

Short Communication

**Population structure and sexual maturity of the calico box crab
Hepatus epheliticus Linnaeus (Brachyura, Hepatidae) from
Yucatan Peninsula, Mexico**

Patricio Hernández¹, Artur Rombenso², Marcelo A.A. Pinheiro³ & Nuno Simões⁴

¹Laboratory of Bioecology and Crustacean Systematics, Postgraduate Program
Department of Biology, FFCLRP, University of São Paulo, Av. Bandeirantes 3900
CEP 14040-901, Ribeirão Preto, São Paulo, Brazil

²Oceanology School of the University of Federal of Rio Grande

³Research Group in Crustacean Biology (CRUSTA), University Estadual Paulista (UNESP)
Campus Experimental do Litoral Paulista (CLP), Praça Infante Dom Henrique s/n
Parque Bitaru, 11330-900, São Vicente, SP, Brazil

⁴Unidad Multidisciplinaria de Docencia e Investigación de Sisal, Facultad de Ciencias
Universidad Nacional Autónoma de México

ABSTRACT. The calico box crab *Hepatus epheliticus* is an abundant species from shallow and continental shelf waters of the Atlantic coast of USA and Mexico. Information about population structure and sexual maturity is absent, even though this crab is caught to be used as bait for the octopus fishery in the Campeche Bank, Mexico. In order to achieve such information, a total of 768 individuals were collected from January to March 2010 through baited traps installed in the Yucatan Peninsula, Mexico. Our results showed that sex ratio is biased towards more males than females (1:0.55), contradicting to that reported in other brachyuran crabs. The absence of ovigerous females suggests that they did not enter into the traps during embryogenesis. Males reached a larger maximum size than females (64.0 ± 6.15 and 58.4 ± 5.60 mm carapace width, respectively). The general scheme of growth being positive allometric throughout ontogeny of both sexes. Males presented a transition phase from juveniles to adult corresponding to the puberty moult. The estimation of the onset of functional sexual maturity revealed a steady situation for the population, with 21.5 and 13.8% of males and females, respectively, morphologically immature at the time of catch. This study constitutes the first report on population structure and sexual maturity in a population of the calico box crab *H. epheliticus*.

Keywords: population structure, sexual maturity, biometry, *Hepatus epheliticus*, Yucatan Peninsula, México.

**Estructura poblacional y madurez sexual en el cangrejo caja moteado
Hepatus epheliticus Linnaeus (Brachyura, Hepatidae) procedente de la
Península del Yucatán, México**

RESUMEN. El cangrejo caja moteado *Hepatus epheliticus* es un abundante braquiuro perteneciente a la familia Hepatidae, distribuido desde aguas someras hasta la plataforma continental en la costa atlántica de Estados Unidos y México. La información sobre su demografía poblacional y madurez sexual es actualmente inexistente, aun cuando esta especie es intensamente capturada como carnada en la pesquería del pulpo del estado de Campeche, México. Entre enero y marzo de 2010, se colectaron 768 especímenes usando trampas instaladas en la Península de Yucatán, México. Los resultados mostraron una proporción sexual completamente inclinada hacia los machos (1:0,55), lo cual contradice el esquema general reportado en otras especies de braquiuros. La ausencia total de hembras ovígeras, sugiere su resistencia a ingresar a las trampas durante el periodo de incubación de los embriones. Los machos alcanzaron un tamaño promedio mayor que las hembras ($64,0 \pm 6,15$ y $58,4 \pm 5,60$ mm de ancho del caparazón, respectivamente), siendo el crecimiento de tipo alométrico positivo a lo largo de la ontogenia de ambos sexos. Los machos presentaron una fase de transición desde juveniles a adultos correspondiente a la muda de pubertad. La estimación de la madurez sexual funcional mostró una situación normal para la población, con 21,5 y 13,8% de machos y hembras

respectivamente, morfológicamente inmaduros al momento de ser capturados. Este estudio constituye la primera aproximación a la estructura poblacional y madurez sexual del cangrejo caja moteado *H. epheliticus*.

Palabras clave: estructura poblacional, madurez sexual, biometría, *Hepatus epheliticus*, península de Yucatán, México.

