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Ecological Observations on *Talorchestia brito* (Stebbing, 1891) and *Allorchestes plumicornis* (Heller, 1866) (Amphipoda, Talitridae) inhabiting the Red Sea Coast, Egypt

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Abstract. The abundance, population structure and their relations with the ambient environmental conditions of two talitirid amphipod species; *Talorchestia brito* and *Allorchestes plumicornis* were studied at two sites in the Egyptian Red Sea Coast; site 1 is Marine Biological Station (MBS) and site 2 is Safaja Fishermen Harbour (SFH). Samples were collected monthly during the warm period (April- August, 2007) from the two sites. Individuals were subdivided according to sex and length and abundance was calculated for each species in each sampling site. Abundance of *Talorchestia brito* varied during the study period with a marked decrease in April. Sex ratio was female biased. The males of *T. brito* grow larger than females; the males reached a maximum length of 13 mm while females reached 10 mm. On the other side, males of *Allorchestes plumcornis* were more abundant than females throughout the study period. The sex ratio fluctuated between 0.54 during August and 0.86 in July. The unusual dominance of males of *A. plumcornis* may be attributed to high mortality of females as a result of hard conditions during the warm period. Females and males of *A. plumcornis* become distinguishable at 5mm. The absolute length range recorded for *A. plumcornis* was 2-5 mm for juveniles, 5-9 mm for females and 5-10 mm for males. The results revealed that, temperature was the most important factor affecting the occurrence of *A. plumcornis* population while, it was insignificant for *T. brito*. The early stages of *T. brito* were more sensitive to dissolved oxygen concentrations while those of *A. plumcornis* were sensitive to salinity variations. On the other side, the adult forms of the two species showed the reverse pattern.

Keywords: Amphipoda, Talitiridae, Population structure, Abundance, Red Sea, Egypt.

Introduction

Amphipods inhabit a diverse range of aquatic and terrestrial habitats and have an importance as a link between detritus feeders and larger predators (Johnston *et al*., 2004). Also, they are considered as food item for inshore populations of shrimp and young fishes (Allam, 1995). Talitrid amphipods are important members of the wrack fauna throughout the world (Persson, 1999). They are unique among the order Amphipoda as they are the only family to have successfully made the transition onto land and they are also more generally accepted as a trans-littoral family: having representatives at all levels of the intertidal zone, in fully terrestrial habitats and in freshwaters (Richardson and Swain, 2000). Amphipoda Talitridae constitutes one of the most important groups in sandy beach fauna and is used as an environmental indicator (Weslawski *et al*., 2000; Fialkowski *et al*., 2000 and Prato *et al*., 2009).

Marine life in the Red Sea is rich with crustacean communities including amphipods which hide within algae, corals, sponges, shingles and stones (Ismail, 1997). Few studies were carried out on terrestrial talitrids in the Red Sea. Lyons & Myers (1990, 1991 & 1993) gave a list of thirty five species of gammaridean amphipods from the Gulf of Aqaba and Ismail (1997 & 2003) studied the biological characters of a species of the genus *Parhyale*.

The present work is aimed to study the temporal changes in the abundance and population structure of two talitirid amphipods namely: *Talorchestia brito* (Stebbing, 1891) and *Allorchestes plumicornis* (Heller, 1866) which inhabit the Egyptian Red Sea Coast during the warm period and their relations with the prevailing environmental conditions.

