Population biology of *Hyale nigra* (Haswell,1979) (Amphipoda, Hyalidae) associated to *Bryocladia thyrsigera* (J. Agardh) at Peruibe, Itanhaém beach, southeastern Brazil

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Abstract

The size-class structure, density trends, fecundity and sex-ratio of a population of *Hyale nigra* of the intertidal region were studied from collections made at the low mark of spring tides at the algae *Bryocladia thyrsigera* belt, once a month from march/1997 to february/1998. A total of 26909 individuals was sampled. The total population density increased from early summer to late autumn. Small juveniles constituted the bulk of the population throughout the year, with the exception of May, when females dominated. A sex-ratio biased in favour of females was recorded in all sampling dates. *Hyale nigra* appears to be an r strategist, with: iteroparous female, multivoltine cycle and recruitment throughout the year. The reproductive strategy of the species appears to be the production of small eggs related to a decrease in the maturation size of females, which in turn allows the production of more than one brood per year, increasing the intrinsic growth rate of the population.

Key words: *Hyale nigra*, population biology, Itanhaém.

Introduction

Marine algae often forms habitat patches occupied by an associated fauna composed mainly by crustaceans such as amphipods and isopods. Species of these groups present as a rule continuous reproduction, with females carrying their embryos in a ventral pouch. Phytal amphipods adjust their reproduction cycle in order to be able to quickly explore favourable environmental conditions. The biology of *Bryocladia thyrsigera* (J. Agardh), dominant amphipod species such as *Hyale nigra* (Haswell, 1979), *Caprella penantis* Leach, 1814 and *Caprella danileviskii* Czerniavski, 1861 contributes to the alternation of the numerical dominance of each population, so that flutuations of dominants species indicate an attempt to distinguish an ecological niche by means of reproductive estrategies such as life cycles, incubation periods and fecundities (Valério –Berardo and Flynn, 2002).

Hyalid species occur in dense populations in a wide range of intertidal habitats (Barnard, 1979) and although many hyalid species have been known for a long time, biological studies are still rare (Hiwarati and Kajihara, 1984; Buschmann, 1990). The genus dominates the phytal communities of the rocky intertidal shores in abundance and number of species (Lancelloti and Trucco, 1993).

In Southeastern Brazil, distribution, dietary patterns, growth and reproduction of some hyalid species were described by Wakabara *et al.*, 1983; Tararam *et al.*, 1985 and 1986; Dubiaski-Silva and Masunari, 1995 ; Leite, 1996 a and b; Tanaka and Leite, 2003. Besides distributional information on regional faunal lists, little work has been published on the population biology of *H. nigra*. Leite *et al* (2000) registered a temporal increase of abundance of this species, from 1972 to 1997 at sheltered sites indicating the replacement of species less tolerant to antropic pollution by the more tolerant and generalist one as *H. nigra*. The species seems to have the ability to recover rapidily from disturbance episodes as described by Martin-Smith (1994) for tropical macroalgae epifaunal communities.

In this paper we report on the size-class structure, density trends, reproduction, fecundity and sex-ratio of a population of *H. nigra* living at the intertidal zone of Poço de Anchieta, Peruibe Beach associated to the algae *B. trysigera*. The monthly addition of juveniles to the population of intertidal hyalid prevents the following of a particular cohorts of individuals.

Materials and Methods

Collections were made at the rocky shore known as "Poço de Anchieta" in Peruíbe Beach (24°10´30"S- 46°45´45"W) Itanhaém, Southeastern Brazil (Fig.1). "Poço de Anchieta" is a partially sheltered beach protected from the strong waves by the rocks and stones, where algae belts are very common. Amphipod'samplings were accomplished at low mark in a belt of *B. trysigera*, during spring tides monthly from March, 1997 to February, 1998. The vertical width of the algae belt was about 0.5m from the bottom to top (30 cm above low mark of springe tide). As the amphipods are quite strongly attached to the substrata, approximately 200ml of algae were scrapped carefully from the rock and were placed on plastic bags with sea water. Then, the algae and associated fauna were preserved in alcohol 70% and taken to the laboratory where the material was sorted using a stereomicroscope and the specimens of *H. nigra* separated for further analysis.The algae were dried at 60°C for 48 hours and weighted. The density data are expressed as number of individuals per 50 g of the algae dried weight.