Corresponding author: Patricio Hernández (phernahez@lycos.com)

The calico box crab *Hepatus epheliticus* Linnaeus (Hepatidae) is an abundant subtidal crab that lives buried in sandy substrate between depths of 2 to 91 m (Franks *et al.*, 1972). This species occurs throughout the Chesapeake Bay to western Bay of Campeche, Mexico (Rickner, 1977), but it has also been reported from Cuba, Jamaica and Dominican Republic (Williams, 1984). In the Campeche Bank, Mexico, this crab is heavily fished and used as bait for the octopus fishery (*Octopus maya* Voss & Solís-Ramírez, 1966). In Mexico the octopus fishery is the third most important not only in volume, but also in value, and it is concentrated in the Campeche and Yucatan coastal states (Salas *et al.*, 2009). From early August to mid December, the octopus fishery demands high numbers of crabs for bait, which are used tied at the end of slowly dragging lines over hard bottom, to which the octopus grabs (Arreguín-Sánchez *et al.*, 1987, 2000). The calico box crab is also fished as by-catch in the baited crab traps set up for portunids (“jaibas”), popular year-round on the local seafood market. Although there are reports on the octopus fishery, little is known on the catch statistics of *H. epheliticus* and collateral effects of the octopus-jaibas fishing pressure on their populations. In fact, as far as we know, there is no report on neither size-frequency distribution, sex ratio nor on sexual maturity of this crab. Such lack of data on the population biology of this crab species impedes any attempt for ecosystem based management by the local authorities, as the species is a natural prey item of both octopus and other demersal fishes.

The present study examines for the first time the population structure and sexual maturity in the calico box crab *H. epheliticus* from the Yucatan Peninsula, Mexico. Such information provides valuable insights into the ecology of this crab and could facilitate future sustainable management of this species in the gulf of Mexico.

Specimens were collected between January and March 2010 from subtidal zone along the coast of Sisal, Yucatan Peninsula, Gulf of Mexico (21°10'N, 90°00'W). Crabs were collected using baited traps (2 cm diameter mesh) and identified according to Williams (1984). After collecting the crabs, each individual was sexed based upon macroscopic

characters such as the morphology of the abdomen (Fig. 1), presence of gonopods (males) and number of pleopods. Specimens of each sex were grouped into 1 mm CW size classes (CW = carapace width); thereafter, data were plotted as length-frequency histograms to analyze the population structure of each morphotype (males, females without eggs, and ovigerous females). The normal component of each sex was separated using the Bhattacharya method and confirmed by Normsep routine, both included in FiSAT software (Gayaniño *et al.*, 1996). This analysis, based on the identification of each cohort's mean, allows the separation of each modal component. Sex ratio was estimated as the number of males divided by the number of females. Departures from the expected 1:1 ratio were tested statistically using a chi-square test ($P < 0.05$, Sokal & Rohlf, 1995). The data distribution was tested using a goodness of fit proof.

The following measurements were made with a precision vernier calipers (nearest 0.1 mm) on each specimen: carapace length (CL: from the anterior margin of the rostrum to the posterior margin of the carapace), carapace width (CW: measured between the base of the principal lateral teeth), and length and height of the propodus of the chelipeds (PL and PH, respectively; Fig. 1). Gonopod length (GL) and 6th abdominal somite width (A_6) was measured on males and females, respectively (Fig. 1). To determine the growth pattern in *H. epheliticus*, the allometric equation ($Y = aX^b$) was used to represent biometric relationship between each dependent variable with respect to the independent variable (CW) for growth phase (juvenile and adult) to obtain the allometric growth constant “b” (see Somerton, 1980). The accuracy of each allometric equation was determined by the coefficient of determination (r^2 , $P < 0.05$), obtained for the log-transformed equations. To analyze the chelae symmetry, a comparison between PL of both chelae was realized (Student's t-test, $P > 0.05$, Sokal & Rohlf, 1995). When t-test analysis was carried out, the Cochran tests were used to test for homogeneity of variances (Zar, 1996).