Materials and Methods

Samples were collected monthly throughout the warm period (April-August, 2007) from two sites of the coastal area of the Red Sea; site 1 is Marine Biological Station (MBS) (6km north of Hurghada) and site 2 is Safaja Fishermen Harbor (SFH) (70 km South Hurghada). The present sites were selected for such study since they have a relatively high density of *Talorchestia brito* and *Allorchestes plumicornis* specimens. Figure 1 illustrates the area of investigation and location of the sampling sites. At each site, samples were collected from three quadrates (30×30 cm^2 each) and preserved in 5% formalin. Environmental parameters such as temperature (T), salinity (S), PH, dissolved oxygen (DO), and total dissolved solids (TDS) were also measured monthly at each site during the study period. In the laboratory, the species were identified using the available amphipod keys (Chevreux and Fage, 1925 and Barnard, 1971). Specimens of *T. brito* and *A. plumicornis* were isolated, counted, measured and determined their sex. Individuals of the two species were classified as juveniles, females or males. Sexual dimorphism was only evident in the adult animals. Sex was determined by the presence of oostegites in females and development of the second gnathopod in males. Animals without these characteristics were considered to be juveniles. The sex ratio (number of females to number of males) of the total population was estimated. Total length was measured using binocular microscope, equipped with micrometrical ocular lens and calibrated with objective micrometers. Each month, the total number of individuals collected in each quantitative sample x m^2 was calculated.

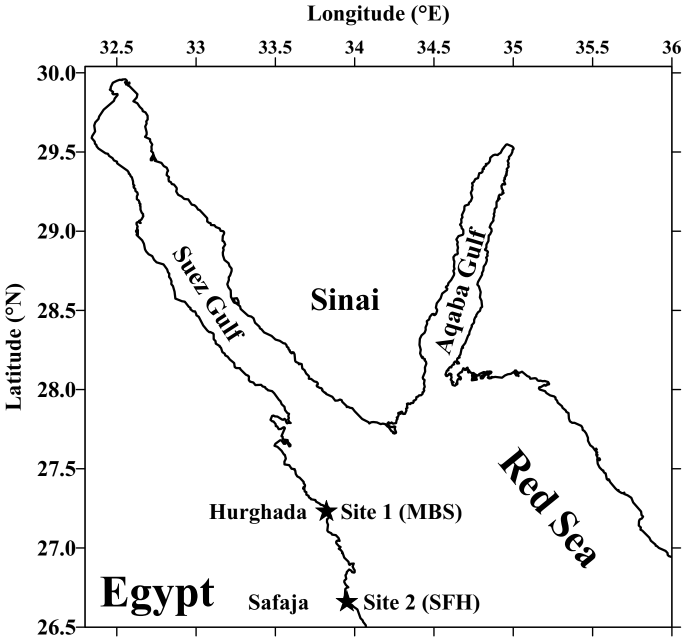

Fig. 1. The Red Sea and locations of sampling sites.

Correlation coefficients of the population densities (juveniles, females and males) of *T. brito* and *A. plumicornis* with some environmental factors are calculated.

Results and Discussion

1- Water Characteristics

Values of the environmental parameters monitored in the two sampling sites during the study period are shown in Table 1. In both stations, the higher values of water temperature of the two sites were recorded during June and August (38.0 and 39.7°C respectively) while the lower ones were found during April and May (29.0 and 27.4°C respectively). In both stations, PH values varied, throughout the study period, from 7.1 during June to 8.2 in August.

Dissolved oxygen in the sea water reflects the state of water quality which controls the different biotic and abiotic processes in the ecosystem. Oxygen availability limits the maximum potential size attainable in amphipods (Chapelle and Peck, 2004). In the present work, the lowest values of dissolved oxygen were 4.8-5.8 mgO_2/l (equivalent to 75-82%) in August, whereas the highest values were found to be 7.6-8.1 mgO_2/l (equivalent to 100-105%) in April.

Salinity fluctuated between 40 and 41.4 throughout the study period. Total dissolved solids (TDS) varied between 38 and 42 in site 1(MBS) and between 38 and 40 in site 2 (SFH).

Table 1. Water characteristics of the study areas during the sampling period.

Month	Marine Biological Station (site 1)					Safaja Fishermen Harbour (site 2)				
	T (°C)	PH	S (‰)	DO (mg O_2/l)	TDS	T (°C)	PH	S (‰)	DO (mg O_2/l)	TDS
April	29.0	7.3	40.4	8.1	38	29.0	7.6	40.0	7.6	38
May	31.4	7.8	41.4	7.9	39	27.4	7.9	41.4	7.0	39
June	38.0	7.5	41.0	7.3	42	37.0	7.1	40.0	6.3	40
July	37.0	8.1	41.0	7.5	42	35.0	7.8	41.2	5.8	40
August	35.5	8.2	40.0	5.8	42	39.7	8.2	40.2	4.8	40

2- Population Density

The density of *T. brito* fluctuated during the study period between 956 ind. /m^2 in April to a maximum of 2955 ind./m^2 in May. Meanwhile the density of *A. plumcornis* increased from 644 ind./m^2 in April to 2989 ind./m^2 during August (Table 2).

