BIOCYT©

www.iztacala.unam.mx/biocyt

6(21): 426-437, 2013

ISSN 2007-2082

abril-junio

Revista BIOCYT es editada en la Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México

POPULATIONAL ASPECTS OF *CARDISOMA CRASSUM* SMITH, 1870 (DECAPODA: GECARCINIDAE) IN THE ESTUARY EL SALADO, PUERTO VALLARTA, JALISCO, MEXICO

ASPECTOS POBLACIONALES DE *CARDISOMA CRASSUM* SMITH, 1870 (DECAPODA: GECARCINIDAE) EN EL ESTERO EL SALADO, PUERTO VALLARTA, JALISCO, MEXICO

Elías Matamoros-Contreras

Laboratorio de Ecología y Conservación, Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México. Av. De Los Barrios, No. 1, Los Reyes Iztacala, Tlalnepantla, Estado de México, México. C. P. 54090.

ABSTRACT

Quadrants were made in El Salado Estuary, Puerto Vallarta, Jalisco, México. An area of 1200 m^2 was covered, 1939 burrows of *C. crassum* were counted; the average density was 1.66 burrow / m^2 and the average diameter was 4.74 cm. Frequency histograms were constructed. No significant differences were found between the sampling sites and sampling periods (densities and diameters of the burrows). It was observed that the first ovigerous females arrive at the beach to spawn the first week of July. In August, small organisms of *C. crassum* (2.03 cm) were observed in El Salado Estuary, something that is not common before July. It was concluded that a) this is the first formal study of *C. crassum* that is carried out in El Salado Estuary, b) the density of *C. crassum* in the estuary is high in comparison with crabs of the same family in other study sites, c) the spawning season begins the first week of July, d) the *C. crassum* burrows were simple one-entrance burrows and e) there is a total lack of knowledge about the biology of *C. crassum*.

Key words: burrows, Gecarcinidae, *Cardisoma crassum,* crabs, land crabs, density, El Salado, estuary, Jalisco, population structure, quadrants, sex ratio, age.

Correspondence to author:

colgsens@gmail.com

Manuscrito recibido el 12 de febrero de 2013 aceptado el 23 de abril de 2013.

RESUMEN

Se establecieron cuadrantes en el estero El Salado, Puerto Vallarta, Jalisco, México. Se cubrió un área de 1200 m^2, se contaron 1939 madrigueras de *C. Crassum*; la densidad promedio fue 1.66 madrigueras/m^2 y el diámetro promedio fue 4.74 cm. Se construyeron histogramas de frecuencia. No se encontraron diferencias significativas entre los sitios y los periodos de captura (densidades y diámetros de las madrigueras). Se observó que las primeras hembras ovígeras llegan a la playa a desovar la primera semana de julio. En agosto se observaron organismos pequeños de *C. crassum* (2.03 cm) en el estuario El Salado, lo que no es común antes de julio. Se concluyó que a) este es el primer estudio formal de *C. crassum* que se realiza en el estero El Salado, b) la densidad de *C. crassum* en el estuario es alta en comparación con cangrejos de la misma familia en otros sitios de estudio, c) el periodo de desove inicia la primera semana de julio, d) la entrada de las madrigueras de *C. Crassum* es simple y e) existe un total desconocimiento acerca de la biología de *C. crassum.*

Palabras clave: madrigueras, Gecarcinidae, *Cardisoma crassum,* cangrejos, cangrejos terrestres, densidad, El Salado, estuario, Jalisco, estructura poblacional, cuadrantes, proporción sexual, edad.

INTRODUCTION

Land crabs have successfully colonized both tropical islands and continental maritime forests and may have large populations exhibiting high densities (Green, 1997; Sherman, 2002). Land crabs occur on many islands throughout the tropics, where their density often exceeds one crab per m^2 (Burggren and McMahon, 1988) and averaging 1137 kg/ha (Green, 1997).

Land crabs have acquired such an important relevance in biology that a whole book has been dedicated to them (Burggren and McMahon, 1988), but more recently information on these crustaceans has been widen, dealing with subjects that go from mainly ecological, dietary aspects and abundance estimation methods. For instance, population ecology has been studied in *Gecarcoidea natalis* Pocock, 1888 (Adamczewska and Morris, 2001), reproduction on *Johngarthia lagostoma* H. Milne Edwards, 1837, and *Gecarcinus ruricola* Linnaeus, 1758 (Hartnoll et al., 2007, 2010), feeding on *Cardisoma carnifex* Herbst, 1796 (Micheli et al., 1991).

One topic that has lately been intensively treated is the manner how to measure population density and animal size in land crabs by using indirect nondestructive methods. The first, by measuring directly crab burrows or conducing visual observations (Warren, 1990; Macia et al., 2001; Skov and Hartnoll, 2001; Skov et al., 2002; Cupul-Magaña, 2004a; Cupul-Magaña and Reyes-Juárez, 2005; Govender and Rodríguez-Fourquet, 2008) and the second by measuring real crab body size and correlating it with the diameter of the burrow opening (Lourenco et al., 2000; Lee and Lim, 2004; Govender and Rodríguez-Fourquet, 2008; Schmidt et al., 2008).

