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Aspects of the reproductive cycle of the prawn *Macrobrachium nipponense* (De Haan, 1849) from Al-Hammar Marsh, Southern Iraq

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Abstract -The reproductive cycle of the Macrobrachium nipponense (De Haan, 1849) was studied in Al-Hammar Marsh, Southern Iraq during Dec. 2015 to Nov. 2016.The averages of total length, carapace length and weight for males were 65.7 mm, 28.8 mm and 2.9 g respectively, and for ovigerous females were 60.1 mm, 26.0 mm and 3.3 g respectively. Length-weight relationship of M. nipponense was W= 0.407 L e 0.031 (r = 0.67) for the females and W= 0.177 L e 0.043 (r = 0.90) for the males. The highest percentage of ovigerous females was 98.88 % attained in August. The maximum gonado somatic index was recorded in March (10.66) and the minimum was 5.72 recorded in July 2016. The condition factor for the males was ranging from 1.30 to 2.90 in November and August, respectively, while for the females it was between 1.11 and 2.10 at the same periods. Total number of eggs per female was from 799 to 2047 egg/ind. Minimum sex ratio (males: females) was 1:0.17 recorded in February, and the maximum 1:9.00 was recorded in June.

مظاهر الدورة التكاثرية في الروبيان Macrobrachium nipponense (De Haan, 1849) في هور الحمار، جنوب العراق

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المستخلص - درست الدورة التكاثرية في الروبيان Macrobrachium nipponense (De Haan, 1849) في هور الحمار، جنوب العراق للفترة من كانون الثاني 2015 إلى كانون الأول 2016. بلغت معدلات الطول الكلي وطول الخطم والوزن للذكور 65.7 ملم و 28.8 ملم و2.9 غم على التوالي. بينما بلغت هذه القياسات للإناث حاملة البيض بين 60.1 ملم و 26.0 ملم و 3.3 غم على التوالي. تمثلت علاقة الطول بالوزن في اناث الروبيان M. nipponense بالمعادلة (W= 0.407 L e 0.031) (r = 0.67)، وفي الذكور (W= 0.177 L e 0.043) (r = 0.90). لوحظ أعلى نسبة للإناث حاملة البيض (98.88 %) في شهر آب. سجل أعلى معدل لدالة المناسل في آذار وبلغت 10.66 وأقل نسبة في حزيران وبلغت 5.72 تراوح معدل الحالة للذكور بين1.30- 2.90 في كانون الأول وآب على التوالي، وتراوح في الاناث بين 1.11- 2.10 في نفس تراوح عدد البيض الكلي بين 799 الى 2037 بيضة / فرد، وسجلت أقل نسبة الجنس (ذكر: انثى) (0.17:1) وسجلت في شباط، بينما لوحظت اعلى نسبة جنس (9.00:1) في شهر حزيران.

الكلمات المفتاحية: روبيان، *Macrobrachium nipponense* ، تكاثر، هور الحمار، العراق

Introduction

Macrobrachium nipponense (De Haan, 1849) is a small prawn with maximum length of 86 mm for males and 75 mm for females, sexual maturity occurred at 4-5 months old and mating occurred between newly molted females and hard shelled males (New *et al.*, 2010). *M. nipponense* is originated from China, and was recorded in Japan and Taiwan (Cai and Ng, 2002), also, recorded

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in Singapore and Philippines (Cai and Shokita, 2006), in Ozbakstan (Mirabdullaev and Niyazov, 2005). However, recently it was recorded in the Caspian lake basin in North Iran (De Grave and Ghane, 2006). In Iraqi waters, this prawn was observed for the first time in the year 2002, specimens of *M. nipponense* appearing as benthic animals from the Garmmat Ali River, near the Al-Hammar Marshes (Salman *et al.*, 2006). The knowledge of reproductive biology of palaemonid prawns is an important tool to define strategies for biodiversity preservation (Castex *et al.*, 2008). Therefore, the goal of this study was to investigate the reproductive cycle of *M. nipponense* as an invasive species which is essential for culture programs of prawn and habitat especially there is only a few studies on this species in Iraq, such as Al-Maliky (2017) and Abbas *et al.* (2018).