All biometric relationships were submitted to the MATURE software (Somerton, 1980; Somerton & Macintosh, 1983), and statistical data were confirmed by the program “R” Version 2.5.0 (Ihaka &

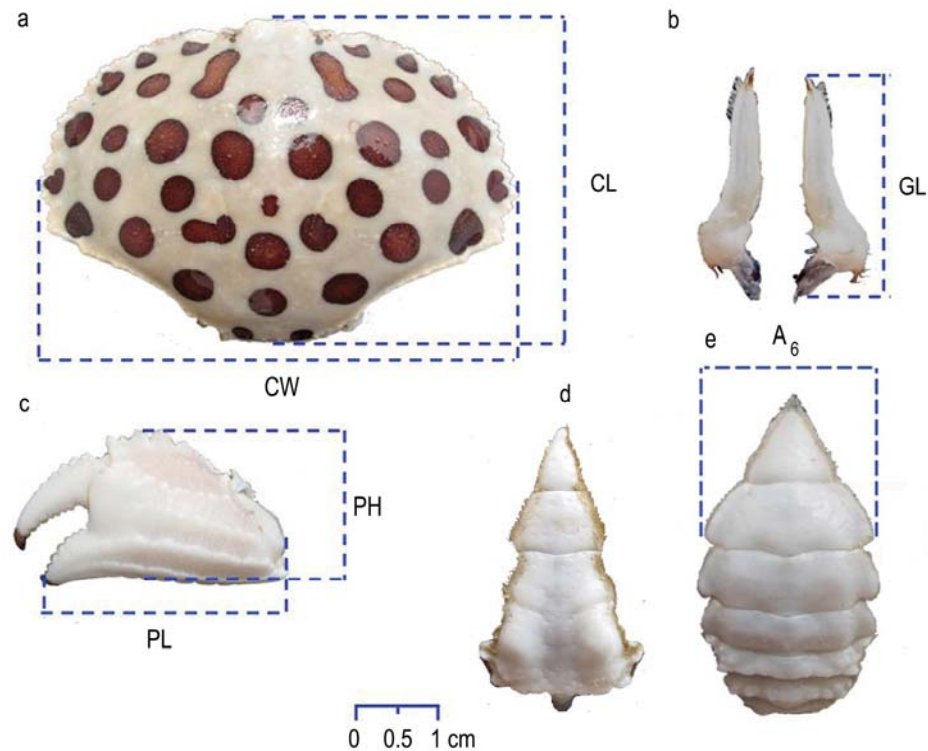


Figure 1. Morphometric variables measured in the a) carapace, b) gonopod, c) chela, d) abdomen of the adult male, and e) female. Where CL: carapace length; CW: carapace width; PL: chelar propodus length; PH: chelar propodus height; GL: gonopod length; A_6 : width of sixth abdominal segment. Scale measurement is valid for all structures.

Figura 1. Variables morfológicas medidas en los individuos: a) caparazón, b) gonópodo, c) quela, d) abdomen masculino y e) femenino de ejemplares adultos. Donde CL: longitud del caparazón; CW: ancho del caparazón; PL: longitud del propodio de la quela; PH: altura del propodio de la quela, GL: longitud del gonópodo; A_6 : longitud del sexto segmento abdominal. Escala de mediciones válida para todas las estructuras.

Gentleman, 1996), to identify break point(s) in the empiric point trend during ontogeny (puberty size). The MATURE program was developed to estimate the size at sexual maturity specifically for crustaceans, based on morphometric data. During postlarval development, brachyuran crabs can display body changes with the onset of the development of secondary sexual characters (Hartnoll, 1974), with two phases (juvenile and adult) separated by a critical molt (puberal or pubertal molt). Each phase is represented by a mathematic equation (power function) following one of four patterns described by Somerton (1980). In a simpler pattern (*e.g.*, chelar variables in males) there is no overlap between phases, where dependent variable (y) grows better of the independent one (x), where pubertal molt occurs. The MATURE program requests a size (CW) range that contains a “visible” inflection in data trend (size at maturity) established by a smaller “ x ” value (only juveniles) and a greater one (only adults). A linear regression (log-transformation of $Y = a^b$) was fitted to each subset and

established an initial intersection value. The data were grouped according to each ontogenetic phase, and regression lines were obtained interactively until the best one with a minimum residual sum of square was found. After this interactive process, a statistical test was performed to determine if the resulting two lines fit the data better than a single one. If the fit was not significantly better, there was little justification for using two lines to describe the data, revealing the need for other procedures to estimate maturity.