The blue land crab, *Cardisoma guanhumi* Lattreille, 1825 is a species highly adapted to terrestrial life that is found in estuarine areas throughout tropical and subtropical regions in the Atlantic Coast of the New World, from the state of Florida (USA) to the state of Santa Catarina (southern Brazil). It is an important food resource due to its large body size, which often exceeds 11 cm in carapace length (Hostetler et al., 1991; Amaral and Jablonski, 2005).

In Mexico, *C. guanhumi* is captured in Veracruz and Tabasco; its fishery and marketing has not been carried out in a rational or technified manner, which has caused that in areas where we could find large populations before, they have disappeared almost completely nowadays. This has been reported in the Gulf of Mexico, in the states of Tabasco, Veracruz and Quintana Roo, in the north, in Isla Mujeres, Puerto Morelos and Cozumel, and in the south, from Punta Herrero to Xcalak (Oliva, 2005); On the other hand, we can find *C. crassum* on the shores of the Mexican Pacific; however, the information on this species is almost non-existent,

limited to a few records about its presence in some locations, one of which is the El Salado Estuary in Puerto Vallarta, Mexico, where we only know that adult organisms are captured in the rainy season despite of the fact that it is a protected natural area. For this reason, it is important to gather information on the biology of *C. crassum*, since these crabs are important for the ecosystem. Authors like Green (1997), Griffiths et al., (2007) and Kristensen (2008) mention that land crabs are engineers of the ecosystem because they modify their environment. On the other hand, these crabs are indiscriminately exploited and there is no information in this regard. Therefore, the objective of this study was to determine populational density of *C. crassum* in El Salado Estuary in Puerto Vallarta, Mexico.

MATERIAL AND METHODS

Study area

"El Salado" Estuary (Fig.1) is a body of coastal water; during the last four decades it has been surrounded by the urban sprawl of Puerto Vallarta, Jalisco (Gómez-Graciano and Cupul-Magaña, 2001). In 2000, the State Government declared it a protected natural area (Cupul-Magaña, 2004b). This area is located on the coastal plain of the Mexican Pacific (between the Western Sierra Madre and the Southern Sierra Madre). This plain is denominated Banderas Bay (Avelarde-Gómez et al., 2007).

Banderas Bay comprises the southwestern part of the coast of Nayarit and Jalisco's northwest side (Gómez-Graciano and Cupul-Magaña, 2001); the estuary is located at 20° 39'- 20° 41' N, 105° 13' – 105° 15' W coordinates, it has a warm sub-humid climate with summer rainfall (A w1 (w)) and a semi-warm sub-humid climate with summer rainfall (A w2 (w)) (Téllez et al., 2010). Usually, the estuary has (as the Köppen system described it) a warm humid climate (Awn (x) I), where the temperature and the average annual rainfall range from 26 to 28° C and 930.8 and 1668.0 mm, respectively (Navarro et al., 2004). The estuary is located on the Ameca River Delta, which has a total length of 75 km (consisting of fluvial material), and it is connected to the ocean by a permanent mouth which was modified during the sixties and the eighties of last century in order to build the inner harbor and the yacht marina (Gómez-Graciano and Cupul-Magaña, 2001). The estuary has 3.14 Km^2 where 95% of its surface is land and it is one of the most important wetlands in the region. The soil is mainly composed of quartz type very fine and fine sands mixed with montmorillonite and kaolinite clays (Avelarde-Gómez et al., 2007), which favors the type of vegetation consisting of mangrove (1.4 km^2). The main species are *Rhizophora mangle* L., 1753, *Avicennia germinans* L. and *Laguncularia racemosa* (L.) Gaertn. f. There are also important patches of marsh vegetation (0.352 km^2) and tropical sub-deciduous forest (0.01km^2), thorn forest and aquatic vegetation (Gómez-Graciano and Cupul-Magaña, 2001).

