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Research Paper

Comparative study on the Levels of Heavy Metals in the Bitter Lakes and Lake Temsah, (Suez Canal) in Relation to the Reproductive Cycle of the Rabbit Fish *Rhabdosargus haffara*

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Abstract: *The concentrations of Cu, Zn, Pb, Cd, Fe, Mn, Cr, Ni and Co in muscles, liver and gonads of fish Rhabdosargus haffara from the Bitter lakes and Lake Temsah, (Suez Canal) were investigated seasonally from 2010 to 2011. Muscles recorded the lowest concentrations of metals than other organs which ranged between 0.161-0.717, 1.848-5.081, 0.102-0.136, 0.019-0.079, 3.066-6.284, 0.153-0.246, 0.020-0.059, 0.015-0.041 and 0.019-0.148 wet weight for Cu, Zn, Pb, Cd, Fe, Mn, Cr, Ni and Co respectively in Bitter Lakes, while in lake Temsah the concentration of these metals in muscles were 0.919-1.098 3.908-5.481, 0.107-0.152, 0.033-0.095, 4.748-6.824, 0.139-0.292, 0.039-0.062, 0.019-0.053 and 0.080-0.214. The highest concentrations of all studied metals were found in gonads. Variation of metals in fish muscles through different seasons indicated that the most studied metals their highest value during . Gonadosomatic index (GSI) and its relationship with metal accumulation was calculated for the studied fish. By using seasonal changes in the values of Gonadosomatic index, it was found that their spawning season is during spring.*

Keywords: Heavy metals, *Rhabdosargus haffara*, reproductive cycle, Bitter Lake, Temsah Lake, Suez Canal.

Introduction

Metals differ from other toxic substances in that they are neither created nor destroyed by human, the pollution levels of the aquatic environmental by heavy metals can be estimated by analyzing water, sediment and marine organisms[20]. Living organisms require trace amounts of some heavy metals, including cobalt, copper, iron, manganese and zinc. The concentration of heavy metals in marine fishes has received much attention, especially the commercial fishes, since high levels of these metals in their muscles represent a potential human health hazard.

The Bitter Lakes (30°20′ N, 32°23′ E) are the largest water bodies along the length of the Suez Canal, containing about 85% of the system's water. The Great and Small Bitter Lakes, separated by a narrows, are saline lakes situated between the north and south parts of the Suez Canal (Figure 1). El-Temsah Lake formed in a depression situated in a fault trough [12,18] covered with Nile Delta sediments. The lake covers about 15Km^2 between 30^0 $32^\backslash$ and 30^0 $36^\backslash$ north latitude and 32^0 $16^\backslash$ and 32^0 $21^\backslash$ east longitude, and is located near the middle of the Suez Canal, at a point 80 Km south of Port Said. *Rhabdosargus haffara* is a tropical fish found in the western Indian Ocean, Red Sea and especially common in the North. It inhibits shallow waters, mainly around coral reefs, and over sandy or mud-sandy bottoms Feeds chiefly on molluscs and to a lesser extent on crustaceans which are crushed with its developed molars. Its common size is 10 - 20 cm and the maximum is 35 cm [14]. The present work aim to study the variation of metals (Cu, Zn, Pb, Cd, Fe, Mn, Cr, Ni and Co) in the muscles, liver and gonads of *Rhabdosargus haffara* collected from the Bitter Lake and Lake Temsah. In addition, the relationships between accumulation of metals and maturity stage of fish gonads were investigated.

Material and Methods

Rhabdosargus haffara fish were collected seasonally from Bitter lakes and Lake Temsah during 2010-2011(Figure 1). All samples were weighed, measured and dissected where their gonads, were examined morphologically to determine the maturity stages. Gonadsomatic index (GSI) (the percentage of gonad weight to the gutted weight of fish) was determined seasonally and calculated as:

$$\text{GSI} = \frac{\text{gonad weight}}{\text{gutted weight}} \times 100$$

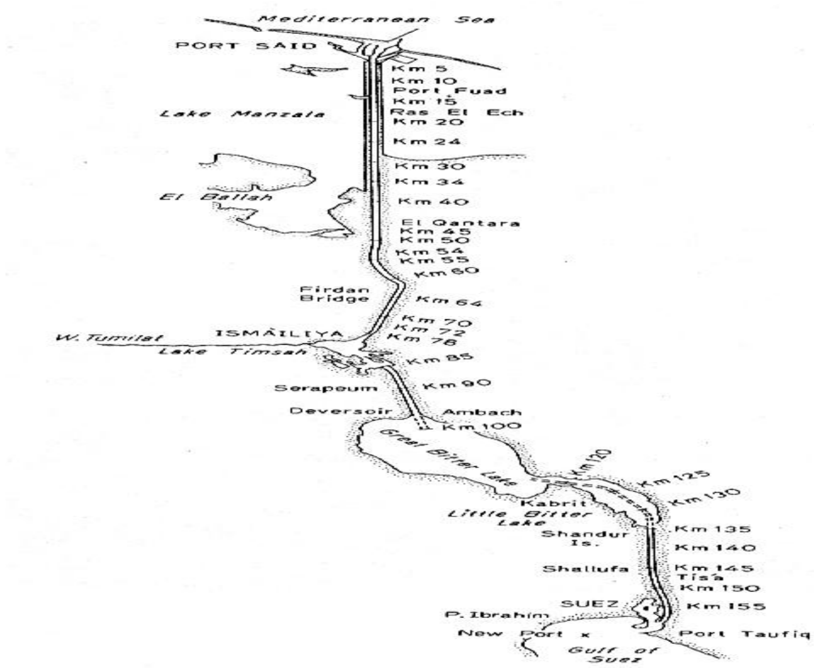

Figure 1: Map of Suez Canal demonstrating Bitter lakes and Temsah Lake

Fish organs (muscles, liver and gonads) were separated and a known weight was digested by conc. HNO_3 in Teflon digestion vessels. Wet digested samples were diluted with deionized distilled water and analyzed, using flame atomic absorption spectrophotometer (Perkin Elmer Model A analyst 100) the obtained data were expressed as µg/g wet weight. The data were statistically analyzed, using computer program.