Each *H. nigra* individual was sexed and sorted into four categories (Serejo, 1999): first, males, presenting a developed second gnathopod; second, females, with oostegites and without a developed second gnathopod; third, ovigerous females, with both oostegites and eggs; and fourth, juveniles, lacking both oostegites and a developed second gnathopod. Twenty individuals were randomly choosen of each sex categories, and were measured, at each month, from the beginning of the cephalon to the telson insertion and grouped in 1 mm size class. Body length was determined under a binocular microscope with camera lucida. Eggs from ovigerous females were counted, only when the brood pouches were undisturbed, allowing the number of embryos to be counted reliably. The development stage of eggs were not established.

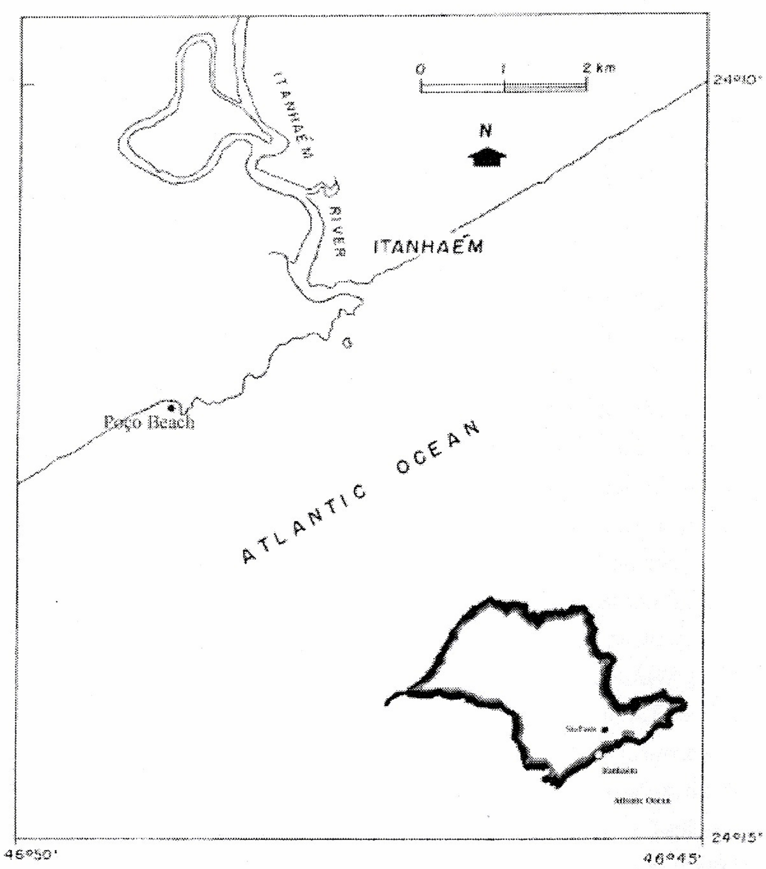

Figure 1: Map of the site.

The proportion of males to total females, as well as male to ovigerous females, were calculated for each month. Fecundity was determined by the mean number of eggs per brood.

Results

Values of salinity varied from 28 to 35 UPS, with the exception of December when a minimum value of 11 UPS was taken during a heavy rain. Water temperature ranged from a minimum of 19 °C in July (winter) to 28 °C in March and February (summer).

A total of 26909 individuals was sampled. Of this total, 6110 were females, 1068 were ovigerous females, 2021 were males and 17710 were juveniles. The population of *H. nigra* showed the highest densities in late autumn (May, 1997) and in summer (December, 1997 and January-February, 1998). The lowest density was recorded in spring (October, 1997). The same pattern was observed for females, ovigerous females, males and juveniles. Juveniles dominated throughout the year with the exception of May and October when total females were more abundant (Table I and Figure 2).

Table I: Monthy abundance (number of individuals per 50 gr of the algae dried weigth) of males, females, ovigerous females, juveniles and sex-ratio of *Hyale nigra* collected.

date	females	ovigerous	males	juveniles	total	sex-ratio
03-1997	210	21	115	1053	1378	0.54
04-1997	284	68	137	1762	2183	0.48
05-1997	2691	303	589	2001	5281	0.21
06-1997	356	7	127	798	1281	0.35
07-1997	392	29	81	1022	1495	0.20
08-1997	231	117	161	584	976	0.69
09-1997	531	111	151	1560	2242	0.28
10-1997	74	22	12	86	172	0.16
11-1997	70	17	26	689	785	0.37
12-1997	638	90	180	1907	2725	0.28
01-1998	410	103	132	3078	3620	0.32
02-1998	1291	180	310	3170	4771	0.24

Size-frequency distribution of males, females and juveniles are shown in Figure 3. Juveniles were small, varying between 1.34 to 4.09 mm (Table II). They were bigger in colder months (May, June, July and August). Female had a body length varying between 2.01 to 6.7 mm. They were smaller in June and July. Males were larger, and their length ranged between 2.3 to 6.7 mm, with higher values in May, August, September, October and November (Fig.4).

