THE PELAGIC CRAB *PLANES CYANEUS* (DANA, 1851) (DECAPODA, BRACHYURA, GRAPSIDAE) IN THE SOUTHWESTERN ATLANTIC OCEAN IN ASSOCIATION WITH LOGGERHEAD SEA TURTLES AND BUOYS

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ABSTRACT

This study describes the population structure of the crab *Planes cyaneus* Dana, 1851 associated with loggerhead sea turtles, *Caretta caretta* (Linnaeus, 1758), and inanimate flotsam in the southwestern Atlantic Ocean. Samples were collected by scientific observers onboard fishing vessels of the Uruguayan tuna fleet operating between 29°-38°S and 30°-56°W, from May 2002 to July 2005. A total of 140 crabs were sampled, with cephalothorax lengths ranging from 5.6 to 22.9 mm. Eighty-eight percent of the crabs found on loggerhead turtles were adult. However, adults represented only 50% of the crabs found on buoys. We detected no relation between the turtles' carapace size and the number of crabs on each turtle. Over 50% of the sampled turtles presented a single crab; the rest presented two to five crabs. Some characteristics observed for *P. cyaneus* in the southwestern Atlantic Ocean were similar to those found by other authors for its congener, *Planes minutus*, in the North Atlantic. Results from the present study, also, extend the known geographic distribution of *P. cyaneus* in the southwestern Atlantic Ocean into offshore waters and suggest that these crabs opportunistically colonize whatever substrates are available in pelagic environments where substrates are scarce.

RESUMEN

Este estudio describe la estructura poblacional del cangrejo *Planes cyaneus* Dana, 1851 en asociación con la tortuga cabezona, *Caretta caretta* (Linnaeus, 1758), y boyas en el Océano Atlántico Sur oeste. Las muestras fueron recolectadas por observadores científicos a bordo de barcos pesqueros de la flota atunera Uruguaya que operaron entre los 29°-38°S y 30°-56°W entre Mayo de 2002

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y Julio de 2005. Un total de 140 cangrejos fueron muestreados, con un largo de cefalotórax que varió entre 5,6 y 22,9 mm. Ochenta y ocho por ciento de los cangrejos encontrados en las tortugas cabezonas eran adultos. Sin embargo los adultos sólo representaron el 50% de los cangrejos encontrados en boyas. No se detectó relación entre el tamaño del caparazón de las tortugas y el número de cangrejos presentes en las mismas. Más del 50% de las tortugas muestreadas presentaron un único cangrejo; el resto presentó una alta heterogeneidad de grupos de dos a cinco individuos. Algunas características observadas para *P. cyaneus* en el Océano Atlántico Sur oeste fueron similares a las encontradas por otros autores para su congénere, *Planes minutus*, en el Atlántico Norte. Los resultados del presente estudio, además, amplían la distribución geográfica conocida de *P. cyaneus* en el Océano Atlántico Sur oeste hacia aguas más alejadas de la costa y sugieren que este cangrejo tiene hábitos oportunistas colonizando diferentes sustratos disponibles, particularmente en el ambiente pelágico donde los mismos son escasos.

INTRODUCTION

The crabs of the genus *Planes* Bowdich, 1825 are distributed in tropical and temperate waters of the Atlantic, Indian, and Pacific oceans. This genus comprises three species of marine grapsid crabs: *Planes minutus* (Linnaeus, 1758), *Planes cyaneus* Dana, 1851, and *Planes marinus* Rathbun, 1914. All three species of *Planes* have all been documented from the Atlantic Ocean. *P. minutus* was reported from the coasts of Africa and in the North Atlantic (from 11°N to 52°N); *P. cyaneus* for Africa, Brazil, and Uruguay, as well as for the North Atlantic and the Gulf of Mexico; and *P. marinus* for Brazil, Argentina, and St. Helena Island (Chace, 1951; Juanicó, 1976; Spivak & Bas, 1999; Prado & De Melo, 2002; Carranza et al., 2003; Bugoni et al., 2007).

