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The density and reproductive biology of the Fiddler Crab *Uca sindensis* (Alcock, 1900) (Crustacea: Ocypodidae) in intertidal zone of Shatt Al-Basrah river –Khor Al-Zubair, Iraq.

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Abstract

The density and reproductive biology of *Uca sindensis* were studied in intertidal zone of Khor Al-Zubair, south of Shatt Al-Basrah river, Basrah, Iraq. The crabs were collected randomly three 0.25m^2 quadrates during low tide periods from November 2014 to October 2015. Density of crabs, sex ratio, distribution, population structure, diameter burrow, breeding season and fecundity were investigated. The results showed that crabs population fluctuated and depended on the months of the year. Crabs density in study area was (181ind/ m^2 in April 2015) and (19 ind./m^2 in December 2015). The CW of females ranged from 4 to 13.5 mm and of males from 5 to 16 mm indicating sexual dimorphism. The relationship between Carapace width (CW) × Carapace height (CH) was positive in males and females. The equation (Log CH=Log-4.644+4.362LogCW) for males ($P<0.05$) and Log CH=Log-2.152+3.299LogCW for females ($P<0.05$). Sex ratio showed lower number of females than males for study area, The overall sex ratio was 1:1.26 and did not differ significantly from the expected 1:1 (χ test, $P>0.05$), however the monthly sex ratio was different from expected 1:1(χ test, $P<0.05$). Breeding took place during warm season of March to October 2015. The regression analysis showed that the number of eggs increased linearly with the increase of carapace width (r^2= 0.775, n=38). It was concluded that some factors of temperature, Salinity and TOM in sediment affected at density growth and reproduction pattern in *U. sindensis*.

Keywords: Population biology, Khor Al-Zubair, Sex ratio, carapace.

Introduction

The fiddler crab *Uca sindensis* (Alcock, 1900) (Crustacea: Brachyura: Ocypodidae) is distributed in the northern coasts of the Arabian Sea (Pakistan, Iran, Iraq, and Kuwait). Its typical habitat is on high intertidal areas with higher salinity, which might restrict its distribution, especially within the Arabian Gulf.(Apel and Türkay 1999; Naser et al. 2010; Al-Behbehani, 2010; Mokhlesi

et al. 2011; Naderloo and Türkay 2012). Its ecology and behavior have been studied in Kuwait (Al-Behbehani, 2010), Iran (Mokhlesi et al. 2011), and Pakistan (Saher and Qureshi 2012). *Uca* crabs are a famous group of brachyuran crabs in intertidal zone (Rosenberg, 2001). The activity of most intertidal organisms and *Uca* crabs occur in low as well as high tides because they spend some activity time in semi-terrestrial habitat, then returns to their burrows at high tide (Klassen and Ens, 1993). The properties of habitat Such as: type of vegetation, food availability, temperature, tide, salinity, sediment of surface and other animals play a major role in biodiversity, population dynamic and distribution and density of fiddler crabs (Smith, 2012; Smith et al, 2012; Johnson, 2014; Smith, 2015). Crabs are consumed by birds, invertebrates and fish, because they are source of energy for both terrestrial and marine ecosystems (Skov and Hartnoll, 2001; Litulo, 2004a). Males have a major claw for burrowing digs (Crane, 1975). Their adaptive radiation is considered to be related to the habitat and food sources through modifications of their own morphology, behavior, ecology and physiology (Crane, 1975; Johnson, 2014; Smith, 2015). They are deposit-feeders and they construct burrows that have different shapes because the burrows shape associated surface sediments (Olafsson and Ndaro, 1997). *Uca sidensis* have been recorded in the intertidal zone of Shatt Al-Basrah river –Khor Al-Zubair in south of Iraq. The study of breeding season in Crustacean can facilitate the understanding of impact of environmental factors on reproduction. Brachyuran Crabs diversified to shape to maximize egg production and offspring survivorship (Oliveira Silva, *et al.* 2016). In the present study, the population biology and reproduction of *Uca sindensis* is assessed with emphasis on size structure, sex ratio, breeding season, fecundity, distribution, burrow depth and handedness in intertidal zone of–Khor Al-Zubair, in Shatt Al-Basrah river, south of Iraq.