Results and Discussion

Metals concentration in different fish organs: In fact, Suez Canal environment comprises almost all types of land based sources of pollution and severely affected by most types of pollutants [2]. Metals are the main objective of this study. Tables (1-9) showed the seasonal variations of heavy metals concentrations in muscles, liver and gonad of the fish *Rhabdosargus haffara* collected from Bitter Lakes and Temsah Lake. Distribution of studied heavy metal ions in these organs, muscles showed the lowest values for all studied metals. Annual means of metals (Cu, Zn, Pb, Cd, Fe, Mn, Cr, Ni and Co) in muscles of *Rhabdosargus haffara* from Bitter Lakes were (0.431±0.35, 3.139±0.15, 0.119±0.05, 0.055±0.07, 4.541±0.23, 0.204±0.27, 0.041±0.05, 0.029±0.04 and 0.104±0.05), respectively.

On the other hand, annual mean of heavy metal ions (Cu, Zn, Pb, Cd, Fe, Mn, Cr, Ni and Co) in muscles of *Rhabdosargus haffara* from Temsah Lake were (1.009±0.34, 4.496±0.27, 0.129±0.07, 0.067±0.04, 5.585±0.60, 0.247±0.17, 0.051±0.02, 0.037±0.03 and 0.154±0.07), respectively (Tables 1-9).

Data of the present study indicated that, heavy metal concentrations in *Rhabdosargus haffara* tissues were relatively high in Temsah Lake compared with that of Bitter lakes. This may be due to the heavy pollution that Lake Temsah suffered especially from sewage and agricultural effluent, and consequently had high concentrations of heavy metals.

Hamed (2005)[16] reported that heavy metal concentrations of seawater in Bitter lakes were lower than those found in lake Temsah. El-Moselhy (2006)[10] recorded that Lake Temsah organisms have high concentration of mercury than those in the Bitter lakes. The present results approved that there is an organ-metal-specific accumulation. This pattern is in an agreement with the findings of Fujise *et al.*, (1988), El-Moselhy (1999, 2000), Abd El-Azim (2002) and El-Moselhy and El-Boray (2004) [8,9,10]. Therefore, muscles were selected to discuss the seasonal variation of metals in *Rhabdosargus haffara*.

Seasonally, spring and winter showed higher values of the most studied metals in fish muscles obtained from Bitter lakes except Ni recorded its highest value in spring and summer season. On the other hand in Lake Temsah the highest values of metals in fish muscles were recorded during spring and autumn, respectively. Annual means of metal ion concentrations showed that metals were ordered as follow Cr< Co< Cd< Ni< Pb< Mn< Cu< Zn< Fe (Tables 1-9).

Studied the correlation matrix between metals in different organs of *Rhabdosargus haffara* showed that, there are very highly significant correlations between Cu and Mn (r=0.86), Cd and Zn and Cd and Pb (r=0.78, 0.76, respectively), in muscles of *Rhabdosargus haffara* from Bitter Lakes (Table 10). Moreover, similar significant correlations were found between Mn and Ni, Co (r=0.65 and r=0.77, respectively) and Ni and Co (r= 0.80) in liver of *Rhabdosargus haffara* collected from Bitter Lakes (Table 11), while in gonad of *Rhabdosargus haffara* high significant correlation were found between Zn and Co and Fe and Ni (r=-0.72 and r=0.64, respectively). On the other hand, the correlation matrix between studied metals in muscles of *Rhabdosargus haffara* collected from Lake Temsah recorded high significant correlations between Cd and Mn (r=0.76), Fe and Mn (r=0.73), Cr and Co (r=0.90) (Table 10). Cu and Cd, Co (r=-0.80, and r=-0.74, respectively), Pb and Cd, Ni (r=0.88 and r= -0.67, respectively) showed significant correlations with each other in liver of *Rhabdosargus haffara* collected from (Table 11). Meanwhile, in gonad of *Rhabdosargus haffara* from Lake Temsah, very highly significant correlation between Zn and Mn (r=0.71), Pb and Ni (r=0.71) (Table 12).

Table 1

Seasonal variation of Cu (µg/g) in muscle, liver and gonad of *Rhabdosargus haffara* from Bitter lakes and Temsah Lake during 2010-2011

Season	muscle		liver		gonad	
	Bitter	Temsah	Bitter	Temsah	Bitter	Temsah
Autumn	0.161±0.15	0.919±0.22	2.810±1.15	3.453±1.27	4.858±1.49	5.149±1.95
Winter	0.362±0.23	0.988±0.32	3.923±2.15	4.450±1.06	3.223±1.77	4.165±1.87
Spring	0.717±0.78	1.098±0.28	2.433±0.93	2.759±1.02	3.112±0.95	4.910±1.88
Summer	0.484±0.14	1.030±0.56	3.890±2.20	4.269±2.41	3.337±2.06	3.896±1.16
Annual mean	0.431±0.35	1.009±0.34	3.264±1.61	3.733±1.24	3.633±1.57	4.530±1.75

Table 2: Seasonal variation of Zn (µg/g) in muscle, liver and gonad of *Rhabdosargus haffara* from Bitter lakes and Temsah Lake during 2010-2011