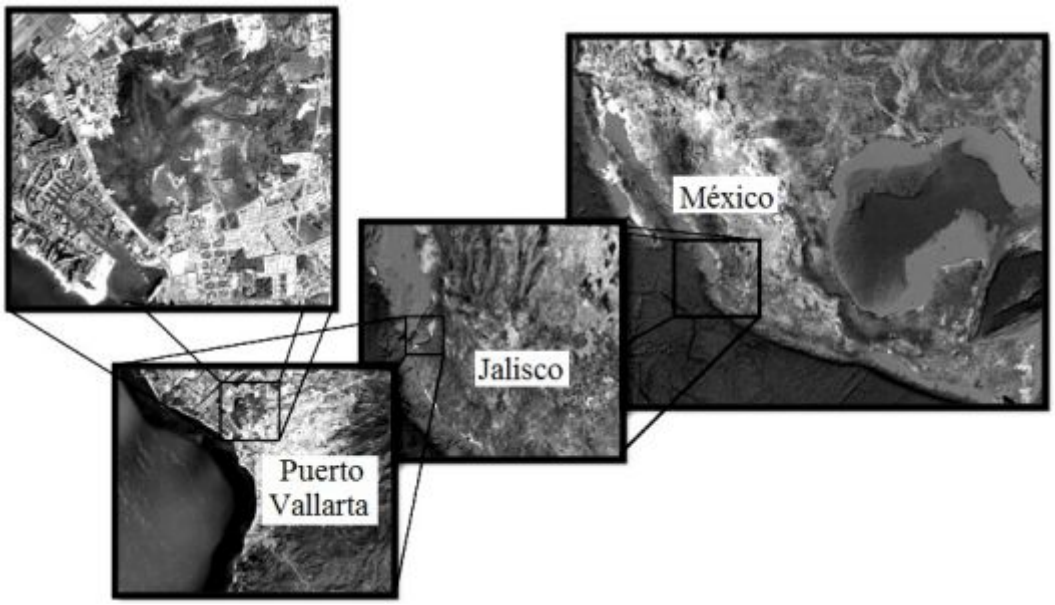

Fig. 1. El Salado Estuary, Puerto Vallarta, Jalisco, Mexico.

10x10m quadrants were made (Cupul-Magaña, 2004a; Cupul-Magaña and Reyes-Juárez, 2005; Carmona-Suárez, 2007; Griffiths et al., 2007; Govender and Rodríguez-Fourquet, 2008; Carmona-Suárez, 2011; Carmona-Suárez and Guerra-Castro, 2012) in October, 2011 and April, July, August and October, 2012. The burrows in each quadrant were counted and the entrances diameters were measured (included within fecal pellets and without fecal pellets), likewise the burrows were examined with a metal stick and plastic stick to verify possible connection In October (2012) sampling were excavated 10 burrows at random to confirm or not connection among burrows The density was expressed as the number of burrows/m^2 (Cupul-Magaña, 2004a; Cupul-Magaña and Reyes-Juarez, 2005).

With the data of the burrows entrance diameter, size frequency histograms were constructed to determine the population structure (Fig. 2) (Emmerson 2001; Cupul-Magaña and Reyes-Juarez, 2005).

To compare the sampling sites and sampling periods (densities and diameters of burrows) a two-way ANOVA was used (Sokal and Rohlf, 2003; Carmona-Suárez, 2011).

At the same time, organisms were collected by hand and using a spoon net All organisms caught were sexed, measured (carapace length and width) using a Vernier caliper (±0.01 mm) and weighted on a digital scale (± 0.001g). The sex ratio was estimated using the formula:

$$So = (Mo-Fo)/(Mo+Fo)$$

Where: So is the sex ratio, Mo is the number of males in the sample and Fo is the number of females in the sample (modified of Christiansen et al., 1990) (Daniels, 2001). Finally, the migration of the gravid females to the sea was observed.

RESULTS

An area of 1200 m^2 was covered, counting a total of 1939 burrows; we observed a mean density of 1.66 burrows/m^2 (Table 1), the minimum diameter observed was 1.05 and the maximum was 11.05 cm with an average of 4.74 cm (±0.041 cm). We were not observed connection among burrows.

In the months of October (2011 and 2012) and April organisms were not captured; in July, 104 crabs were captured, of which 39% were males and 61% females (six were gravid females); in August, 32 organisms were captured, 59% were male and 41% were females. The minimum size (length) of the females was 1.07 and 6.82 cm was the maximum size, with an average of 4.41 cm (±0.17 cm). The minimum size of the males was 1.16 and the maximum size was 4.71, with an average of 3.88 cm (±0.28 cm).

The minimum weight of the females was 1.7 and 300.0 g was the maximum weight with an average of 121.33 g (±1.47 g). The minimum weight of the males was 2.1 and the maximum weight was 240.0 g, with an average of 119.83 g (±2.34 g). The minimum weight of the gravid females was 85.63 and the maximum was 201.91 g with an average of 131.75 g (±2.51 g). Were counted between 242937 and 289784 eggs, with a mean of 271354 (±56 eggs). The egg mass weighed between 6.26 and 10.09% (±0.5%) of the body weight The sex ratio was 1:1.54 (males:females) (So = -0.21).

The analysis of variance to compare the number of burrows and quadrants (per month), (α=0.05, Treatment *f g* 3 and Error *f g* 6, the value of F=4.76) and the diameters of burrows and quadrants (per month) (α=0.05, Treatment *f g* 3 and Error *f g* 6, the value of F=4.76), showed no significant differences.

Table 1. Number of burrows per quadrant.