Table 2. Population densities (ind.m^{-2}) and percentage frequencies of *Talorchestia brito* and *Allorchestes pulmicornis* in the study area during the sampling period.

Month	*T. brito*				*A. plumicornis*			
	Site 1		Site 2		Site 1		Site 2	
	Ind.	%	Ind.	%	Ind.	%	Ind.	%
April	956	10.06	115	12.39	77	12.60	644	9.91
May	2955	31.11	236	25.43	106	17.35	888	13.66
June	1733	18.24	208	22.41	96	15.71	1201	18.48
July	2344	24.68	188	20.26	93	15.22	778	11.97
August	1511	15.91	181	19.51	239	39.12	2989	4598
Total	9499		928		611		6500	
Mean	1900		186		122		1300	

3- Population Structure

The knowledge of population structure is important for the study of environmental and faunistic changes caused by anthropogenic interference or by natural fluctuations (Prato *et al*., 2009). In the present study, the population structure of *T. brito* at station 1 showed that, juveniles formed about 20.63%, females 55.14% and males formed 24.23% of the total density of the species population (Table 3). The presence of juveniles in the population allowed the determination of reproductive period. Differences in recruitment of juveniles in the population were observed with a peak in August (700 ind. /m^2). The proportion of juveniles present in the population declined from 46.33% in August to 13.44% during June. They were absent from the sampling site during April (Table 3).

Females of *T. brito* were more abundant than males throughout the study period and showed two peaks, *i.e.* 1889 ind./m^2 in May and 1482 ind./m^2 in July representing 63.93% and 63.22% of the total population respectively (Table 3). The maximum density of males (633 ind./m^2) was observed during June while the lowest one was 211 ind. /m^2 in August. The percentage frequency of males showed two peaks in April and June representing 58.16% and 36.53% of the total population respectively (Fig. 2). The dominance of females of *T. brito* seems to be a general character of talitrid amphipods and agrees with the observations carried out by many authors on different species, *e.g.* in *Orchestia gammarellus* (Jones and Wigham, 1993 and Persson, 1999); *Pseudochestia brasiliensis* (Cardoso and Veloso, 1996); *Talorchestia capensis* (Van Senus, 1988) and *T. deshayesii* (Prato *et al*., 2009).

Table 3. Population structure and sex ratio of *Talorchestia brito* at MBS (site 1) during the sampling period.

Month	Juveniles		Females		Males		Sex ratio (F/M)
	ind.m^{-2}	%	ind.m^{-2}	%	ind.m^{-2}	%	
April	0	0.0	400	41.84	556	58.16	0.72
May	633	21.4	1889	63.93	433	14.65	4.36
June	233	13.44	867	50.03	633	36.53	1.37
July	393	16.77	1482	63.22	469	20.01	3.16
August	700	46.33	600	39.71	211	13.96	2.84
Total	1959		5238		2302		2.28
Average	392		1048		460		