Materials and Methods

M. nipponense were sampled monthly, from December 2015 to November 2016, during the morning time by a trawl net of 1 cm mesh-size, for 20 min. The sampling

site was located at Al-Hammar Marsh at water depth of 5-6 m, the site's GPS is (30º 39´ 34.27" N, 47º 39´ 13.81" E) (Fig. 1). All samples were fixed with 70 % Alcohol on the boat and were stored in plastic containers. During sampling, water temperature, salinity, dissolve oxygen and pH were recorded. Absolute fecundity (total number of eggs) of the females was estimated. The eggs were carefully removed from the pleopods and counted under a light microscope, the relationship between the total length (TL) and fresh weight (W) of the Prawn was expressed by the equation: $W = a L^{b}$; Where: W=Weight of the Prawn in (g), L=Total Length (TL) of the Prawn in (cm), a=Constant (intercept), b=The Length exponent (slope).

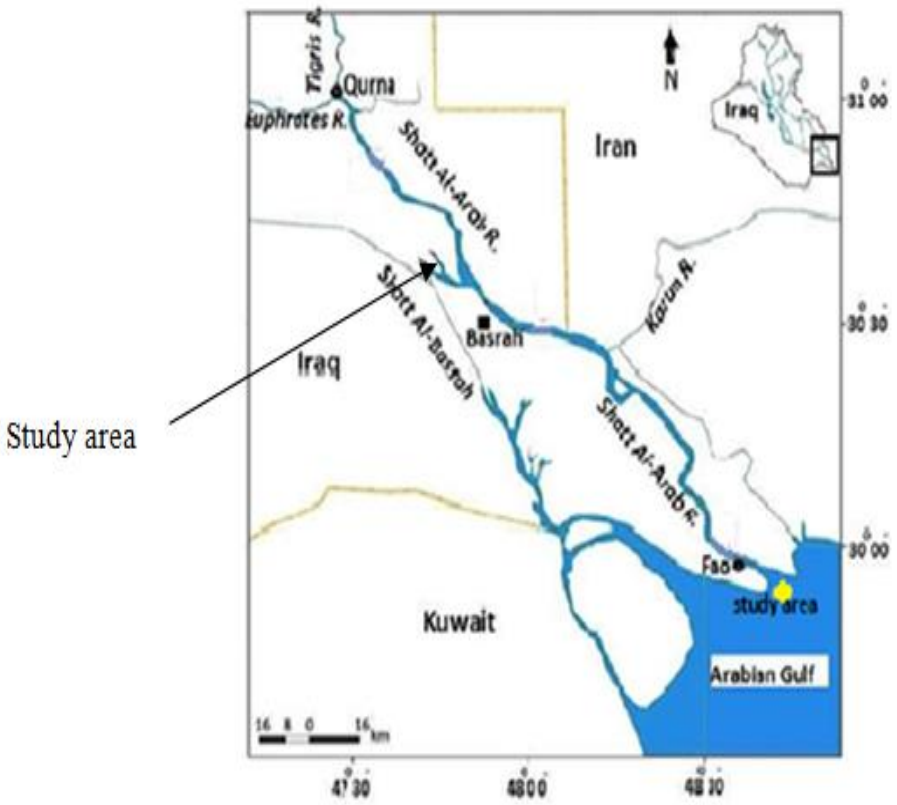

Figure 1. Geographical location of the sampling site in Al-Hammar marsh, Southern Iraq.

Condition factor (Kn) was calculated by the formula: K=100W/L3; Where: Kn=Condition factor, W=Weight of the Prawn in grams, L=Length of the Prawn in centimeters (Enin, 1994).

According to Namin *et al*. (2014), index of gonado somatic index (GSI) was determined from the formula: GSI=100 (GW)/BW; Where: GW=Gonad weight, BW=Body weight. The sex of each prawn was determined by the presence in the males of the appendix masculina on the second pleopods while it is absent in the females (Deekae and Abowei, 2010).