Season	muscle		liver		gonad	
	Bitter	Temsah	Bitter	Temsah	Bitter	Temsah
Autumn	1.848±0.14	4.583±0.29	8.098±0.13	8.922±0.79	8.555±0.82	9.268±0.57
Winter	5.081±0.24	5.481±0.22	9.459±0.45	9.894±0.43	10.073±0.48	10.172±0.29
Spring	2.531±0.12	3.907±0.23	7.441±0.12	7.539±0.39	8.021±0.35	9.760±0.34
Summer	3.098±0.23	4.015±0.35	6.091±0.13	6.231±0.21	7.504±0.20	8.123±0.17
Annual mean	3.139±0.15	4.496±0.27	7.772±0.25	8.147±0.45	8.538±0.45	9.335±0.39

Table 3: Seasonal variation of Pb (µg/g) in muscle, liver and gonad of *Rhabdosargus haffara* from Bitter lakes and Temsah Lake during 2010-2011

Season	muscle		liver		gonad	
	Bitter	Temsah	Bitter	Temsah	Bitter	Temsah
Autumn	0.102±0.01	0.107±0.02	0.105±0.03	0.119±0.04	0.123±0.07	0.132±0.03
Winter	0.136±0.06	0.152±0.04	0.146±0.09	0.155±0.02	0.163±0.01	0.169±0.07
Spring	0.128±0.09	0.134±0.04	0.139±0.09	0.142±0.03	0.143±0.03	0.154±0.05
Summer	0.113±0.05	0.122±0.06	0.132±0.05	0.135±0.03	0.139±0.01	0.147±0.01
Annual mean	0.119±0.05	0.129±0.07	0.131±0.07	0.138±0.05	0.142±0.06	0.151±0.06

Table 4: Seasonal variation of Cd (µg/g) in muscle, liver and gonad of *Rhabdosargus haffara* from Bitter lakes and Temsah Lake during 2010-2011

Season	Muscle		liver		gonad	
	Bitter	Temsah	Bitter	Temsah	Bitter	Temsah
Autumn	0.019±0.08	0.033±0.02	0.042±0.03	0.056±0.01	0.077±0.04	0.081±0.01
Winter	0.074±0.07	0.095±0.04	0.092±0.07	0.103±0.02	0.120±0.03	0.136±0.03
Spring	0.079±0.05	0.088±0.03	0.091±0.01	0.097±0.04	0.104±0.06	0.113±0.02
Summer	0.049±0.09	0.052±0.07	0.072±0.09	0.087±0.05	0.092±0.04	0.107±0.09
Annual mean	0.055±0.07	0.067±0.04	0.074±0.04	0.086±0.03	0.098±0.04	0.109±0.03

Table 5: Seasonal variation of Fe (µg/g) in muscle, liver and gonad of *Rhabdosargus haffara* from Bitter lakes and Temsah Lake during 2010-2011

Season	muscle		liver		gonad	
	Bitter	Temsah	Bitter	Temsah	Bitter	Temsah
Autumn	3.066±0.22	5.035±1.02	8.152±0.45	10.339±0.69	9.138±0.29	11.680±0.52
Winter	6.284±0.24	6.824±0.23	9.864±0.81	12.982±0.15	10.800±0.38	12.718±0.41
Spring	3.511±0.16	4.748±0.93	7.085±0.51	9.749±0.96	7.914±0.43	10.460±0.62
Summer	5.302±0.32	5.732±0.22	8.212±0.35	9.497±0.56	8.709±0.49	10.016±0.50
Annual mean	4.541±0.23	5.585±0.60	8.328±0.53	10.642±0.59	9.140±0.39	11.219±0.51

Table 6: Seasonal variation of Mn (µg/g) in muscle, liver and gonad of *Rhabdosargus haffara* from Bitter lakes and Temsah Lake during 2010-2011

Season	muscle		liver		gonad	
	Bitter	Temsah	Bitter	Temsah	Bitter	Temsah
Autumn	0.153±0.13	0.199±0.11	0.249±0.13	0.377±0.29	0.293±0.05	0.389±0.21
Winter	0.246±0.23	0.292±0.15	0.305±0.29	0.413±0.29	0.336±0.18	0.512±0.18
Spring	0.190±0.21	0.239±0.14	0.261±0.17	0.376±0.19	0.273±0.09	0.479±0.15
Summer	0.227±0.31	0.256±0.12	0.269±0.12	0.366±0.11	0.275±0.14	0.445±0.17
Annual mean	0.204±0.27	0.247±0.17	0.271±0.18	0.383±0.26	0.294±0.13	0.456±0.15

Table 7: Seasonal variation of Cr (µg/g) in muscle, liver and gonad of *Rhabdosargus haffara* from Bitter lakes and Temsah Lake during 2010-2011

Season	muscle		liver		gonad	
	Bitter	Temsah	Bitter	Temsah	Bitter	Temsah
Autumn	0.020±0.05	0.039±0.03	0.019±0.02	0.027±0.03	0.041±0.02	0.062±0.06
Winter	0.059±0.07	0.062±0.06	0.071±0.09	0.079±0.07	0.087±0.04	0.096±0.03
Spring	0.047±0.09	0.055±0.04	0.050±0.04	0.067±0.01	0.073±0.02	0.083±0.02
Summer	0.039±0.06	0.046±0.01	0.043±0.03	0.051±0.05	0.065±0.03	0.073±0.01
Annual mean	0.041±0.05	0.051±0.02	0.046±0.05	0.056±0.06	0.067±0.03	0.079±0.05