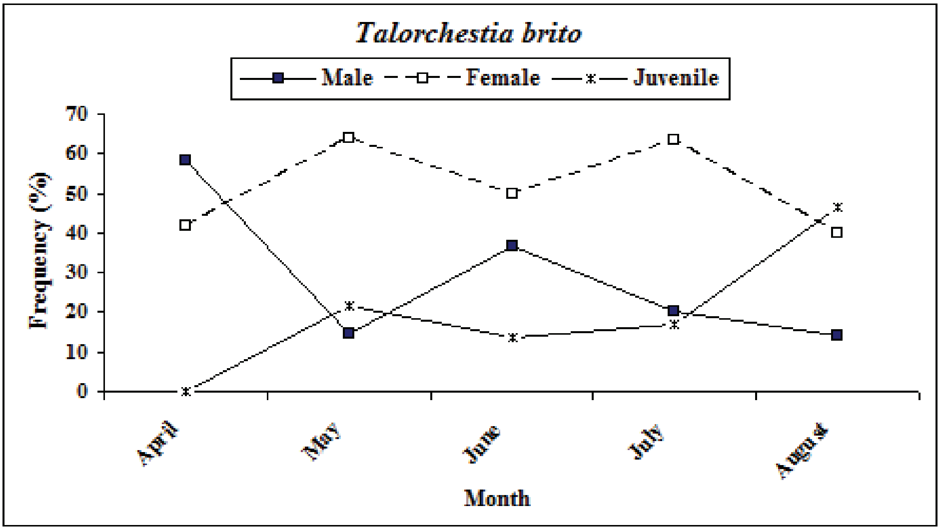

Fig. 2. Percentage frequencies of juveniles, males and females of *Talorchestia brito* at MBS (site 1) during the sampling period.

In the present study, the population structure of *A. plumcornis* showed that, juveniles formed about 10.10%, females 35.55% and males formed 54.35% of the total population density. Monthly analysis of species population indicated that, there was a gradual decrease in the percentage frequencies of juveniles from April (17.24%) to August (7.06%).

Males of *Allorchestes plumcornis* were more abundant than females throughout the study period and showed only one peak (1800 ind./m^2) in August representing 60.22% of the total population. On the other side, the percentage frequencies of females showed a gradual increase from April (31.05%) to July (42.80%) and dropped to 32.72%

during August (Table 4 & Fig. 3). The unusual dominance of males of *A. plumcornis* may be attributed to high mortality of females as a result of hard conditions during the warm period.

Table 4. Population structure and sex ratio of *Allorchestes plumicornis* at SFH (site 2) during the sampling period.

Month	Juveniles		Females		Males		Sex ratio (F/M)
	ind.m^{-2}	%	ind.m^{-2}	%	ind.m^{-2}	%	
April	111	17.24	200	31.05	333	51.71	0.60
May	111	12.50	333	37.50	444	50.00	0.75
June	167	13.91	467	38.88	567	47.21	0.82
July	56	7.20	333	42.80	389	50.00	0.86
August	211	7.06	978	32.72	1800	60.22	0.54
Total	656		2311		3533		0.65
Average	131		462		707		

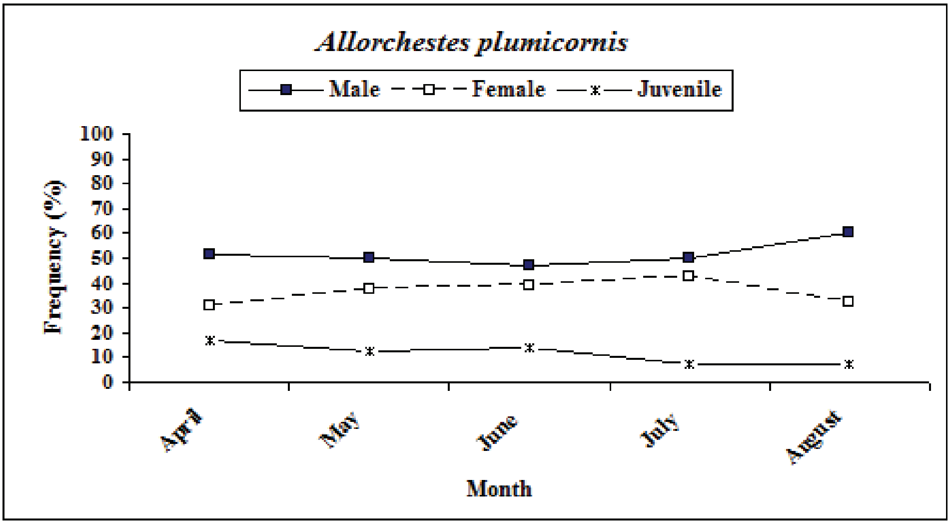

Fig. 3. Percentage frequencies of juveniles, males and females of *Allorchestes plumicornis* at SFH (site 2) during the sampling period.