Results

Environmental Factors:

In the present study, the environmental parameters; temperature, salinity, pH and dissolve oxygen were measured during the reproductive period of *M. nipponense*. The ranges of temperature were fluctuated between 12±1ºC during Jan. and 28±1.5ºC during July 2016. Salinity was between 0.8±0.4 ppt. during April and 2.0±0.5 ppt. during November. The pH values ranged was between 7 and 7.6 during January and August, respectively. The minimum dissolved oxygen was 5.5±0.4 mg/l, recorded during July and the maximum value was 8.2±1.2 mg/l during December.

Size and Weight:

Table (1) shows morphological measurements of the prawns characteristics. Mean values of the total length, carapace length and weight for males were 65.7 mm, 28.8 mm and 2.9 g, respectively. While for non ovigerous females were 53.6 mm, 39.7 mm and 2.8 g, respectively, and for ovigerous females were 60.1 mm, 26.0 mm and 3.3 g, respectively.

Length-Weight Relationship:

The length-weight relationships parameters (a and b) of the equation: $W = a L^b$ were estimated for *M. nipponense* as in the following: (W= 0.407 L e 0.031) with significant positive correlation (r = 0.67) for females, and (W= 0.177 L e 0.043) with significant positive correlation (r = 0.90) for males (Figs. 2 and 3).

Reproductive Activity:

Fecundity:

The present investigation revealed that ovigerous females (reproductive period) were started from March and continued until September 2016, whereas non-ovigerous females were observed in the samples of the other months. The maximum percentage of the females were 98.88 % in August compared with 1.21 % for non-ovigerous female.

Maturity was recorded at a length of 42.74 mm and a weight of 1.18 g (Fig. 4). The maximum GSI for *M. nipponense* females was recorded in August (10.66), while the minimum value was 5.72 during July 2016 (Fig. 5).

Table 1. Total length, carapace length and weight of the *Macrobrachium nipponense* from Al-Hammar Marsh, Iraq.

Prawns	Characters	Average	Minimum	Maximum
Males	Total length (mm) Carapace length (mm) Weight (g)	65.7 28.8 2.9	52.1 21.0 2.0	74.7 31.6 4.5
Females (non-ovigerous)	Total length (mm) Carapace length (mm) Weight (g)	53.6 39.7 2.8	41.3 15.4 0.7	62.1 57.2 3.4
Females (ovigerous)	Total length (mm) Carapace length (mm) Weight (g)	60.1 26.0 3.3	48.3 19.3 1.6	69.1 28.2 4.3

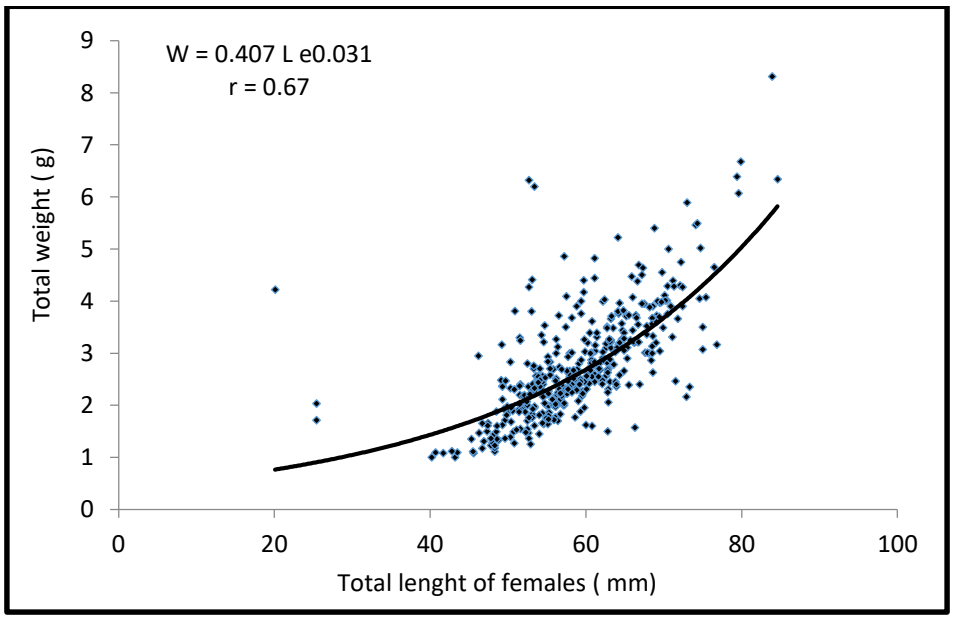

Figure 2. Relationships between length and weight in females *Macrobrachium nipponense* Al-Hammar Marsh, Southern Iraq during Dec. 2015 to Nov. 2016.

