On the reproductive biology of the talitrid amphipod *Platorchestia monodi* (Mateus *et al.*,1986) from the Shatt Al-Arab region, Basrah, Iraq

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ABSTRACT

The life history and breeding activity of the supralittoral amphipod, *Platorchestia monodi* (Mateus *et al.* 1986) were studied. The amphipods were sampled from the Garmat-Ali region, Basrah, over the period from 26th August 1993-28th January 1995. Random samples were taken on a monthly basis. The amphipods were mostly abundant under drifted aquatic plants (wrack), which were providing food and shelter.

Sexual maturity occurred in the males at a size of 5.25 mm and 5.0 mm in the females. Ovigerous females were found throughout the year. Mean egg size (0.75 mm) was increasing during the embryonic development. Mean brood size was ranging from 5-18 ova, and the fecundity was an exponential function of size of female. There was a preponderance of females (1.9:1) over males in the population. The population was polymodal throughout the entire sampling period. The life span of the males was 11-14 months, whereas that of the females was 15 months.

Key words: reproductive biology, amphipod, *Platorchestia monodi* , Shatt Al- Arab River.

Introduction

The family Talitridae is the only family that contains truly terrestrial and semi-terrestrial amphipods, the landhoppers (Spicer *et al.*, 1987; Bousfield, 1991). This family is having a worldwide distribution, especially in the coastal and land regions of the temperate and tropics (Wildish, 1979). Talitrids amphipods constitute one of the most

important group in sandy beach fauna (Wildish, 1988; McLachlan and Jaramillo, 1995). They are found underneath beach "wrack, the plant and animal litter cast ashore by wave and tide, which is a highly variables rigorous habitat providing food and shelter for both aquatic and terrestrial animals" (Behbehani and Croker, 1982). However, Bousfield (1984) pointed out that these amphipods are found under plant remains or waste from ships thrown on the shores.

The distribution and occurrence of the semi-terrestrial talitrid amphipods are influenced by the suitable climatic conditions like warm temperature and high humidity (Humberto *et al.*, 1991), moreover, the presence of plant remains high on the shore provide shelter and protection against desiccation (Chelazzi and Ferrara, 1978).

Members of this family play an important role in the food chain (Bousfield, 1988), for they consume aquatic plant remains washed ashore, therefore playing an important role in energy transfer for other invertebrates and vertebrates like arthropods, fish and birds (Wildish, 1988), to ensure this fact, these animals were considered the prime colonizer of aquatic plant remains thrown by water on the shore (MacIntyre, 1963; Griffiths and Stenton-Dozey, 1981; Behbehani and Croker, 1982).

Their ecological relevance is justified from the great quantity of existing literature (Prato *et al.*, 2009). However, talitrids' reproductive strategies and their contribution to the energy balance in beach ecosystems are still poorly understood (Goncalves *et al.*, 2003). Moreover, there are few studies on talitrids' population biology (see Goncalves *et al.*, 2003 for references).

The talitrids of Iraq and the Arabian Gulf are poorly known and nothing, whatsoever has been done on their population biology, except some notes on the distribution of *Orchestia platensis* Kröyer in Kuwait, where it occurs high on the shore, amongst muddy sand or gravel under stones or weed in the supralittoral zone (Jones, 1986), and *Talorchestia martensii* (Weber) which lives in the supralittoral zone on sandy beaches where it forms a zone associated with washed up seaweeds and debris (Jones, 1986). Moreover, Basson *et al.* (1981) pointed out to the amphipods of the Saudia Arabia coasts and didn't give scientific names

of the talitrids but refers to them as sand-hoppers or beach fleas distributed among decayed aquatic vegetations washed up high on the beach. In Iraq, however one talitrid *viz Parhyale basrensis* was described from the intertidal zone of the Shatt Al-Arab River (Salman. 1986) and Ali and Salman (1986, 1987) studied it's reproductive biology, growth and production, and Ali (2001) estimated it's oxygen consumption, metabolism and calculated it's energy budget. Furthermore, Salman and Abdullah (1997) made a record of *Platorchestia monodi*, from the supralittoral zone of Shatt Al-Arab River and the wetland close to the River and from gardens of houses in Basrah province.

The present article is devoted to the reproductive biology of *Platorchestia monodi*, in the Shatt Al-Arab region . The present study forms part of a series of articles on the bioenergetics of the species in this region, a study which was done for the first time in the area.

Noteworthy, most of the previous studies on Crustacea in general and Amphipoda in particular, were done in temperate and boreal areas, whereas those on the tropical and subtropical regions are scarce and scanty. Therefore, such studies would add to our scientific knowledge in what respect does temperature, as a main factor, affecting growth and reproduction of populations living in such region.

Study area

The sampling site is located near Garmat-Ali river where Khurtrad creek joins the river at the University campus of Garmat-Ali. The area is a supralittoral, characterized by a sandy-muddy substratum, covered by remains of aquatic plants swept by the tide into this region. *Phragmites australis*, *Typha* sp.,*Vallisneria spiralis*, *Ceratophyllum demersum* and *Potamogeton crispus* are the common plants in the area in addition to *Cladophora* sp. (Al-Saadi and Al-Mayah, 1983). Among the invertebrates inhabiting the area are the amphipod *Parhyale basrensis*, the isopod *Asellus coxalis*, (H.E. Grüner, personal communication) some Coleoptera, Diptera and Isoptera as well as insects larvae and mites. *P. monodi* was noticed to occur in a quite large numbers in the areas were aquatic plants remains are common, which provide shelter,

protection and feeding grounds. The species is apparently common in rural areas and in gardens of some houses.

Sampling

The beachhoppers, sandhoppers and landhoppers (Spicer *et al.*, 1987; Lindeman, 1990 and Bousfield, 1991) are one of the most difficult animals to be sampled quantitatively. We have tried several ways to sample them but without success. Therefore, we decided to make qualitative samples, sampling at each occasion as much amphipod as possible. The population was sampled monthly for 18 months from 26. 8. 1993 to 28.1. 1995. The specimens were sorted out in the laboratory and fixed with 4% formaldehyde solution. Specimens were examined under a wild dissecting microscope provided with graduated graticle. Total length was measured (to the nearest 0.01 mm) from the base of 1st antenna to the tip of telson, which is a reasonable measures of length of the amphipod (Marden, 1991). The animals were sorted into males and females according to the shape of the 1st and 2nd gnathopods, which are modified in the male, particularly the 2nd gnathopods, which become enlarged to grasp the female during copulation (Bousfield, 1982). Individuals smaller then 5 mm total length were classified as juveniles and were divided between the two sexes according to the sex ratio (1 males:1.9 females) obtained in the present study.