Quadrant	Date sampling	Number of burrows	Minimum size (cm)	Maximum size (cm)	Average (cm)
1	oct-11	191	2.53	6.8	4.07
2	oct-11	176	1.23	6.25	3.84
3	oct-11	207	1.37	9.14	4.59
4	abr-12	179	1.05	9.48	4.23
5	abr-12	123	1.25	8.72	4.26
6	abr-12	70	2.18	8.82	5.99
7	jul-12	159	2.03	7.28	4.56
8	jul-12	131	2.22	11.05	5.99
9	jul-12	123	4.09	10.38	6.4
10	oct-12	229	1.16	9.98	3.92
11	oct-12	217	1.27	8.41	3.85
12	oct-12	134	2	10.65	5.15
	Total	1939			
	mean	161.58	1.4766	9.68	4.306

It was observed that the first ovigerous females come ashore to lay their eggs the first week of July. It was also observed that these females emerge from their burrows before dark, approximately after 18:00 pm; afterwards, they begin to congregate in the vegetation near the beach and, at 22:00 h approximately, the females come to the beach to lay their eggs.

Cardisoma crassum is predated by local people living around the El Salado Estuary, who capture organisms between July and August, when there is a greater density of crabs.

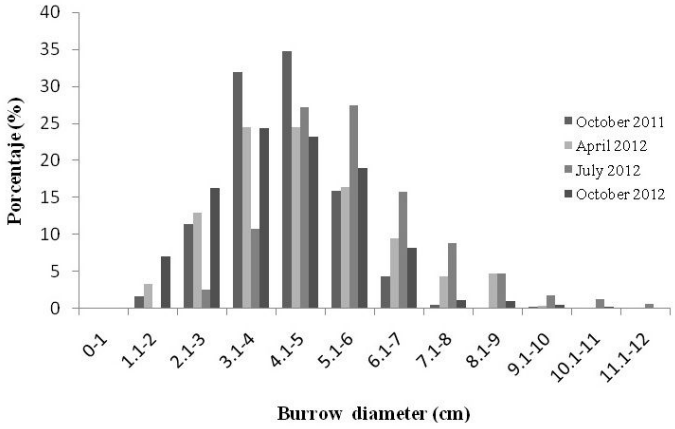

Fig. 2. Relative frequency of diameter sizes in the burrows of *C. crassum* in four sampling periods.

DISCUSSION

In a sampled area of 280 m^2, Griffiths et al., (2007) recorded an average density of 0 to 5.3 crabs_*Gecarcinus quadratus* De Saussure, 1853 per m^2 in Corcovado National Park, Costa Rica. Govender and Rodriguez-Fourquet (2008) reported a density of 0.18 *C. guanhumi* crabs per m^2 at various locations in Puerto Rico where they sampled an area of 600 m^2; the same authors carried out the counting of burrows considering on one hand those presenting fecal pellets and those that did not present them, in order not to overestimate the density, and they concluded that counting the presence of burrows with pellets is better to estimate the populational size; in the present study, all the burrows observed in the quadrants were considered (Table 1) since in the burrows of *C. crassum* with fresh sludge (which showed crab recent activity) fecal pellets were not observed (54%); and on the contrary, in the entrances of burrows without apparent activity, pellets were observed (65%). Authors like Carmona-Suarez (2011) and Macia et al., (2001) mention that very often the burrows of land crabs have more than one entrance (serving as escape routes), overestimating thereby the actual density. This was mentioned in a document from the FAO (2005) where it is stated that the burrows of crabs commonly known as Moors or mouthless crabs (*C. crassum*) have several communications. Even authors like Carmona-Suárez (2011) mention that hands or fingernails were introduced to see if the burrows were connected or not (in the case of *C. guanhumi*) avoiding an overestimation of the density.

In the present study, 10 burrows were randomly excavated to corroborate the abovementioned; in none of the cases communication holes between the burrows were observed, in some cases, an excavation of 80 cm in depth was carried out and only simple entrances were observed. Significantly, in several works related to the density of gecarcinid crabs in Navidad Island (*G. natalis* and *Discoplax hirtipes* Dana, 1852) in different areas of

Venezuela and Puerto Rico (*C. guanhumi*), it has been argued that these burrows exhibit more than one entrance and are interconnected. This has not been observed in the study area of *C. crassum*. In the August sampling, quadrants could not be carried out since most of El Salado estuary was flooded during the rainy season and only 13 organisms were captured. Nevertheless, two types of burrows were observed: in the higher areas of the estuary, associated with the roots of palm trees and some other trees, the burrows showed communication between them, but apparently this was due to unconsolidated sediment between roots, which facilitates their collapse; in some other areas, only flooded burrows were observed (average 11.64 ±0.73 cm) with a kind of vent (average 5.83 ±0.76 cm); these burrows were not connected in the interior, which was verified extracting water from the main entrances of five of them. It was observed that the adjacent burrows remained with water, showing no alteration (distance between the burrow and the vent: average 27.08 ±16.75 cm), the small hole can not be considered as an escape route since it would be too small for the occupant.

