Population dynamics of *Dardanus insignis* (Saussure, 1858) (Crustacea, Anomura, Diogenidae) in the Ubatuba region, São Paulo, Brazil

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Abstract

The aim of this study was to evaluate the population dynamics of *Dardanus insignis*, focusing on size-frequency distribution, sex ratio, and juveniles recruitment period. Sampling was carried out by trawling with two double-rig nets from September 1995 through August 1996 and from January 1998 through December 1999 in Ubatuba region, São Paulo, Brazil. The 4667 individuals obtained were separated into 12 size classes based on shield length. The presence of males and the absence of females in the largest size classes could be the result from a difference in energy expended by the sexes. The monthly frequency distribution indicates that these crabs reproduce seasonally. The slope of the sex ratio suggests a standard pattern in *D. insignis*. Skewing of the sex ratio is an important regulating factor in reproduction and agonistic behavior.

Key words: Anomura, Diogenidae, *Dardanus insignis*, populational dynamics

Introduction

Populations possess characteristics that are exclusive to each group, such as density, natality, mortality, age distribution, biotic potential, dispersion, and growth form. The dynamics of a population can be estimated by comparing the number of males and females. In decapod crustaceans, behavioral differences, breeding migrations, and differences in growth and mortality rates can explain disparities in sex ratios (Haley, 1979).

Studies of population structure involving aspects of sex ratio, juveniles recruitment, migration, and reproduction are fundamental to understanding the dynamics and functioning of the life cycles of species. Among the studies of hermit crab population structures in Brazil are those of Negreiros-Fransozo *et al.* (1991), Negreiros-Fransozo and Fransozo (1992), Pinheiro *et al.* (1993), Fransozo and Mantelatto (1998), Bertini and Fransozo (1999), Turra and Leite (1999), Garcia and Mantelatto (2001), and Martinelli *et al.* (2002).

The objective of the present investigation was to describe the population structure of *Dardanus insignis*, focusing on the monthly size-class distribution to assess possible recruitment period of juveniles and ovigerous females. The sex ratio in the different size classes were also evaluated.

Material and Methods

Crabs were monthly collected from September 1995 through August 1996 and from January 1998 through December 1999, in the region of Ubatuba, on the Northern coast of the state of São Paulo, Brazil. Individuals of *Dardanus insignis* were caught from a commercial fishing boat outfitted with two double-rig (Mexican) nets. The nets were towed over a distance of

approximately 1 km. After each tow the nets were hauled in and the catch was stored on crushed ice in insulated containers. In the laboratory, the animals were sexed and the length of the cephalothoracic shield (CS) was measured in mm.

To analyze the population structure, the crabs were arranged in size classes according to the formula of Sturges (1926). Student's *t* test was used to analyze the differences between the means of sizes for males and females.

Results

A total of 4667 specimens of *D. insignis* were obtained, including 2772 males, 1635 females, and 260 ovigerous females. The animals were arranged in 12 size classes ranging from 2.0 to 24.8 mm CS, with an interval of 1.9 mm CS.

Males were significantly larger than females ($p<0.01$). This difference was verified by means of the *t* test for heteroscedastic samples (Table I).

The total-frequency distribution shows that the population tends toward an asymmetrical unimodal distribution, with the peak in class 3 (5.8 —] 7.7 mm) (Figure 1).

The monthly size-frequency distribution is shown in Figure 2. Juveniles individuals were present in all months of the year, and ovigerous females occurred mainly from September through February. Although they are not specifically indicated in the graph, 3 ovigerous females occurred in the samples in March, and 1 in April.

The sex ratio by size is shown in Figure 3, where is possible to verify that from class 5 ahead the percentage of males is higher than females. The curve obtained coincides with the Standard pattern studied by Wenner (1972).

Table I: Distribution by size class of the individuals of *Dardanus insignis* collected off the coast of Ubatuba, state of São Paulo.

Sex	Minimum size (mm)	Maximum size (mm)	Mean (mm)	Standard deviation (±)
Males	2.2	24.2	7.23*	2.53
Females	2.0	15.1	6.16*	1.47
Total	2.0	24.2	6.80	2.23

* $p<0.01$

Discussion

In this sample series, the males of *D. insignis* were significantly larger than the females, indicating that this species is sexually dimorphic. This type of dimorphism has also been observed in other species of hermit crabs, such as *Calcinus tibicen* studied by Fransozo and Mantelatto, 1998), *Petrochirus diogenes* by Bertini and Fransozo (1999), *Clibanarius antillensis* by Turra and Leite (1999), and *Paguristes erythrops* by Garcia and Mantelatto (2001). Sexual dimorphism appears to influence courtship in hermit crabs, because in many species the male grasps the female's shell for a period of time, until it is ready to copulate (Hazlett, 1966).

Several factors, acting either alone or in concert, appear to influence sexual dimorphism. According to Bertness (1981), one of the factors is the differential energy expended for growth, since males do not have to produce eggs and can expend more energy on growth. In a laboratory

experiment, Bertness (1981) observed that male hermit crabs grow three times faster than females when both sexes have access to an unlimited number of shells and equal access to food.