Unlike other grapsid crabs, these species are exclusively pelagic and occur in association with different floating objects (Chace, 1951; Davenport, 1992). They are often found associated with living substrates such as algae (e.g., *Sargassum* spp.), scyphozoans (e.g., *Velella* spp.), gastropods (e.g., *Janthina* spp.) (Chace, 1951; Davenport, 1994; Dellinger et al., 1997), sea turtles (*Caretta caretta* (Linnaeus, 1758), *Chelonia mydas* (Linnaeus, 1758), *Lepidochelys olivacea* (Eschscholtz, 1829) and *Eretmochelys imbricata* (Linnaeus, 1766)) (Geiselman, 1983; Davenport, 1994; Frick et al., 2000, 2004, 2006; Wicksten & Behrens, 2000; Miranda & Moreno, 2002; Carranza et al., 2003; Bugoni et al., 2007), as well as on inanimate objects such as wood, buoys, rope, and plastic, among others (Juanicó, 1976; Dellinger et al., 1997; Spivak & Bas, 1999).

During recent years there have been several reports of *Planes* spp. associated with sea turtles, the majority of which deal with *P. minutus* and the loggerhead sea turtle, *C. caretta*, in the North Atlantic (Davenport, 1994; Dellinger et al., 1997; Frick et al., 2000, 2004). These studies suggest a mutualistic relationship between crabs and turtles. The crabs are thought to forage on epibiota, thereby cleaning turtles of fouling organisms and improving their hydrodynamic performance (Frick

et al., 2000, 2004); in turn, the turtles' carapaces serve as rare resources in the pelagic environment: a substrate that also provides refuge habitat, food resources, and dispersal capacity.

Information about the association of *P. cyaneus* with marine turtles in the western South Atlantic is relatively recent; the first report, involving loggerheads, was made by Carranza et al. in 2003. Subsequently, in 2005 Bugoni et al. (2007) found *P. cyaneus* associated with hawksbill (*E. imbricata*), green (*C. mydas*), and loggerhead sea turtles. The present study continues in this line, with information on the population structure of *P. cyaneus* associated with loggerhead sea turtles and also with buoys in the southwestern Atlantic Ocean.

MATERIAL AND METHODS

Specimens of *Planes cyaneus* were collected from loggerhead sea turtles captured as bycatch by the Uruguayan tuna longline fleet and also from recovered flotsam, between May 2002 and July 2005. Data collection was done by scientific observers of the DI.NA.R.A. (Dirección Nacional de Recursos Acuáticos) under the PNOFA (Programa Nacional de Observadores de la Flota Atunera [National Observer Programme of the Tuna Fleet]), conducted by the Pelagic Resources Department.

All the turtles and flotsam were sampled in the area between 29°-38°S and 30°-56°W (fig. 1). Once on board, crabs were removed from turtles and flotsam and then preserved in 70% ethanol for later processing in the laboratory. Maximum cephalothorax length (CL) and width (CW), and the length of the last three segments of the second pereiopod (L2P) of each crab were measured with Vernier callipers (precision 0.1 mm). Species identification was based on morphometric features following Chace (1951).

Each crab was sexed and classified as immature (= juvenile) or mature (= adult) following the criteria used by Dellinger et al. (1997). Mature females were classified on the basis on their pleon width. Those whose pleon reached the coxae of the walking limbs were considered mature. Males were considered mature if the first pair of gonopods was clearly visible. Each crab was assigned to one of the following classes: immature male, immature female, mature male, mature female, and ovigerous female (if they had eggs under the pleon). The overall sex-ratio was tested for departure from a 1 : 1 ratio with a Chi-Square test. Student's *t*-test (Sokal & Rohlf, 1979) was used to determine differences between cephalothorax size of males and females.