Maturity size can be estimated using different criteria (Hernández & Wehrmann, 2007). In our study, the size at morphological sexual maturity (MSM) was estimated by biometric analysis of males (GL x CW and PL x CW) and females (A_6 x CW and PL x CW). The constant “ b ” of the power function provides information concerning the increment of one biometric dimension in relation to another. We considered growth to be isometric when “ b ” ranged between 0.90 and 1.10, negative allometric when $b < 0.90$, and positive allometric when $b > 1.10$ (Pinheiro

& Fransozo, 1993; Hernáez & Wehrtmann, 2007). Student-*t* test was used to verify the significance of this value related to the unit ($P > 0.05$) (see Pinheiro & Hattori, 2006). All incomplete individuals were excluded from these analyses.

A total of 768 individuals of *H. epheliticus* (497 males = 65%; and 271 females = 35%) were analyzed. Males captured ranged from 48.4 to 82.7 mm CW, and females from 40.3 to 73.3 mm CW. Average CW of males was significantly larger than females (64.0 ± 6.2 mm vs 58.4 ± 5.6 mm CW, $t = 12.46$, $P < 0.05$). The size structure in both sexes was polymodal, and the majority of males (59%) and females (58%) were registered in the range of 61.0 to 70.0 mm CW and 51.0 and 60.0 mm CW, respectively (Fig. 2). The cohort analysis revealed the presence of five and four cohorts in males and females, respectively (Fig. 2). Males were significantly more abundant than females (test $\chi^2 = 66.5$, $P < 0.05$). No ovigerous female was caught during the study period.

The empirical points in each biometric relation analysed were well aligned and fitted the power function (Table 1). MATURE and “R” routines revealed in the relations PL x CW (males) and A_6 x CW (females), a similar growth pattern throughout the ontogeny (Table 1). In males, two break points were indicated for the relationship PL x CW (Fig. 3) between 59.3 and 67.3 mm CW (Fig. 3), where the puberty molt occurs. In contrast, in females the biometric analysis of A_6 x CW (using “R”) did not reveal a distinction between line phases; however, at the last one was observed two regression lines (juvenile and adults) with an overlap registered at 51.3 mm CW (Fig. 3).

A comparison of the PL of both chelae revealed that males and females ($n = 30$ each) have symmetric chelae (paired Student’s *t*-test, males: $t = -0.61$, $P > 0.05$; females $t = 0.45$, $P > 0.05$). Therefore, data from the left chelae was used to estimate MSM. A comparison between the left and right GL revealed significant differences of this variable in males (paired Student’s *t*-test, males: $t = 8.37$, $P < 0.05$).

Crabs used as bait (e.g. *Callinectes* spp., *Libinia dubia*, *Cardisoma guanhumi*, and *H. epheliticus*) are normally sold at around US\$ 2.00-2.25 per kg depending both on the availability of crabs and time passed since the beginning of the octopus fishery period, with higher prices towards the end of the fishing season. The bait-crabs are supplied by local fisherman, fishing with baited traps close to the shore, but crabs are also imported from other states of Mexico (e.g. Tabasco, Chiapas and Veracruz). In

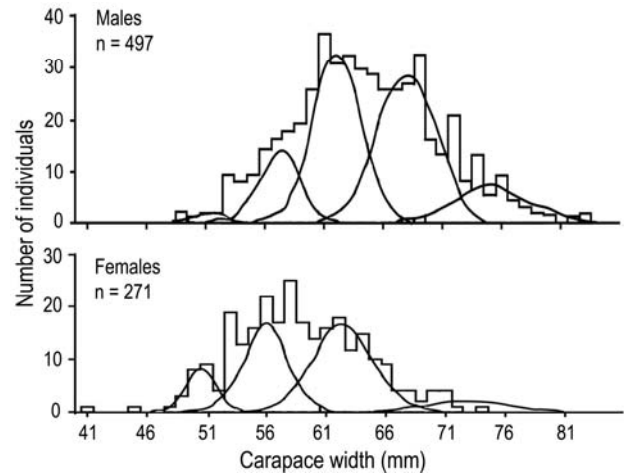


Figure 2. Size and age structure by sex of the benthic population of the calico box crab, *Hepatus epheliticus*, from Yucatan, Mexico.

