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Impact of Water Temperature and Salinity on the Distribution and Abundance of Shrimp (Crustacean: Decapoda) at Lake Burullus, Egypt

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Abstract: The impact of water temperature and salinity on the abundance and distribution of shrimp in Lake Burullus, Egypt was studied at 7 selected sites during the period from January to December 2015. The shrimp in Lake Burullus during this work is represented by three species (*Metapenaeus stebbingi, M. monoceros* and *Penaeus semisulcatus*). They dominated by *P. semisulcatus* being constituted 51% of the annual mean of shrimp number while *M. monoceros* came to the second which represent 35%, at the same time the *M. stebbingi* was occupied the third status by 14%. *P. semisulcatus* and *M. monoceros* appeared in the period between (September and December) while species *M. stebbingi* was collected during the period between (April and June). Regarding sites, the shrimp present in sites 1, 2, 3, 4, 5 and 6 but they absent at site 7. The highest annual mean of shrimp density was 872.50 ± 372.45 Ind./CPUE/ 12h but the lowest annual one was 230.17 ± 84.03 Ind./CPUE/ 12h. Monthly, the maximum mean of shrimp number was 2209.67 ± 522.40 Ind./CPUE/12h during October, but the minimum one was 195 ± 86.25 Ind./CPUE/12h in June with an annual mean being 460.54 ± 195.15Ind./CPUE/ 12h. During this work, temperature has positive correlation with non-significant effect on the collected species ($P>0.05$), while the relation between the abundance of all collected species and salinity was positively significant relationship ($P<0.05$).

Keywords: Lake Burullus, Salinity, Temperature, Shrimp, Abundance

1. Introduction

Lake Burullus is shallow slightly brackish water situated along the Egyptian Mediterranean Sea coasts [1, 2]. It occupies an area of about 455.3346 km² (108,413 feddans) till 2015, the length of the lake about 51.52 km, its width ranged between 5.52 and 15.89 km with an average 10.705 km and it has water depth 0.8 m. to 2.5 m., the depth increases from east to west [3]. In Egypt, the majority of shrimp fisheries production consists of small species (*Metapenaeus stebbingi, Trachypenaeus curvirostris, Parapenaeus longirostris and Solenocera crassicornis*), while larger sized species (*P. japonicus, P. semisulcatus, P. kerathurus, P. latisulcatus and Metapenaeus monoceros*) are caught only in small quantities [4]. According to [3], the economic crustacean production from Lake Burullus is restricted to the saline water which represented as shrimp about 92% of the total production of the northern lakes and about 5% of total Lake Burullus production. Temperature and salinity are the most important abiotic factors affecting the growth and survival of aquatic organisms [5]. The present work was conducted to study the effect of the water temperature and salinity on the abundance and occurrence of shrimp.

2. Material and Methods

2.1. Study Area

Lake Burullus lies between longitude 30º 33`–31º 07` E and latitude 31º 22`–31º 26` N. and, it lies on the eastern side of the Rosetta branch of the River Nile, Egypt about 60 km east of Rosetta and 70 km west of Damietta Branch [2]. While the Northern shore of the lake is sandy, the southern one is largely muddy [6]. The lake is connected to the sea through a narrow (171 m width) passage called Al-Burg Inlet or Boughaz Al-Burullus [3].

2.2. Sampling

The samples (shrimp and water) were collected monthly during one year from January to December 2015 at 7 selected sites

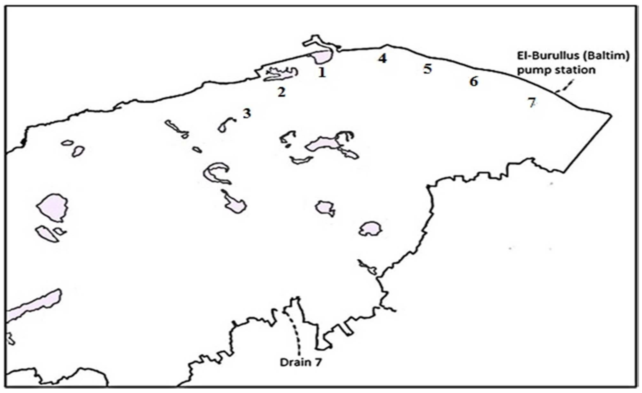

Figure 1. *The samples collection sites at the eastern portion of Lake Burullus.*