All females were examined under the dissecting microscope for the presence or absence of setae on the oostegites, as the presence of long setae indicates the reproductive condition of the female (Hynes, 1954; Chariniaux-Cotton, 1957; Bregazzi, 1972; Hynes and Harper, 1972; Miller, 1982; Kevrekidis and Koulouras, 1988). Adult females were classified into ovigerous and nonovigerous.

The eggs were extruded from the brood pouch of the female, counted and measured by two dimensions and the size of which was calculated as (length + breadth) 1/2.

The various developmental stages of the eggs were arbitrarily classified (Table 1).

The population structure was studied by plotting the size of the individual in each month versus their percentage occurrence.

Fecundity was estimated through the relation of female's size against number of eggs she carry, as follows:-

$$Y \text{ (no. eggs)} = a + b\ X \text{ (size of female)}$$

About 8966 individuals were examined in this study.

Table 1. Arbitrary diagnostic features of the various embryonic stages inside the brood pouch of the amphipod *Platorchestia monodi* from Garmat-Ali region.

stage	Diagnostic features
I	egg spherical with yolk.
II	egg at gastrulation.
III	embryonic tissues enveloping the egg partially or totally.
IV	appendages are developing with eyes pigmented.
V	appendages complete and the embryo well developed.

Four ovigerous females were selected (eggs at the embryonic stage V) to monitor the growth of the newly released juveniles until sexual maturity stage (total length 5.0 mm) was reached. Females were placed singly in a glass vessel with diameter 7 cm and a height of 18 cm on 20/10/1994. Wet vegetation were placed in each vessel with some water just to keep the plants wet. On the third day (22/10/1994) the females start to release their youngs at different time intervals on the same day. Females were removed from the vessels to avoid competition on food and space. Total number of the newly released juveniles were 23 and the average individual size was 2.44 mm.

To estimate the growth rate of larger individuals, live *P. monodi* were brought from the field on June 1994, and divided into 3 size groups, the largest of which were discarded, as it is difficult to follow up their growth because they may cess growth after the last moult or when they approach it (Venables, 1981a). The other groups, the smaller ones: 0.01-2.9 mg WM and the 3-8 mg WM, each was placed in a glass tank. About 200 individuals were placed in each tank with clean wet aquatic plant remains brought from the field were added to each tank. The tanks were left under laboratory conditions of temperature and illumination. The

experiment was lasted for 12 weeks, with weekly records of air and tank's temperature. Ten randomly collected samples were weekly taken with a 25 cm^3 beaker from each tank, they were found to contain 4-16 individuals. Each individual was placed in a gelatinous capsule of known weight. Weighing (wet weight) was done by a Cahn elecro-microbalance with accuracy to the nearest 0.01 mg. The animals were then returned to their original tanks.

Weekly growth rate, in the laboratory, was estimated by the Von Bertalanffy (1938) expression:-

$$L_t = L_\infty [1-e^{-k(t-to)}]$$

Where L is the total length in mm at time t, L_∞ is the theoretical maximum length of the amphipod, k and t_o constants. The value of k was obtained from the negative logarithmic value of the Ford Walford plot, whereas the value of t_o was obtained from:

$$t_o = t + (1/k) \ln [(L_\infty - L_t)/ L_\infty]$$

The time interval was a week.

Results

Sex discrimination of the amphipod *Talorchestia monodi* was possible at the size group 5.0 mm total length. Males are possessing 2 pairs of gnathopods specialized for grasping the female during the process of copulation. The male 2^{nd} pair is particularly greatly enlarged. Individuals larger than 5 mm were considered females when they possess small gnathopods. The smallest ovigerous female was 5.0 mm long, whereas, the smallest male was 5.25 mm long. The largest male ever recorded was 16.1 mm and the largest female was 15.0 mm long.

Egg size

The changes in egg size during the embryonic development expressed by the increase in diameter of the eggs in relation to female's size were listed in Table 2. Nine size groups were recognized from 8.0-12.5 mm total length at an intervals of 0.5 mm. It is apparent that egg size

increased with the embryonic stages and with the size of female. The smallest eggs at stage I were 0.64±0.10-0.97±0.01 carried by females of 8.0-12.0 mm long. Whereas, the sizes of embryos at stage V were 2.09±0.10-3.03±0.13 mm. The average size of stages I and V were 0.75 and 2.11 mm, respectively. However, the total number of eggs examined were 2677.

Fecundity

The relation between the brood size and the size of ovigrous females, the average number of eggs against female's size at 18 size groups of females (Table 2) indicates that the number of eggs increased with increasing size of females, varying from 5 (at female size of 5.0 mm) to 18 eggs (at female size of 13.5 mm), with an average of 9.8±1.6. The relationship can be expressed in the following: (Fig. 1)

$$Y = 1.4219\ X - 3.1319, \text{ with}$$

$r = 0.77$; $n = 87$; $p < 0.05$.

where Y= numbers of eggs

X= total length of ovigerous female, in mm.

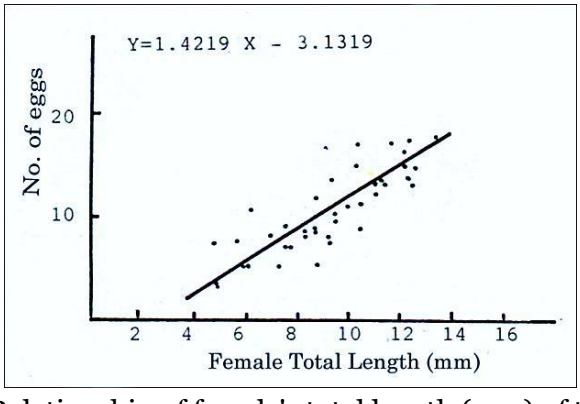

Figure 1. Relationship of female's total length (mm) of the amphipod *Platorchestia monodi* and number of eggs carried by the female at Garmat-Ali, Basrah.

Population structure and reproduction

Monthly samples of *P. monodi* were sorted into 0.5 mm size-groups and were plotted against percent occurrence, for the two sexes separately, and for the period August 1993-January 1995 (Figs. 2 & 3).

Obviously, juveniles less than 5 mm were present in every sample indicating that reproduction is almost continuous. It is apparent that the population is in most cases polymodal (Figs. 2 & 3).

Table 2 : Mean egg diameter (D) in mm, standared deviation (±) and total no. of eggs (T) for various females sizes and at different embryonic developmental stages of *P. monodi* from Garmat-Ali.