Figura 2. Tamaño y estructura de edad de ambos sexos en la población bentónica del cangrejo caja moteado *Hepatus epheliticus* procedente de Yucatán, México.

average, each small fishing boat uses 5-10 kg of bait-crabs per fishing day which accounts to nearly 20% of operation costs of the fishery (CONAPESCA, 2009). According to the Mexican Carta Nacional Pesquera (2010, data from 2004), there are two main states fishing octopus in the south coast of gulf of Mexico: Campeche and Yucatan. This adds up to 16 and 418 large and 1,617 and 3,300 small fishing fleet vessels in Campeche and Yucatan, respectively. Data corrected to Yucatán during 2008 (CONAPESCA, 2009) reports 2,731 small boats fishing in Yucatan. A simple projection using this last fleet figure fishing for 90 days (75% of the fishing period) and using minimum bait-crab volume per boat (5 kg) would totalize more than 1 million metric tons of bait-crab used. Information obtained in 2011 from local Yucatan markets reveals that each kilogram price of bait-crabs reached an historical peak above US\$ 3.5 (N. Simões, pers. comm.). This high price during 2011 can be explained by reduced crab catches due to fishery demand. This may be the first sign of alert for a possible overexploitation of the crab population in Yucatan.

In many species of brachyuran crabs, the apparition of secondary sex characters allows to estimate the onset of functional sexual maturity (Hartnoll, 1974, 1978; Hines, 1982). These traits include the release of abdominal somites from the thoracic sternites and opening of gonopods (Guinot, 1979), the conspicuous growth of certain cheliped segments (mainly the propodus) (Hartnoll, 1982; Pinheiro & Fransozo, 1993), and colour pattern

Table 1. Regression analyses by biometric relation evaluated for the calico box crab *Hepatus epheliticus* from Yucatan Peninsula, gulf of Mexico. All relations were significant ($P < 0.01$), where: GL: gonopod length; PL: major chelar propodus length; 6th abdominal somite width and CW: carapace width; JM: juvenile males; AM: adult males; TM: total males; JF: juvenile females; AF: adult females; TF: total females. *The best equations to represent the relative growth: allometric levels related to isometry (0), negative allometry(-) and positive allometry (+).

Tabla 1. Análisis de regresión para las relaciones biométricas en el cangrejo caja moteado *Hepatus epheliticus* procedente de la península del Yucatán, golfo de México. Todas las relaciones fueron estadísticamente significativas ($P < 0,01$), donde: GL: longitud del gonópodo; PL: longitud del quelípodo mayor, ancho del 6^{to} somito abdominal y CW: ancho del caparazón; JM: machos juveniles; AM: machos adultos; TM: machos totales; JF: hembras juveniles; AF: hembras adultas; TF: hembras totales. *Representa la mejor ecuación para el crecimiento relativo: 0, - y + : nivel de alometría relacionado a isometría (0), alometría negativa(-) y positiva (+).

Relation	Sex/Stage	N	Equation	R ²	Allometric level
GL x CW	JM	155	GL = 0.13 CW ^{1.15}	0.83	+
	AM	100	GL = 0.35 CW ^{0.91}	0.76	0
	TM	255	GL = 0.19 CW ^{1.05}	0.92*	0
PL x CW	JM	55	PL = 0.12 CW ^{1.33}	0.75	+
	PM	122	PL = 0.05 CW ^{1.53}	0.67	+
	AM	79	PL = 0.19 CW ^{1.22}	0.54	+
	TM	256	PL = 0.10 CW ^{1.37}	0.93*	+
A ₆ x CW	JF	10	PL = 4·10 ⁻¹⁰ CW ^{6.15}	0.54	+
	AF	128	PL = 0.10 CW ^{1.23}	0.66	+
	TF	138	PL = 0.05 CW ^{1.40}	0.71*	+

enhancement of cheliped propodus and dactylus (Hopkins, 1963; Ryan, 1967). The general scheme of growth in crustaceans is confirmed by our data. The growth pattern of *H. epheliticus* was characterized by allometric body symmetry, with slight changes in the biometric relations through ontogeny. However, an analysis of A₆ x CW did not reveal a distinction between line phases. It seems necessary to obtain a greater number of points to achieve a better approximation of the size of the morphological sexual maturity, mainly for females smaller than 60 mm (CW).