Materials and Methods

The specimens were collected from Khor Al-Zubair (Fig. 1). The specimens were collected during low tide at the intertidal zone of Khor Al-Zubair, and crabs were picked up by hands.

Study area

Khor Al-Zubair is an extension of the Arabian Gulf waters in the lower reaches of Mesopotamia (Fig. 1). It has a length of approximate 42 km, and a width of 1km at low tide, with an average depth of 10-20 m. In 1983, this water body was connected to an oligohaline marsh (Hor Al-Hammar) by the Shatt Al-Basrah Canal changing the environment of lagoon of the Khor from a hypersaline to an estuary (Hussain and Ahmed, 1999). The topography of the Khor Al-Zubair looks like a spindle with tapering ends at the northern and southern ends. The northern end receives fresh water influx of average 700 m^3/sec throughout the tidal cycle. The current in the Khor characterized by one

direction throughout the tidal cycle towards the southern end (Arabian Gulf), with velocity exceeding 2m/sec during ebb tide and 0.66 m/sec in flood tide. At the southern end, the water discharge reaches 10000m^3/sec with velocity range of 0.8-5.78 m/sec and with big tidal range at the Umm-Qasar reaching 4.3m (Al-Badran *et al*., 1996).

Fig. 1: Study area at intertidal zone in Khor Al-Zubair, south of Shatt Al-Basrah river.

Sampling Methods

Three 0.25 m2 quadrates were randomly sampled on monthly basis during low tide periods from November 2014 to October. Quadrates were placed at two substrates, sand and silt. The quadrates were excavated with a corer to a depth of 30 Cm and all fiddler crabs presented in the quadrates were collected, bagged, labeled and preserved in 70% ethanol until further analysis.

Laboratory Analysis

In the laboratory, identification of sex specimens was performed. The carapace width (CW) was measured using a vernier caliper (± 0.05 mm accuracy). The number of crabs were recorded for each quadrate. The population size structure was analyzed in function of the size frequency distribution of all individuals collected during the study period. The period of time when ovigerous females were found in the population was considered as the breeding season. To estimated fecundity, 38 ovigerous females with eggs at stage I were selected for egg counting according to the methodology proposed

by Litulo (2004b). Pleopods were removed from the females, placed in petri dishes filled with Saltwater, data were analyzed using the power function (Y=aX + b) of egg number were: (EN)vs. CW. One-way ANOVA was performed to determine right or left major claw during the year. On each sampling date, sediment samples (about 5 Cm deep and 500g) were randomly collected over sampling area in order to analyze the organic matter. Then, samples were incinerated at 550 °C for 3h and weighed again. Finally, organic matter content was calculated as the percent weight loss after combustion. Temperature was recorded from sediment surface by thermometer 2-3 times during the sampling (Koch et al., 2005). T-test was performed to determine whether the organic matter changed during the year.

Results

A total of 571 crabs were sampled during low tide period of which 252 were males (44.10%), 291 non – ovigerous females (50.95%), and 28 ovigerous females (4.95%) (Table. 1). The crabs higher density (males and female) in study area was (81 ind. /m^2 in April 2015) while lower density was (19 ind. /m^2 in December 2015).

Table 1: *Uca sindensis*- total number (density) (individual/ m^2) and sex ratio of individuals collected monthly at Khor Al-Zubair, south of Shatt Al-Basrah river.

Month	Males		Non-ovigerous females		Ovigerous females		Males and females		Sex ratio
	Total	%	Total	%	Total	%	Total	%	F : M
Nov. 2014	10	3.96	12	4.12	0	0	22	3.85	1: 1.25
Dec. 2014	9	3.57	10	3.43	0	0	19	3.32	1: 1.11
Jan. 2015	12	4.76	11	3.78	0	0	23	4.02	1: 0.91
Feb. 2015	30	11.9	34	11.6	0	0	65	11.38	1: 1.16
Mar. 2015	28	11.1	29	9.96	3	10.71	60	10.50	1: 1.14
Apr. 2015	35	13.8	41	14.1	5	17.8	81	14.01	1:1.31
May 2015	31	12.3	32	10.9	4	14.2	67	11.73	1: 1.16
Jun. 2015	29	11.5	35	12.0	6	21.4	70	12.25	1: 1.41
Jul. 2015	22	8.73	22	7.56	5	17.8	49	8.58	1: 1.22
Aug. 2015	14	5.55	23	7.90	3	10.71	39	6.83	1: 1.78
Sep. 2015	17	6.74	22	7.56	1	3.57	40	7.00	1: 1.35
Oct. 2015	15	5.95	20	6.87	1	3.57	36	6.30	1: 1.41
Total	252	44.1	291	50.95	28	4.95	571	100	1: 1.26