Female size groups (mm)	Stage I	Stage II	Stage III	Stage IV	Stage V
8.0-8.5	0.64 (D) ± 0.10 26 (T)	0.66 0.02 18	0.78 0.03 25	1.03 0.39 12	2.09 0.10 11
8.6-9.0	0.65 (D) ± 0.07 44 (T)	0.67 0.06 75	0.78 0.13 96	1.10 0.16 43	2.13 0.11 36
9.1-9.5	0.68 (D) ± 0.10 78 (T)	0.69 0.08 68	0.74 0.09 36	1.13 0.50 23	2.43 0.63 49
9.6-10.0	0.71 (D) ± 0.29 72 (T)	0.77 0.09 52	0.80 1.41 40	1.25 0.10 17	2.65 0.12 80
10.1-10.5	0.89 (D) ± 1.23 129 (T)	1.04 1.88 47	1.06 0.75 42	1.09 0.06 20	2.70 0.50 89
10.6-11.0	0.97 (D) ± 0.11 72 (T)	1.24 0.25 112	1.29 0.09 87	1.47 0.13 91	2.81 0.06 41
11.1-11.5	0,93 (D) ± 0.05 59 (T)	1.28 0.48 79	1.44 0.05 45	1.48 0.41 63	2.87 0.15 54
11.6-12.0	0.96 (D) ± 0.01 40 (T)	1.29 0.10 120	1.48 0.15 58	1.56 0.03 40	2.93 2.41 113
12.1-12.5	0.97 (D) ± 0.01 48 (T)	1.34 0.07 32	1.58 0.04 33	1.60 0.06 40	3.03 0.13 37
Mean egg diameter mm	0.75	0.89	1.02	1.21	2.11
Total no. of eggs examined	568	600	462	537	510

Females

Females were separated into mature and ovigerous females, to which added the females with setae on their oostegites, which emphasize that they have released their broods in a very short time before the sampling

date (one to few days). Ovigerous females were present in every sample all the year round indicating that breeding is continuous (Fig. 2). This is supported by the presence of juveniles in each sample throughout the period of sampling.

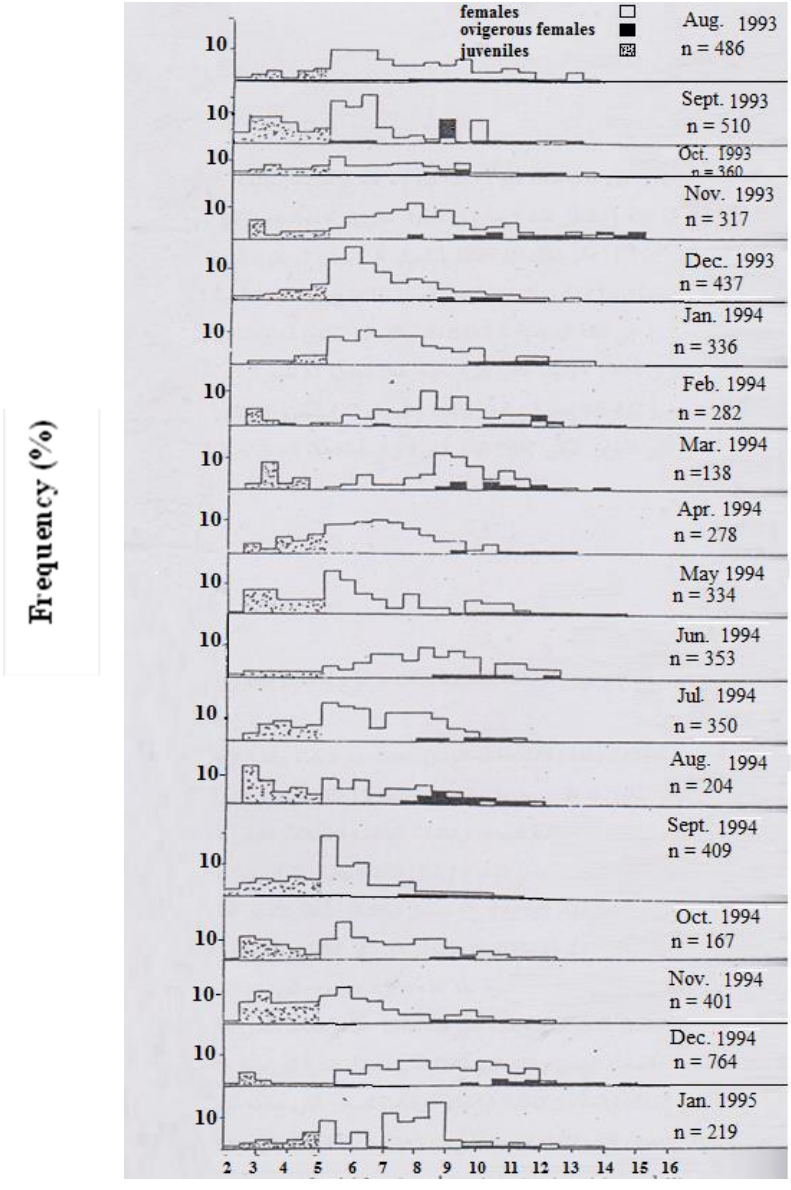

Fig.2. Size-frequency distribution of females of the amphipod *P. monodi* for the period August 1993-January 1995, at Garmat-Ali, Basrah.

Obviously, there were two peaks in abundance of ovigerous females, the first in March and the second in August 1994 (Fig.4). Sizes of mature females ranged from 5.0-15.0 mm. The smallest ovigerous females was 5.0 mm long. Some of the cohort were followed, as in the males. Cohort A was at a size group 8.5-9.0 mm in August 1993, attained a size of 14.5-15.0 mm in May 1994. Therefore, its growth rate is 0.66 mm per month. Cohort B, on the other hand, had a size of 6.0-6.5 mm in August 1993, reached a size of 12.0-12.5 mm in June 1994, therefore, it grew by 0.6 mm per month. Meanwhile, cohort C, was at a size of 3.0-3.5 mm in August 1993, grew to a size of 11.0-11.5 mm in July 1994, indicating a growth rate of 0.72 mm per month (Fig. 2). Hence, the average life span of the female cohorts was 15 months (Figs. 2& 6).

Juveniles

Percentage occurrence of juveniles versus percentage ovigerous females together with females having long bristle on the oostagites throughout the sampling period August 1993-January 1995 indicate that both categories are present t hroughout the whole sampling period (Fig. 4). It is apparent that peaks of release of youngs are associated with decline in numbers of ovigerous females, and as females increase in numbers a decrease is occurred in numbers of juveniles, except in August 1994 and to a lesser extent in May
of the same year. This suggests that the incubation period is very short and did not exceed a month, as there would be no close relation between the peaks of the two category, for at the time of peaks of juveniles in September 1993 there would be a decrease in numbers of ovigerous females, so as the case in the peaks of May and November 1994, and this is true for the peak of ovigerous females in March 1994 which is associated with the decrease in numbers of juveniles during that month, the only exception is the peak of ovigerous females in August which is accompanied by an increase in numbers of juveniles at that time.