Table 1. *The sample collection sites, Longitude and Latitude of Lake Al-Burullus, Egypt.*

Sites No	Sample collection sites	Longitude	Latitude
Site No 1	1 km western Boughaz Al-Burullus	30°58'23.59 east	31°33'59.79 north
Site No 2	3 km western Boughaz Al-Burullus	30°57'20.51 east	31°33'22.10 north
Site No 3	5 km western Boughaz Al-Burullus	30°56'11.54 east	31°32'50.31 north
Site No 4	1 km eastern Boughaz Al-Burullus	30°59'28.02 east	31°34'14.20 north
Site No 5	3 km eastern Boughaz Al-Burullus	31°0'42.95 east	31°34'2.85 north
Site No 6	5 km eastern Boughaz Al-Burullus	31°2'3.49 east	31°33'41.71 north
Site No 7	Opposite Al-Burullus (baltim) water pump station	31°4'18.42 east	31°33'6.59 north

2.3. Shrimp Samples

The samples were collected at depth range between 1 –2 m at night during 12-hour sampling period (from 5 pm to 5 am) because the shrimp is nocturnal, the fishing was occurred by fisherman engaged the lake which uses special methods called Al – Dewar. Al – Dewar is a small mesh size net with 10 m long and fixed to the bottom by reed pieces it is a bridge from the nets and one pocket at each side being 1m in diameters. For some months, the sampling was suspended during summer at high temperature and winter at low temperature. Large individuals were kept in plastic container containing 10% formalin solution with label provided with date and place of collection then transported to the laboratory for identification.

2.4. Water Samples

The water samples were collected directly from the water surface.

Temperature (°C) and Salinity (ppt) were determined by YSI-Operations Manual Eco Sense Portable Conductivity, Salinity and Temperature Instrument. Model: EC300A, Serial NO: JC00293.

2.5. Identification and Classification of the Species

Shrimp species were identified according to [7, 8, and 9].

2.6. Statistical Analysis

The correlations between environmental variables and species abundance were tested by the Pearson correlation test. The association between the abundance of shrimp collected and the physicochemical parameters was evaluated separately for each parameter and species using simple regression analysis with a significance level of 5%. Abundance data were log-transformed for the analysis, to improve their normality. Data handling and refinement carried out using Microsoft Excel 2013.

Diversity (H) (Shannon and Wiener, 1963) [10] was used to estimate the community structure. It was sampling station with the Prima 5 Statistical Package Program.

2.6.1. Shannon Index (H)

The most widely used index of heterogeneity was calculated by the following formula:

$$H=3.3219\ [\log N-(1/N)\ \Sigma\ n_i \log n_i]\ [11]$$

Where, N=Total number of individuals of all species and ni=Number of individuals of a species.

2.6.2. Alpha Index

Number of species/unit area

2.6.3. The Evenness Index (E)

Was calculated according to the following formula:

$$E=H/S\ [12]$$

Where, H=Shannon index and S=Number of species.

2.6.4. Species Richness (D)

Was calculated according to the following formula:

$$D=S-1\ /Ln\ N\ [13]$$

Where, S=Total number of species and N=Total number of individual in the sample.

2.6.5. Similarity Index

Percentage of similarity between different sites was calculated by the following equation:

Kulczynski coefficient=1/2 [(S/(S+U)) + (S/(S+V))] * 100

Where, S=Number of species common in both sites (A and B), U=Number of species found in A and absent in B and V=Number of species found in B and absent in A.