Only 35% of the total individuals analyzed were females. The major percentage of males observed in the population of *H. epheliticus* contradicts the scenario reported in other crab species (including hepatid crabs), where females predominate in all habitat types from shallow waters (Wolff & Cerda, 1992; Mantelatto *et al.*, 1995; Jesse & Stotz, 2003). The deviation from the expected 1:1 sex ratio is very common in decapods (Wenner, 1972), and may be attributed to spatial segregation (Jesse & Stotz, 2003) and/or temporal variations in sexual composition of the population (Wenner, 1972; Bas *et al.*, 2005). However, when the capture method involves baited

traps, it is common that ovigerous females do not enter (Howard, 1982; Smith *et al.*, 2004). This suggests that ovigerous females of *H. epheliticus* may concentrate in other locations to incubate their eggs, which explains the disparity of the sex-ratio observed during study period. The total absence of ovigerous females during the study period supports this hypothesis. However, we do not discard temporal migrations of the females to other areas away from the fishing area. Long-term studies are necessary to answer this question.

This is the first evaluation concerning the population structure and sexual maturity of the calico box crab *H. epheliticus*. The antecedents compiled in this study reveal a stable situation for the population studied, with 21.5% and 13.8% of males and females, respectively, morphologically immature at the time of catch (Fig. 4). Finally, our results suggest that the breeding cycle and spatial distribution of each population component are aspects that require a more thorough revision, especially considering the development of management strategies for a future sustainable fishery of this resource in the waters of Mexico and neighboring countries.

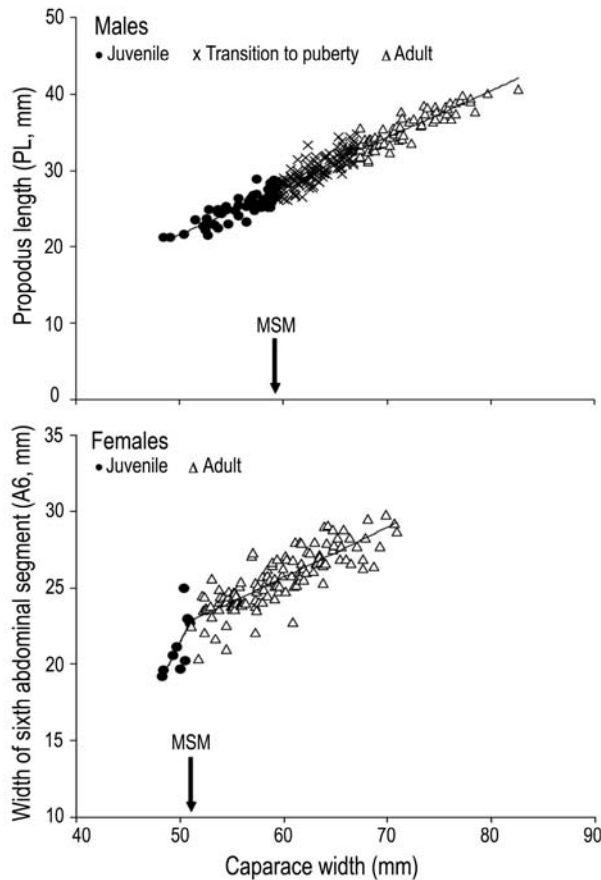


Figure 3. Chelar propodus length (PL) versus carapace width (CW) scatterplot in males ($n = 256$) and females ($n = 138$) of the calico box crab, *Hepatus epheliticus*, from Yucatan, Mexico. The arrow indicates the size when juveniles transform into adult crab in each sex.

Figura 3. Relación entre la longitud del propodio de la quela (PL) y el ancho del caparazón (CW) en machos ($n = 255$) y hembras ($n = 138$) del cangrejo caja moteado *Hepatus epheliticus* procedente de Yucatán, México. La flecha indica el tamaño en el cual los juveniles de ambos sexos pasan a la etapa adulta.

ACKNOWLEDGEMENTS

The first author is grateful to the Red de Macrouniversidades de América Latina y El Caribe (Red MACRO) by financial support during their stay in Sisal, Mexico. We are also grateful to the Unidad Multidisciplinaria de Docencia e Investigación de Sisal, Yucatan, Mexico (UMDI-UNAM) for providing facilities for this study and specifically to the technical assistant of laboratory Maribel Badillo Alemán, the researchers Carlos Rozas and Xavier Chiapas, and students Ana Kiel and Mariana Mata-Lara.