Males

The size range of males varied from 5.25-16.10 mm. A by-eye follow up of the various peaks in the population indicate that cohort A (size-group 6.5-7.0 mm) in August 1993 (Figs. 3 & 6) may attain a size of 12.5-13.0

mm by May 1994. This means that it takes 9 months to reach this size, hence the growth rate would be 0.66 mm per month. Cohort B, on the other hand, was at 4.5-5.0 mm in August 1993 and attained 12.5-13.0 mm by June 1994, therefore it appeared for 10 months in the sampling period, and grew by 0.80 mm per month.

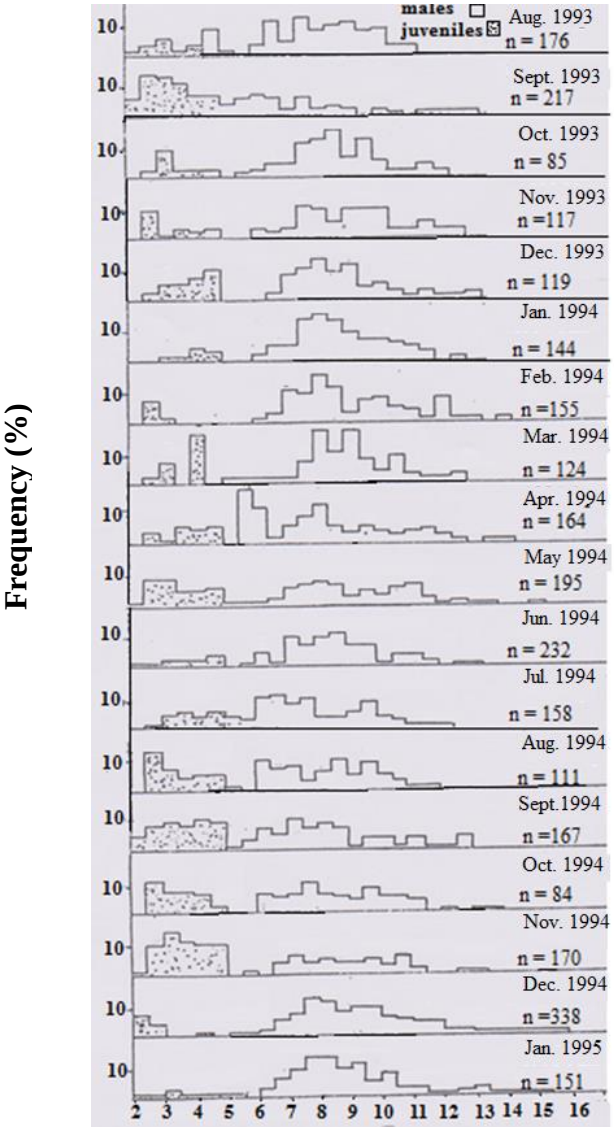

Figure 3. Size-frequency distribution of males of the amphipod *Platorchestia monodi* for the period August 1993-January 1995, at Garmat-Ali, Basrah.

Similarly, the peak at 2.5-3.0 mm (cohort C) in September 1993 reached 13.0-13.5 mm in October 1994, then it grew by 0.80 mm per month. The life span of some of the cohorts which appeared throughout their entire life during the sampling period like cohorts C & D, were ranging from 11-14 months for the (Figs. 3 &.6).

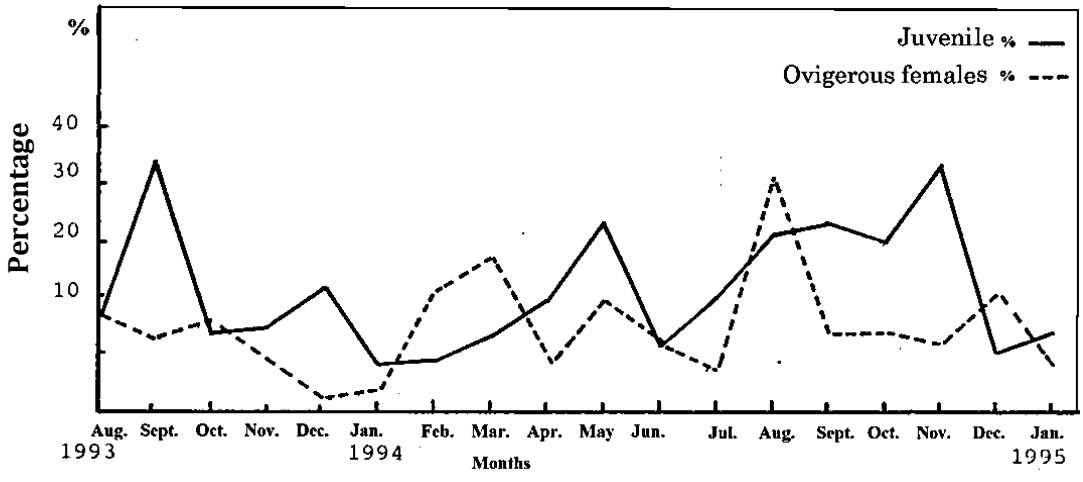

Figure 4. Monthly changes of the percentages of juveniles (solid line) and ovigerous females with females carrying long bristles on the oostegites (broken line) of the amphipod *P. monodi* , at Garmat-Ali, Basrah from August 1993-January 1995.

Sex ratio

Table (3) shows the numbers of males and females and the ratio of males to females throughout the sampling period, and the X^2 test to indicate whether the differences between the two sexes are significant from the hypothetical ratio of 1:1 or not.

The results emphasize that the females are significantly outnumbered the males in every sample, except in March 1994 when the difference between the two sexes was not significant ($P>0.05$). The overall ratio of males to females for the period August 1993 to January 1995 was 1:1.9 ($X^2=1082.37$, $P<0.05$).

Table 3: Sex ratio of the amphipod *P.monodi* at Garmat-Ali, * significant value.