Sex ratio showed lower number of females than males for study area, The overall sex ratio was F: M=1:1.25 and did not differ significantly from the expected 1:1 (χ test, $P>0.05$), however the monthly sex ratio was different from expected 1:1(χ test, $P<0.05$). The correlation between carapace width (CW) and number of eggs was high (r^2=0.7758.) (Fig. 3).

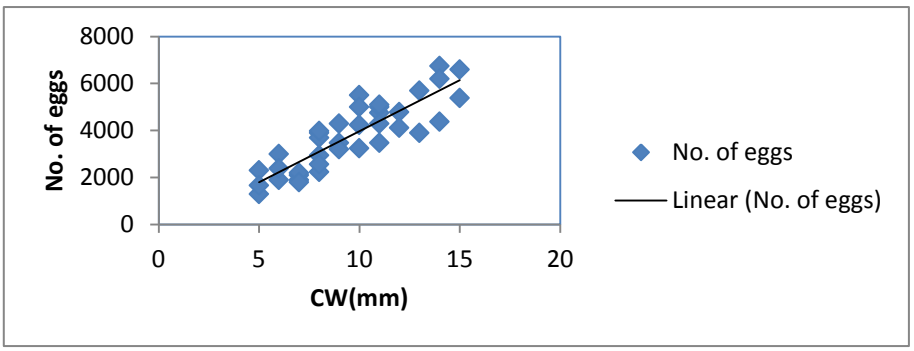

Fig. 3. Linear relationship between carapace widths (CW) of *Uca sindensis* crabs and the number of eggs (n=38).

Reproductive activity of *Uca sindensis* in Khor Al-Zubair area was restricted to warm seasons (spring and summer) (Fig. 4). Ovigerous females were higher in June 2015 (Fig. 5). Fecundity ranged from 1946 (CW=5mm) to 6110 (CW= 14mm) (Fig. 5). (Fig. 6) show the yearly size frequency distributions for males and females. Males were a high abundant in the size classes between (9-10 mm) and females were a high abundant in the size classes between (8-9 mm). The relationship between CW×CH was positive of males and females (Figs.7, 8). The equation: (Log CH = Log - 4.644 + 4.362 Log CW) for males ($P<0.05$) and Log CH=Log-2.152+3.299 Log CW for females ($P<0.05$).

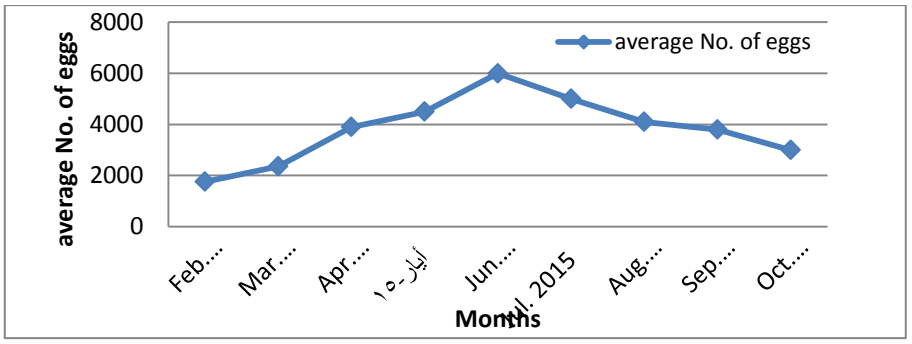

Fig. 4: Linear relationship between months and average number of eggs in *Uca sindensis* in study area.