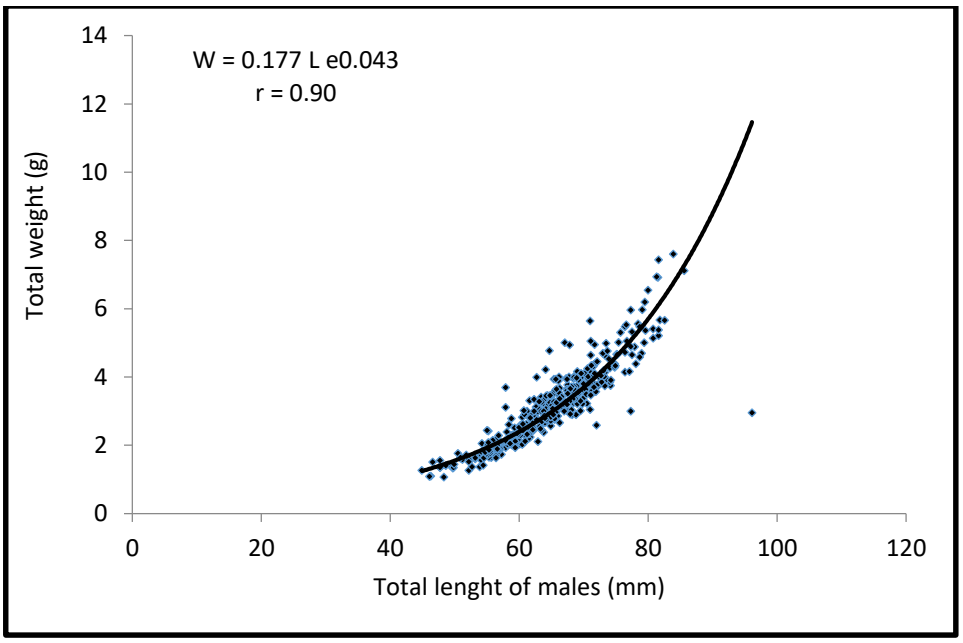

Figure 3. Relationships between length and weight in males *Macrobrachium nipponense* in Al-Hammar Marsh, Southern Iraq during Dec. 2015 to Nov. 2016.