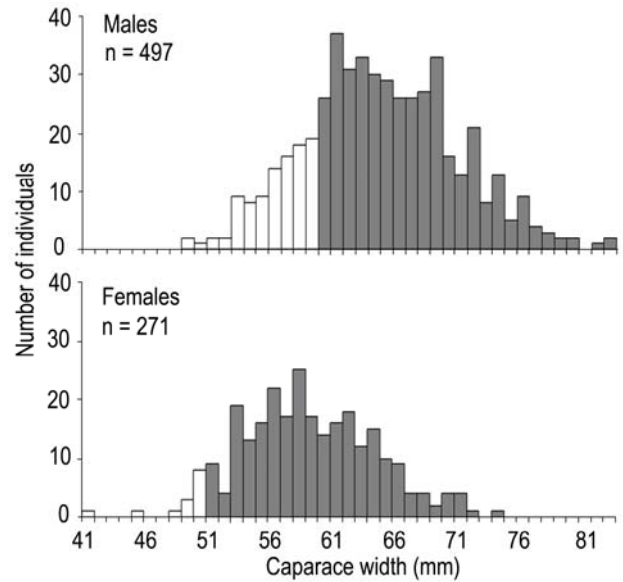


Figure 4. Size frequency distribution of the calico box crab, *Hepatus epheliticus* from Yucatan, Mexico. Mature morphological individuals are represented by darker bars.

Figura 4. Distribución de frecuencia por clase de talla en el cangrejo caja moteado *Hepatus epheliticus* procedente de Yucatán, México. Los individuos morfológicamente maduros corresponden a las barras oscuras.

REFERENCES

- Arreguín-Sánchez, F.J., J.C. Seijo, D. Fuentes & M. Solís-Ramírez. 1987. Estado de conocimiento de los recursos pesqueros de la Plataforma de Yucatán y región adyacente. Contribuciones de Investigación Pesquera. Documento técnico. Secretaria de Pesca, Instituto Nacional de la Pesca, Centro Regional de Investigaciones Pesquera, Yucaltepén, 4: 1-41.
- Arreguín-Sánchez, F., M. Solís-Ramírez & M.E. González de la Rosa. 2000. Population dynamic and stock assessment for *Octopus maya* (Cephalopoda: Octopodidae) fishery in the Campeche Bank, Gulf of México. *Rev. Biol. Trop.*, 48(2-3): 323-331.
- Bas, C., T. Luppi & E. Spivak. 2005. Population structure of the South American estuarine crab, *Chasmagnathus granulatus* (Brachyura: Varunidae) near the southern limit of its geographical distribution: comparison with northern populations. *Hydrobiologia*, 537: 217-228.
- Carta Nacional Pesquera. 2010. Comisión Nacional de la Pesca. SAGARPA, México, 230 pp.
- Comisión Nacional de Acuicultura y Pesca (CONAPESCA). 2009. Programa maestro de pulpo en el estado de Yucatán. Sistema producto pulpo de Yucatán, SAGARPA, México, 263 pp.