Carmona-Suárez (2011) sampled an area of 1600 m^2 between November 2009 and January 2010 and 1120 m^2 during June and July 2010 in at least 75% of the Venezuelan coastline; this author mentioned that the density in the burrows of *C. guanhumi* presented a significant variation; he found the lowest density during June-July in the northern region (Zazárida) with 0.24 burrows per m^2 and the highest density in November- January in the western region (Barranquita) with 5.48 burrows per m^2; however, when analyzing the regions and sampling periods simultaneously, he found no significant differences. During the period November-January, in the samplings the same author reported an average of 46.7 mm in the size of the burrows in the western part (Min 15.5 / Max 102.0 mm) and of 54.3 mm in the central part (Min 16.7 / Max 134 mm) and 51.5 mm in the eastern part (Min 14.5 / Max 158.0 mm). These results are similar to the averages registered in April during the dry period (Table 1); in the same places during June-July averages of 58.2 (163.0 mm 25.6 / Max Min) 68.3 (Min 24.8 / Max 194.0 mm) and 72.3 mm (160.0 mm Min 30.2 / Max) were registered. These values are also similar to the ones reported in July during the rainy season in Mexico (Table 1). Turner et al., (2011) reported the highest size frequencies of *D. hirtipes* with 75, 85, 95, 125 and 135 mm (for males) and 70, 80 and 85 mm (for females) and they argued that the smaller sizes of the females was due to the large amount of energy used in reproductive processes, which affects growth. The same authors mention that in gecarcinid crabs it is common that males present larger sizes.

The density of *Gecarcoidea natalis* red crabs, Pocock, 1888 in Navidad Island during the non-migration period (January-October) was 0.09 to 0.57 / m^2, the average density for males was 0.14 ±0.03 / m^2, the highest density registered during the migration period was 1.35 org / m^2 (Adamczewska and Morris, 2001). Oliva-Rivera (2005), sampled two areas of 500 m^2, one in the Reserve Banco Chinchorro (RBCH) and another in the coast of Punta Gavilán (PG) (both located in Quintana Roo, Mexico); in the first location he estimated a density of 0.45 org / m^2 (*C. guanhumi*) during the non-breeding season (October-June); in the breeding season (July-September) in PG he reported a density of 0.056 org / m^2 (*C. guanhumi*); only ovigerous females were observed and this low density was attributed to the fact that the sampling was carried out at the end of the breeding season. The same author reported a mean size for the females of 7.6 cm in crabs of RBCH and of 6.3 cm in crabs of PG. In general, the size of the organisms in RBCH was higher than the ones in the coast PG which had an average carapace width of 8.52 and 6.39 cm respectively. The difference in size indicates a subsistence fishing pressure in PG (Oliva-Rivera, 2005). Carmona-Suárez and Guerra-Castro (2012) captured a total of 118 organisms of *C. guanhumi* in February and April, 2011 in the town of Carenero in Venezuela, (73 males and 45 females); the average size of carapace length was 58.79 ±3.18 mm (32.8 Min / Max 104.7 mm).

On the other hand, Sherman (2003) reported a density of 6 org / m^2 (*G. quadratus*) in Cordovado National Park, Costa Rica (July 1994 - July 1995 and January, March and June, 1996) in an area of 125 m^2.

Regarding the number of burrows per quadrant and the diameters of burrows per quadrant (the number of burrows and quadrants ((per month), α=0.05, Treatment *f g* 3 and Error *f g* 6, the value of F=4.76) and the diameters of burrows and quadrants (per month) (α=0.05, Treatment *f g* 3 and Error *f g* 6, the value of F=4.76)), no significant differences were observed and this may be because the sampling area is too small (3.14 km^2) to detect differences; therefore, we can appreciate that the distribution of *C. crassum* is homogeneous in the area. Adamczewska and Morris (2001) mention that the distribution of *G. natalis* is not homogeneous in Navidad Island (which has an area of 134 Km^2); the authors mention that there are different strata on the island, ranging from sea level to about 200 m in height and that these conditions restrict the organisms activities. El Salado estuary, in turn, is a land in the coastal plain, and the soil is mainly composed of quartz type very fine and fine sands mixed with montmorillonite and kaolinite clays (Avelarde-Gomez et al., 2007) and, in general, the estuary has a warm sub-humid climate, where temperatures and average annual rainfall range from 26 to 28°C and 930.8 and 1668.0 mm, respectively (Navarro et al., 2004), which apparently contribute to a homogeneous distribution of the burrows and the organisms.

The number of eggs observed in *Gecarcoidea lalandii* H. Milne Edwards, 1837 females (average carapace width 57 ±7 mm) varies between 70000 and 210000 depending on the size of the female (Liu and Jeng, 2007), in *C. guanhumi* were counted between 19000 and 20000 eggs, a female weighing 160.0 g would thus release about 370000 eggs at each spawning, were observed that in seven females the egg mass weighed 11.9% (±2.2) of the body weight (Gifford, 1962). In *Johngarthia lagostoma* H. Milne Edwards, 1837, the fecundity ranged from 35000 to 109100 with a mean of 71800.

In the present study, the sex ratio was 1:1.54 (males:females), Turner et al., (2011) reported 2:1 (males:females) to *D. hirtipes* at Ross Hill Gardens (one locality in Christmas Island), same author mention that most other residential populations of land crabs that have been previously examined contain broadly equal numbers of males and females or a larger number of females compared to males. The results of Turner et al., (2011) suggest that the normal condition of the *D. hirtipes* population at Ross Hill Gardens is to have an excess of males. Shinozaki-Mendes et al., (2012) found an average proportion of 1:1.75 (males:females) in *C. guanhumi*, there were no statistically significant differences between the number of males and females (P≥0.05) along the different months, indicating there is no seasonality in the proportion of individuals of different sexes.