4- Sex Ratio (F/M)

The sex ratio (number of females to number of males) of *T. brito* fluctuated throughout the study period and has been biased in favor of females with the exception of April (Table 3). The mean value in this study was 2.28. On the other side, the sex ratio of *A. plumcornis* was a minimum of 0.54 in August and a maximum of 0.86 in July with a mean value of 0.65 (Table 4). Goncalves *et al*. (2003) found a sex ratio different for two populations of *T. brito*, a sex ratio male biased for a population of the Portuguese coast and a population dominated by the females in Tunisia. Watt (1994) showed that photoperiod influenced the sex ratio of *Gammarus duebeni* with the preponderance of the males, when exposed to long days, and preponderance of females on exposure to short days. Skewed sex ratios may be affected by the factors dependent on life cycle, such as the different mortality, longevity and growth rate between sexes (Hamilton, 1967; Wenner, 1972 and Prato *et al*., 2009).

5- Size Frequency Distribution

A total of 346 individuals of *T. brito* and a total of 230 individuals of *A. plumcornis* were randomly selected from the collected samples and measured to study the size frequency distribution throughout the study period.

The males of *T. brito* grow larger than females; the males reached a maximum length of 13 mm while females reached 10 mm. The absolute length range recorded for *T. brito* was 2-5 mm for juveniles, 4-10 mm for females and 5-13 mm for males (Table 5).

Table 5. Monthly variations in the body length (mm) of *Talorchestia brito* population at MBS (site 1) during the sampling period.

Month	Juveniles (mm)			Females (mm)			Males (mm)		
	Min.	Max.	Average	Min.	Max.	Average	Min.	Max.	Average
April	0	0	0	4	10	7	8.0	13.0	10.5
May	3	5	4	4	10	7	5.0	12.0	8.5
June	2	5	3.5	4	10	7	7.0	10.0	8.5
July	3	4	3.5	4	9	6.5	6.0	11.0	8.5
August	3	5	4	5	10	7.5	5.0	11.0	8
Mean	2.2	3.8	3	4.2	9.8	7	6.20	11.40	8.8
SD±	1.30	2.17	1.70	0.45	0.45	0.35	1.30	1.14	0.97

The lengths of *T. brito* were classified into 6 length groups (Fig. 4 and Table 6). The smallest length group (2-4 mm) was presented in all months and formed about 16.76% of the species population. It was particularly dominant in August (26.09%). The second length group (5-6 mm) occurred in all the samples and contributing about 21.68% of the species population. It was common in May and August. The third length group (7-8 mm) was the most important size group contributing 30.92% of the total population. It was common in May and June. The fourth length group (9-10 mm) exhibited two peaks, the first occurred in June and the second one occurred during July. The fifth length group (11-12 mm) was dominated during April and missing in June. The sixth length group (>12 mm) was the lowest represented group in the samples and appeared only during April (Table 6 & Fig. 4).