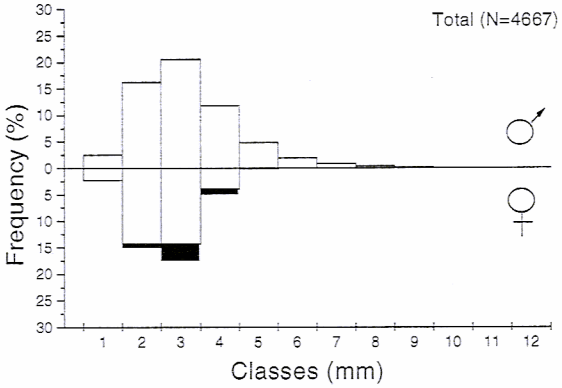

Figure 1: Frequency distribution of the total population of *Dardanus insignis* by size class (N = total number of individuals; black bars = ovigerous females).

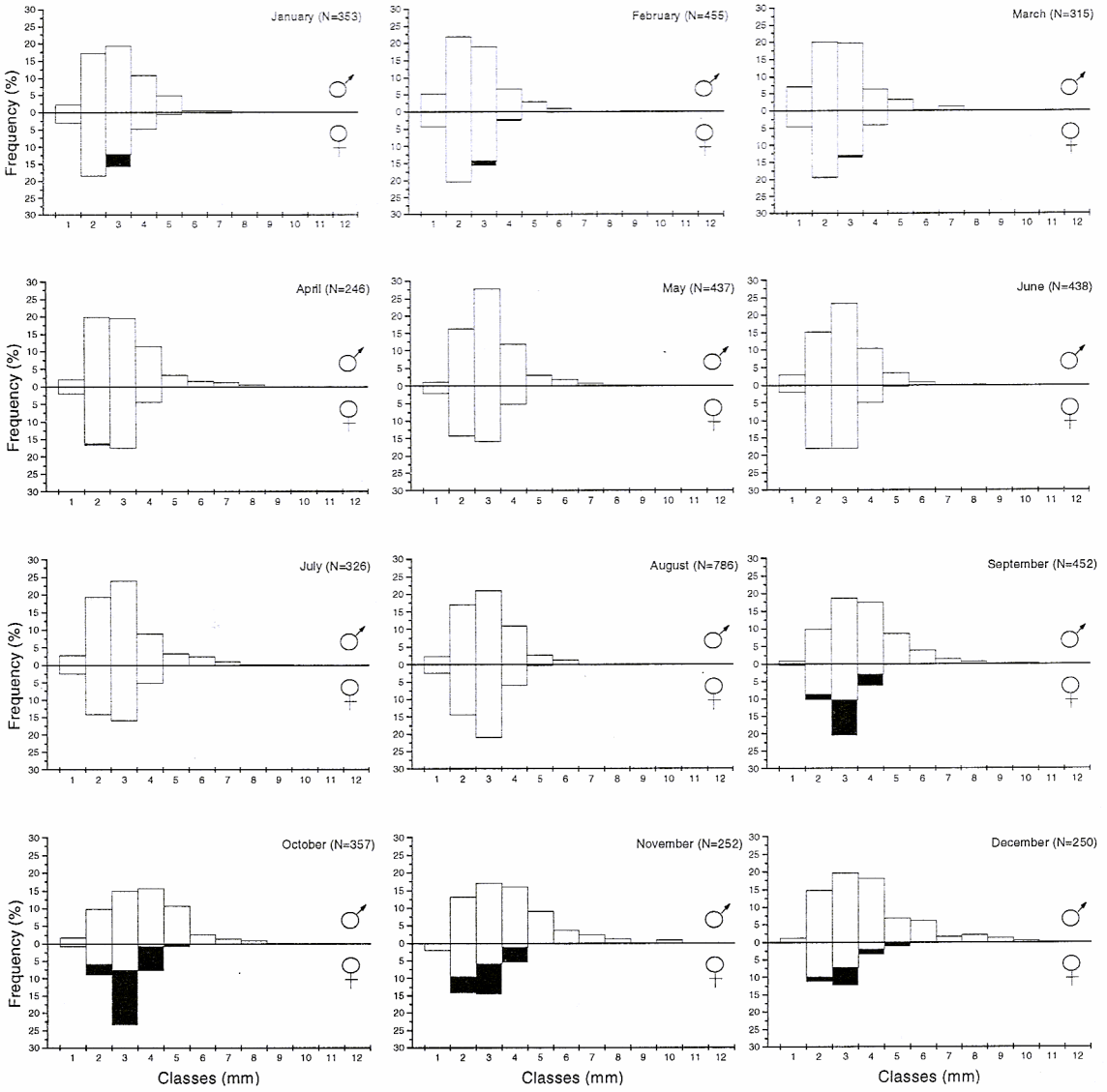

Figure 2: Frequency distributions of individuals of *Dardanus insignis* by month and size class (N = number of individuals in each month; black bars = ovigerous females).

