The Egg Characteristics of the Narrow-Clawed Crayfish *Astacus leptodactylus* Under Natural Conditions

Seyed Mehdi Mirheydari [1], Abbas Matinfar[2], Mehdi Soltani [3], Abolghasem Kamali[1], Yousef Ali Asadpour-Ousalou [4]

[1.] Department of fisheries, Faculty of agriculture and natural resources, Science and research branch, Islamic Azad University, Tehran, Iran
[2.] Department of aquaculture, Iranian fisheries research organization, Tehran, Iran (PO. Box; 14155-6116)
[3.] Department of aquatic animal health, Faculty of veterinary medicine, University of Tehran, Tehran, Iran
[4.] Iranian artemia research center, Golmankhaneh Harbor, Urmia, Iran.(PO. Box; 316)
mehdi.mirheydari@yahoo.com

Abstract: This study was carried out with the aim of examining the seasonal fecundity and developmental characteristics of the eggs of the female narrow-clawed crayfish *Astacus leptodactylus* from Aras Dam Lake, Western-Azerbaijan, Iran. Ovarian and pleopodal fecundity, egg diameter and egg weight were measured in a total of 45 mature size females on November 2011 and January 2012. A positive correlation was found between both ovarian and pleopodal fecundity and female size. The mean value of ovarian eggs was (206.55). Pleopodal fecundity was 37.3% lower than ovarian fecundity. The value of the gonadosomatic index (GSI) of females' sampled on November was 13.53% (11.63 - 15.91%). The average size of pleopodal eggs was 2.2 mm (1.07 - 6.59 mm). The number of eggs attached to 3rd and 4th pairs of pleopods was significantly higher than other pleopods. The egg number and gonadosomatic index increased significantly with female size.
[Mirheydari SM, Matinfar A, Soltani M, Kamali A, Asadpour-Ousalou YA **The Egg Characteristics of the Narrow-Clawed Crayfish *Astacus leptodactylus* Under Natural Conditions.***Life Sci J* 2024;21(8):21-29]. ISSN 1097-8135 (print); ISSN 2372-613X (online). http://www.lifesciencesite.com. 04. doi:10.7537/marslsj210824.04.

Keywords: *Astacus leptodactylus*, pleopodal fecundity, ovarian Fecundity, egg weight, egg diameter.

1. Introduction

Astacus leptodactylus is a widespread species distributed throughout Europe, eastern Russia, and the middle east (Souty-Grosset et al., 2006). Due to their large size and commercial interest, *Astacus leptodactylus* have been stocked in a large number of water bodies, particularly during the last century (Skurdal and Taugbol, 2002). In Iran, the narrow-clawed crayfish *Astacus leptodactylus* was reported not only in the Iranian coast of Caspian Sea up to 5–10 km offshore (Veladykov, 1964) but also in some freshwater inland reservoirs (Karimpour et al., 2011). *A. leptodactylus* lives in cold and clear water of Anzali lagoon and Aras Dam Lake in northern Iran, naturally. Although this species has been introduced to some other reservoirs throughout Iran in recent years (Naviri, 1994), however there have been some fluctuations in the production of *A. leptodactylus* in the recent decade. The export of crayfish in Iran increased remarkably after 1996. The exports of crayfish increased from 32.5 tons in 1998 to 84.7 tons in 1999 (Karimpour et al., 2011).

Fecundity is described as the egg number or female offspring (Abercrombie et al., 1992). The freshwater crayfish, especially Astacidae family, shows the lowest fecundity between crustaceans (Reynolds 2002). The average pleopodal fecundity of some populations of *A. leptodactylus* in Iranian inland waters have stated by some previous authors which differed from 221 to 251 eggs for Anzali lagoon (Karimpour et al., 1989; Danesh-Khosh-Asl and Karimpour 2004) and 322 eggs for Aras Dam Lake (Karimpour and Hosseinpour, 1999). The difference between pleopodal and ovarian fecundity has reported as 21% for Aras Dam Lake, 19% for Anzali lagoon (Danesh-Khosh-Asl and Karimpour, 2004) and 30% for northern coasts of the Caspian Sea (Kolmykov, 2002).