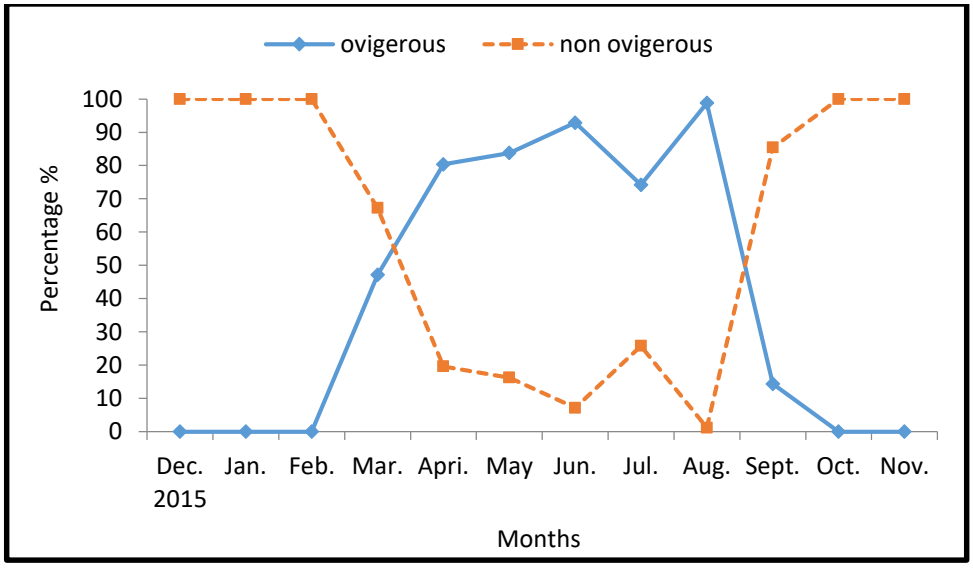

Figure 4. Percentage of ovigerous and non ovigerous females *Macrobrachium nipponense* at Al-Hammar Marsh, Southern Iraq during Dec. 2015 to Nov. 2016.

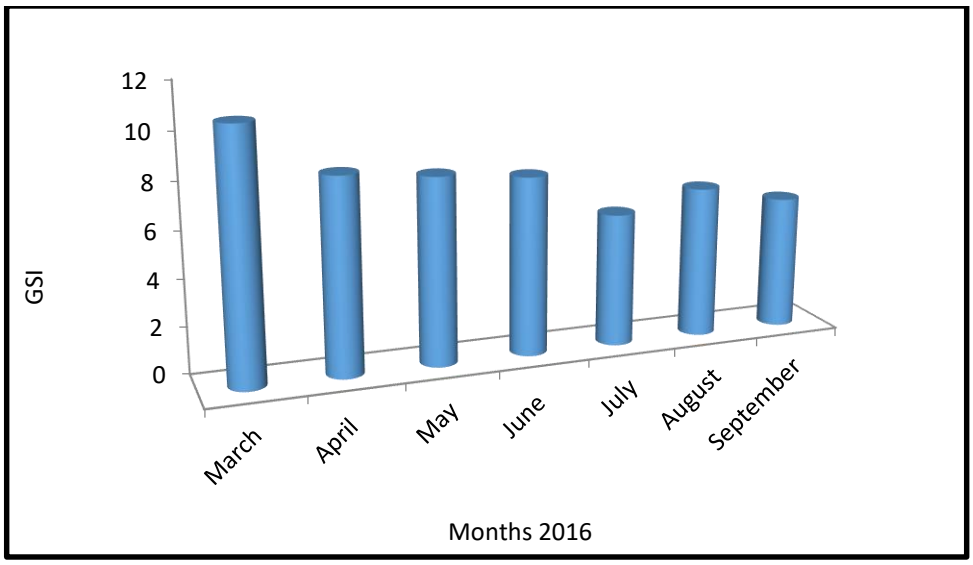

Figure 5. Gonadal somatic index for *Macrobrachium nipponense* at Al-Hammar Marsh, Southern Iraq during the reproductive periods that extended from March to September 2016.

The Kn values for males were ranging between 1.30 and 2.90 in November and August, respectively, while for the females they were between 1.11 and 2.10 in the same periods (Fig. 6). The total length and the fresh weight of the females were found in this study ranging from ٤٨,٣٠ to 69.1 mm and the weight from 1.60 to 4.37 g, respectively, and for males the length were 52.1 to 74.70 mm and the weight from 2.0 to 4.5 g. The number of eggs per female was ranged from 799 to 2047 (Fig. 7).