Respect to weight, Turner et al., (2011) recorded to *D. hirtipes* minimum weight of the females of 75.0 and 350.0 g as the maximum weight with an average of 214.7 g (±8.04 g) and minimum weight of the males of 10.0 and maximum weight of 520.0 g, with an average of 259.15 g (±11.29 g), same author mention that the rate of growth appeared to be greater for females despite males growing larger in terms of weight when compared to females, in the present study, with the obtained data, the weight in females appeared to be greater that in males.

In the size distribution a large number of burrows was observed in an interval of 4.1 to 5.0 cm during the months of October, April and July (Figure 2), there were no significant differences regarding the number of burrows and quadrants (per month) (α=0.05, Treatment *f g* 3 and Error *f g* 6, value of F=4.76) and the diameters of burrows and quadrants (per month) (α=0.05, Treatment *f g* 3 and Error *f g* 6, value of F=6.94). Skov and Hartnoll (2001) mention that the size of *Uca annulipes*, H. Milne Edwards, 1837 may very well be estimated from the diameter of the burrow entrance; following this observation, we can then establish that the burrows measured in El Salado estuary accurately reflect the size of the crabs *C. crassum*, since no organisms greater than 11.01 cm have been registered (this is the maximum diameter measured

in a burrow so far), although FAO (2005) mentions that *C. crassum* reaches sizes up to 13.2 cm. Govender and Rodríguez-Fourquet (2008) observed the highest frequency of sizes in the burrows of *C. guanhumi* (in Puerto Rico) in an interval of 5-6 cm; they also registered organisms with sizes larger than 9 cm, although burrows were observed with sizes ranging between 13 and 14 cm. On the other hand, Carmona-Suárez (2011) observed a correspondence between the size of *C. guanhumi* and the diameter of the burrows (in Venezuela). They registered the highest percentage of burrows sizes in an average of 58.17 mm from November to January and 51.39 mm for June-July; the largest size registered for a burrow diameter was 194 mm.

In October and April organisms were not captured because in the dry months their activity decreases (pers. obs., El Salado estuary staff), with the traps used, only one organism was captured; in July and August 136 organisms were captured and this can be explained because from early July to late August, the reproductive stage occurs (observations of the staff of Centro Universitario de la Costa, University of Guadalajara, Jalisco, Mexico and El Salado estuary). It should be noted that the first week of July, 2012 there was a full moon (www.tablademareas.com 2012); Liu and Jeng (2007) observed that ovigerous females of *G. lalandii* follow a lunar rhythm and spawn before new moon. They also mention that this release occurs in maximum tides and that these females go near the beach after midnight and wait several minutes before releasing their larvae; others wait a few hours. Adamczewska and Morris (2001) observed that the females of *G. natalis* spawn during the rainy season and that when these females return to their shelters after spawning, small size organisms (~2 cm) that are not observed during migration of females to the beach also return. In August, small organisms (2.03 cm) of *C. crassum* were observed in El Salado estuary, which is not common before July.

Cardisoma crassum is depredated within El Salado estuary primarily by birds and raccoons; however, local people enter illegally into the estuary between July and August, when there is a high concentration of organisms in the study area. Usually there is no sex selection and the crabs are killed with pellet guns or slingshots; in the estuary it is common to see dead crabs with injuries in the shell and without chelae. It has been corroborated that the extraction and sale of *C. crassum* do not represent the regulated exploitation of the resource. On the other hand, the consumption of these organisms is not common at least in the municipality of Puerto Vallarta as it happens with *C. guanhumi* which is highly exploited in the coast of the Gulf of Mexico.

Due to the above mentioned, it can be concluded that a) this is the first formal study of *C. crassum* carried out in El Salado estuary, b) the density of *C. crassum* in the estuary is high compared with crabs of the same family in other study sites, c) the spawning season begins the first week of July, d) the burrows of *C. crassum* have a single entrance and e) there is a total lack of knowledge about the biology of *C. crassum*.

ACKNOWLEDGEMENTS

The author thanks staff of estero El Salado, Puerto Vallarta, Jalisco, México; Biól Jaime Alberto Torres Guerrero, Biól. Victor Enrique Hernández Santos, Lic. en Turismo Julio Cesar Llamas, and Dr. Fabio Germán Cupul-Magaña, Dr. Arturo Rocha-Ramírez, Dr. Fernando Vega Villasante and Dr. Horacio Vázquez-López for revising the manuscript.

REFERENCES

1. Adamczewska, A.M. and S. Morris, 2001. Ecology and Behavior of *Gecarcoidea natalis*, the Christmas Island Red Crab, During the Annual Breeding Migration. Biological Bulletin, 200: 305–320.

2. Amaral, A.C.Z. and S. Jablonski, 2005. Conservação da biodiversidade marinha e costeira no Brasil. Megadiversidade, 1: 43- 51.