The current study was aimed to comprehensively survey between the ovarian and pleopodal fecundity of the narrow-clawed crayfish under Aras Dam Lake conditions.

2. Material and Methods

The sampling was conducted seasonally on 6 November, 2011 and 13 January, 2012 in the "Aras Dam" Lake in Qare-Ziaoddin region, Western-Azerbaijan Province, Iran. The sampling area is located between 231°20□ and 231°25□ N latitudes, and between 225□25 and 225□50□E longitudes, around Aras town in Qare-Ziaoddin region in west- northern border of Iran.

A total of 20 and 25 mature size females were collected on November and January, respectively. Total

body length was measured to the nearest 0.1 mm with a caliper, from the rostral apex to the posterior median edge of the telson, and ranged between 53.4 and 148.1 mm. The carapace length ranged between 35.0 and 62.3 mm. The wet weight was measured to the nearest 0.1 g and ranged between 42.9 and 92.4 g.

Right after sampling, carapaces were lifted away and ovaries were dissected out. The gonads were weighed via an electronic digital scale to the nearest 0.001 g. The GSI was evaluated as follows; (GSI; ovarian wet weight/total body weight × 100) (Ferré et al., 2012). The dissected out ovaries placed in 4 % formalin and then the ovarian eggs were counted (Schulz and Smietana, 2001).

The eggs extruded in the beginning of January. Crayfish were transferred to the laboratory complex of Islamic Azad University by air in a Styrofoam box containing meshed ice, where the pleopodal fecundity was evaluated. The eggs were removed from the pleopods, and the number of ripe eggs was counted.

The mean ± standard error (SE) and linear regression of the data in the current study were done by Microsoft Excel 2003 and Statistica software. Mean values and SE of the data were evaluated via ANOVA and subsequent Duncan's multiple range tests. The pair wise comparison was performed by LSD test. ANCOVA test showed the difference between ovarian and pleopodal fecundity in which total body length of female considered as a covariance. Linear correlations were performed for the ovarian and pleopodal fecundity. Data were shown as mean ± SE, with $p < 0.05$ presented as significant difference.

3. Results

The mean total body length and mean total body wet weight of 25 mature size females trapped in November were 74.41±22.79 (50.08-107.39) mm and 42.95±12.67 (31.86-65.03) g, respectively. The mean value of ovarian fecundity was calculated to be 206.55±□38.08, ranging from 132 to 275 eggs. The ovarian fecundity relative to the total body length have presented in a linear regression (Figure 1A, $r2 = 0.2302$; $p>0.05$). The mean egg diameter and the mean egg weight were measured as 1.00±0.11 mm (0.83- 1.25 mm) and 0.026±0.005g (0.018-0.035g) respectively (see Table 2). The largest females didn't present the highest amount of GSI, as well (11.63- 15.91%). The average gonadosomatic index of females was found to be 13.53±5.11%.

The mean total body length and mean total body wet weight of 60 mature size females trapped in January was 114.12 ± 23.45 mm (99.25-124.44 mm) and 57.18±21.13 g (42.29-73.07 g), respectively. The mean pleopodal fecundity was found to be 129.51±65.87 (16-244) eggs. The pleopodal fecundity presented a linear regression (Figure 1B, $r2 = 0.3919$; $p > 0.05$) to the body length. The estimated pleopodal fecundity was 37.3 % lower than the estimated ovarian fecundity. According to the result of ANCOVA test, there was a significant difference between ovarian and pleopodal fecundity when female size considered as a covariance ($p < 0.05$). The mean pleopodal eggs of each pair of pleopods and their statistical comparison has presented in the Table 1. A statistically significant difference was found ($p < 0.05$) between the number of eggs carried on each pair of pleopods. The highest egg number was attached on the 4 th and 3 rd pair of pleopods with 34.45±15.82 (6-69) and 30.75±15.76 (4-57) eggs, respectively. The lowest egg number was attached on the 1st pair and the abdominal surface around of pleopods with 5.38±4.38 (0-14) and 9.45±6.65 (0-30) eggs, respectively (see Table 1). The mean diameter of eggs attached to the pleopods was 2.2±1.26 mm (1.07-6.59 mm) (see Table 2). A positive significant correlation was found between the female size and both ovarian and pleopodal fecundity.