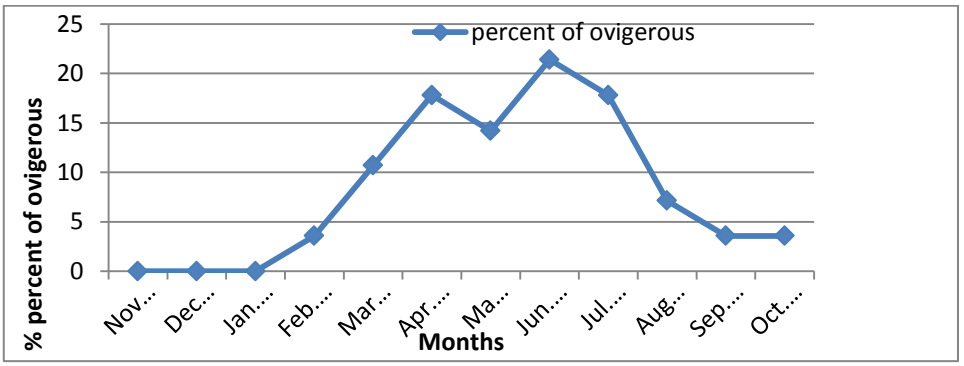

Fig. 5: Monthly percent of ovigerous females of *Uca sindensis* collected from Khor Al-Zubair, south of Shatt Al-Basrah river.

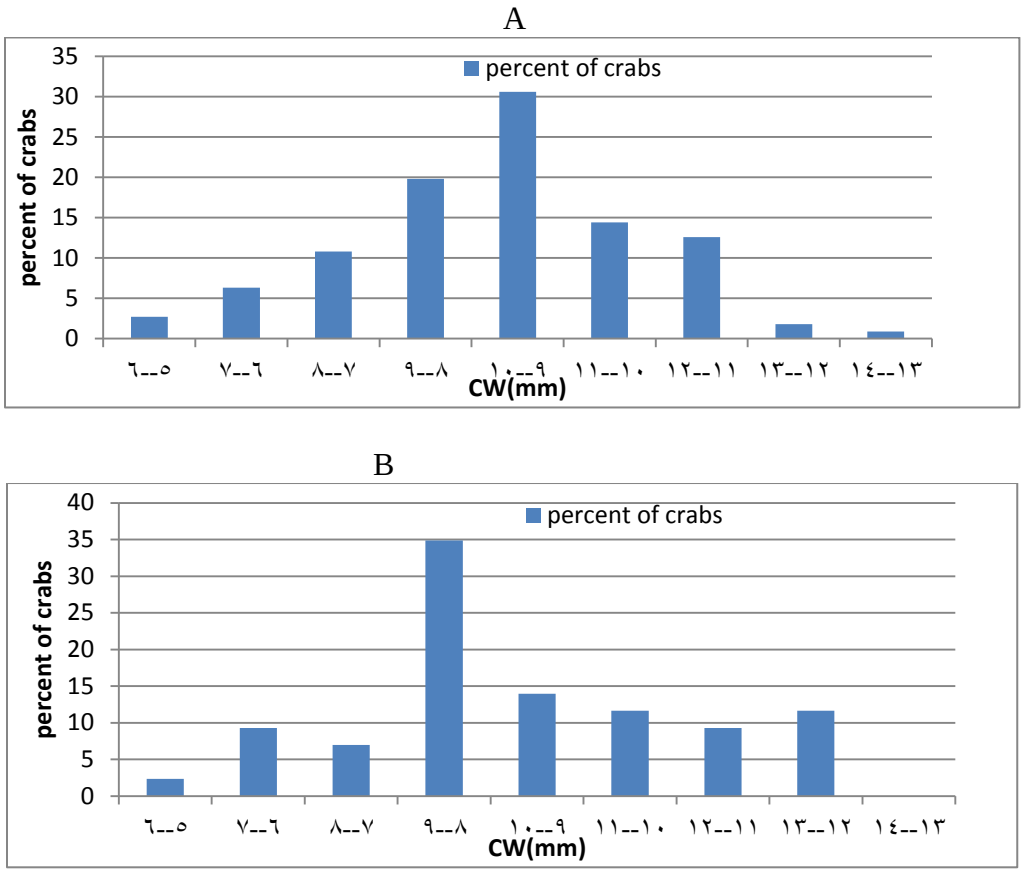

Fig. 6: Yearly Size frequency distribution of *Uca sindensis* (A male, B female) in Khor Al-Zubair, south of Shatt Al-Basrah river.