3. Results

3.1. Temperature

Table (2) showed that, its maximum mean (33.16 ± 0.17°C) was measured in July, but the minimum one occurred in January (13.73 ± 0.17°C) while its annual mean was 25.13 ± 1.95°C. Regarding sites, its maximum annual mean (25.44 ± 1.92°C) was recorded at site 3, but the minimum one (24.88 ± 1.86°C) occurred at site 1.

Table 2. *Variations of water temperature (ºC) recorded in the studied sites during the period from January to December 2015 at Lake Burullus Egypt.*

Sites / Months	1	2	3	4	5	6	7	Mean ± S. E
Jan	13.1	13.6	14.2	13.5	13.2	14.5	14	**13.73 ± 0.17**
Feb	15.1	14.6	15.2	14.5	14.2	13.5	15	**14.59 ± 0.20**
Mar	17.1	16.4	17.2	17.5	17.2	16.5	16	**16.84 ± 0.18**
Apr	25	25.2	25.1	24	25	25	25	**24.90 ± 0.13**
May	27.1	26.6	26.3	27.5	27.2	27.5	27.1	**27.04 ± 0.15**
Jun	30.5	31	31	29.5	31	31	31	**30.71 ± 0.19**
Jul	32.1	33.6	33.2	33.5	33.2	33.5	33	**33.16 ± 0.17**
Aug	32.1	33	33.3	32.5	33.2	33.5	34.1	**33.10 ± 0.21**
Sep	28.9	29.8	29.5	29.5	28.2	29.5	28.5	**29.13 ± 0.20**
Oct	26.1	26.5	28.2	26.5	27.2	27.5	29	**27.29 ± 0.34**
Nov	26.9	27	28	28	26.9	27.5	28.1	**27.49 ± 0.18**
Dec	24.5	23.1	24.1	23.5	23.5	24.1	22.3	**23.59 ± 0.24**
Mean ± S. E	**24.88±1.86**	**25.03± 1.99**	**25.44 ± 1.92**	**25.00 ± 1.92**	**25.00 ±1.97**	**25.30 ± 2.01**	**25.26 ± 2.01**	**25.13 ± 1.95**

3.2. Salinity

Table (3) showed that, its maximum mean (15.65 ± 2.36 ppt) was recorded at February while the minimum one (3.29 ± 0.19 ppt) was measured at August with an annual mean being 11.44 ± 0.99 ppt. Regarding sites, its maximum mean was 18.83 ± 2.01 ppt at site 4 while the minimum one was 3.65 ± 0.18 ppt at site 7.

Table 3. *Variations of salinity (ppt) recorded in the studied sites during the period from January to December 2015 at Lake Burullus Egypt.*

Sites / Months	1	2	3	4	5	6	7	Mean ± S. E
Jan	10.9	6.5	5.1	21.2	7.41	7.5	4	**8.94 ± 1.91**
Feb	25.9	16.5	12.21	23.2	15.41	11.7	4.6	**15.65 ± 2.36**
Mar	17.9	14.5	12.1	23.2	11.41	10.5	4.3	**13.42 ± 1.96**
Apr	13	11.5	10.2	10.1	10.4	8	2.6	**9.40 ± 1.10**
May	24.1	12.5	12.1	26.2	15.41	11.5	3.52	**15.05 ± 2.56**
Jun	17	13.6	10.5	22	14.3	12.2	3.7	**13.33 ± 1.85**
Jul	10.9	6.5	5.1	23.2	7.41	7.5	4	**9.23 ± 2.14**
Aug	3.2	3.1	3.1	3.6	2.41	3.3	4.3	**3.29 ± 0.19**
Sep	19.8	13.2	11.2	24	15.2	10.2	2.6	**13.74 ± 2.27**
Oct	17.9	15.5	10.1	21.1	10.3	11.5	3.2	**12.80 ± 1.93**
Nov	13.6	11.8	10.8	11	12	10.2	3.4	**10.40 ± 1.07**
Dec	15.2	12.2	11.6	17.2	13.2	10.98	3.6	**12.00 ± 1.40**
Mean ± S. E	**15.78 ± 1.78**	**11.45 ± 1.17**	**9.51 ± 0.92**	**18.83 ± 2.01**	**11.24 ± 1.15**	**9.59 ± 0.74**	**3.65 ± 0.18**	**11.44 ± 0.99**