The values of egg number and egg weight are shown in Table 2. Both egg diameter and egg weight of the November sampled females positively correlated to the female size (Figures 2A. 3A), while there were a negative correlation between the mentioned characteristics and the females sampled on January (Figures 2B. 3B).

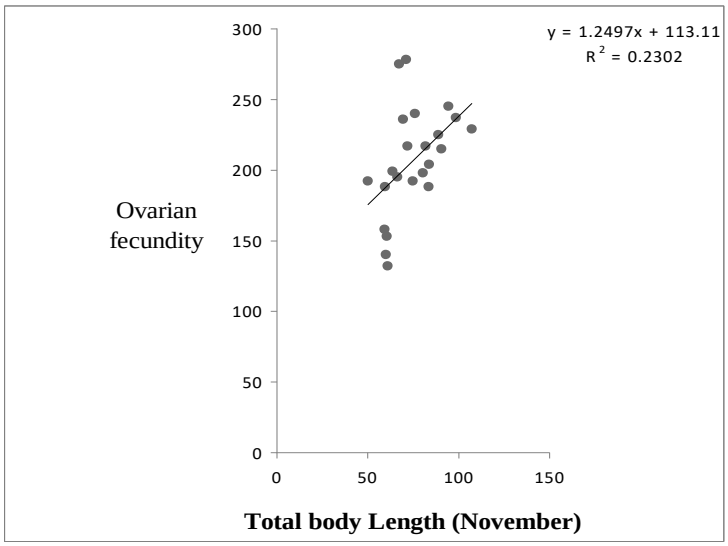
Figure Legends

Figure 1. (A) The linear regression between female size and ovarian eggs, November 2011 in 20 mature size individuals of (*A.leptodactylus*). (A), and between female size and number of pleopodal eggs, January 2012, in 25 mature size individuals of (*A.leptodactylus*), Aras Dam Lake, Western Azerbaijan, Iran.

Figure 2. (A) The linear regression between female size and egg weight, November 2011 in 20 mature size individuals of (*A.leptodactylus*). (A), and between female size and egg weight, January 2012, in 25 mature size individuals of (*A.leptodactylus*), Aras Dam Lake, Western Azerbaijan, Iran.

Figure 3. (A) The linear regression between female size and egg diameter, November 2011 in 20 mature size individuals of (*A.leptodactylus*). (A), and between female size and egg diameter, January 2012, in 25 mature size individuals of (*A.leptodactylus*), Aras Dam Lake, Western Azerbaijan, Iran.

A)



B)