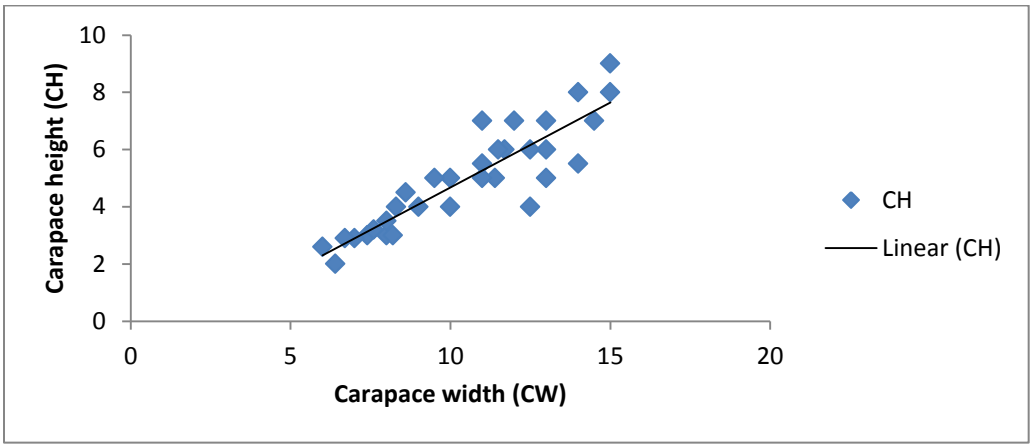

Fig. 7: Relationship between Carapace height and carapace width in males of *U. sindensis* from Khor Al-Zubair, south of Shatt Al-Basrah river.

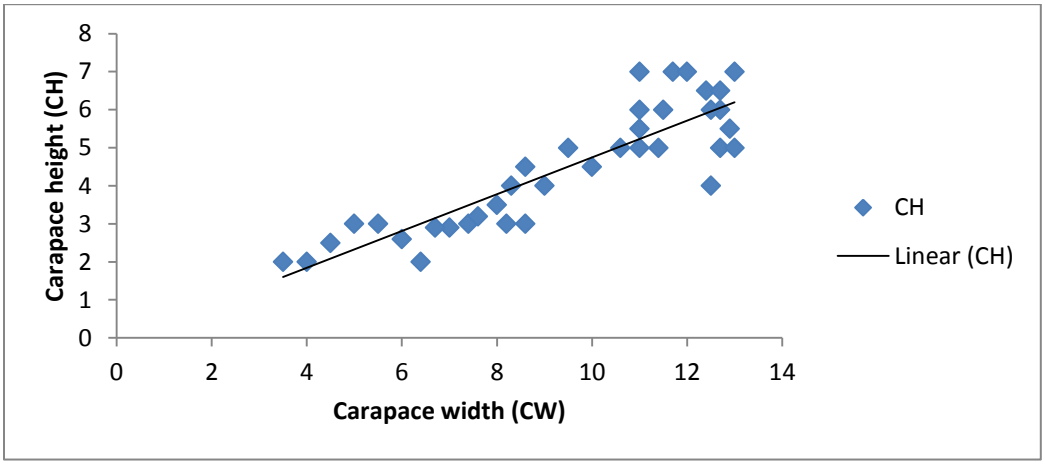

Fig. 8: Relationship between Carapace height and carapace width in females of *U. sindensis* from Khor Al-Zubair, south of Shatt Al-Basrah river.

Environmental factors

Temperature at the sediment surface at low tidal was 33.5°C during August 2015, while it descending to 11.5°C in January 2015 (Table 2). Salinity differed significantly among study months, with the lowest levels recorded during the winter months and the highest during the summer months. The estimated percent organic matter contents were higher (1.3mg/L) in February 2015 and lower (0.84mg/L) in August 2015 (Table 2). Pearson correlation coefficient indicated strong positive relationship between the density of crabs and temperature ($p<0.01$), but there was negative strong correlation between growth rate and total organic matter of sediments ($p<0.05$).