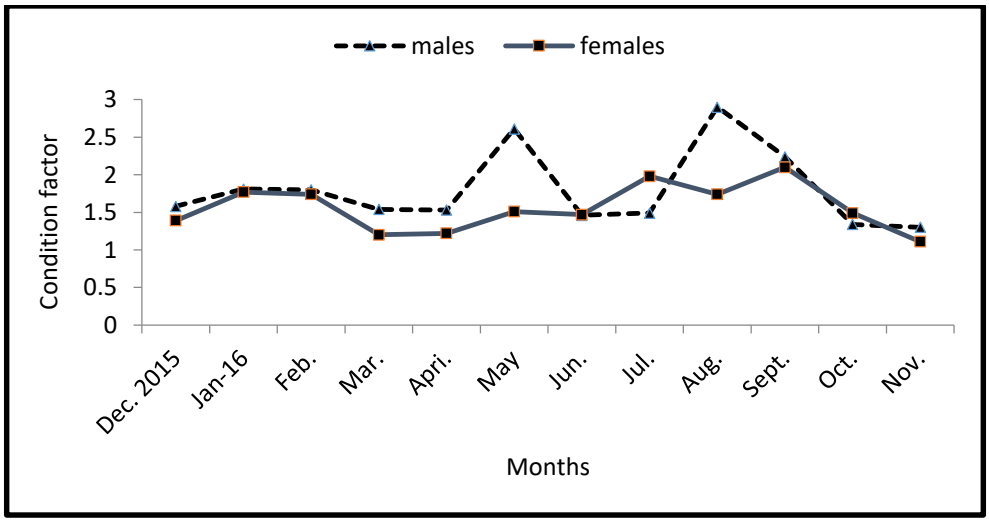

Figure 6. Condition factor (Kn) of *Macrobrachium nipponense* at Al-Hammar Marsh, Southern Iraq during Dec. 2015 to Nov. 2016.

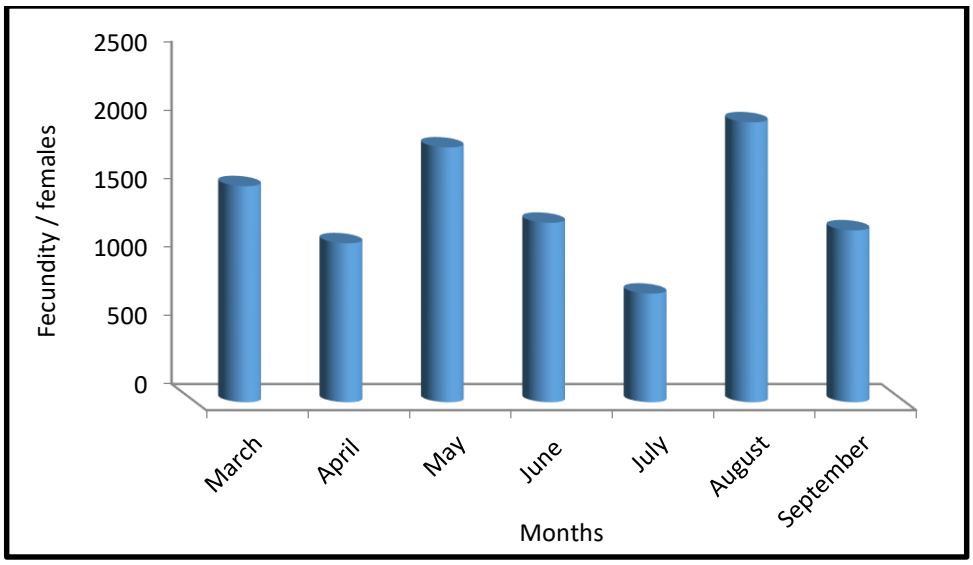

Figure 7. Fecundity of *Macrobrachium nipponense* females at Al-Hammar Marsh, Southern Iraq during the reproductive period that extended from March to September 2016.

Figure (8) shows a positive correlation between total length and number of eggs (fecundity) (F = 267.4 L e 0.024, r = 0.94), and a positive correlation between weight and fecundity (F = 692.7 W e 0.174, r = 0.90) (Fig. 9). Table (2) showed the percentage of sex ratio for 1694 individuals, involving 1010 females with a ratio of 59.62 %, and 684 males with a ratio of 40.37 %. During the study we observed clear variation in the sex ratio with different reproductive seasons, the minimum sex ratio (males:females) was 1:0.17 during February, and the maximum 1:9.00 during June.