3. Avelarde-Gómez, Ma. De La Luz, F.F.A. González, F.V. Flores, G.L. López, A.J. Orozco, V.S. Guerrero, P.M. Pérez, L.A. Cupul-Magaña, M.R.G. Quevedo, C.V.O. Barragán, G.J.A. Torres and M.O.F. González, 2007. Fideicomiso para la protección del estero de El Salado y desarrollo de las áreas colindantes: Área natural protegida-zona de conservación ecológica estero El Salado, Plan de manejo actualizado. Puerto. Vallarta, Jalisco, México, 70pp.

4. Burggren, W.W. and R.B. Mcmahon, 1988. Biology of the Land Crabs. Cambridge University Press, 492 pp.

5. Carmona-Suárez, C.A., 2007. Spatial distribution, density, and relative growth of *Microphrys bicornutus* (Latreille, 1826) (Brachyura: Majidae) in five biotopes in *Thalassia* complex. Scientia Marina, 71(1): 5-14.

6. Carmona-Suárez, C.A., 2011. Present status of *Cardisoma guanhumi* Latreille, 1828 (Crustacea: Brachyura: Gecarcinidae) populations in Venezuela. Interciencia, 36(12): 908-913.

7. Carmona-Suárez, C.A. and E. Guerra-Castro, 2012. Comparison of three quick methods to estimate crab size in the land crabs *Cardisoma guanhumi* Latreille, 1825 and *Ucides cordatus* (Crustacea: Brachyura: Gecarcinidae and Ucididae). Biología Tropical, 60(1): 139-149.

8. Christiansen, B., O. Pfannkuche and H. Thiel, 1990. Vertical distribution and population densities of the necrophagous amphipod, *Eurythenes gryllus*, in the west European basin. Marine Ecology Progress Series, 66: 35-45.

9. Cupul-Magaña, F.G., 2004a. Estudio exploratorio de la densidad del cangrejo violinista *Uca latimanus* (Rathbun, 1893) en "El Salado", Jalisco. Ciencia y Mar, 8(22): 41-47.

10. Cupul-Magaña, F.G., 2004b. Mirmecofauna (Hymenoptera: Formicidae) común del estero "El Salado" y Puerto Vallarta, Jalisco, México. Dugesiana, 11(1): 13-20.

11. Cupul-Magaña, F.G. and A. Reyes-Juárez, 2005. Density and recruiment off the fiddler crab *Uca latimanus* (Decapoca Ocypodidae) in the estuary El Salado, Jalisco, México. Ciencia y Mar, 19(26): 3-8.

12. Daniels, S.R., 2001. Allometric growth, handedness, and morphological variation in *Potamonautes warreni* (Calman, 1918) (Decapoda, Brachyura, Potamonautidae) with a redescription of the species. Crustaceana, 74(3): 237-253.

13. Emmerson, W.D., 2001. Aspects of the population dynamics of *Neosarmatim meinerti* at Mgazana, a warm temperate mangrove swamp in the East Cape, South Africa, investigated using an indirect method". Hidrobiología, 449: 221–229.

14. FAO (Food and agriculture organization of the United Nations). 2005. Guía para la identificación de especies para los fines de pesca: Pacifico Centro-Oriental. Vol. 1, Plantas e invertebrados. FAO Roma. 647pp.

15. Gifford, CH.A., 1962. Some observations on the general biology of the land crab, *Cardisoma guanhumi* (Latreille), in South Florida. Biological Bulletin, 123(1): 207-223.

16. Govender, Y. and C. Rodríguez-Fourquet, 2008. Techniques for assessment of population density and body size of the land crab *Cardisoma guanhumi* (Latreille, 1825) in Puerto Rico. Tropical Estuarios, 1: 9- 15.

17. Gómez-Graciano, F.S. and F.G. Cupul-Magaña, 2001. La técnica de análisis de amenazas como herramienta de diagnóstico ambiental: caso Estero El Salado. Ciencia y Mar, 5(4): 33-42.
Green, P.T., 1997. Red crabs in rain forest on Christmas Island, Indian Ocean: Activity patterns, density and biomass. Journal of Tropical Ecology, 13(1): 17-38.

18. Griffiths, M.E., B.A. Mohammad and A. Vega, 2007. Dry season distribution of land crabs, *Gecarcinus quadrates* (Crustacea: Gecarcinidae), in Corcovado National Park, Costa Rica. Biología Tropical, 55(1): 219-224.

19. Hartnoll, R.G., S.P.M. Baine, A. Britton, Y. Grandas, J. James, A. Velasco and G.M. Richmond, 2007. Reproduction of the black land crab, *Gecarcinus ruricola*, in the San Andres archipelago, western caribbean. Journal of Crustacean Biology, 27(3): 425-436.

20. Hartnoll, R.G., C.A. Broderick, J.B. Godley, S. Musick, M. Pearson, A.S. Stroud and E.K. Saunders, 2010. Reproduction in the land crab *Johngarthia lagostoma* on ascension Island. Journal of Crustacean Biology, 30(1): 83-92.