In addition, curved carapace length (notch to tip) (CCL) of each turtle sampled was measured according to Bolten (1999). The number of crabs per turtle or

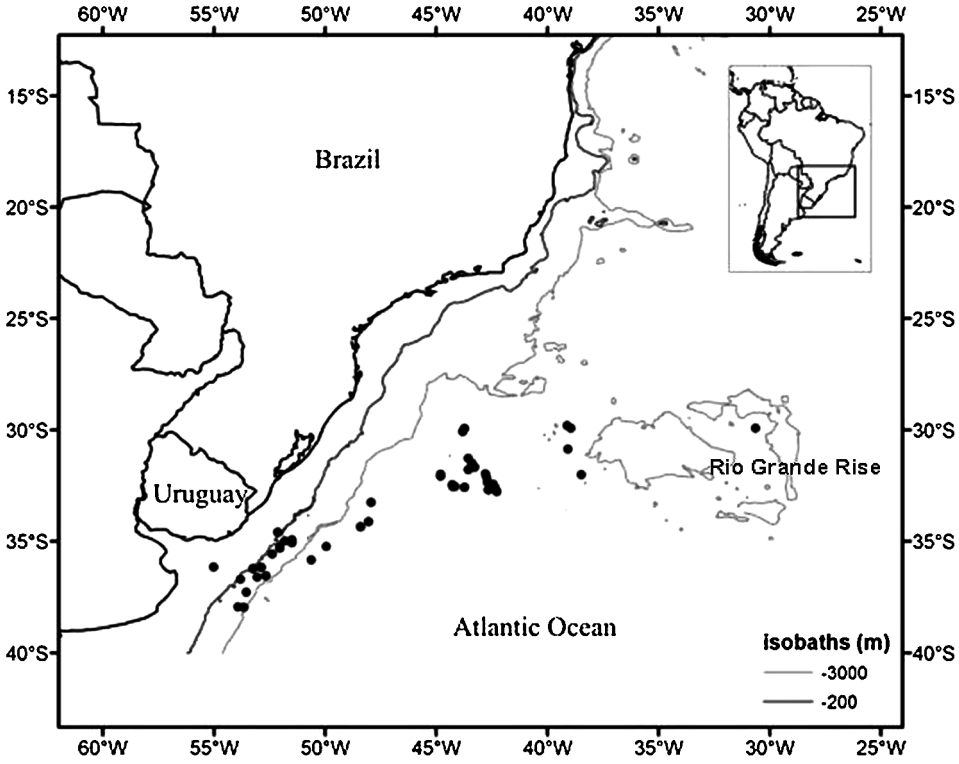

Fig. 1. Map showing the study area. The dots represent the positions from where specimens of *Planes cyaneus* Dana, 1851 were sampled.

flotsam item (buoy), and the composition of each grouping by sex, size, and reproductive condition, were also recorded. The relation between turtle CCL and number of crabs present was evaluated by a Pearson correlation coefficient (Daniels, 1994). All mean sizes presented are followed by their standard deviation after the ± sign.

RESULTS

A total of 128 crabs was collected from loggerhead sea turtles *Caretta caretta*, out of which 117 were collected from 72 individual loggerheads and 11 crabs from an unknown number of loggerheads with no supporting host data. In addition, 12 crabs were found on three buoys (two marker buoys for active fishing gear and a single lost buoy). Following Chace (1951), all crabs were identified as *Planes cyaneus*: cephalothorax length ranged from 5.6 to 22.9 mm (table I); CL : CW ratio ranged from 0.93 to 1.09; and CL : L2P ratio ranged from 0.63 to 0.90. A total of 85% were adults (66 males and 53 females), and the remaining 15% were juveniles

TABLE I

Size of *Planes cyaneus* Dana, 1851 grouped by substrate, showing cephalothorax length (CL) and cephalothorax width (CW) both in mm, with their respective range, mean, and standard deviation (sd.) for different subsamples of crabs. (*) 117 were collected from 72 individual loggerheads and the other 11 crabs were collected from an unknown number of loggerhead sea turtles (x)

