535	0.367	1.000					
Se	0.197	0.452	0.466	0.016	0.903	0.694*	0.755*	-0.199	-0.391	0.363	1.000				
Cd	0.955	1.000*	1.000**	0.885	0.809	0.612	0.694*	0.496	-0.944**	-0.452	0.386	1.000			
Co	-0.981	-0.997*	-0.996	-0.930	-0.742	0.492	0.425	0.869**	-0.698*	-0.555	0.069	0.814**	1.000		
Mn	-0.776	-0.916	-0.923	-0.648	-0.970	0.185	0.062	0.929**	-0.377	-0.611	-0.124	0.547	0.890**	1.000	
Fe	-0.972	-0.999*	-0.999*	-0.913	-0.770	-0.074	0.073	-0.887**	0.428	0.824**	0.304	-0.597	-0.849**	-0.920**	1.000
Spring															
Monog.	1.000														
Crs.	0.251	1.000													
Ext.	0.640	0.904	1.000												
Di.	0.596	-0.627	-0.235	1.000											
Temp.	0.596	0.927	0.998*	-0.289	1.000										
Ni	0.804	0.777	0.972	0.002	0.957	1.000									
Pb	0.992	0.125	0.537	0.694	0.488	-0.331	1.000								
Cr	1.000**	0.251	0.640	0.596	0.596	0.245	-0.880**	1.000							
Zn	0.655	0.896	1.000*	-0.217	0.997*	-0.545	0.919**	-0.868**	1.000						
Cu	0.751	0.828	0.988	-0.082	0.978	0.573	-0.811**	0.840**	-0.790*	1.000					
Se	-0.581	0.642	0.253	-1.000*	0.308	-0.756*	0.826**	-0.796*	0.948**	-0.856**	1.000				
Cd	-0.955	0.047	-0.384	-0.808	-0.331	-0.664	0.847**	-0.843**	0.959**	-0.827**	0.985**	1.000			
Co	-0.645	-0.902	-1.000**	0.229	-0.998*	0.921**	-0.226	0.106	-0.371	0.484	-0.590	-0.464	1.000		
Mn	-0.983	-0.424	-0.770	-0.439	-0.733	-0.074	-0.816**	0.921**	-0.739*	0.627	-0.569	-0.636	-0.163	1.000	
Fe	0.483	0.969	0.982	-0.415	0.991	0.092	-0.843**	0.975**	-0.771*	0.801**	-0.678*	-0.733*	-0.028	0.951**	1.000
Summer															
Monog.	1.000														
Crs.	0.990	1.000													
Ext.	-0.355	-0.486	1.000												
Di.	0.213	0.070	0.838	1.000											
Temp.	0.154	0.295	-0.978	-0.933	1.000										
Ni	-0.704	-0.799	0.914	0.544	-0.810	1.000									
Pb	0.658	0.542	0.471	0.876	-0.643	-0.529	1.000								
Cr	0.427	0.292	0.693	0.974	-0.828	0.913**	-0.631	1.000							
Zn	0.517	0.388	0.616	0.946	-0.766	-0.881**	0.755*	-0.841**	1.000						
Cu	-0.835	-0.906	0.811	0.360	-0.672	0.245	0.583	0.016	0.032	1.000					
Se	0.910	0.960	-0.711	-0.211	0.549	0.364	-0.879**	0.523	-0.640	-0.767*	1.000				
Cd	0.206	0.063	0.841	1.000**	-0.935	0.150	0.673*	0.010	0.195	0.927**	-0.836**	1.000			
Co	0.495	0.365	0.636	0.954	-0.782	-0.646	0.916**	-0.708*	0.900**	0.364	-0.832**	0.530	1.000		
Mn	0.485	0.353	0.645	0.958	-0.790	-0.612	0.199	-0.357	0.690*	-0.341	-0.149	-0.136	0.473	1.000	
Fe	0.569	0.445	0.566	0.924	-0.725	0.928**	-0.710*	0.972**	-0.922**	-0.063	0.616	-0.101	-0.791*	-0.497	1.000*
Autumn															
Monog.	1.000														
Crs.	0.660	1.000													
Ext.	0.955	0.854	1.000												
Di.	0.741	0.994	0.907	1.000											
Temp.	0.998*	0.711	0.973	0.786	1.000										
Ni	0.410	-0.415	0.120	-0.309	0.346	1.000									
Pb	0.751	0.992	0.914	1.000**	0.795	0.702*	1.000								
Cr	-0.688	-0.999*	-0.873	-0.997*	-0.737	0.591	0.078	1.000							
Zn	-0.421	-0.959	-0.672	-0.921	-0.483	-0.205	0.356	-0.627	1.000						
Cu	0.215	0.875	0.495	0.815	0.282	0.315	-0.174	0.684*	-0.856**	1.000					
Se	0.127	-0.661	-0.174	-0.572	0.058	0.805**	0.574	0.787*	-0.437	0.464	1.000				
Cd	0.833	0.965	0.960	0.989	0.870	-0.670*	-0.295	-0.893**	0.585	-0.678*	-0.865**	1.000			
Co	-0.985	-0.780	-0.992	-0.846	-0.995	-0.721*	-0.824**	-0.234	0.149	-0.211	-0.744*	0.502	1.000		
Mn	0.382	0.946	0.639	0.903	0.445	-0.837**	-0.430	-0.877**	0.598	-0.677*	-0.941**	0.934**	0.650	1.000	
Fe	-0.992	-0.562	-0.910	-0.652	-0.981	0.515	-0.075	0.962**	-0.789*	0.805*	0.699*	-0.851**	-0.170	-0.843**	1.000

