External factors determining breeding season in the red mangrove crab *Goniopsis cruentata* (Latreille) (Crustacea, Brachyura, Grapsidae) on the São Paulo State northern coast, Brazil

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ABSTRACT. This study evaluated the influence of the water and air temperatures, pluviosity and photoperiod on the breeding season of *Goniopsis cruentata* (Latreille, 1803), in Ubatuba littoral, southeastern Brazilian coast. Monthly collections were conducted out from January/95 to December/96 in an estuarine area from 23°29'10"-23°29'45"S to 45°09'10"-45°10'00"W. Water and air temperature variation showed the highest correlation coefficient with the frequency of ovigerous females, r^2 = 0.73 and 0.68, respectively. However, an analysis of the set of environmental variables, revealed the photoperiod as the factor of highest association with the ovigerous frequency (r^2 = 0.68). This degree of association allow us to suggest that the breeding season duration of *G. cruentata* might have some variations over different latitudes, and such results could be quite diverse in populations from different latitudes.

KEY WORDS. Breeding season, *Goniopsis cruentata*, Grapsidae, reproduction, Ubatuba.

Determination of the crabs' reproductive cycle, and its duration along the seasons, have been studied by many authors (e.g. Haefner 1978, Choy 1988, Henmi 1989, Yau 1992). According to Kennelly & Watkins (1994), this kind of research provides useful information for application of management programs for commercially important species and for animals in protection areas.

Sastry (1983), assumed the duration of breeding periods is the result of interaction between intrinsic and extrinsic factors, that may have immense inter-and intraspecific variations among the various groups inhabiting different environments. Traditionally, breeding season is determined based on the intervals in which females of a population are ovigerous. Notable peaks of frequency of the ovigerous females over this time are generally associated with variations in environmental factors such as temperature, photoperiod and food availability.

The pluviosity, photoperiod, water and air temperatures are considered the most important environment factors that may cause variations in the duration of breeding periods, been the last one especially affecting terrestrial and semi terrestrial animals. The action of those factors can vary considering different species-and localities, and can also affect over the food availability in the environment (Wear 1974, Haefner 1978, Stoner 1980, Dayakar & Rao 1992).

Even for terrestrial or semi terrestrial crabs, the variation of water temperature has large influence on the breeding seasons duration, once that its plancktonic larval phases are exposed to the variations of the marine water temperature, in contrast to the semi or terrestrial conditions of the adults (Pillay & Nair 1971).

This paper provides information about the correlation of water and air temperatures, photoperiod and pluviosity with the breeding season duration of the red mangrove crab *Goniopsis cruentata* (Latreille, 1803), in an estuarine area of São Paulo State northern coast, in southeastern Brazil.

MATERIAL AND METHODS

The red mangrove crab *Goniopsis cruentata* is a grapsid brachyuran, commonly found in mangrove areas. This species can be found wandering on the substratum above the tide level, in burrows or climbing in live branches of mangrove trees, occupying practically all microhabitats of the mangal ecosystem.

This work was developed in an estuary formed by Escuro and Comprido rivers, in the Ubatuba littoral, located in São Paulo State northern coast (23°29'10"-23°29'45"S and 45°09'10"-45°10'00"W). Monthly samplings were conducted out from January, 1995 to December, 1996, at low tide conditions, between 0.0 to 0.5 m high. The collections were performed by hand, with a catch effort of two people during one hour.

Females' carapace width (CW) were measured, with a vernier caliper to an accuracy of 0.1 mm and inspected about the presence of egg mass attached to the pleopods. Size classes were adopted according to Cobo & Fransozo (2000), with 11 classes, in intervals of 4 mm, with the minimum size of 8.0 mm of CW.

Breeding season duration was determined through the record of monthly frequency of ovigerous females in relation to the adult females in the population during the studied period. Data of water and air temperatures and pluviosity to Ubatuba area, were provided by LabMet, Instituto Oceanográfico da Universidade de São Paulo (I.O.-U.S.P.), and the photoperiod values were supplied by the Seção de Climatologia Agricola do Instituto Agronômico – Estação Experimental de Ubatuba, São Paulo, Brazil.