	N	CL (range; mean ± sd.) in mm	CW (range; mean ± sd.) in mm
TOTAL SUBSTRATES			
Mature males	66	7.0-22.9; 14.6 ± 3.6	7.1-23.0; 14.4 ± 3.5
Mature females (non-ovigerous)	35	13.2-21.1; 17.4 ± 3.0	12.9-21.5; 17.3 ± 3.2
Ovigerous females	18	11.9-21.8; 18.6 ± 3.5	11.9-22.0; 18.7 ± 3.5
Immature females	20	6.2-17.0; 12.1 ± 2.7	6.1-17.0; 12.2 ± 2.6
Immature individuals, undetermined sex	1	5.6	5.6
MARINE TURTLES, N = 72 + x(*)			
Mature males	61	7.0-22.9; 14.7 ± 3.40	7.1-23.0; 14.4 ± 3.4
Mature females (non-ovigerous)	35	13.2-21.1; 18.1 ± 1.9	12.9-21.5; 18.5 ± 1.9
Ovigerous females	17	11.9-21.8; 18.2 ± 3.0	11.9-22.0; 18.3 ± 3.1
Immature females	14	8.9-17.0; 12.5 ± 2.7	9.1-17.0; 12.5 ± 2.6
Immature individuals, undetermined sex	1	5.6	5.6
BUOYS, N = 3			
Mature males	5	7.0-19.1; 12.7 ± 4.7	7.0-19.1; 12.9 ± 4.9
Ovigerous females	1	15.5	16.1
Immature females	6	6.2-13.7; 10.8 ± 2.7	6.1-13.8; 11.1 ± 3.3
TOTAL	**140**	**5.6-22.9; 14.5 ± 3.8**	**75.6-23.0; 15.4 ± 3.8**

(20 females and 1 undetermined sex). Mature female crabs, including ovigerous females (CL mean = 17.9±3.2 mm) were significantly larger ($t = 5.2$, $P < 0.05$) than mature males (CL mean = 14.6 ± 3.6 mm). Eighteen females collected were ovigerous (CL mean = 18.6 ± 3.5 mm), (table I) and they were present in all months sampled. The sex ratio of all crabs sampled did not differ significantly from a 1 : 1 ratio ($X^2 = 0.357$, $P > 0.05$).

The 72 turtles were live loggerheads (*Caretta caretta*) that ranged from 42 to 70 cm curved carapace length (CCL mean = 54 ± 6.5 cm); hence, they were all immature in their pelagic stage (Bolten, 2003). Crabs were found near the tail and in the inguinal pocket of the turtles.

Thirty-nine turtles hosted single crabs, principally adults; 24 hosted two crabs (96% heterosexual pairs); 7 presented three crabs, with variable combinations of sexes and stages of maturity; one turtle hosted four crabs; and one had five crabs (table II).

TABLE II

Observed frequencies for group composition vs. group size of *Planes cyaneus* Dana, 1851 living on loggerhead sea turtles *Caretta caretta* (Linnaeus, 1758) (n = 72). (*) M, adult males; H, mature females; Ho, ovigerous females; h, immature females; x, undetermined sex

	Group size (number of crabs per turtle)																
	1				**2**				**3**							**4**	**5**
Group composition (*)	M	H	Ho	h	MM	MH	MHo	Mh	MMM	HHh	Hhh	MMHo	MHh	Mhh	Mhx	HHHoHo	MMHhh
Number of turtles per group	19	11	5	4	1	11	9	3	1	1	1	1	1	1	1	1	1

No significant relationship was observed between turtle CCL and the number of crabs present ($r = 0.02$, $P > 0.05$). The largest turtle presented a single crab while the smallest presented three crabs.

Regarding *P. cyaneus* associated with loggerheads, 88% were adults (61 males and 52 females), and the remaining 12% were juveniles (14 females and 1 undetermined sex). Mature female crabs, including ovigerous females (CL mean = 18.14 ± 2.30 mm, N = 52) were significantly larger ($t = 4.9$, $P < 0.05$) than mature males (CL mean = 14 ± 3.40 mm, N = 61). Seventeen females collected were ovigerous (CL mean = 18.2 ± 3.0 mm) (table I). The sex ratio did not differ significantly from a 1 : 1 ratio ($X^2 = 0.281$, $P > 0.05$).

Of the 12 crabs collected from buoys, 3 were found on two radiobuoys of the gear and 9 on a single drift floating buoy, viewed and collected during a haul. Fifty percent of the crabs collected on buoys were adult (5 males and 1 ovigerous female) and the rest were immature females. Within the same sex-age class, crabs from buoys were smaller than those found on turtles (table I).