Monog: Monogenea, Crst: Crustacea, Ext: External, Dig. Digenea, Temp: Temperature, *Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed)

DISCUSSION

Fish parasites represent a major part of aquatic biodiversity and so become affected by biotic or abiotic changes in the environment (Dzika and Wyzlic, 2009). To investigate the relationship between fish parasite communities and water quality, external metazoan parasites were examined in 360 fish specimens of deferent three fish species.

Temperature is the most important abiotic parameter and affects parasites at all life-cycle stages. The seasonal prevalence of the recorded parasites was differing from season to another. The highest rate occurred in summer and spring while, the lowest rate was in autumn and winter, respectively. It is clear in the obtained data, there were high positive significant correlations between temperature and the prevalence of the detected parasites especially monogeneans through studied months and seasons. In general, it explains that increases in temperature accelerate growth rates, development and evolution probably by shortening generation time and enhancing the speed of life cycle of the monogeneans (Bayoumy *et al*., 2012). Therefore, parasites should be able to complete their life cycles, even complex ones such as digeneans, more rapidly. In temperate latitudes, fish parasites possessing complex life cycles typically produce one or two generations per year.

Also, the obtained data showed that Monogeneans prevalence showed highly significant positive correlations with Crustaceans, external parasites, Digeneans. These results may be attributed to simple nature of monogenean life cycle that characterized by direct infestation and have only one generation (Bayoumy *et al*., 2008). Therefore, infestation by monogenean parasites may increase fish susceptibility to another infestation as result of immune disorder of the host. While, in case of parasitic crustaceans are mostly spend part of their life cycle as particularly male ones, where the fertilized female are parasitic to lay their eggs and to maintain the continuation of their life and developmental stages in the water column (Dzika and Wyzlic, 2009). On the same manner, digenetic trematodes have complex life cycle and more than one host to complete their life cycle (Ruckert *et al*., 2009).

Aquatic systems are affected by a variety of anthropogenic activities that decrease water quality through the introduction of organic and inorganic pollutants. Therefore, the present data under discussion revealed that Monogeneans and external parasites prevalence showed highly significant positive correlations with Zn and Se. While, external parasites and digeneans showed significant positive correlations with Se only. On the other hand, Monogeneans there is antagonist action with Cr and Fe and Ni. Crustaceans showed highly significant positive correlations with Zn and Se. On the other hand, Crustaceans showed highly significant negative correlations with Cr, Fe and Ni. While, Digeneans showed a significant negative correlation with Cr. On the same manner, external parasites showed highly significant negative correlations with Cr and Fe.

From the previous data we can concluded that, parasites interact with contaminants in synergistic or antagonistic ways (Torres *et al*., 2012). Where, fish parasites closely interact with the metabolisms of the host. Furthermore, parasite infra-populations can be affected by changes of the host physiology and substances accumulated with the host´s food (Bayoumy *et al*., 2008; Palm and Ruckert, 2009). If the host is living within a polluted environment where some pollutants also enter the fish, the concentration of these substances in the immediate surroundings of the parasite can also increase. In such cases, some fish parasites can accumulate pollutants in a much higher concentration as their host organisms and serve as accumulation indicators (Madanire-Moyo and

Barson, 2010). Therefore, ecological parameters such as the prevalence and intensity of infection with different parasites have been applied to demonstrate faunistic differences between polluted (influenced) and non-polluted sampling sites (Palm and Ruckert, 2009; Madanire-Moyo and Barson, 2010).

CONCLUSION

It can be concluded that knowledge of the biology of the parasite and the host-parasite relationship and the environment can help to detect environmental change. Another interesting use of fish parasites as bioindicators concerns their potential to elucidate aspects of the biology of the host organism.

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