Table 8: Seasonal variation of Ni (µg/g) in muscle, liver and gonad of *Rhabdosargus haffara* from Bitter lakes and Temsah Lake during 2010-2011

Season	muscle		liver		gonad	
	Bitter	Temsah	Bitter	Temsah	Bitter	Temsah
Autumn	0.015±0.05	0.019±0.01	0.019±0.01	0.035±0.03	0.049±0.07	0.063±0.03
Winter	0.041±0.02	0.053±0.04	0.043±0.03	0.062±0.04	0.063±0.01	0.083±0.06
Spring	0.035±0.06	0.042±0.03	0.046±0.02	0.053±0.03	0.054±0.09	0.077±0.04
Summer	0.027±0.03	0.034±0.02	0.029±0.01	0.043±0.02	0.045±0.03	0.061±0.02
Annual mean	0.029±0.04	0.037±0.03	0.034±0.02	0.048±0.03	0.053±0.05	0.071±0.04

Table 9: Seasonal variation of Co (µg/g) in muscle, liver and gonad of *Rhabdosargus haffara* from Bitter lakes and Temsah Lake during 2010-2011

Season	muscle		liver		gonad	
	Bitter	Temsah	Bitter	Temsah	Bitter	Temsah
Autumn	0.019±0.01	0.080±0.03	0.035±0.01	0.091±0.02	0.083±0.02	0.105±0.07
Winter	0.128±0.04	0.214±0.02	0.150±0.05	0.183±0.04	0.193±0.08	0.219±0.11
Spring	0.148±0.08	0.189±0.06	0.157±0.05	0.161±0.06	0.174±0.03	0.202±0.13
Summer	0.121±0.06	0.133±0.09	0.140±0.06	0.169±0.03	0.179±0.03	0.217±0.07
Annual mean	0.104±0.05	0.154±0.07	0.121±0.04	0.151±0.04	0.157±0.04	0.186±0.09

Table 10
Correlation between the different measured metals in muscles of *Rhabdosargus haffara* collected from Bitter lakes and Lake Temsah during 2010-2011

		Cu	Zn	Pb	Cd	Fe	Mn	Cr	Ni	Co
Bitter Lakes	Cu	1.00								
	Zn	-0.45	1.00							
	Pb	0.61	-.44	1.00						
	Cd	-0.36	0.78	-0.76	1.00					
	Fe	-0.13	0.56	0.10	0.09	1.00				
	Mn	0.86	-0.45	0.75	-0.52	-0.06	1.00			
	Cr	0.27	0.31	0.60	-0.02	0.40	0.25	1.00		
	Ni	-0.45	-0.04	0.42	0.46	0.31	0.17	0.36	1.00	
	Co	-0.27	0.37	0.40	-0.16	0.70	-0.16	0.72	0.74	1.00
Lake Temsah	Cu	1.00								
	Zn	-0.31	1.00							
	Pb	-0.18	-0.40	1.00						
	Cd	0.42	-0.20	-0.21	1.00					
	Fe	0.01	0.37	-0.22	0.58	1.00				
	Mn	0.28	0.18	-0.13	0.76	0.73	1.00			
	Cr	0.50	-0.05	-0.01	0.08	-0.55	0.02	1.00		
	Ni	0.19	-0.01	-0.52	0.55	-0.01	0.05	0.35	1.00	
	Co	0.26	-0.05	0.27	0.04	-0,52	-0.02	0.90	0.25	1.00

Table 11
Correlation between the different measured metals in liver of collected from Bitter lakes and Lake Temsah during 2010-2011

		Cu	Zn	Pb	Cd	Fe	Mn	Cr	Ni	Co
Bitter Lakes	Cu	1.00								
	Zn	-0.54	1.00							
	Pb	-0.31	0.25	1.00						
	Cd	-0.58	0.02	-0.05	1.00					
	Fe	0.01	0.06	-0.13	0.48	1.00				
	Mn	-0.21	0.11	-0.16	0.48	0.23	1.00			
	Cr	0.30	-0.35	-0.33	-0.32	-0.60	-0.17	1.00		
	Ni	-0.20	0.44	-0.02	0.00	0.07	0.65	0.00	1.00	
	Co	-0.12	0.27	-0.06	-0.10	-0.11	0.77	-0.02	0.80	1.00
Lake Temsah	Cu	1.00								
	Zn	-0.08	1.00							
	Pb	-0.66	-0.28	1.00						
	Cd	-0.80	-0.17	0.88	1.00					
	Fe	0.12	0.24	-0.26	-0.12	1.00				
	Mn	-0.62	-0.18	0.76	0.79	-0.38	1.00			
	Cr	0.35	0.66	-0.42	-0.33	-0.12	-0.23	1.00		
	Ni	0.64	-0.01	-0.67	-0.59	0.54	-0.65	0.13	1.00	
	Co	-0.74	0.34	0.51	0.57	0.14	0.37	-0.35	-0.57	1.00

Table 12
Correlation between the different measured metals in gonad of collected from Bitter lakes and Lake Temsah during 2010-2011