DISCUSSION

Results from the present study extend the known geographic distribution of *Planes cyaneus* in the western South Atlantic. Previous studies confirmed the occurrence at 27.5°-37°S and 44.8°-50.3°W (Carranza et al., 2003; Bugoni et al., 2007), and it is now more clear that the species is widespread in offshore pelagic waters of Uruguay and southern Brazil, out to the Rio Grande Rise (29°-38°S and 30°-56°W, see fig. 1), the most offshore record to date. The problem is that most references for these crabs deal with dead individuals collected on beaches (Prado & De Melo, 2002), which are of limited value for documenting oceanographic distributions.

The results of this study show that *P. cyaneus* associates with both live substrates (juvenile loggerhead turtles) and also inanimate drifting objects (fishing buoys) in the southwestern Atlantic Ocean. It is known that *P. cyaneus* is associated with a variety of hard-shelled marine turtles (Bugoni et al., 2007) in this area. In the present study it was seen only associated with the loggerhead sea turtle as that is the predominant marine turtle species captured in the Uruguayan pelagic longline fishery (Domingo et al., 2006).

The size ranges of *P. cyaneus* reported herein are consistent with previous studies for the western South Atlantic (Prado & De Melo, 2002; Carranza et al., 2003; Bugoni et al., 2007). The range and mean size of ovigerous females are also similar to those reported by Bugoni et al. (2007) for the same area. We found that the minimum size of mature females was around 12 mm CL. Also, the mean and

range size of males, and the absence of immature males, were consistent with the data reported by Bugoni et al. (2007).

Some characteristics found for *P. cyaneus* were very similar to those reported for *P. minutus* in the North Atlantic and for *P. marinus* found in Mar Chiquita, Argentina (Spivak & Bas, 1999). As noted by Frick et al. (2004) for *P. minutus*, mature females are larger than mature males and reach sexual maturity at larger sizes.

Also, as with *P. minutus* in association with loggerhead turtles (Dellinger et al., 1997; Frick et al., 2006), a large proportion (88%) of the *P. cyaneus* found on loggerheads were mature individuals and were present in heterosexual pairs. Dellinger et al. (1997) suggest that some form of sexual discrimination occurs and possibly adult males and females behave territorially. That was suggested by the presence of the low incidence of limb damage in crabs living on turtles ("presumably the victors of conflicts") in relation to those observed in inanimate flotsam (Dellinger et al., 1997).

The presence of four or five crabs on a single loggerhead turtle is more than reported by other studies, that found a maximum of three crabs per turtle for both *P. cyaneus* (cf. Carranza et al., 2003; Bugoni et al., 2007) and also *P. minutus* (cf. Dellinger et al., 1997; Frick et al., 2004). The high proportion of turtles with a single specimen of *P. cyaneus* also agrees with the results of studies on *P. minutus* in the North Atlantic (Frick et al., 2004).

There were differences in average cephalothorax length between crabs found on floating objects and those found on turtles. A lower proportion of adult specimens and ovigerous females were found on buoys than on marine turtles. Similar results were obtained by Dellinger et al. (1997) for *P. minutus*, where 71% of the crabs on turtles were ovigerous females whereas only 21% of the crabs on inanimate objects were ovigerous. That author suggests that crabs associated with turtles have certain advantages over those found on inanimate substrates. However, the sample size of crabs collected on buoys in the present study was too small for statistical analysis.

It is notable that two fishing buoys that had been in the water for only approximately 12 hours were already colonized by 1 and 2 crabs, respectively. The rapid colonization of marker buoys, as well as the presence of singletons or groups of same sex individuals on turtles, indicates that these crabs do not always remain on the same substrate but move from one to another. At the mating time, mature individuals without partners could move to a substrate to find a mate or to host the arrival of a mate to their substrate. The results of this study indicate that these crabs opportunistically colonize whatever substrates are available in pelagic environments where substrates are scarce, as shown by the rapid colonization of the marker buoys.

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