The evaluation of the degree association between frequency of ovigerous females (ovigerous ratio) and the variations of environmental factors, were analyzed by means of the Pearson's correlation. Analyses of multiple regression by selection of variables, were performed for the evaluations of association between the frequency of ovigerous females and the set of environmental variables (Zar 1999). The significance level adopted was $\alpha = 0.05$.

RESULTS

A total of 105 ovigerous females was obtained during this study, occurring all over the studied period, except only in June and July, 1995 and from July to September, 1996. Notable peaks of ovigerous-ratio were recorded from February to April and from October to November 1995. During 1996, those peaks occurred from February to April and from October to December (Fig. 1). The size distribution of the ovigerous females was comprised between the size classes from 24 ⊣ 28 to 40 ⊣ 44 mm CW during both years.

Among the evaluated environmental factors, variations of water and air temperatures showed the largest correlation with the presence of ovigerous females, (Pearson's correlation, $p < 0.05$), with determination coefficients, $r^2 = 0.73$ for water (Fig. 2) and 0.68 for the air (Fig. 3). However, when the set of environmental variables were tested, using multiple regression analysis by selection of variables, the photoperiod presented the largest degree of association with frequency of ovigerous females ($r^2 = 0.68$) (Fig. 4). The relationship between pluviosity and frequency of ovigerous females presented the lowest degree of association for the performed analysis ($r^2 = 0.51$) (Fig. 5).

DISCUSSION

The occurrence of the ovigerous females of *G. cruentata* was almost constant during the studied period. However, a great variation on the frequency of those crabs carrying eggs was observed during the period.

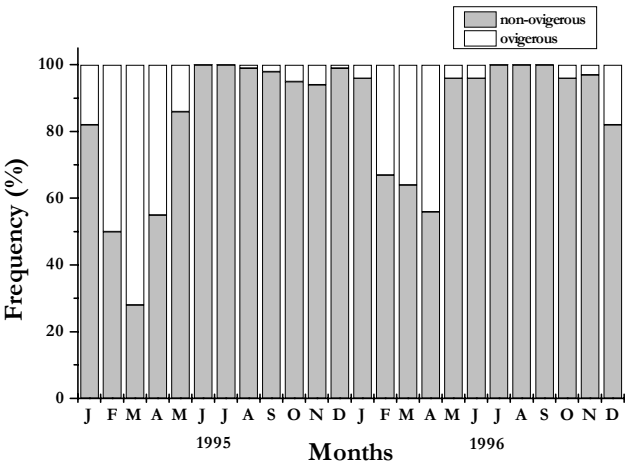


Figure 1. Monthly frequency distribution of the ovigerous and non ovigerous females of *G. cruentatal*, from January, 1995 to December, 1996.