21. Hostetler, M.E., F.J. Mazzotti and A.K. Taylor, 1991. Blue Land Crab (*Cardisoma guanhumi*). http://edis.ifas.ufl.edu/pdffiles/UW/UW01300.pdf

22. Kristensen, E., 2008. Mangrove crabs as ecosystem engineers; with emphasis on sediment processes. Journal of Sea Research, 59: 30–43.

23. Lee, S. and S.S.L. Lim, 2004. Do diameter of burrows and food pellets provide estimates of the size structure of a population of *Dotylla myctiroides* at the sand-flats of Ao Tungkhen, Phuket? Phuket Marine Biological Center, Department of Marine and Coastal Resources, 65: 55-60.

24. Liu, H.G. and M.S. Jeng, 2007. Some Reproductive Aspects of *Gecarcoidea lalandii* (Brachyura: Gecarcinidae) in Taiwan. Zoological Studies, 46(3): 347-354.

25. Lourenço, R., J. Paula and M. Henriques, 2000. Estimating the size of *Uca tangeri* (Crustacea: Ocypodidae) without massive crab capture. Scientia Marina, 64: 437-439.

26. Macia, A., I. Quincardete and J. Paula, 2001. A comparison of alternative methods for estimating population density of the fiddler crab *Uca annulipes* at Saco Mangrove, Inhaca Island (Mozambique). Hydrobiologia, 449: 213–219.

27. Micheli, E., E. Gherardi and M. Vannini, 1991. Feeding and burrowing ecology of two East African mangrove crabs. Marine Biology, 111: 247-254.

28. Navarro-Rodríguez, M.D.C., R. Flores-Vargas, G.L.F. González and R.M.E. González, 2004. Distribution and abundance of *Dormitator latifroms* (Richardson) larvae (Pisces: Eliotridae) in the natural protected area "estero El Salado" in Jalisco, Mexico. Revista de Biología Marina y Oceanografía, 39(1): 31-36.

29. Oliva-Rivera, J.J., 2005. El cangrejo terrestre *Cardisoma guanhumi* ¿un recurso pesquero? ECOfronteras, 25: 15-17.

30. Schmidt, A.J., M.A. De Oliveira, E.P. De Souza, M. May and S.M.A. Brito, 2008. Relaçâo entre abertura de galeria e comprimento de cefalotórax do caranguejo-Uçá, *Ucides cordatus* (Linneus, 1763) (Crustacea-Decapoda-Brachyura). Boletim Técnico-Científico do CEPENE, 6: 51-58.

31. Sherman, P.M., 2002. Effects of land crabs on seedling densities and distributions in a mainland neotropical rain forest. Journal of Tropical Ecology, 18:67–89.

32. Sherman, P.M., 2003. Effects of land crabs on leaf litter distributions and accumulations in Mainland Tropical rain forest. Biotropica, 35(3): 365-374.

33. Shinozaki-Mendes, R.A., J.R.S. Feitosa, J. Santander-Neto and F.H.H. Vieira, 2012. Reproductive biology of the land crab *Cardisoma guanhumi* (Decapoda: Gecarcinidae) in northeastern Brazil. Journal of the Marine Biological Association of the United Kingdom. Available on CJO 2012 doi:10.1017/S0025315412000951

34. Skov, M.W. and R.G. Hartnoll, 2001. Comparative suitability of binocular observation, burrow counting and excavation for the quantification of the mangrove fiddler crab *Uca annulipes* (H. Milne Edwards). Hydrobiologia, 449: 201-212.

35. Skov, M.W., M. Vannini, J.P. Shunula, R.G. Hartnoll and S. Cannicci, 2002. Quantifying the density of mangrove crabs: Ocypodidae and Grapsidae. Marine Biology, 141: 725–732.

36. Sokal, R.R. and J.F. Rohlf, 2003. Introducción a la bioestadística: Serie de biología fundamental. Reverté, 362pp.

37. Téllez, J.L., S.R.T. Amparán, R.A. Camacho, Q.J.A. Delgado, G.L.F. González, V.S. Guerrero, R.M.D.C. Navarro, D.R. Ramírez, S. Soto-Quintero, L.E. Téllez and H.S. Zalapa, 2010. Estudio técnico justificativo para el establecimiento de un área natural protegida parque municipal Boca de Tomates- Boca negra. Desarrollo comunitario y conservación de la naturaleza nuestra tierra A.C. Puerto Vallarta, Jalisco. 89pp.

38. Turner, M.L., P. Hallas and S. Morris, 2011. Population structure of the Christmas Island Blue Crab, *Discoplax hirtipes* (Decapoda: Branchyura: Gecarcinidae) on Christmas Island, Indian Ocean. Journal of Crustacean Biology, 31(3): 450-457.

39. Warren, H.J., 1990. Role of burrows as refuges from subtidal predators of temperate mangrove crabs. Marine Ecology Progress Series, 67: 295-299.

40. www.tablademareas.com/mx/jalisco/puerto-vallarta (accessed in September 28, 2012).