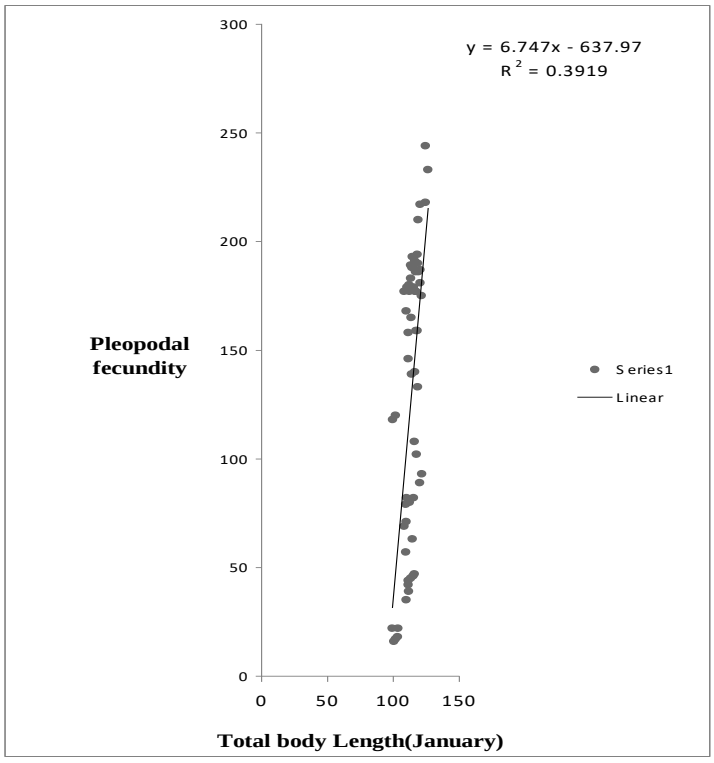
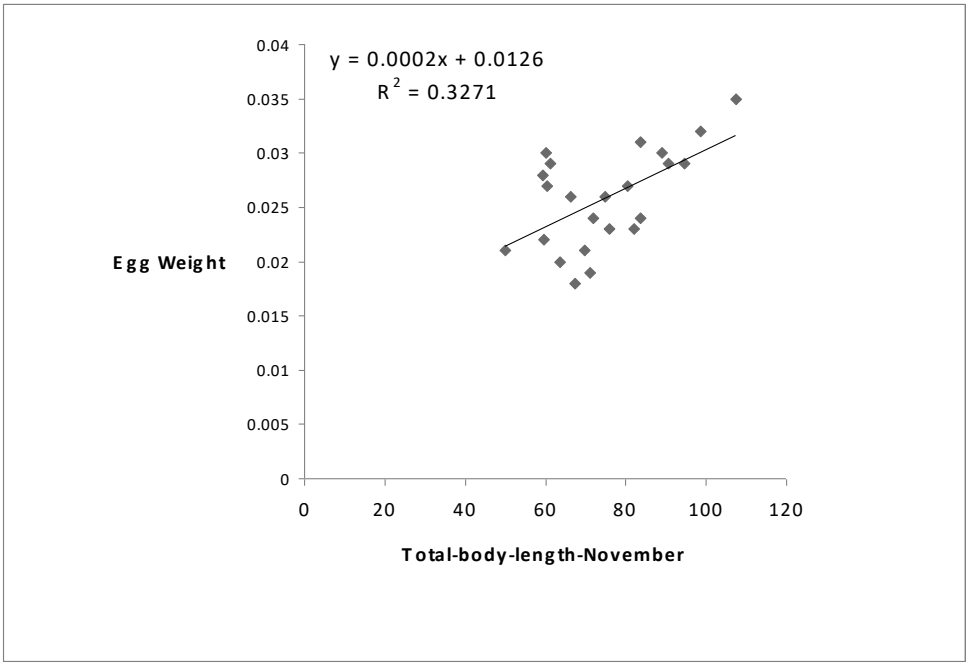


Figure 1. (A) The linear regression between female size and ovarian eggs, November 2011 in 20 mature size individuals of (*A.leptodactylus*). (A), and between female size and number of pleopodal eggs, January 2012, in 25 mature size individuals of (*A.leptodactylus*), Aras Dam Lake, Western Azerbaijan, Iran.

A)



B)