- Franks, J.S., J.Y. Christmas, W.L. Siler, R. Combs, R. Waller & C. Burns. 1972. A study of nektonic and benthic faunas of the shallow gulf of Mexico off the state of Mississippi as related to some physical, chemical and geological factors. *Gulf Res. Rep.*, 4: 1-148.
- Gayanilo, F., P. Sparre & D. Pauly. 1996. FAO-ICLARM stock assessment tools: user's guide. FAO-ICLARM, Rome, 23 pp.
- Guinot, D. 1979. Données nouvelles sur la morphologie, la phylogénèse, et la taxonomie des Crustacés Décapodes Brachyours. *Mem. Mus. Nat. Hist. Nat. Nouv. Ser. A. Paris*, 112: 1-354.
- Hartnoll, R.G. 1974. Variation in growth patterns between some secondary sexual characters in crabs (Decapoda, Brachyura). *Crustaceana*, 27: 131-136.
- Hartnoll, R.G. 1978. The determination of relative growth in Crustacea. *Crustaceana*, 34: 281-293.
- Hartnoll, R.G. 1982. Growth. In: L.G. Abele (ed.). *The biology of Crustacea*. 5. Embryology, morphology and genetics. Academic Press, New York, pp. 111-196.
- Hernández, P. & I.S. Wehrtmann. 2007. Population biology of the burrowing shrimp *Callinectes seilacheri* (Decapoda: Callinectidae) in northern Chile. *Rev. Biol. Trop.*, 55(1): 141-152.
- Hines, A.H. 1982. Allometric constraints and variables of reproductive effort in brachyuran crabs. *Mar. Biol.*, 69: 309-320.
- Hopkins, T.H. 1963. Sexual dichromatism in three species of portunid crabs. *Crustaceana*, 5(3): 238-239.
- Howard, A.E. 1982. The distribution and behaviour of ovigerous edible crabs (*Cancer pagurus*), and consequent sampling bias. *J. Cons. Int. Explor. Mer.*, 40(3): 259-261.
- Ihaka, R. & R. Gentleman. 1996. R: a language for data analysis and graphics. *J. Comp. Graph. Stat.*, 5(3): 299-314.
- Jesse, S. & W. Stotz. 2003. Spatio-temporal distribution patterns of the crab assemblage in the shallow subtidal of the north Chilean Pacific coast. *Crustaceana*, 75(10): 1161-1200.
- Mantelatto, F.L.M., A. Fransozo & M.L. Negreiros-Fransozo. 1995. Population structure of *Hepatus pudibundus* (Decapoda: Calappidae) in Fortaleza Bay, Brazil. *Rev. Biol. Trop.*, 43(1-3): 265-270.
- Pinheiro, M.A.A. & A. Fransozo. 1993. Relative growth of the speckled swimming crab *Arenaeus cribrarius* (Lamarck, 1818) (Brachyura: Portunidae), near Ubatuba, State of São Paulo, Brazil. *Crustaceana*, 65: 377-389.
- Pinheiro, M.A.A. & G.Y. Hattori. 2006. Growth of the speckled swimming crab, *Arenaeus cribrarius* (Lamarck, 1818) (Crustacea, Brachyura, Portunidae), in Ubatuba (SP), Brazil. *J. Nat. Hist.*, 40(21-22): 1331-1341.
- Rickner, J.A. 1977. Notes on a collection of crabs (Crustacea: Brachyura) from the east coast of Mexico. *Proc. Biol. Soc. Wash.*, 90: 831-838.
- Ryan, E.P. 1967. The morphometry of sexually mature instars in the crab *Portunus sanguinolentus* (Herbst) (Brachyura: Portunidae). *Proc. Symp. Crust. India*, 2: 715-723.
- Salas, S., M. Cabrera, L. Palomo & E. Torres-Irineo. 2009. Uso de indicadores para evaluar medidas de regulación en la pesquería del pulpo en Yucatán dada la interacción de flotas. *Proc. Gulf Caribb. Fish. Inst.*, 61: 111-121.
- Smith, K.D., N.G. Hall, S. de Lestang & I.C. Potter. 2004. Potential bias in estimates of the size of maturity of crabs derived from trap samples. *J. Mar. Sci.*, 61: 906-912.
- Sokal, R.R. & F.J. Rohlf. 1995. *Biometry, the principles and practices of statistics in biological research*. W.H. Freeman, New York, 859 pp.
- Somerton, D.A. 1980. A computer technique for estimating the size of sexual maturity in crabs. *Can. J. Fish. Aquat. Sci.*, 37: 1488-1494.
- Somerton, D.A. & R.A. Macintosh. 1983. The size at sexual maturity of blue king crab, *Paralithodes plaripus*, in Alaska. *Fish. Bull.*, 81(3): 621-628.
- Voss, G.L. & M. Solis-Ramirez. 1966. *Octopus maya*, a new species from the Bay of Campeche, Mexico. *Bull. Mar. Sci.*, 16: 625-634.
- Wenner, A.M. 1972. Sex ratio as a function of size in marine Crustacea. *Am. Nat.*, 106: 321-350.
- Williams, A.B. 1984. *Shrimps, lobsters, and crabs of the Atlantic coast of the eastern United States*. Smithsonian Institution Press, Maine, 550 pp.
- Wolff, M. & G. Cerda. 1992. Feeding ecology of the crab *Cancer polyodon* in La Herradura Bay, northern Chile. I. Feeding chronology, food intake, and gross growth and ecological efficiency. *Mar. Ecol. Prog. Ser.*, 89: 213-219.
- Zar, J.H. 1996. *Biostatistical analysis*. Prentice Hall, New Jersey, 328 pp.