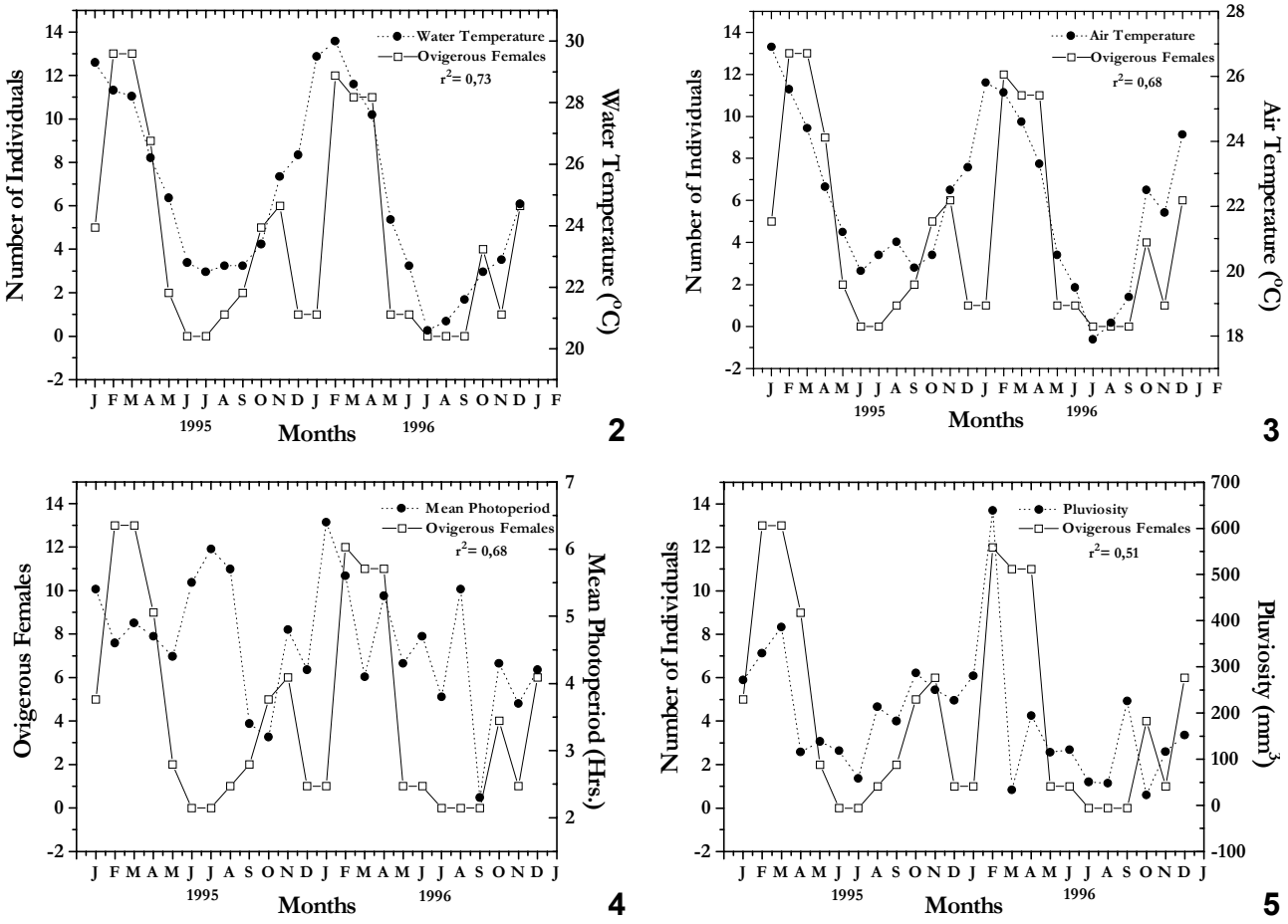
Patterns as obtained in this study, are not unusual among species of Grapsidae family, as may be seen on the table I that bring some examples of the different patterns of frequency of ovigerous females associated with the variation of geographical distribution.

The correlation of environmental factors was evident in the duration of the breeding period in *G. cruentata*, being the water and air temperatures as well as photoperiod, the most important variables on the determination of those breeding seasons. It is reasonable suggest that these variables acting as triggers of reproductive mechanism, corroborating with described previously for other species on literature (Giese 1959, Boolootian *et al*. 1959, Pillay & Ono 1978, Meusy & Payen 1988).

According to Adiyody & Adiyody (1970) and Wear (1974), the temperature act as a catalytic agent, may accelerate the physiologic mechanisms, being probably associated with the development of gonadal tissues in these animals. Water temperature was also reported acting over the larval phases, being observed that higher growth rates are commonly associated with the temperature increase, as reported by Boolootian *et al.* (1959), for some brachyuran crabs.

The photoperiod, is considered by Meusy & Payen (1988), as the main driving factor of the reproductive process in the females, acting as an environmental cue for reproduction beginning. Such factor, also seems to have great importance on the food availability, controlling the plancktonic bloom even in subtropical waters, although Sastry (1983), assumed that the influence of the photoperiod on the food availability, is more important in colder than warmer regions.