3.3. Shrimp Composition and Abundance

The shrimp in Lake Burullus at the present work are represented by three species (*Metapenaeus stebbingi, M. monoceros* and *Penaeus semisulcatus*). They dominated by *P. semisulcatus* which constituted 51% of the annual mean of shrimp number while *M. monoceros* came to the second which represent 35% of the annual mean of shrimp number at the same time the *M. stebbingi* was occupied the third status of the annual mean of shrimp number by 14% (Fig 2).

Table (4) indicated that, during this study site 1 showed the highest annual mean of shrimp number being 872.58 ± 372.45 Ind./CPUE/12h and ranged between 447 Ind./CPUE/12h during April and 4425 Ind./CPUE/12h in October respectively. However, the lowest annual mean was recorded in site 3 being 230.17 ± 84.03 Ind./CPUE/12h, the shrimp number of this site ranged from (41 Ind./CPUE/12h) in June and (747 Ind./CPUE/12h) during November respectively. With regard to sites 7 the shrimp was absent. Monthly, the shrimp occurred during the periods from April to June and from September to December but it absents during the periods from January to March and from July to august. The maximum mean of shrimp number was 2209.67

± 522.40 Ind./CPUE/12h during October, but the minimum one was 195 ± 86.25 Ind./CPUE/12h in June with an annual mean being 460.54 ± 195.15 Ind./CPUE/12h.

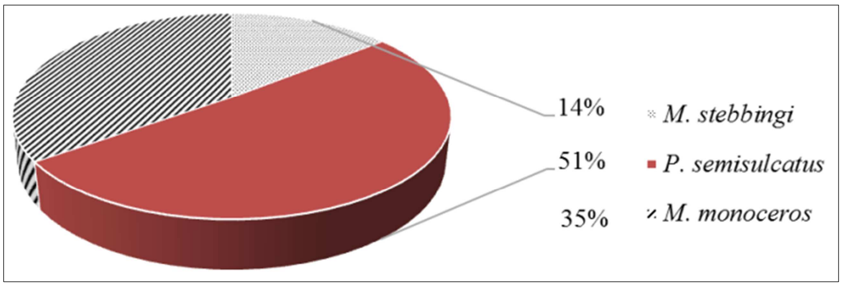

Figure 2. *The percentage of different shrimp species that collected during the period from January to December 2015.*

Table 4. *The shrimp abundance (Ind. / CPUE/12h) collected from the studied sites at AL- Burullus Lake during the period from January to December 2015.*

Sites / Months	1	2	3	4	5	6	7	Mean± S. E
Jan	0	0	0	0	0	0	0	**0.00**
Feb	0	0	0	0	0	0	0	**0.00**
Mar	0	0	0	0	0	0	0	**0.00**
Apr	447	202	217	176	262	66	0	**228.33±51.27**
May	717	235	163	327	533	205	0	**363.33±88.86**
Jun	600	223	41	172	41	93	0	**195±86.25**
Jul	0	0	0	0	0	0	0	**0.00**
Aug	0	0	0	0	0	0	0	**0.00**
Sep	1581	751	607	1928	1000	747	0	**1102.33±217.28**
Oct	4425	2082	692	2550	2218	1291	0	**2209.67±522.40**
Nov	1919	864	747	973	1052	776	0	**1055.17±179.11**
Dec	782	261	295	530	224	144	0	**372.67±97.50**
Mean ± S. E	**872.58 ± 372.45**	**384.83 ± 175.85**	**230.17 ±84.03**	**554.67 ± 244.99**	**444.17 ± 195.85**	**276.83 ± 122.45**	**0.00**	**460.54 ± 195.15**

CPUE=catch per unit effort

3.4. Distribution of Shrimp Species

Table (5) showed that *M. stebbingi* was present in the period from April to June but *P. semisulcatus* and *M. monoceros* present in the period from September to December respectively. All shrimp species absent in the periods from January to March at the mean water temperature ranged between 13.73 –16.84°C and from July to august where it ranged between 33.10–33.16°C.