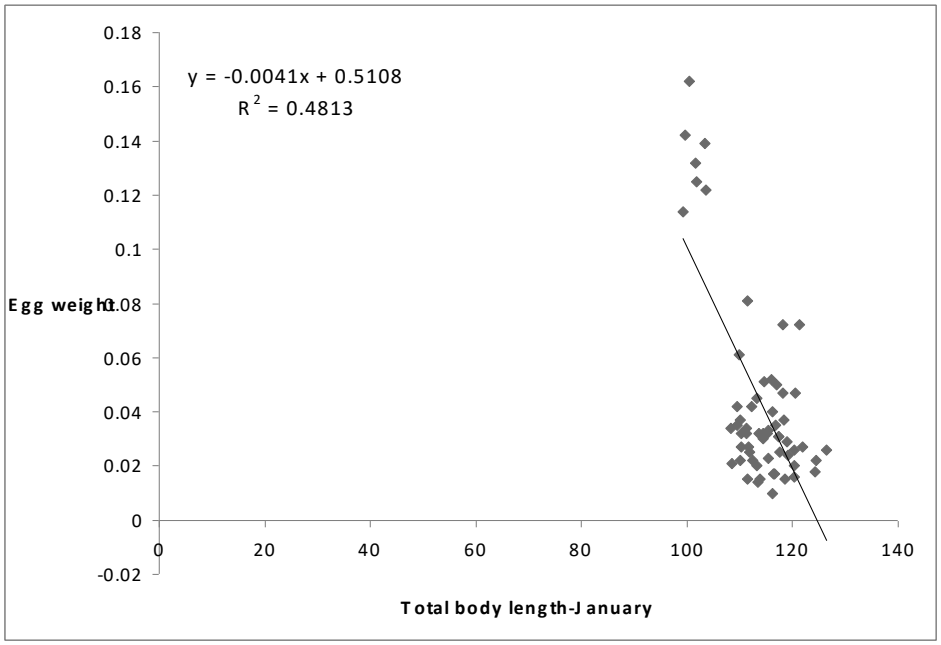
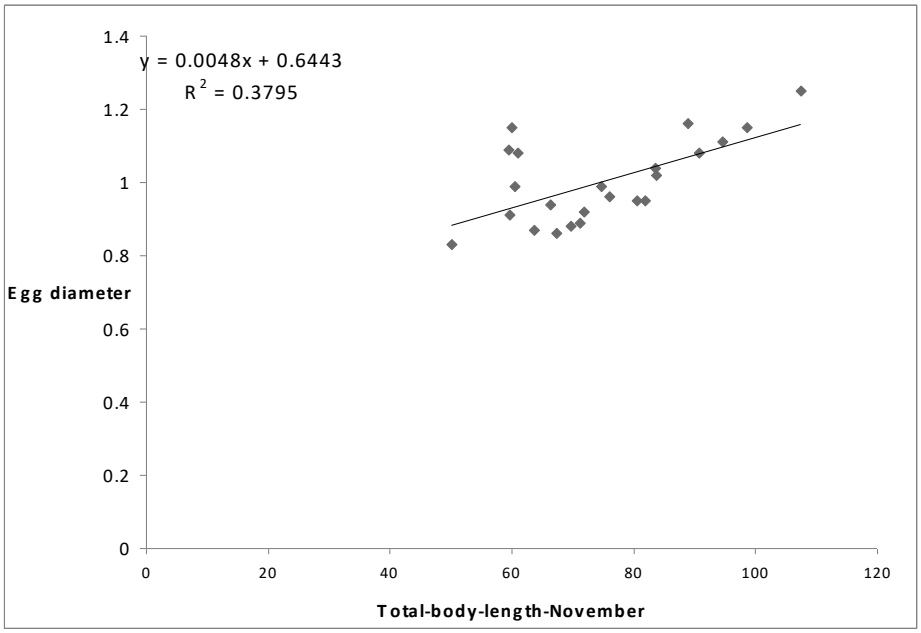


Figure 2. (A) The linear regression between female size and egg weight, November 2011 in 20 mature size individuals of (*A.leptodactylus*). (A), and between female size and egg weight, January 2012, in 25 mature size individuals of (*A.leptodactylus*), Aras Dam Lake, Western Azerbaijan, Iran.

A)



B)