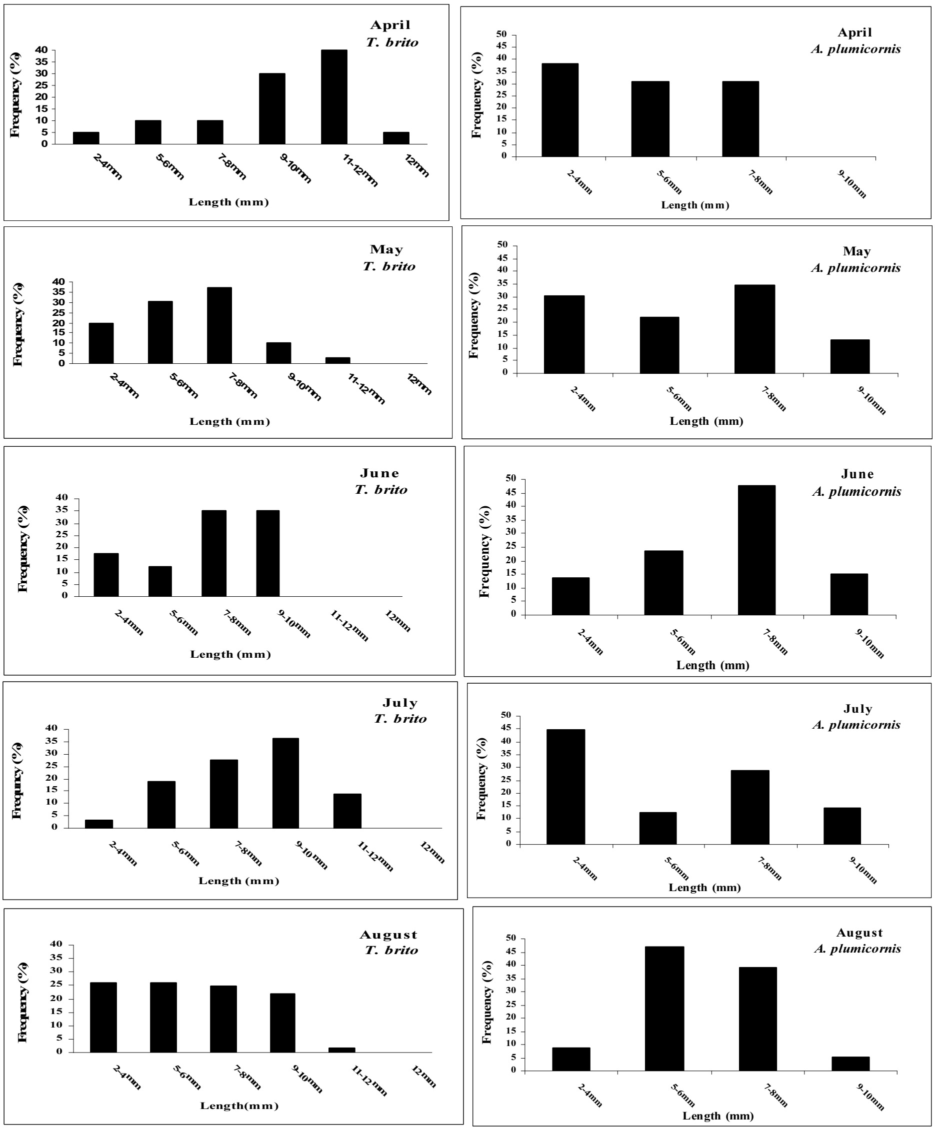

Fig. 4. Size frequency distribution of *Talorchestia brito* and *Allorchestes plumicornis* in the study area during the sampling period.

Table 6. Population analysis of *Talorchestia brito* at MBS (site 1) during the sampling period.

Body length	April		May		June		July		August	
	No.	%	No.	%	No.	%	No.	%	No.	%
2-4mm	1	5.00	21	19.44	16	17.58	2	3.45	18	26.09
5-6mm	2	10.00	33	30.56	11	12.09	11	18.97	18	26.09
7-8mm	2	10.00	40	37.04	32	35.16	16	27.59	17	24.64
9-10mm	6	30.00	11	10.19	32	35.16	21	36.21	15	21.74
11-12mm	8	40.00	3	2.78	0	0.00	8	13.79	1	1.45
>12mm	1	5.00	0	0.00	0	0.00	0	0.00	0	0.00

Females and males of *A. plumcornis* become distinguishable at 5mm.The absolute length range recorded for *A. plumcornis* was 2-5 mm for juveniles, 5-9 mm for females and 5-10 mm for males (Table 7). In the present study males of *T. brito* and *A. plumcornis* attain greater size than females. Crustacean growth usually is similar between sex until maturity, after which the males and females show different ecological or reproductive demands, probably because of parental investment or mating effort, resulting in distinct growth rates between sexes (Low, 1978). The growth progresses more slowly in females due to a prolongation of the intermolt period and a minor increment in size by occasion of the ecdysis, motivated by production and incubation of embryos (Hartinoll, 1982). Amphipod males generally expend most of their reproductive effort in mating while females allocate relatively more time and energy to parental effort, especially the production of large gametes and during the incubation period (Wen, 1992). Besides this, the females do not undergo ecdysis during the period of incubation making it difficult for them to continue to grow at the same pace as males (Cardoso and Veloso, 1996). It is probably that the reproductive difference makes males and females dimorphic in body size (Wen, 1993; Cardoso and Veloso, 1996 and Castiglioni and Buckup, 2008).