The interruptions in the breeding season, recorded for *G. cruentata*, seem to be associated with the variations of the environmental factors, mainly with temperature and photoperiod, as reported by Flores & Negreiros-Fransozo (1998), for *Pachygrapsus transversus* (Gibbes, 1805), which suggest that the variations of environmental factors are large enough to establish a seasonal patterns of breeding period to grapsid crabs in the Ubatuba region. In this sense, Leme (2002) also provides



Figures 2-5. Line graph showing the monthly correlation between the ovigerous-ratio and: (2) the mean temperature of the water, (3) the mean temperature of the air, (4) the mean photoperiod, and (5) the mean pluviosity, from January, 1995 to December, 1996. Pearson Correlation, $p < 0.05$.

similar results, for the breeding season duration in *Aratus pisonii* (H. Milne Edwards, 1873) and *Sesarma rectum* Randall, 1840, studied in the same area of the present work.

The influence of the environmental factors as the drivers of the breeding period in *G. cruentata*, becomes more evident when the monthly frequency of mature gonads was recorded during all months over the year for the both sexes (Cobo & Fransozo 2000). This pattern indicate that this population is producing mature crabs during the all over year, allowing us to infer that the interruptions were associated with the environmental variations, which can be adverse for the survival of its plancktonic larvae, could delay the egg extrusion and consequently reduce the frequency of ovigerous females during those periods.

As breeding season of *G. cruentata*, was strongly associated with the variations of the environmental factors, that according with Pillay & Nair (1971) and Sastry (1983), these factors acting as proximal factors, allowing that those breeding periods taking place over suitable environmental conditions for the larval release.

As already reported for another brachyuran species by Hines (1982), the large latitudinal distances should promote some modifications on duration of the breeding seasons, as a response to environment constrains. The association among breeding duration of *G. cruentata* and environmental factors variations, also suggest that those periods tend to be variable, if the geographical distribution is took into account.

ACKNOWLEDGEMENTS

The authors are thankful to the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and the Universidade de Taubaté (UNITAU), for provide the financial support, as fellowships during the first author's Doctoral Course. The authors also express its gratefulness to the NEBECC coworkers for their help during the collections. To the Dra. Luiza A. Trinca, for your assistance with the statistical analysis, to Prof[a]. Dra. Ilana Wainer, of LabMet-IOUSP, for provide the data of the water and air temperatures and pluviosity of the

Table I. Breeding extension range for some Grapsidae species from different geographic distribution.

Species	Breeding season	Locality	Author
Aratus pisonii (H. Milne Edwards, 1837)	all year around	Jamaica	Warner, 1967
Aratus pisonii (H. Milne Edwards, 1837)	all year around	Brazil	Leme & Negreiros-Fransozo, 1998
Sesarma jarvisi Rathbun, 1914	sea sonal	Jamaica	Diesel and Horst, 1995
Sesarma cinereum (Bosc, 1802)*	all year around	U.S.A.	Seiple, 1979
Sesarma intermedia (De Hann, 1835)	seasonal	Japan	Kyomo, 1986
Cyclograpsus punctatus H. Milne. Edwards, 1837	all year around	South Africa	Broekhuysen, 1941
Hemigrapsus penicilatus (De Hann, 1835)	seasonal	Japan	Fukui, 1988
Hemigrapsus edwardsi (Hilgendorf, 1882)	seasonal	New Zealand	Wear, 1970
Helice crassa (Dana, 1851)	all year around	New Zealand	Jones & Simons, 1983
Planes marinus Rathbun, 1915	all year around	New Zealand	Wear, 1970
Pachygrapsus crassipes Randall, 1839	seasonal	U.S.A.	Boolootian, et al., 1959
Pachygrapsus transversus (Gibbes, 1850)	all year around	Panama	Abele, et al., 1986
Goniopsis cruentata (Latreille, 1803)	all year around	Brazil	this work

* *Sesarma cinereum* = *Armases cinereum* (according to ABELE 1992)

studied area and to Mr. Gentil Godoy Jr., IAC-Ubatuba, for the photoperiod data. To Dra. Maria Lucia Negreiros-Fransozo, Augusto Valero Flores and Dr. Fernando de Luna Marques for their valuable comments and for the revision of the English version.

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Received in 25.XI.2002; accepted in 06.V.2003.