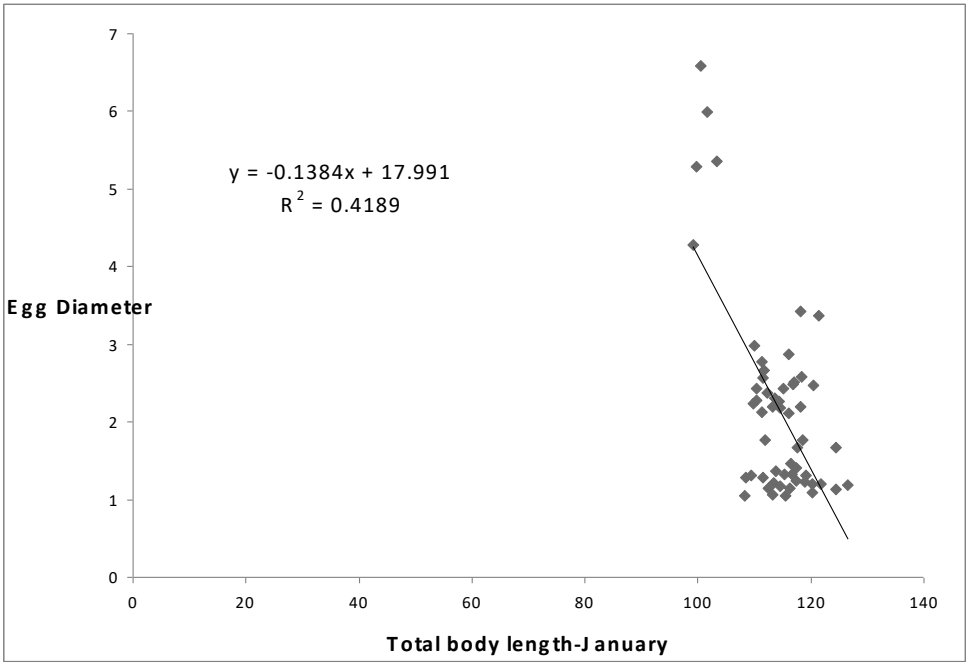


Figure 3. (A) The linear regression between female size and egg diameter, November 2011 in 20 mature size individuals of (*A.leptodactylus*). (A), and between female size and egg diameter, January 2012, in 25 mature size individuals of (*A.leptodactylus*), Aras Dam Lake, Western Azerbaijan, Iran.

Table 1. The mean number of eggs connected to each pairs of pleopods (means in the second row with different superscript were significantly different; P < 0.05)

	1st pair	2nd pair	3rd pair	4th pair	5th pair	Others	Total
Mean ±SD	5.38, SE=□4.38 [c]	24.63±13.96[b]	30.75, SE=□15.76[a]	34.45, SE=□15.82[a]	24.88, SE=□13.73[b]	9.45, SE=□6.65[c]	129.51, SE=□65.87
From min to max	0-14	1-44	4-57	6-69	2-52	0-30	16-244

SD; Standard deviation

Table 2. The mean and range of total body length females, egg number and egg weight

	Total number Of Crayfish	Total body length		Egg number		Egg diameter		Egg weight	
		Mean ± SD	Range (mm)	Mean ± SD	Range	Mean ± SD	Range (mm)	Mean ± SD	Range (g)
Ovaries (November)	25	74.41, SE=22.79	50.08-107.39	206.55, SE=± 38.08	132-275	1.00, SE=0.11	0.83- 1.25	0.026, SE=0.005g	0.018-0.035
Pleopods (January)	60	114.12 ± 23.45	99.25-124.44)	129.51, SE=65.87	16-244	2.20, SE=1.26	1.07-6.59	0.044, SE=0.036	0.10-0.162

4. Discussions

The influence of female size on egg number of some crayfish species has been demonstrated by previous authors (Sommer, 1984; Rouse and Yeh, 1995; Schulz and Smietana, 2001). However the published data about ovarian fecundity of different populations of *A.leptodactylus* was in an extended range including of 211 eggs per female for Egridir Lake in Turkey (Ko¨ksal, 1988), 276 eggs for the northern coast of the Caspian Sea (Kolmykov, 2002), 210-410 eggs for Divzak Lake population and average374 eggs for Mazurian Lake population in Poland (Stypinskaya, 1978), and 204, 210 and 139 eggs for three populations in Norway, Finland and Lithuania Lakes per female, respectively (Skurdal and Taugbol, 2002). Similar various egg numbers of the narrow-clawed crayfish (*A.leptodactylus*) were reported by early authors in the Iranian inland waters (Karimpour et al., 1989; Karimpour and Hosseinpour, 1999; Karimopour and Taghavi 2002; Danesh-Khosh-Asl and Karimpour, 2004).

Reynolds et al. (1992) showed various egg numbers between different populations of the same crayfish species. It could be due to the genotype differences of various populations or may reflect the quality of environmental conditions. In this case, the mean pleopodal (129.5) and ovarian fecundity (206.5) of females is observed in the current study, while Karimpour and Hosseinpour (1999) reported 322 pleoppdal eggs per female and Karimpour and Taghavi (2002) reported 420 ovarian eggs per female for the same population of crayfish in Aras Dam Lake. Regards to the similar female size of the current and previous studies, the causes for these differences are unknown, but such differences may be attributed to influences of different genotypes in various *A.leptodactylus* populations and/or to different environmental parameters during the last decade.

The significant difference obtained between ovarian and pleopodal fecundity in the current study may reflect the oocytes that couldn't be fertilized, oocytes that failed to attach to the pleopods after lying eggs (Abrahamsson, 1972), egg losing through the incubation course, because of unsuitable quality of environmental parameters (Savolainen et al., 1996; Kozak et al., 2006)) and egg losing through the conflict between females carrying eggs (Pursiainen et al., 1989).