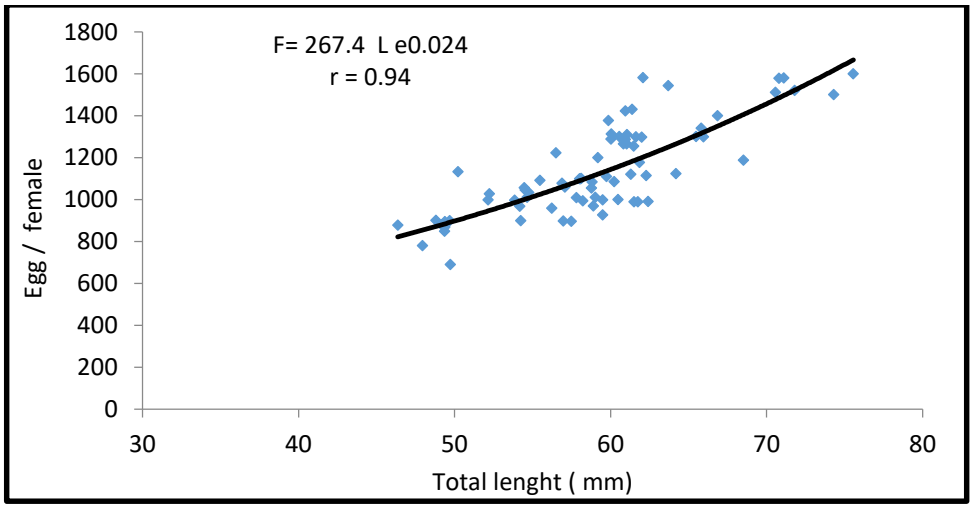

Figure 8. Relationship between total length and fecundity in *Macrobrachium nipponense* females at Al-Hammar Marsh, Southern Iraq during Dec. 2015 to Nov. 2016.

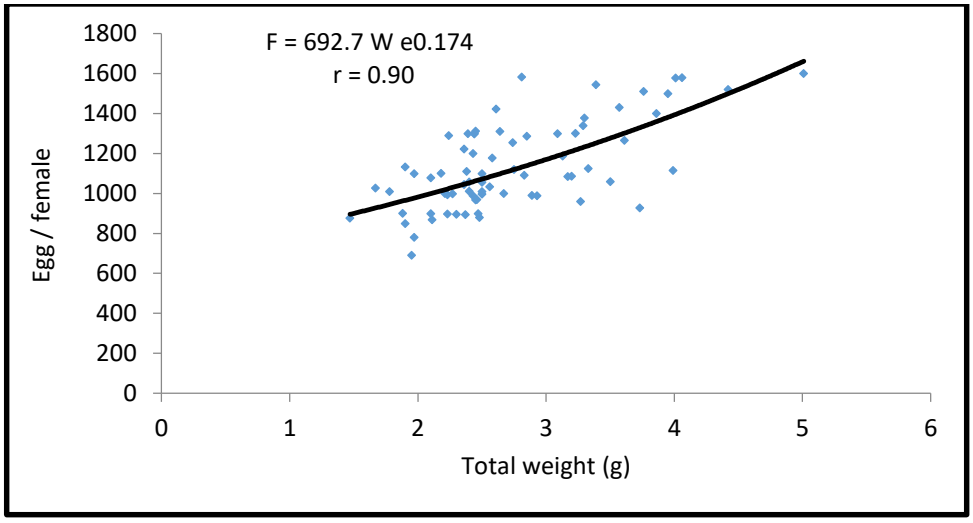

Figure 9. Total weight and fecundity relationship in *Macrobrachium nipponense* females at Al-Hammar Marsh, Southern Iraq during Dec. 2015 to Nov. 2016.

Table 2. Sex ratio of M*acrobrachium nipponense* at Al-Hammar Marsh, Southern Iraq during Dec. 2015 to Nov. 2016.

Months	Sex Ratio (M:F)	No. of Males	No. of Females	Total Prawns
Dec. 2015	1:0.26	133	35	168
Jan 2016	1:0.32	65	21	86
Feb.	1:0.17	78	14	92
Mar.	1:1.52	98	149	247
Apri.	1:2.28	99	226	325
May	1:4.21	40	162	202
Jun.	1:9.00	5	45	50
Jul.	1:5.66	15	85	100
Aug.	1:2.80	20	55	75
Sept.	1:1.33	36	48	84
Oct.	1:0.81	110	90	200
Nov.	1:0.71	38	27	65

Discussion

The temperature, salinity, pH, and dissolved oxygen are essential environmental factors for the success of the prawns, any sudden changes in these factors such as temperature may cause harmful impacts on the prawn's reproduction.