		Cu	Zn	Pb	Cd	Fe	Mn	Cr	Ni	Co
Bitter Lakes	**Cu**	1.00								
	Zn	-0.30	1.00							
	Pb	-0.34	0.57	1.00						
	Cd	-0.39	-0.12	0.02	1.00					
	Fe	0.12	0.42	-0.07	-0.49	1.00				
	Mn	0.22	0.23	0.39	-0.19	-0.51	1.00			
	Cr	0.29	-0.56	-0.22	0.22	-0.23	-0.23	1.00		
	Ni	0.50	-0.04	-0.27	-0.22	0.64	-0.49	-0.02	1.00	
	Co	-0.14	-0.72	-0.34	0.12	-0.54	0.06	0.17	-0.35	1.00
Lake Temsah	**Cu**	1.00								
	Zn	-0.29	1.00							
	Pb	0.34	-0.34	1.00						
	Cd	-0.07	-0.47	-0.37	1.00					
	Fe	0.15	-0.54	-0.01	0.62	1.00				
	Mn	0.15	0.71	-0.53	-0.25	-0.38	1.00			
	Cr	0.20	0.32	-0.26	0.31	-0.01	-0.53	1.00		
	Ni	0.63	-0.42	0.71	-0.49	-0.01	-0.22	-0.26	1.00	
	Co	0.59	-0.13	-0.06	-0.33	-0.01	0.35	0.07	0.64	1.00

This means that, the factors which are responsible for the presence these metals in seawater are similar, whether coming from land activities or naturally as background level. Similar highly significant correlations were recorded between Fe, Mn, Zn and Cu in different marine environment[4].
Levels of the studied metals in the muscle tissues are below WHO limits (FAO, 1992) which were Cu= 30.0, Zn= 1000, Pb= 2.0 and Cd= 2.0 µg/g.

Gonad maturation

In the present study, macroscopically examination was carried out for S. rivulatus and showed the following maturity stages: 1- dormant, 2- Prespawning, 3- spawning and 4- post spawning.

1- Dormant stage: Testes are thin, flaccid, grayish and sometimes with white areas. Ovaries are thin, flaccid, congested and sometimes contain large opaque-yellow residual eggs. This stage was reported in summer.

2- Prespawning: According to their morphology males and females were easily distinguished by the naked eye. Testes are thickened, opaque, filling two thirds of the body cavity, with creamy white color and smooth texture. Ovaries are more rounded, translucent, thickened and large eggs extruded by pressure on abdominal wall. This stage was found in autumn.

3- Spawning: Testes fill the body cavity, pure white, smooth texture and milt extruded by pressure on abdominal wall. Ovaries show somewhat shrinkage due to discharge of a considerable amount of eggs. This stage was obtained in winter.

4- Post spawning: Testes are thin, flaccid, grayish and sometimes with white areas (residual sperms). Ovaries are thin, flaccid, congested and sometimes contain large opaque-yellow residual eggs. This stage was reported in spring.

The monthly changes of maturity stages value of male *R. haffara* are shown in Figures (2-10). The maturity stages showed no obvious changes during summer. A slightly increase observed in autumn. Maximum increase (spawning season) occurred during winter. A significant decrease occurred in spring [7] ($P< 0.05$). These results agree with that of Ibrahim, 1999 [19] on *R. haffara* in the South Sinai and also with that of Abdalah and Faltas, 1998 and Elboray, 2004 [1,4].

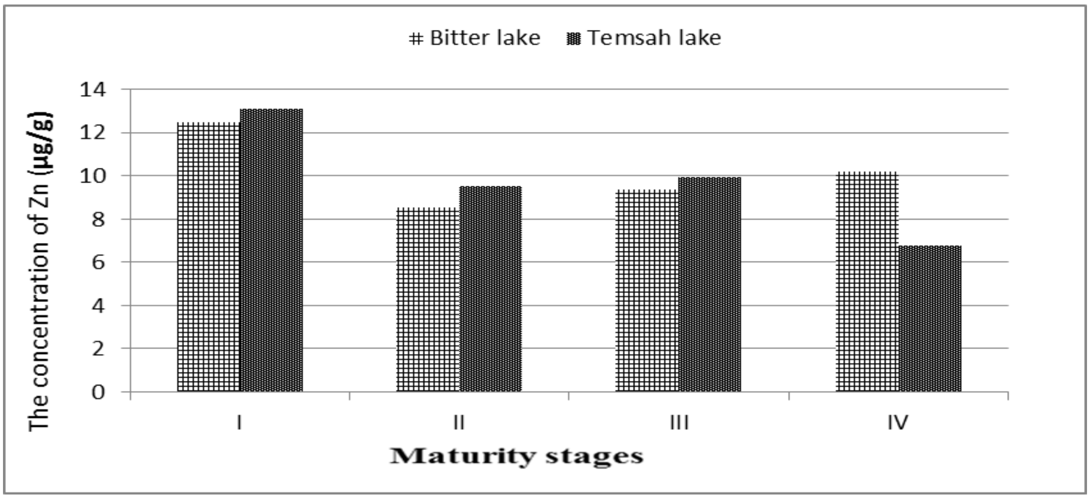

Figure 2: Relation between the concentration of Cu (µg/g) and the maturity stages