Similar to results of the present study, in Turkish populations of crayfish *A.leptodactyls*, mean pleopodal eggs was affected by female size, significantly (Ko¨ksal, 1988; Harlıog˘lu et al., 2004). In other hand Kozak et al. (2006) reported that female size was correlated significantly with GSI and egg number of spiny-cheek crayfish *Orconectes limosus*. Similarly in the present study, the GSI and fecundity of the crayfish *A.leptodactylus* increased significantly with female size.

Results of the present study showed a positive correlation between both egg diameter and egg weight with total body length of November sampled females; however these factors correlated negatively with total body length of January sampled females. Compared to the prsent study, the results for other crayfish species such as such as *Astacus astacus* (Abrahamsson, 1971), *Pacifastacus leniusculus* (Abrahamsson, 1971, Nakata et al., 2004) and *Combaroides japonicus* (Nakata and Goshima 2004) and even another population of the same species (Harlıog˘lu and Tu¨rkgu¨lu¨, 2000) were different from this study.

In Summary, the present study showed that both ovarian and pleopodal fecundity positively correlated with female size. Therefore it could be concluded that more ovarian eggs would extruded after lying eggs of *A.leptodactylus* on January. Both November and January sampled females produced more eggs compared with smaller ones. In addition, females on January reproduced larger and heavier eggs than those of November sampled ones. The larger and heavier eggs might reproduce larger and more resistant juveniles. These factors suggest larger females as broodstock for hatcheries in Iran.

Acknowledgements:

The authors wish to thank to Neda Ahmadi, for her help with improving this manuscript and Reza Assareh for his help during the laboratory work.

Corresponding Author:
Dr. Seyed Mehdi Mirheydari
Department of Fisheries
Faculty of Agriculture and Natural Resources Sciences And Researches Branch
Islamic Azad University, Tehran, , India
E-mail: mehdi.mirheydari@yahoo.com

References

[1]. Souty-Grosset C, Holdrich DM, Noel PY, Reynolds JD, Haffner P. Atlas of craish in Europe. Publications Scientifiques du MNHN-Paris, 2006.