Months	No. females	No. males	Ratio M:F	χ^2-test
Aug. 1993	426	139	1:3.0	145.79*
Sept.	316	90	1:3.5	95.00*
Oct.	153	69	1:2.2	31.79*
Nov.	276	96	1:2.8	87.10*
Dec.	377	85	1:4.4	184.55*
Jan. 1994	310	136	1:2.2	67.88*
Feb.	285	140	1:2.0	34.99*
Mar.	116	112	1:1.0	0.107
Apr.	223	129	1:1.7	25.10*
May	226	127	1:1.7	27.48*
Jun	309	207	1:1.5	19.77*
Jul.	285	123	1:2.3	67.32*
Aug.	143	75	1:1.9	21.21*
Sept.	284	86	1:3.3	105.96*
Oct.	122	55	1:2.2	25.37*
Nov.	250	74	1:3.4	95.61*
Dec.	695	298	1:2.4	158.72*
Jan. 1995	185	135	1:1.4	7.81*

Growth

Growth of juveniles

Growth of the newly released juveniles were followed in the laboratory during the period 22.10.1994 to the end of January 1995. Total length of the exuvia were measured, and the numbers of joints of the flagellum of the first and second antennae were counted. After 2 days of their release, the juveniles underwent moulting.

The processes of moulting occurred by a transverse fissure between the 1st and the 2nd pereomeres, then the animal withdraw the anterior part and then the posterior part of the body. Observation of moulting extended from 20.10 to 7.11.1994, after that no exuvia were found indicating that the amphipod may have consumed them after each moult. But measurements of the amphipod prior to and after moulting were carried out. The growth rate of the amphipod at the 4 moulting

occasions varied from 0.015 mm per day during the first moult to0.14 mm per day during the second moult. This suggests that the average growth rate of juveniles was 1.04 mm/month. However, the newly released juveniles were 2.44 mm long. Attainment of sexual maturity occurred after 3 months with the amphipod's size at 5.56 mm, there were only 14 survivors on 25.1.1995.

Growth rate of adult amphipod:

The growth rate of *P. monodi* expressed by Von Bertalanffy equation is shown in Fig. 5. It was found that the individual size of the amphipod during the first week was 3.3 mm and become 12.0 mm during the 12th week (last week in the experiment). The average weekly growth rate was 0.86 mm, whereas, at the 12th week, the weekly growth rate was 9.0 mm. Value of k and t_0 were calculated as-0.261, 0.230, respectively (Fig. 5), whereas, L_∞ was 12.0 mm, and this emphasize that, it is the largest theoretical size attained by the animal in the laboratory.

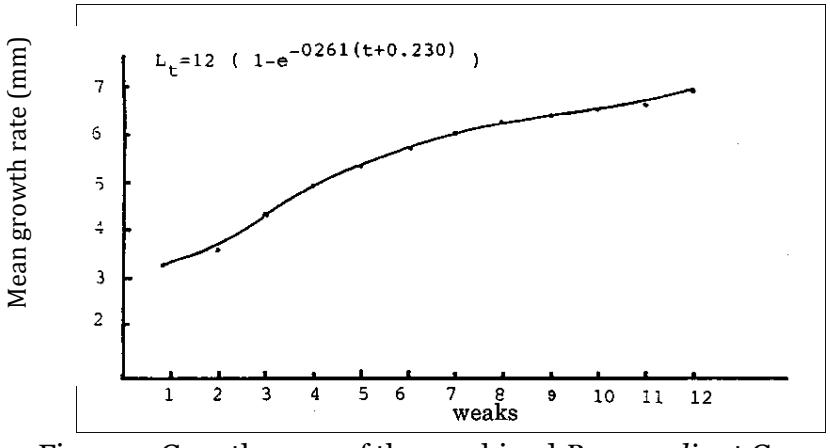

Figure 5. Growth curve of the amphipod *P. monodi*, at Garmat-Ali, Basrah . Data of mean growth rate obtained from result of laboratory rearing of the amphipod.

Average growth rates obtained from the size frequency distribution of *P. monodi* showed that it varied from 0.60-1.05 mm/mo, for the males and from 0.47-0.85 mm/mo, for the females (Fig. 6). Obviously, the average growth rates of males were higher than those of females.

Moreover, cohorts born in spring (cohort F) had higher average growth rates than the overwintering cohorts (A, B, C & D).

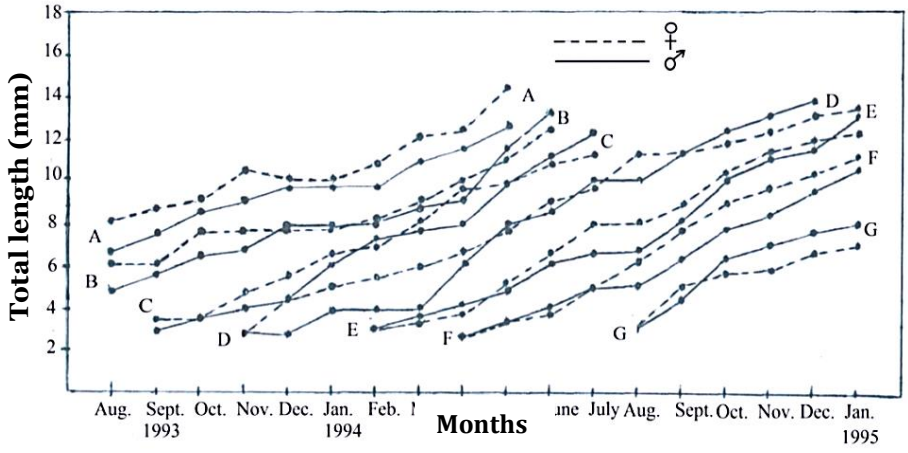

Figure 6. Mean monthly growth rates of different cohorts of males (solid lines) and females (broken lines) of the amphipod *P. monodi* , for the period August 1993-January 1995, at Garmat-Ali, Basrah.

Discussion

Talitridae include a large number of species (over 200+ species) distributed all over the world in the marine, estuarine, freshwater and terrestrial environments (Wildish, 1988). The presence of *P. monodi* in the Shatt Al-Arab region was limited to the areas of the plant remains washed up on the banks of the River by the water currents, or any wet area with decaying plant materials even in gardens of houses. It was noticed that the amphipod is not found in areas devoid of plant remains. Therefore, the presence and absence of *P. monodi* is depend on the changes in the plant cover of the wet areas of the river, and this in accordance with the presence of *Talorchestia margaritae* on the coasts of Venezuela which is dependent on the availability of the sea grass, *Thalassia testudinum*, as a shelter habitat and food, and the wide changes in the population are linked with the presence of these vegetation (Venables, 1981). Moreover, Muir (1977), while studying a population of the amphipod *T. capensis* in the coast of South Africa, found that this species is limited to those areas covered by remains of marine algae. In addition, the presence of the amphipod *Orchestia*

platensis on the sandy coasts of Japan is largely dependent on the aquatic plant remains (Morino, 1978). Morino, suggests that disturbing the presence of these plants causes the amphipod to burrow into the sand or leave the place to one containing these plants. Furthermore, Humberto *et al.* (1991) concluded that the presence of *Platorchestia platensis* on the coasts of Florida is limited to the presence of organic detritus and leaves of mangroves high at the intertidal zone.