Table 5. *The occurrence and abundance of the three-shrimp species in the investigated area during 2015 at Lake Burullus.*

Months / Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
M. stebbingi	-	-	-	+	+++	++	-	-	-	-	-	-
P. semisulcatus	-	-	-	-	-	-	-	-	++	++++	++	+
M. monoceros	-	-	-	-	-	-	-	-	++	++	++	+

(- absent, + low, ++ medium, +++ a lot, ++++ dominated)

Regarding sites, all species were collected at sites 1, 2, 3, 4, 5 and 6 with different abundance but they were absent in sites 7 Table (6)

Table 6. *The occurrence of the three-shrimp species at the investigated sites during 2015 at Lake Burullus.*

Sites / Species	1	2	3	4	5	6	7
M. Monacrous	+++	++	+	++	++	+	-
P. semisulcatus	++++	+++	+	++++	++	++	-
M. stabbing	++++	+	+	++	++	+	-

(- absent, + low, ++ medium, +++ a lot, ++++ dominated)

3.5. Ecological Indices as a Function on Shrimp Diversity

Table (7) indicated that, the number of species were three species in all sites. The index of richness was found to be varied between 0.22 in site 1 and 0.25in sites 3 and 6. The results of Evenness index analysis showed that the value was almost very close to all sites (around 0.9). The lowest value of Shannon species diversity index in sites 4 was 0.94, but the highest one was in sites 5 being 1.02. For Alpha diversity index the value was the lowest at site 1 being 0.29 while the highest index value was found in site 3 being 0.33. For the rest of the sites the value of Alpha diversity index ranged between 0.30 and 0.32.

Table 7. *The diversity indices between the different sites surveyed in AL- Burullus Lake during the period from January to December 2015.*

Sites	Total species	Total ind	Species Richness	Evenness	Shannon	Alpha index
1	3	10471	0.22	0.91	1	0.29
2	3	4618	0.24	0.88	0.98	0.31
3	3	2762	0.25	0.91	1.01	0.33
4	3	6656	0.23	0.85	0.94	0.3
5	3	5330	0.23	0.92	1.02	0.31
6	3	3322	0.25	0.87	0.96	0.32

3.6. Similarity Between Sites

During the period from January to December 2015, the data indicated the presence of two clusters (Figure 3). The first cluster include site 1 with a relatively low similarity to the other sites being 67.9%. The second cluster divided into two sub-clusters, the first one represents the similarity between sites 3 and 6 being 94.6% while the third cluster include site 2, 4 and 5 with highest similarity being 95.3% was between site 2 and 5.

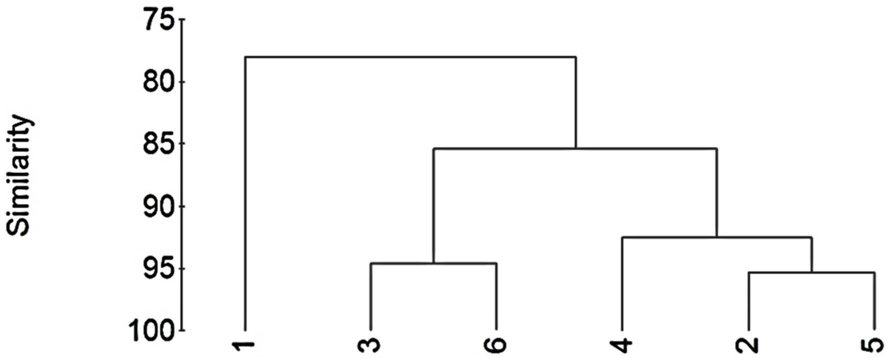

Figure 3. *Dendrogram represented the similarity between the different sites surveyed sites in AL- Burullus Lake during the period from January to December 2015.*

3.7. The Relationship of Shrimp Abundance with Temperature and Salinity

The regression analysis between these variables indicated that, there was no effective relationship between temperature and the abundance of all collected shrimp species ($P > 0.05$), while salinity was significantly influenced the abundance of the three species ($P < 0.05$). According to Table (8), the Pearson correlation analysis indicated that, the abundance of three shrimp species were collected was non-significantly influenced by temperature where $P < 0.05$, and showing weak positive correlation coefficient, but the abundance of collected shrimp showed positive significant correlation coefficient with salinity ($P < 0.05$).