Temperature is the main parameter having effects on various physiological processes such as metabolism, respiration and enzyme reaction inside the animal (Mc Gaw and Curtis, 2013).

The present results indicated a clear significant correlation between the appearance of ovigerous females and temperature (Fig. 4), therefore their high numbers were coincided with the hot months April to August.

Salinity and other parameters (pH and oxygen) recorded in the present investigation were similar to the ranges given by other studies which seems to be suitable for *M. nipponense*.

Regarding the, salinity, these prawns can live at a range of salinities extended from brackish to fully freshwater, and can quickly adapt to such changes (Salman *et al*., 2006).

The length and weight values of the prawn recorded from the marshes were asymptotic to those from the Iranian waters. Gorgin and Sudagar (2008) reported total length for males as 36.8 - 76.3 mm and weight of 0.6 - 7.1 g, while for nonovigerous females was 48-57.1 mm and 1.1-2.2 g, and for ovigerous females 51-68 mm and weight 1.8-4.3 g.

The estimated length-weight equations reveal that it was significant, but males prawns have had greater increase per molt cycle leading to faster growth rate than those of the females, apparently, this is also due to that the males encountered more frequent molting cycles than the females which had never molted during eggs bearing stages (Namin *et al.*, 2014).

Variations of length-weight relationships are a good indicator in crustaceans that reflects the fluctuations of the uptake and allocation of energy, furthermore, these variations are a function of many factors such as food availability, reproductive cycle, sexes and seasons, and these were reported in both wild and cultured populations of the prawn (Lalrinsanga *et al*., 2012).

Generally the length-weight slope values estimated for the prawn *M. nipponense* indicating a pattern of allometric growth comparable to that of other workers for the same species (Namin *et al*., 2014), or the same genus (Lalrinsanga *et al*., 2012).

The Kn of males was higher than that of the females (1.30 to 2.90 for males and 1.11 to 2.10 for females), the difference obviously attributed to the high capacity of females for storing energy as fat to utilize it during the gonadal maturation periods, however, the ovaries in the females comprise higher energy contents compared with testis of the males (Lira *et al.*, 2012).

The GSI is another good index of the ovaries ripening and maturation and according to Martins *et al.* (2007) the differences in GSI between species is related to reproductive strategy. The monthly GSI in *M. nippoense* were different, the maximum value (10.66) was recorded in March which coincide with the beginning of the reproductive season of *M. nipponense* in the marshes, whereas the minimum value (5.78) was recorded in July.

Fecundity, the number of eggs per female may vary seasonally, annually and between areas (Parson and Tuckers, 1985). The species size of prawn also could determine the fecundity, in general, the biggest species produce higher number of eggs compared with smaller size one (New and Nair, 2012).

Based on the data of the present investigation, the fecundity of *M. nipponense* was varies from 799 to 2047 egg/ind. This is much lower than that observed in other species of commercial interest such as the fecundity of *M. rosenbergii* which varies from 40,000 to 60,000 eggs for a female body weight 100 g (Manush *et al.*, 2006). Dinakaran (2010) found egg number from 6,158 to 29,272 (60 and 92 mm total length) in *M. idella idella*. Deekae and Abowei (2010) recorded a fecundity *M. macrobrachium* for a period of a two years (2006 to December, 2007) were ranged from 180 to 5,800 egg per females.

Regarding the sex ratio in the population of the *M. nipponense*, the results appeared seasonal variations between the numbers of males and females with a ratio values different from the supposed general 1:1 ratio in most months.

Mostly the females were dominated the samples during the reproductive months. Usually the sex ratio in different species are greatly affected by the reproductive biology and the behavior of the population, for instance the migration and immigration at different areas and seasons (Deekae and Abowei, 2010).

Conclusions

There are clear relationship between temperature and the onset of the reproductive season which is long ,extended from March to September. The size atmaturity of *M. nipponense* was recognized at length 42.74 mm, fecundity (799 to 2047 egg/individual). The sex ratio data evident that the prawn population have a sort of migration toward the estuary.

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