The present results showed that *P. monodi* in Garmat-Ali river, Basrah, had a continuous reproductive activities, with two peaks of juveniles, one in May and the other in September/November, and two maxima of ovigerous females in March and August. This is apparently due to the food availability in the region and the favorable environmental conditions, particularly temperature. This is in accordance with the conclusion of Van Senus (1988) on *Talorchestia capensis* in South Africa, which had continuous reproduction and there was an increase of the reproductive activities of the adult in the population during the fall and spring, with a decline in the activities in winter and summer. Similarly, the amphipod *Gammarus aequicauda* in the Evros delta, NE Greece, had a continuous reproductive activities throughout the year (Kevrekidis and Koukouras, 1988). Furthermore, Scapini *et al.* (1992) emphasize that amphipod and some other arthropods release their young in seasonal peaks, like the amphipod *Talitrus saltator*, on the Mediterranean beaches, which releases their youngs in two peaks, in June and October, and suggests this as a kind of adaptation to prevent the newly hatched juveniles from being subjected to desiccation during summer.

The present results indicated that there was a positive relation of brood size and the size of females, as the numbers of eggs per females fluctuated between 5 (carried by female 5.0 mm long) and 18 eggs (carried by female 13.5 mm long), with an average of 9.8±1.6 eggs. This is in support to the numerous results emphasizing the close relation between female's body size and brood size in amphipods, for instance *Talorchestia margaritae* carried 2-14 eggs, with an average of 7 eggs (Venables, 1981), *T. capensis*, held 2-8 eggs (Van Senus, 1988), *T. quoyana,* females carried 13-36 eggs (females size 13-17 mm; Marsden,

1991), *P. platensis* females carried 1-15 eggs with an annual average of 5±3.0 eggs (sizes of females 6.5-12.5 mm; Humberto *et al*., 1991), and Koch (1990) concluded that in the amphipod *Traskorchestia traskiana*, from the Pacific NW U.S.A., the egg number is linearly correlated with females size. It can be concluded, however, that fecundity in talitrid amphipods inhabiting the supratidal zone, is generally low, this isperhaps a consequence of living high in the intertidal zone which represent a transition from aquatic to terrestrial life, and accompanied by harsh environmental conditions like desiccation, high temperature and fluctuation in the amount of aquatic plant remains swept high on the river's bank which provide protection and food for the animals (Marsden and Duncan, 1989).

The average egg size of *P. monodi* was about 0.75 mm and this is close to egg sizes of some Talitridae like *Orchestia mediterranea* (0.72 mm) and *O. cavimana* (0.69 mm) and slightly smaller than that of *Talitrus saltator* (0.88 mm; Williams, 1978) and *Traskorchestia traskiana* (0.85 mm; Koch,
1990), but, more than that of *P. platensis* (0.6 mm; Humberto *et al*., 1991),whereas, the intertidal talitrid, *Parhyale basrensis* of Shatt Al-Arab region, had an average egg size of about half that of the present species (0.387 mm ; Ali and Salman, 1986). However, *Talorchestia quoyana* had strikingly larger eggs (1.39 mm; Marsden, 1991).

Marsden (1989), suggests that the large size of egg of *P. monodi* is in accordance with the general trend of egg size of gammaridean amphipod and claimed that larger egg size leads to large sizes of the newly released juveniles, which can tolerate the adverse conditions of desiccation high in the intertidal habitat. Moreover, egg size increase with the embryonic development and with the increase of female's size. This is concur with the conclusion of Marsden (1991) on *T. quoyana* in New Zealand. However, the relation between brood size and the size of the female in *P. monodi* was significant and highly positive ($R=0.77$, $P<0.05$).

The life span of *P. monodi* was 11-14 months for the males and 15 months for the females, and this is within the range of 12-18 months reported for the amphipods inhabiting the supralittoral zone (Wildish, 1979).

Of the other strategies undertaken by *P. monodi* in this region is the biass of sex ratio in favor of the females (1.9♀♀:1♂♂), this reflects that there is always an access of females to compensate for the reduction in fecundity. Moreover, this ratio emphasize that the male may copulate with more than one female during the season. The present results of sex ratio is consistent with that of *P. platensis* from Florida (1.69:1; Humberto *et al*., 1991) and of *Traskorchestia traskiana* from the Pacific NW U.S.A. (1.7: 1; Koch, 1990) which were in favour of females also. Koch (1990) suggests the process is an ecological adaptation for increase the reproductive potential in the populations by increasing the numbers of reproductive individuals which ultimately providing the population with more individuals. Moreover, Wildish (1971) concluded that the preponderance of females represent an adaptation of the population of the amphipods to promote the reproductive potential to its maximum limit, hence is a mean of keeping the population density to its optimum level, especially if the females were carrying limited numbers of eggs.

From laboratory rearing experiments of newly hatched juveniles (size 2.44 mm) of *P. monodi,* it was found that they need 3 months to be sexually matured (size 5.56 mm). However, larger sized individuals may need 17.3 months for males and 15.9 months for females to attain their maximum size. It seems , however, that these values of life span of *P. monodi* were longer than naturally they are, as the experiments were carried out during the winter months in which the growth is lower than it normally be. Furthermore, stresses may be imposed on the amphipod once they were kept in captivity.

The present results indicated that in the laboratory *P. monodi* reached sexual maturity within 3 months (temperature 23 ˚C). *Talitrus saltator*, also attain sexual maturity in the laboratory within 3 months at temperature of 25 ˚ C (Scapini *et al*, 1992). Moreover, Marsden (1991) reported that juveniles of *Talorchestia quoyana*, grew at a rate of 1.7 mm per month, and suggested that this rapid growth rate is due to the reason of juveniles being continuously feeding on sea weeds widely available at the sandy supratidal zone in New Zealand, particularly the alga *Macrocystis pyrifera*.