Table 7. Monthly variations in the body length (mm) of *Allorchestes plumicornis* population at SFH (site 2) during the sampling period.

Month	Juveniles (mm)			Females (mm)			Males (mm)		
	Min.	Max.	Average	Min.	Max.	Average	Min.	Max.	Average
April	3	4	3.5	5	7	6	7	9	8
May	3	5	4	5	8	6.5	7	10	8.5
June	3	4	3.5	5	8	6.5	6	10	8
July	2	4	3	5	9	7	6	9	7.5
August	2	5	3.5	5	9	7	5	9	7
Mean	2.6	4.4	3.5	5	8.2	6.6	6.2	9.4	7.8
SD±	0.5	0.5	0.4	0.0	0.8	0.4	0.8	0.5	0.6

The lengths of *A. plumcornis* were classified into 4 length groups (Fig. 4 and Table 8). The smallest length group (2-4 mm) was presented in all months and formed about 22.61% of the species population. It was dominant in July (44.64%) and April (38.46%). The second length group (5-6 mm) occurred in all the samples and contributing about 29.13% of the species population. It was dominated during August (46.84%). The third length group (7-8 mm) was the most important size group contributing 37.83% of the total population. It was dominated during June. The fourth size group (9-10 mm) was missing in April and rather frequent during May, June and July (Fig. 4 and Table 8).

Table 8. Population analysis of *Allorchestes plumicornis* at SFH (site 2) during the sampling period.

Body length	April		May		June		July		August	
	No.	%	No.	%	No.	%	No.	%	No.	%
2-4mm	5	38.46	7	30.43	8	13.56	25	44.64	7	8.86
5-6mm	4	30.77	5	21.74	14	23.73	7	12.50	37	46.84
7-8mm	4	30.77	8	34.78	28	47.46	16	28.57	31	39.24
9-10mm	0	0.00	3	13.04	9	15.25	8	14.29	4	5.06

6-Statistical Analysis

Most changes in the structure of sandy beaches communities seem to be the result of environmental change, food limitation and an anthropic influence (Brown and Mc Laclan, 1990; Weslawski *et al*., 2000 and Marques *et al*., 2003). These changes are important to evaluate how the organisms can adapt themselves to environmental and human-induced changes, foreseeing a sustainable use of beach environments (Prato *et al*., 2009). In the present study, the correlation coefficient of *T. brito* population with some environmental parameters is given in Table 9. The results revealed that, a significant correlation was found between the species population and PH, salinity as well as dissolved oxygen. Meanwhile, the correlations were insignificant with temperature and total dissolved solids. The negative correlation between the number of juveniles and dissolved oxygen ($r = -0.60$ $P \leq 0.05$) indicated the high consuming of oxygen during the early stages while the adults (males and females) were more sensitive to salinity (Table 9).

Table 9. Correlations of population structure and sex ratio of *Talorchestia brito* with some environmental parameters at MBS (site 1) during the sampling period.

		Environmental parameters				
		Temp. (°C)	**PH**	**S (‰)**	**DO (mg/l)**	**TDS**
Juveniles	R	0.263	0.831	0.037	-0.604	0.376
Females	R	0.101	0.345	0.849	0.33	0.014
Males	R	-0.026	-0.804	0.511	0.753	-0.241
Total Density	R	0.174	0.422	0.804	0.197	0.101
Sex ratio	R	0.082	0.682	0.468	-0.116	0.116

Salinity and temperature are the common environmental factors affecting the regional distribution and occurrence of most marine invertebrates (Skadsheim, 1983 & 1984). In the present study, the correlation coefficient of *A. plumcornis* population with some environmental parameters revealed that, a positive correlation was found between species population (Juveniles, females and males) and temperature (Table 10). On the other side, a negative correlation was found with salinity in the early stages ($r = -0.63$ $P \leq 0.05$) while in the adult forms (males and females), it was found with dissolved oxygen (Table 10). This means that, the early stages of *A. plumcornis* were more sensitive to salinity variations while dissolved oxygen affecting the occurrence of adults.