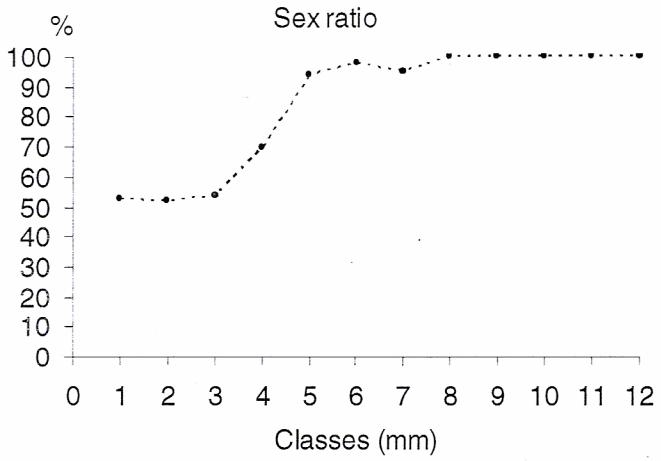

Figure 3: Percentage of males of *Dardanus insignis* in each size class.

According to Abrams (1988), one hypothesis for sexual dimorphism is sexual selection, which is based on the idea that breeding aptitude increases rapidly with size for males, because of intrasexual competition among them for the females; the other hypothesis is a kind of intersexual dislocation as a result of competition for shells.

No individuals of *D. insignis* smaller than 2.2 mm in cephalothoracic-shield length were collected. However, individuals of several other species of hermit crabs that were less than 2 mm in shield length were caught in the same collect sites, which negate the possibility of biased sampling and leads us to suppose that a conjunction of factors, like food availability and shelter, was responsible for the absence of small individuals from these locations. Small-sized crabs may have been present in areas that we did not sample, since some specimens of *D. insignis* were observed in the infralittoral zone at a depth of approximately 9 meters, in contact with unconsolidated substrate and close to rocks (personal observation). Hartnoll and Bryant (1990) hypothesized that the absence of small individuals, as observed in many species of decapod crustaceans, is generally attributable to sampling deficiencies, because of the cryptic habit of these individuals.

The unimodality observed for both sexes in this study is a common pattern seen in tropical decapod crustaceans (Warner, 1967). According to Díaz and Conde (1989), unimodality indicates that continuous recruitment is occurring, with no interruption in the classes where mortality rates are constant.

The breeding season in crustaceans must coincide with favorable conditions for molting and growth of the progeny and it can be characterized by the presence of ovigerous females during the year, as their occurrence may be continuous or seasonal (Sastry, 1983).

Thorson (1950) and Sastry (1983) noted that most tropical species tend to reproduce continuously, as observed by Martinelli *et al.* (2002) for the hermit crab *Loxopagurus loxochelis*. However, in the present study, ovigerous females of *D. insignis* occurred mainly from September through January. This seasonal reproduction is similar to the patterns observed in *C. tibicen* by Fransozo and Mantelatto (1998), *P. diogenes* by Bertini and Fransozo (1999), and *P. erythrops* by Garcia and Mantelatto (2001) at the same region.

The proportion of sexes by size class differed from the expected 1:1, with an increased number of males and an absence of females in the largest classes. The curve obtained coincides with the Standard pattern studied by Wenner (1972). The same pattern was found for the population of *P. diogenes* studied by Bertini and Fransozo (1999) in the Ubatuba region.

In mature crustaceans, deviations from the 1:1 sex ratio may occur because of differential energy expenditure between the sexes, limitations on food, behavioral differences, and migration

(Wenner,1972). Góes and Fransozo (2000) also suggested that deviations from the expected 1:1 proportion may be directly linked to sampling methods and to the choice of appropriate locations for capturing individuals. Moreover, other factors such as differential growth rate, different life expectancies for each sex, environmental pressures, habitat partitioning, availability of food, and reproductive strategies can lead to differences in the size classes during ontogeny.

Fernandes-Góes and Fransozo (2000) observed that in population of *D. insignis*, males can reproduce when they reach sizes above 7.42 mm CS, as also found by using estimates of relative growth. For females, in this population, the size at molt to puberty can be indicated by the size of the smallest ovigerous female, which in this case was 4.1 mm CS.

Females of *D. insignis* attain sexual maturity before the males, i.e., mature females first appeared in the second size class (3.9 —] 5.8 mm). Reproductive males were found only from the third class upwards 5.8 mm CS. Reproducing females and males were both concentrated in third class, which showed a higher frequency of individuals than the other classes, indicating the reproductive potential of the species.

Based on these assumptions, we can infer that the population of *D. insignis* in the Ubatuba region is stable. Recruitment of young is continuous, as seen by their entry into the population during every month of the year, mainly in February and March. Seasonal reproduction in spring and summer could explain the entry of these juveniles in these months. Therefore, we can infer that this species is stable since it's reproducing, the juveniles are present in the population favoring colonization and its establishment in the region.

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