Growth rates of *P. monodi* in the Shatt Al-Arab region was described by the Von Bertalanffy (1938) expression and compared with those of *Talorchestia margaritae*, in Venezuala based on laboratory experiments and with *Orchestia platensis* obtained from field data in Bermuda (Sutchliffe, 1965; Table 8). It is apparent that the growth rate of *P. monodi* is very much lower than those of the other two species. However, Wildish (1972) concluded that the growth in Crustacea is governed by two main factors, the number of moults underwent by the species and the increase of weight during each moult. Moreover, he followed up the growth of juveniles of *Orchestia remyi roffensis* and noticed that their growth rate was slow and suggested that this amphipod lives on driftwoods thrown on the supratidal zone and these materials are known by their low nutritional value as opposed to weeds and algae, and added that the slow growth rate of animals is an important physiological evolutionary aspect towards the invasion of land. Furthermore, Hurley (1968) pointed out that terrestrial amphipod are recognized by slow growth rate especially those species living high in the supratidal zone. However, Hartnoll (1982) draw the attention to the fact that rearing under laboratory conditions may affects the rate of growth of crustaceans, whereas Cooper (1965) concluded that the growth rate of *Hyalella azteca* in the laboratory either equal to or higher than that in the natural population, which was subjected to cohort analysis. Meanwhile, Wildish and Frost (1991) emphasize that laboratory conditions didn't affect the growth of talitrid amphipods. It can be concluded, therefore, that the slow growth rate of *P. monodi* in Garmat-Ali region is a physiological step towards evolving a land-living habit, which is a further support to the conclusion of Wildish (1972).

The success of the reproductive strategy of the landhopper may be due to several reasons of which the production of a few large-sized eggs with the increase of size of female may help in protection of the new releases and the production of large-sized juveniles may ensure the protection of the new releases against desiccation and predation (Marsden, 1991). Moreover, the success of *P. monodi* in its habitat imposed by its wide spreading in the region with higher densities is a reflection of their highly evolved reproductive strategy. The life span of the females are comparatively long and they produce fewer juveniles at an early stage of

their lives at short intervals, indicate that they give more than one brood in their lifetime, together with their protection of the brood in the brood pouch and the continuity of breeding throughout the year leed to increasing young production in the field.

The ability of *P. monodi* to maintain the population density at its optimum throughout the year, is dependent on the availability of food (small animals and vegetation) washed up high in the supratidal zone and by its behavioral and physiological adaptation to extreme conditions of heat and desiccation together with the reproductive strategy outlined in this article.

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References

Ali, M.H. (2001). The energy gains and energy losses by the intertidal amphipod *Parhyale basrensis* from the Shatt Al-Arab Region. Marina Mesopotamica, 16(1): 141-158.

Ali, M.H. and Salman, S.D. (1986). The reproductive biology of *Parhyale basrensis* Salman (Crustacea, Amphipoda) in the Shatt Al-Arab river. Estuarine Coastal and Shelf Sciences, 23: 339-351.

Ali, M.H. and Salman, S.D. (1987). Growth and production of the amphipod *Parhyale basrensis* (Talitridae) in the Shatt Al-Arab region . Marine Ecology, Progress Series, 40: 231-238.

Al-Saadi, H. A. and Al-Mayah, A.A. (1983). Aquatic plants of Iraq. Publications of Centre for Arab Gulf studies, University of Basrah. 192 pp.

Basson, P.W., Burchard, J.E., Hardy, J. T. and Price, A.R. (1981). Biotopes of the western Arabian Gulf. ARAMCO, Saudi Arabia. 284pp.

Behbehani, M.I. and Croker, R.A. (1982). Ecology of beach wrack in northern New England with special reference to *Orchestia platensis*. Estuarine Coastal and Shelf Sciences. 15: 611-620.

Bousfield, E. L. (1982). The amphipod super family Talitroidea in the northeastern Pacific region.1. Family Talitridae: systematic and distributional ecology. National Museum of Natural Science, Ottawa. Publ. Biol. Oceanogr.11: 1-73.

Bousfield, E. L. (1984). Recent advances in the systematic and biogeography of landhoppers (Amphipoda:Talitroidea) of the Indo-Pacific region. In: Biogeography of the tropical Pacific, Proceedings of a symposium. F.J. Radovsky, P.H. Raven, and S.H. Sohmer (eds.). Bishop Museum, special Publication, 72: 171-210.

Bousfield, E. L. (1988). Crustaceans of tropical seas. The amphipod. Seawind, 2(3): 15-19.

Bousfield, E. L. (1991). New sandhoppers (Crustacea:Amphipoda) from the gulf coast of the United States. Gulf Research Reports, 8(3): 271-283.

Bregazzi, P.K. (1972). Life cycles and seasonal movements of *Cheirimodon femoratus* (Pfeffer) and *Tryphosella kergueleni* (Miers) (Crustacea:Amphipoda). British Antarctic Servey Bulletin, 30: 1-34.

Charniaux-Cotton, H. (1957). Croissance, regeneration et determinisme endocrinien des caracteres sexuelsd' *Orchestia gammarella* (Pallas) Crustacea, Amphipoda. Ann. Sci. Nat. Zool. Biol. Anim., 19: 411-559.

Chelazzi, G. and Ferrara, F. (1978). Researches on the coast of Somalia. The shore and the dune of Saruanie.19. Zonation and activity of terrestrial isopods (Oniscoidea). Monitore Zool. Ital. Suppl.,(Nova Serie), 11: 184-219.

Cooper, W.E. (1965). Dynamics and production of a natural population of a freshwater amphipod, *Hyalella azteca*. Ecological Monographs, 35: 377-394.

Griffiths, C.L. and Stanton-Dozey, J. (1981). The fauna and rate of degradation of stranded kelp. Estuarine Coastal and Shelf Sciences. 12: 645-653.

Gonçalves,S. C., Marques, J.C., Pardal, M.A., Bouslama, M.F., El-Gtari, M. and Charif-Cheikhrouha,F. (2003). Comparison of the biology, dynamics, and secondary production of *Talorchestia*

brito (Amphipoda, Talitridae) in Atlantic (Portugal) and Mediterranean (Tunisia) populations. Estuarine Coastal and Shelf Sciences. 58: 901-916.

Hartnoll, R. G. (1982). Growth. In: L.G. Abele (ed.) The biology of Crustacea. Academic Press, New York and London, 1(2): 111-196.

Humberto, A. Graces, B. and Alex Marsh, G. (1991). Studies on the distribution and ecology of *Platorchestia platensis* (Kröyer) at Lake Wyman, Boca Ration, Florida. Florida Scientist, 54(1): 1-10.

Hurley, D.E. (1968). Transition from water to land in amphipod crustaceans. Am. Zool., 8: 327-353.

Hynes, H.B. N. (1954). The ecology of *Gammarus duebeni* Lilljeborg and its occurrence in fresh water in western Britain. J. Anim. Ecol., 23: 38-84.

Hynes, H.B. N. and Haper, F. (1972). The life histories of *Gammarus lacustris* and *G. pseudolimnaeus* in Southern Ontario. Crustaceana, (suppl.)3: 329-341.

Jones, D. A. (1986). A field guide to the sea shore of Kuwait and the Arabian Gulf. University of Kuwait. 192 pp.