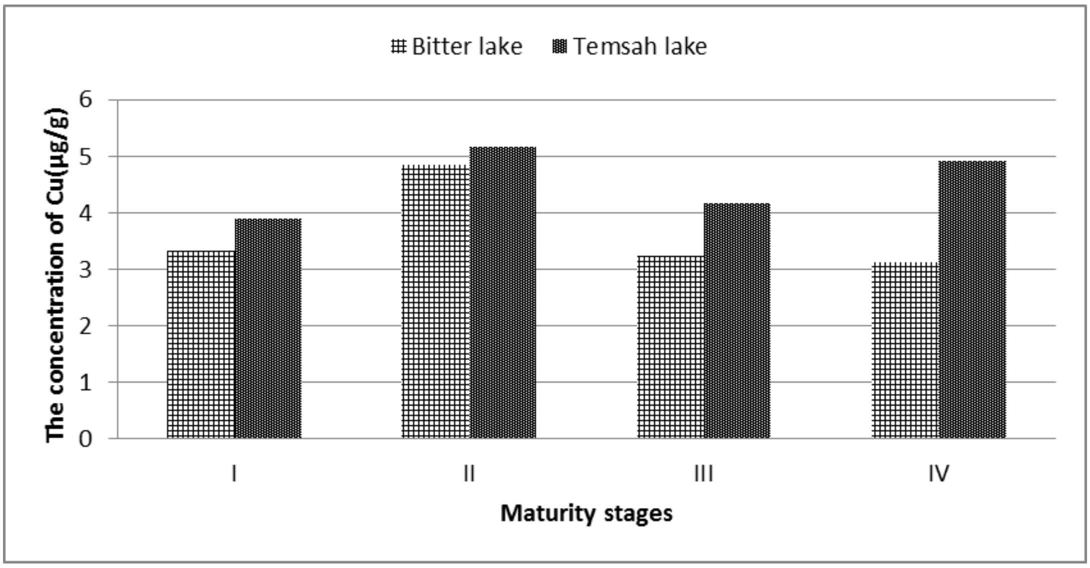

Figure 3: Relation between the concentration of Z (µg/g) and the maturity stages

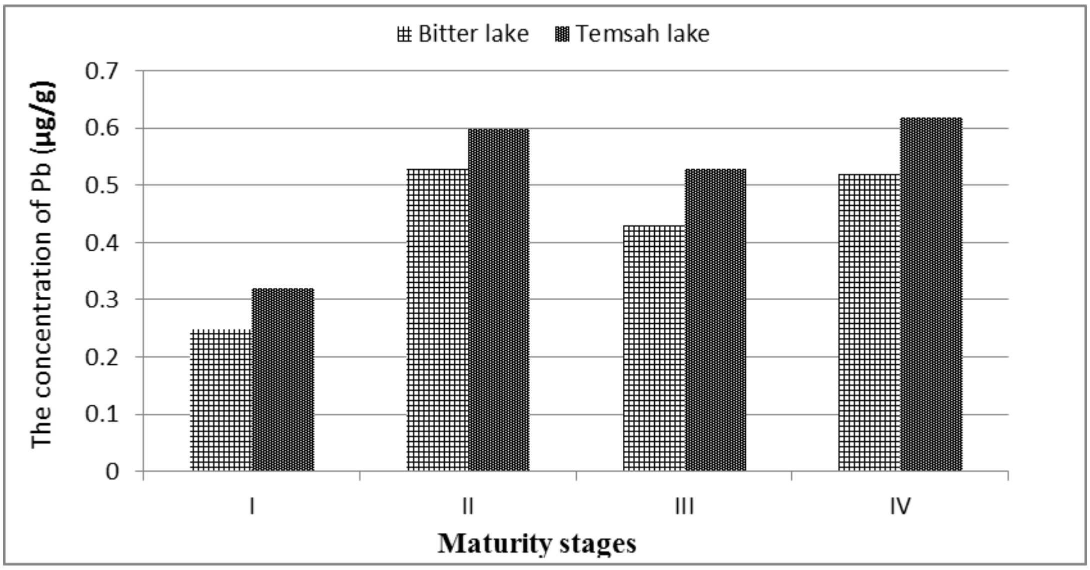

Figure 4: Relation between the concentration of Pb (µg/g) and the maturity stages

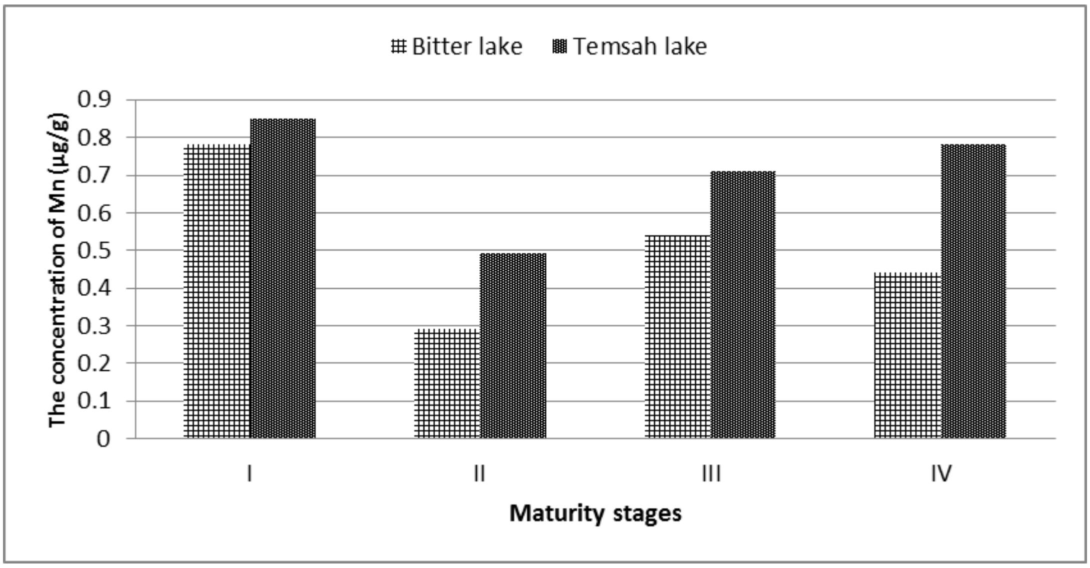

Figure 5: Relation between the concentration of Cd (µg/g) and the maturity stages