Table 2: Monthly variation of Sediment temperature, salinity and percent organic matter content at Khor Al-Zubair, south of Shatt Al-Basrah river.

Months	Sediment temp. (°C)	Salinity (PSU)	O. M.C. (mg/L)
Nov. 2014	26.5	6	0.96
Dec. 2014	18	6	0.99
Jan. 2015	11.5	5	1.2
Feb. 2015	13.5	3	1.3
Mar. 2015	19	8	1.1
Apr. 2015	22.5	6	0.95
May 2015	24	7	0.87
Jun. 2015	29.5	9	0.88
Jul. 2015	30	10	0.89
Aug. 2015	33.5	11	0.84
Sep. 2015	28.5	12	0.92
Oct. 2015	27	8	0.94

Discussion

Uca sindensis at intertidal zone of Khor Al-Zubair, south of Shatt Al-Basrah river, showed higher density in both bigger and smaller size in males and females respectively. In addition, it showed population of crabs fluctuated and depended on the months of the year. Crabs density in study area was (81ind./m^2 in April 2015) and (19 ind./m^2 in December 2015). In this study, the overall sex ratio did not differ significantly from the expected 1:1 ratio but significant deviations were observed in some months. Litulo (2005) did not find significant differences from 1:1 sex ratio *Uca annulipes*. In crustaceans, sexuality may be responsible for unbalanced sex ratio (Johnson, 2003). The diameters of *Uca sindensis* burrows (BD) correlated with crab carapace width (CW). Similar results were found by Christy (1987) in *Uca puligator* and by Skov and Hartnoll (2001) in Uca annulipes from Zanzibar (Tanzania) (Fig. 2). The relationship between burrow diameter and carapace size suggested that the size structure of this species could be estimated from the analysis of burrow diameters and represent defensive behavior to prevent being displaced by larger crabs and predators. Reproduction of *Uca sindensis* in Khor Al-Zubair, south of Shatt Al-Basrah river, located in subtropical area indicated that ovigerous females were seasonal, primarily between April to October throughout the year. In most subtropical and tropical regions, reproduction occurs during the warmer months when plankton food sources are more abundant (Sastry, 1983; Ashton et al., 2003). Total organic matter, temperature and salinity were found to be as critical factors for *U. sindensis*. The number of eggs produced by fiddler crabs varies widely, with an increase in number of eggs as the crab grows larger. Moreover, fecundity may vary in relation to latitudinal range and foods disposal and temperatures (Hines, 1982). The fecundity of *U. sindensis* estimated with CW is found in other brachyurans. The determination coefficients for the relationship between egg number and female size was higher, suggesting that this was a good estimator for fecundity and that egg losses were minimal, since variation was estimated about 0.99%. This study constitutes the first account on the population ecology and reproductive of *U. sindensis* in this area. Further research on spatial distribution, secondary production, microbial community and larval ecology and reproductive output will be necessary in order to understand *U.sindensis* life cycle. Total organic matter, temperature and salinity are critical factors affecting growth and reproductive pattern in *U. sindensis* at intertidal area of costal of Khor Al-Zubair in Shatt al-Basrah, south Basrah city. Temperature was also found to have a strong influence on the density of the active crabs in the area; also total organic matters in sediment is effective on growth rate and reproductive period. Organic matter of sediment in July, when the growth rate was the highest, differed significantly with data of January. It could be suggested that among the

various factors, organic matter enhanced feeding crabs, as was documented previously in Thailand (Nielsen et al., 2003). The *Uca sindensis* breeds during spring and summer in Khor Al-Zubair south of Shatt al-Basrah, although in Mozambique (tropical region) breeding was continuous throughout the year (Litulo, 2005). Low temperature has been reported to limit the active season and affect feeding and reproduction of land crabs (Wolcott,1988). Temperature was also found to have a strong influence on somatic and gonadic growth in crustaceans (Meusy and Peyen, 1988).

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