Kevrekidis, Th. and Koukouras, Ath. (1988). Life cycle and reproduction of *Gammarus aequicauda* (Crustacea: Amphipoda) in the Evros delta (NE Greece). Canadian Journal of Zoology, 35: 137-149.

Koch, H. (1990). Aspects of the population biology of *Traskorchestia traskiana* (Stimpson, 1857)(Amphipoda) in the Pacific NorthWest U.S.A. Crustaceana, 59(1): 35-52.

Lindeman, D.H. (1990). Phylogenys and zoogeography of the New World terrestrial amphipods (land hoppers) (Crustacea: Amphipoda: Talitridae). Can. J. Zool., 69: 1104-1116.

MacIntyre, R. J. (1963). The supralittoral fringe of New Zealand beaches. Trans. R. Soc. N. Z., 88: 89-103.

Marsden, I.D. (1989). An assessment of seasonal adaptation in the beach hopper *Talorchestia quoyana* (Milne-Edwards). J. Exp. Mar. Biol. Ecol., 128: 203-218.

Marsden, I.D. (1991). Kelp-sandhopper interactions on a sand beach in New Zealand. 1. Drift, composition, distribution. J. Exp. Mar. Biol. Ecol., 152: 61-74.

Marsden, I.D. and Duncan, K.W. (1989). Reproduction in sand dwelling talitrid amphipods : Evolutionary adaptation for terrestrial life. Memoires of the Queensland Museum. 96 pp.

McLachlan, A. and Jaramillo, E. (1995). Zonation on sandy beaches. Oceanography and Marine Biology. An Annual Review, 33: 305-335.

Miller, S. A. (1982). The life history of *Gammarus pseudolimnaeus* Bousfield in a central Wisconsin stream (Amphipoda: Gammaridea). Crustaceana, 43(1): 89-99.

Morino, H. (1978). Studies on the Talitridae (Amphipoda: Crustacea) in Japan. III. Life history and breeding activity of *Orchestia platensis* Kroyor. Publ. Seto. Mar. Biol. Lab., 24: 245-267.

Muir, D. G. (1977). The biology of *Talorchestia capensis* (Amphipoda: Talitridae) including a population energy budget. M. Sc. Thesis, University of Cape Town, 110pp.

Prato, E., Trono, A. and Biandolino, F. (2009). Life history of *Talorchestia deshayesii* (Amphipoda: Talitridae) in the Ionian Sandy Beach (Southern Italy). Braz. Arch Biol. Technol. 52(4): 911-922.

Salman, S.D. (1986). *Parhyale basrensis* a new species of talitrid amphipod from the Shatt Al-Arab region, Iraq. Crustaceana, 50: 287-294.

Salman, S.D. and Abdullah, A. E. (1997). The first record of *Platorchestia monodi* (Mateus *et al*., 1986) from the South of Iraq. Marina mesopotamica, 12(1): 39-46.

Scapini, f., Chelazzi, L., Colombini, I. and Fallaci, M. (1992). Surface activity, zonation and migrations of *Talitrus saltator* on a Mediterranean beach. Marine Biology, 112: 573-581.

Spicer, J. I., Moore, P.G. and Taylor, A.C. (1987). The physiological ecology of land invasion by the Talitridae (Crustacea:Amphipoda). Proc. R. Soc. Lond. Biol., Sci., 232: 95-124.

Sutchliffe, W.H. Jr. (1965). Growth estimates from ribonucleic acid content in some small organisms (Talitridae) : effects of size and temperature. Crustaceana, 41(1): 89-94.

Van Senus, P. (1988). Reproduction of the sandhopper *Talorchestia capensis* (Dana) (Amphipoda: Talitridae). Crustaceana, 55: 93-103.

Venables, B.J. (1981). Aspects of the biology of a Venezuelan beach amphipod, *Talorchestia margaritae* (Talitridae), including estimates of biomass, daily production and respiration rates. Crustaceana, 41: 271-285.

Von Bertalanffy, L. (1938). A quantitative theory of organic growth. Human Biology,10: 181-213.

Wildish, D. J. (1971). Adaptive significance of a biased sex ratio in *Orchestia*. Nature (London), 233: 54-55.

Wildish, D. J. (1972). Post embryonic growth and age in some littoral *Orchestia* (Amphipoda: Talitridae). Crustaceana, 3: 267-274.

Wildish, D. J. (1979). Reproductive consequences of the terrestrial habit in *Orchestia* (Crustacea:Amphipoda). Int. J. Invertebrate Reproduction. 1: 9-20.

Wildish, D. J. (1988). Ecology and natural history of aquatic Talitridae . Can. J. Zool., 66: 2340-2359.

Wildish, D. J. and Frost, B. (1991). Volumetric growth in gammaridean Amphipoda. Hydrobiologia, 223: 171-176.

Williams, J. A. (1978). The annual pattern of reproduction of *Talitrus saltator*. J. Zool., 184: 231-244.

حياتية التكاثر لمزدوج الاقدام *Platorchestia monodi* (Mateus *et al*., 1986) من منطقة شط العرب، البصرة، العراق.

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الخلاصة

دُرست دورة الحياة والتكاثر للنوع القشري مزدوج الاقدام *Platorchestia monodi* في المنطقة العليا الرطبة لحافات نهر كرمةعلي في البصرة، خلال المدة من 26 آب 1993 الى 28 كانون الثاني 1995. جمعت عينات بصورة عشوائية على اساس شهري. كانت الاعداد الكثيرة من الحيوان تنتشر تحت جذوع وبقايا النباتات المائية والاشجار الساحلية الملقاة على اعلى الضفاف والتي توفر لها الغذاء والحماية.

وجد ان ذكور الحيوان تنضج جدنسياً عند بلوغها حجم 5.25 ملم والاناث عند 5.0 ملم. وجدت الاناث الحاملة للبيض على مدار السنة، وكان معدل قطر البيضة 0.75 ملم وكان يكبر خلال مراحل التطور الجنيني، ومعدل اعداد البيض التي تحملها الاناث يتراوح بين 5–18 بيضة. الخصوبة كانت ترتبط كدالة آسية لحجم الاناث. ظهرت نسبة الاناث اعلى معنوياً من الذكور (1:1.9) في عينات الجماعه السكانية للحيوان. كانت الجماعة السكانية متعددة التوزيع (الاجيال) خلال كل مدة جمع العينات، وقدرت مدة حياة الذكور من 11–14 شهر، بينما الاناث كانت مدة حياتها 15 شهراً.

كلمات مفتاحية: بايلوجية التكائر، امفيبودا، *Platorchestia monodi*، شط العرب.