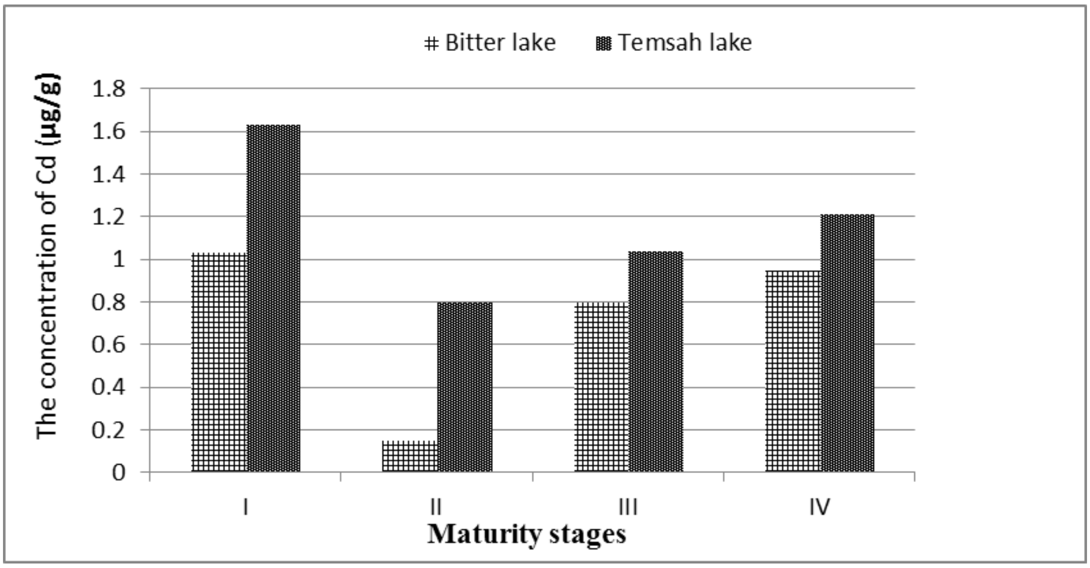

Figure 6: Relation between the concentration of Fe (µg/g) and the maturity stages

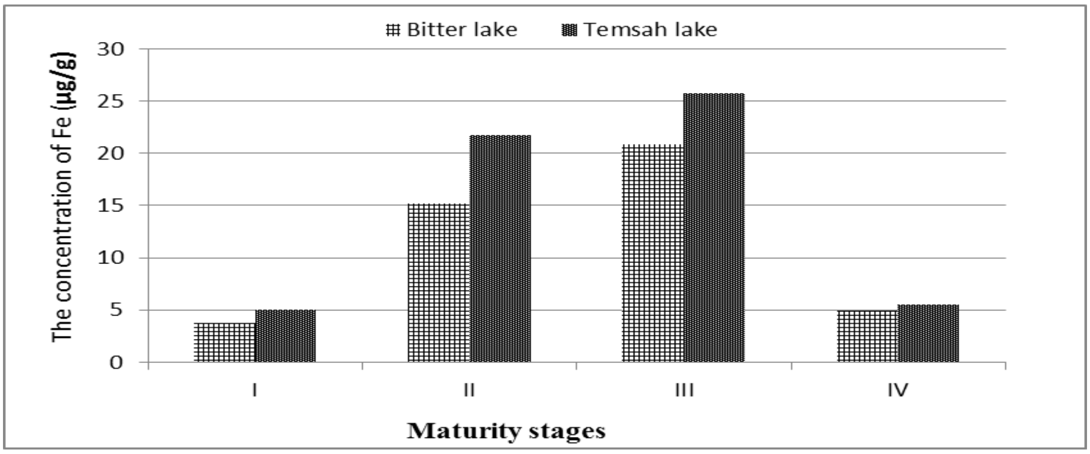

Figure 7: Relation between the concentration of Mn (µg/g) and the maturity stages

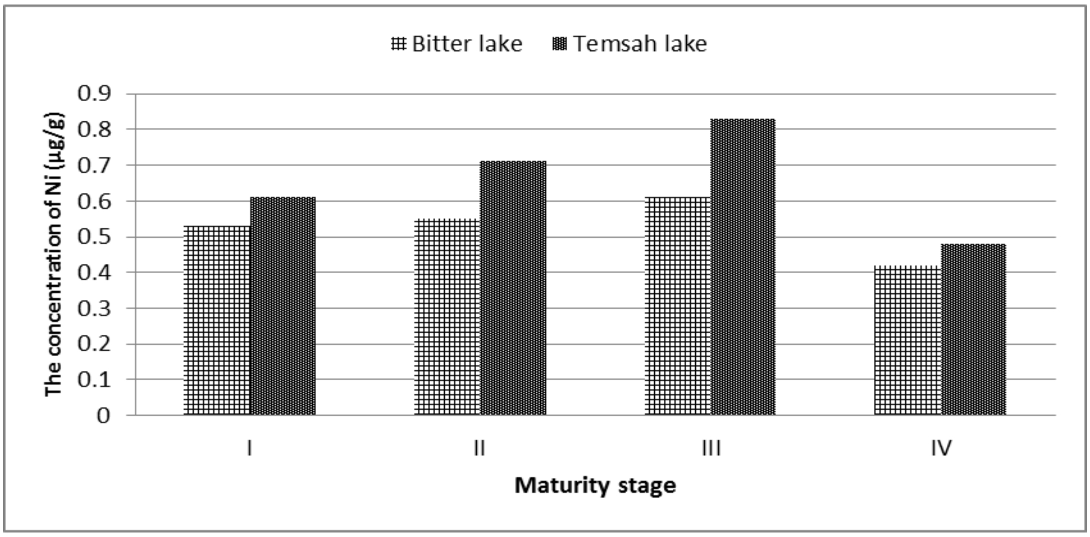

Figure 8: Relation between the concentration of Cr (µg/g) and the maturity stages