[2]. Skurdal J, Taugbol T. *Astacus* in; Biology of freshwater crayfish (Ed by Holdich), Blackwell Science, UK. 2002: 467- 510.
[3]. eladykov, V.D. 1964. Inland fisheries resources of Iran especially of the Caspian Sea with special reference to Sturgeon, Report to Government of Iran, FAO Report, FAO, Rome, 188; 64.
[4]. Karimpour M, Harliogˇlu MM, Aksu Ö. Review Status of freshwater crayfish (*Astacus leptodactylus*) in Iran. Knowledge and Management of Aquatic Ecosystems 2011: 401(18): 1-15.
[5]. Naviri S. Distribution of narrow clawed crayfish *Astacus leptodactylus* in Anzali harbor. Iranian Journal of Fisheries Sciences 1994: 4; 13-22.
[6]. Abercrombie M, Hickman M, Johnson ML, Thain M. Dictionary of Biology. Penguin Books, Middlesex, England, 1992: 596.
[7]. Reynolds JD. Growth and reproduction. *In:* Biology of Freshwater Crayfish, (Ed by D.M. Holdich). Blackwell Science Ltd., London, 2002: 152-191.
[8]. Karimpour M, Hosseinpour SN, Haghighi D. Anzali Lagoon freshwater crayfish *Astacus leptodactylus* biological survey, Gillan Fisheries Research Center, Bandar Anzali, 1989: 57.
[9]. Danesh-Khosh-Asl A, Karimpor M. The reproductive biology of the Caspian crayfish *Astacus leptodactylus* in the Iranian coast (Anzali lagoon). Final report of a research project. Inland Water Aquaculture Institute, Bandar Anzali, 2004: 72.
[10]. Karimpour M, Hosseinpour SN. Population dynamism and determination of MSY of Arass water reservoir freshwater crayfish *Astacus leptodactylus*, Caspian Sea Bony Fishes Research Center, Bandar Anzali, 1999: 186.
[11]. Kolmykov EB. *Pontastacus eichwaldi* Bott, 1950, Caspian Sea Fisheries Research Institute, Astrakhan, 2002: 8.
[12]. Ferré LE, Medesani DA, Fernando García C, Grodzielski M, Rodríguez EM. Vitellogenin levels in hemolymph, ovary and hepatopancreas of the freshwater crayfish *Cherax quadricarinatus* (Decapoda: Parastacidae) during the reproductive cycle. Rev. biol. trop, San José mar. .(HTML copy). 2012: 60: 1
[13]. Schulz R, Smietana P. Occurrence of native and introduced crayfish in northeastern Germany and northeastern Poland. Bull. Fr. Peche Piscic. 2001: 361: 629-641.
[14]. Sommer TR. The biology response of the crayfish *Procombarus clarkii* to transplantation into California rice field. Aquaculture 1984: 41: 373-384.
[15]. Rouse DB, Yeh HS. Factors influencing spawning of *Cherax quadricarinatus* in indoor hatcheries. Freshwater crayfish 1995: 10: 605-610.
[16]. Köksal G. *Astacus leptodactylus* in Europe. *In*: Freshwater Crayfish: Biology, Management and Exploitation (Eds by D.M. Holdich and R.S.Lowery) , Chapman and Hall, London, 1988: 365–400.
[17]. Stypinskaya M. Individual variabilities in absolute fecundity of crayfish *Astacus leptodactylus* occurring in the water of Majuran Lake District. Rocz. Nauk. Rdn.H, 1978: 93.
[18]. Reynolds JD, Celada JD, Carral JM, Matthews MA. Reproduction of Astacid crayfish in captivity-current developments and implications for culture, with special reference to Ireland and Spain. Invertebrate Reproduction Development 1992: 22 (1-3): 253-266.
[19]. Karimpour M, Taghavi SA. The research on biological characteristics, density of distribution and test for best kind traps to fish Caspian Sea crayfish *Astacus leptodactylus eichwaldii*, Caspian Sea Bony Fishes Research Center, Bandar Anzali, 2002: 163.
[20]. Abrahamsson SAA. Fecundity and growth of some population of *Astacus astacus* in Sweden. Reproduction Inst. Freshwater Research 1972: 52: 23-37.
[21]. Savolainen R, Westman K, Pursiainen M. Fecundity of Finnish noble crayfish, Astacus *astacus* L., and signal crayfish, *Pacifastacus leniusculus*, in various natural habitats and in culture. Freshwater Crayfish 1996: 11: 319- 338.
[22]. Kozak P, Buric M, Policar T. The fecundity, time of egg development and juvenile production in spiny- cheek crayfish (*Orconectes limosus*) under controlled conditions. Bull. Fr. Pêche Piscic 2006: **380-381:** 1171-1182.
[23]. Pursiainen M, Jarvenpa T, Westman K. The reproductivity of female noble crayfish *Astacus astacus* in northern oligotrophic Lake. Freshwater crayfish 1989: 7: 99- 105.
[24]. Harlıogˇlu MM, Barım O¨, Tu¨rkgu¨lu¨ I, Harlıogˇlu AG. Potential fecundity of an introduced population, Keban Dam Lake, Elazıgˇ , Turkey, of freshwater crayfish, *Astacus leptodactylus leptodactylus* (Esch., 1852). Aquaculture 2004: 230: 189–195.
[25]. Abrahamsson SAA. Density, growth and reproduction in populations of *Astacus astacus* and *Pacifastacus leniusculus* in an isolated pond. Oikos 1971: 22: 373-380.
[26]. Nakata K, Tanaka A, Goshima S. Reproduction of the alien crayfish species *Pacifastacus leniusculus* in Lake shikaribetsu,

Hokkaido, Japan, J. Crustacean Biololgy 2004: 24: 496-501.

[27]. Nakata K, Goshima S. Fecundity of the Japanese crayfish, *Combaroides japonicus;* ovary formation, egg number and egg size. Aquaculture 2004: 242: 335-343.

Harlıog˘lu MM, Tu¨rkgu¨lu¨ I. Therelationship between eggsize and female size in freshwater crayfish, *Astacus leptodactylus*. Aquaculture international. 2000: 8: 95- 98.

6/5/2024