Table 8. *Pearson correlation analysis between shrimp abundance (Ind./CPUE/12h) and environmental parameters at AL- Burullus Lake during the period from January to December 2015.*

Species / Parameters		*M. stebbingi*	*P. semisulcatus*	*M. Monoceros*
Temperature	**R**	0.181	0.177	0.180
	P	0.099	0.107	0.101
Salinity	**R**	.256*	.259*	.255*
	P	0.019	0.017	0.019

R= Correlation coefficient and P= probability of significance; $\alpha = 0.05$.

4. Discussion

The water temperature is one of the most important factors controlling growth of marine shrimp [14]. In crustacean's respiration generally increases with an increase in temperature which has been observed in many species of shrimp [15, 16,].

During this work, the abundance of shrimp showed an intimate relationship with the physicochemical parameters analyzed. Temperature has positive correlation with non-significant effect on the collected species (P>0.05). However, the shrimp was occurred in months with mean temperature ranged between 23.59 and 30.71°C within different abundance and absent during months with low mean temperature ranged from13.73 to 16.84°C and high mean temperature ranged between 33.10 and 33.16°C.

This is similar with that of DoF (2009) [17] who reported that suitable range of water temperature for prawn is 25-32°C. Also, Mazid (2009) [18] who stated that both shrimp and prawn production would be better at the temperature of 25-30°C. Suboptimal temperature conditions cause stress which affects behavior, feeding, metabolism, growth, and immunity to disease [19, 20].

The relation between the abundance of all collected species and salinity was positively significant relationship (P<0.05), it's worth to mention that, the shrimp was absent in August where the salinity ranged between 1.5 - 4.3 ppt because the large amount of fresh water discharged in to the lake. If salinity is too high, shrimp will start to lose water to the environment [21, 22]. DoF (2009) [17] reported that suitable range of water salinity is 5-30 ppt for shrimp farming, and also reported that suitable range of salinity content for larval production and surviving should be 12 to 16 ppm in freshwater and brackish water, respectively. Whetstone *et al*., (2002) [23] listed that the desired concentration of salinity for shrimp culture is 5–35 ppt. Temperature directly affects the rate of physiological processes while salinity places an osmoregulatory demand on aquatic organisms [16].

Our results were also in agreement with Meireles *et al*., (2006) [24] who said significant regressions were not detected for temperature and organic matter (P>0.05). [25] said the Salinity and the abundance of individuals were only weakly correlation. [26] reported that, the pronounced emigration of prawns from the estuarine environment after floods was due to the decreased salinity. Da Silva *et al.,* (2014) [27] who stated that, there was a strong correlation between Penaeid and Caridean shrimps' abundance and the bottom temperature and sediment. In addition, he indicates that water temperature may be the spatial regulating factor of the species, in particular, *Xiphopenaeus kroyeri.*

5. Conclusion

- The shrimp in Lake Burullus during this work are represented by three species viz, *Metapenaeus stebbingi, M. monoceros* and *Penaeus semisulcatus.*
- These species occurred during the periods from April to June and from September to December but it absents during the periods from January to March and from July to august.
- The maximum mean of shrimp density was 2209.67 ± 522.40 Ind./CPUE/ 12h during October, but the minimum one was 195 ± 86.25 Ind./CPUE/ 12h in June.
- The shrimp present in sites 1, 2, 3, 4, 5 and 6 but it absents in site 7.
- Temperature has positive correlation with non-significant effect on the collected species (P>0.05), while the relation between the abundance of all collected species and salinity was positively significant relationship (P<0.05).

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