Table 10. Correlations of population structure and sex ratio of *Allorchestes plumicornis* with some environmental parameters SFH (site 2) during the sampling period.

		Environmental parameters				
		Temp. (°C)	**PH**	**S (‰)**	**DO (mg/l)**	**TDS**
Juveniles	R	0.578	0.091	-0.631	-0.477	0.285
Females	R	0.783	0.489	-0.280	-0.869	0.602
Males	R	0.701	0.578	-0.314	-0.805	0.457
Total Density	R	0.729	0.529	-0.327	-0.816	0.498
Sex ratio	R	-0.067	-0.517	0.502	0.108	0.386

Conclusion

In conclusion, the results revealed that, temperature was the most important factor affecting the occurrence of *Allorchestes plumcornis* population while, it was insignificant for *Talorchestia brito*. The unusual dominance of males of *A. plumcornis* may be attributed to high mortality of females as a result of hard conditions during the warm period. The early stages of *T. brito* were more sensitive to dissolved oxygen concentrations while those of *A. plumcornis* were sensitive to salinity variations. On the other side, the adult forms of the two species showed the diverse pattern.

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ملاحظات بيئية على مزدوجة الأقدام
(Talorchestia brito and *Allorchestes plumicornis)*
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المستخلص. تمت دراسة الوفرة العددية والتركيب المجتمعي وعلاقاتهما بالظروف البيئية المحيطة لنوعين من مزدوجة الأقدام هما *Talorchestia brito* and *Allorchestes plumicornis* في موقعين على الساحل المصري للبحر الأحمر. الموقع ١ هو المحطة البحرية البيولوجية والموقع ٢ هو ميناء صيد سفاجا. وقد جمعت العينات من موقعي البحث بصفة شهرية خلال الفترة الحارة (إبريل– أغسطس ٢٠٠٧م). كما تم تقسيم الأفراد في كل نوع حسب الجنس، وقياس الطول، وحساب الوفرة العددية في كل موقع، وقد أظهرت النتائج اختلاف الوفرة العددية *T. brito* خلال فترة الدراسة، مع ملاحظة وجود نقص واضح في أعداد الأفراد خلال شهر إبريل. كما أظهر حساب نسبة الجنس سيادة الإناث على الذكور. كما اتضح أيضا أن ذكور *T. brito* تنمو أسرع من الإناث حيث تصل إلى أقصى طول ١٣ ملم بينما الإناث تصل إلى ١٠ ملم. على العكس في النوع الآخر *A.plumicornis* تبين سيادة الذكور على الإناث طوال فترة الدراسة. وقد تراوحت نسبة الجنس بين ٠,٥٤ أثناء شهر أغسطس و ٠,٨٦ في شهر يوليو. وربما تعزى السيادة غير المعتادة للذكور على الإناث فى مجتمع *A.plumicornis* إلى كثرة الوفيات فى الإناث بسبب الظروف البيئية الصعبة أثناء الفترة الحارة. وقد أمكن التمييز

بين الإناث والذكور لهذا النوع عند طول ٥ ملم، وقد تراوح مدى الطول في الأطوار غير الناضجة بين ٢–٥ ملم، وفى الإناث بين ٥–٩ ملم والذكور بين ٥–١٠ ملم. وقد أظهرت النتائج أن درجة الحرارة تمثل عاملا مهما يؤثر فى وجود مجتمع *A.plumicornis* بينما كانت غير مؤثرة بالنسبة لمجتمع *T. brito* كما أتضح أن الأطوار غير الناضجة من *T. brito* كانت شديدة الحساسية للتغير في تركيزات الأكسيجين الذائب بينما مثيلاتها من *A.plumicornis* كانت أكثر حساسية للتغيرات فى الملوحة. على الجانب الآخر فقد أظهرت الأطوار البالغة لكلا النوعين العكس.