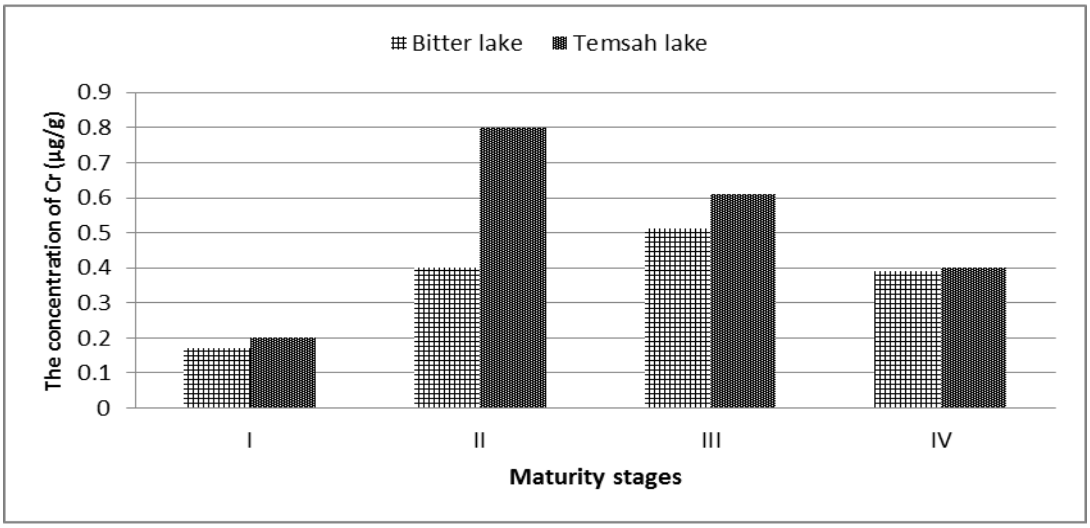

Figure 9: Relation between the concentration of Ni (µg/g) and the maturity stages

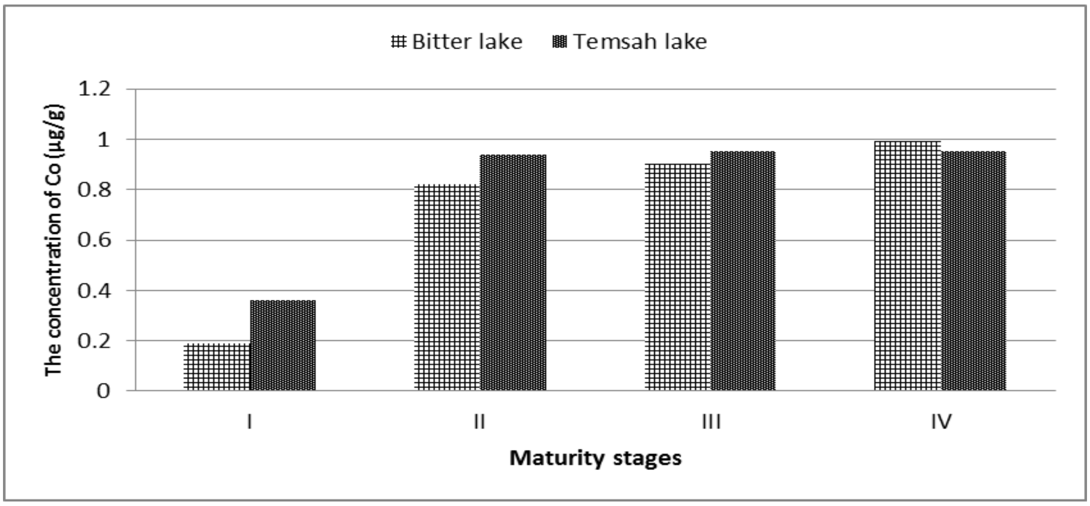

Figure 10: relation between the concentration of Co (µg/g) and the maturity stages

Relation between heavy metals and gonad maturation

Tables (1-9) showed the variation of metals content in the fish gonads according to changes in level of GSI, which mainly represent the maturity stages. In fish from Bitter lakes and Temsah Lake, Zn exhibited highest level in the dormant stage and post spawning stage, while Fe metal appeared in the pre spawning and spawning stages. In contrast, the lowest concentration of metals varying according to maturity stages where Cr in stage I, Cd & Mn in stage II, Pb in stage III and Ni in stage IV in Bitter lakes and Temsah Lake. The concentration of metals in male fish fluctuated during the reproductive cycle for all studied organs.

Heavy metals may insert their deleterious effects on fish reproduction and gamete development via disruption of the endocrine system and the inhibition of hormone production, such as disruption of hypothalamic-pituitary system [20]. Low levels of Pb pollution could cause some adverse effects on fish health and reproduction[5]. Lamb, (1983) and Heath, (1987)[17,21] reported that reproductive cycles does not appear to be the cause of the observed variation of metals concentration in the tissues. Sindhe and Kulkarni (2004)[25] demonstrated that liver forms important organ of the body, which has a role in the ovarian development. On exposure to heavy metals at sublethal concentration both GSI (gonadosomatic index) and HSI (hepatosomatic index) are reduced.

Metallothionein (MT) plays an important role in metal regulation in fish. Its main functions are detoxification of non-essential metals, like Cd and Hg and maintenance of the homeostasis as a function of the reproductive status of Zn and Cu [24]. The concentration of hepatic MT in fish fluctuates as a function of reproductive status for Zn and Cu, since these elements are essential cofactors of many enzymes involved in the synthesis of DNA, RNA and proteins [22,23]. In the present study, Zn in gonads of *R. haffara* recorded the highest concentration. This means that such metals play an important role in gonadal development.

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