Sex ratio fluctuated throughout the study period (Fig. 5). A sex ratio biased in favor of females was recorded in all sampling dates, with a marked increase on the proportion of females in May and July. Mean sex ratio for all the sampled individuals was 1 male: 3.38 females.

A linear relationship, representing fecundity, between the mean number of eggs per brood (x) and the body length of ovigerous female (y) was found (Fig. 6):

$y = 0.811\, x + 3.0855$

where:

x = number of eggs

y = body lentgh of ovigerous females

The mean number of eggs per brood was 4.1 and the amplitude of variation per female was from 1 to 9 eggs.

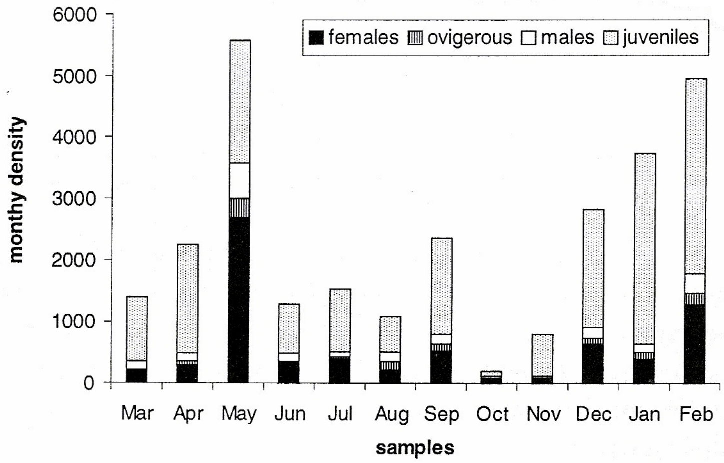

Figure 2: Temporal variation of *Hyale nigra* population densities (number of individual by 50g of algae dry weight).

Discussion

Hyale nigra appears to be an amphipod species known as a monotonic colonizer (in the Martin-Smith, 1994 sense), i. e., a species characterized as colonizer due to a rapid increase of abundance when the enviromnent conditions are favorable, with iteroparous female, a multivoltine cycle, low number of eggs per brood (4.1 per clutch) and recruitment throughout the year. This is the most common pattern in epifaunal species (van Dolah and Bird, 1980) from physically controlled communities according to stability-time theory (Sanders, 1969). The intertidal region is considered an environmentally stressed systems where it should be expected the evolution of opportunistic adaptative strategies to take place such as a continuos sexual activity throughout the year (Martin- Smith, 1994). Data showed that ovigerous females and juveniles were found throughout the year. Fluctuations in population density indicate periods of intense reproduction, high densities of females in May and December and January marking peaks of reproduction. The high number of juveniles throughout the year seems to indicate that the species has a high survival rate. This assumption is corroborated by the small number of eggs found in each female, indicating low pos marsupial mortality (Leite, 1996a and b).

Females always outnumbered males, which is a common feature in amphipods populations (Hasting, 1981; Dauvin, 1988; Marques and Nogueira, 1991). The sex ratio of 1:3.38 biased towards females is generally assumed, as in the genus *Ampelisca* Kroyer, 1842 to be due to the drastic decline in numbers of males which undergo ecdysis, copulation and then die (Klein *et al*, 1975; Hastings, 1981). In *H. nigra* this has not yet been verified. Another proposal to explain the higher number of females in amphipod populations is that females' life span is greater than that of males and they remain longer in the population, but they don't grew larger, since males are frequently, as in this instance, longer than females. This may be due to females higher energy investment in reproduction (production and maintenance of eggs and embrios) and to the fact that females do not undergo ecdyses during incubation. Deviation from the sex ratio is not uncommon in amphipods and is very common in terrestrial or intertidal species (Tamura and Koseki, 1974; Moore and Francis, 1986).

Many physical and biological factors, such as temperature, seasonality, food availability, geographical location, competition and predation, can affect brood production and mortality as well as embryo number and volume in amphipods (Morino, 1978; Wildish, 1982; Williams, 1985). It has been shown that low embryo production and continuous reproduction in amphipods is part of a reproductive strategy related to the high-risk littoral habitat of species of this group which are exposed to variation in tides, osmotic pressure and thermal shocks (Saint-Marie, 1991).

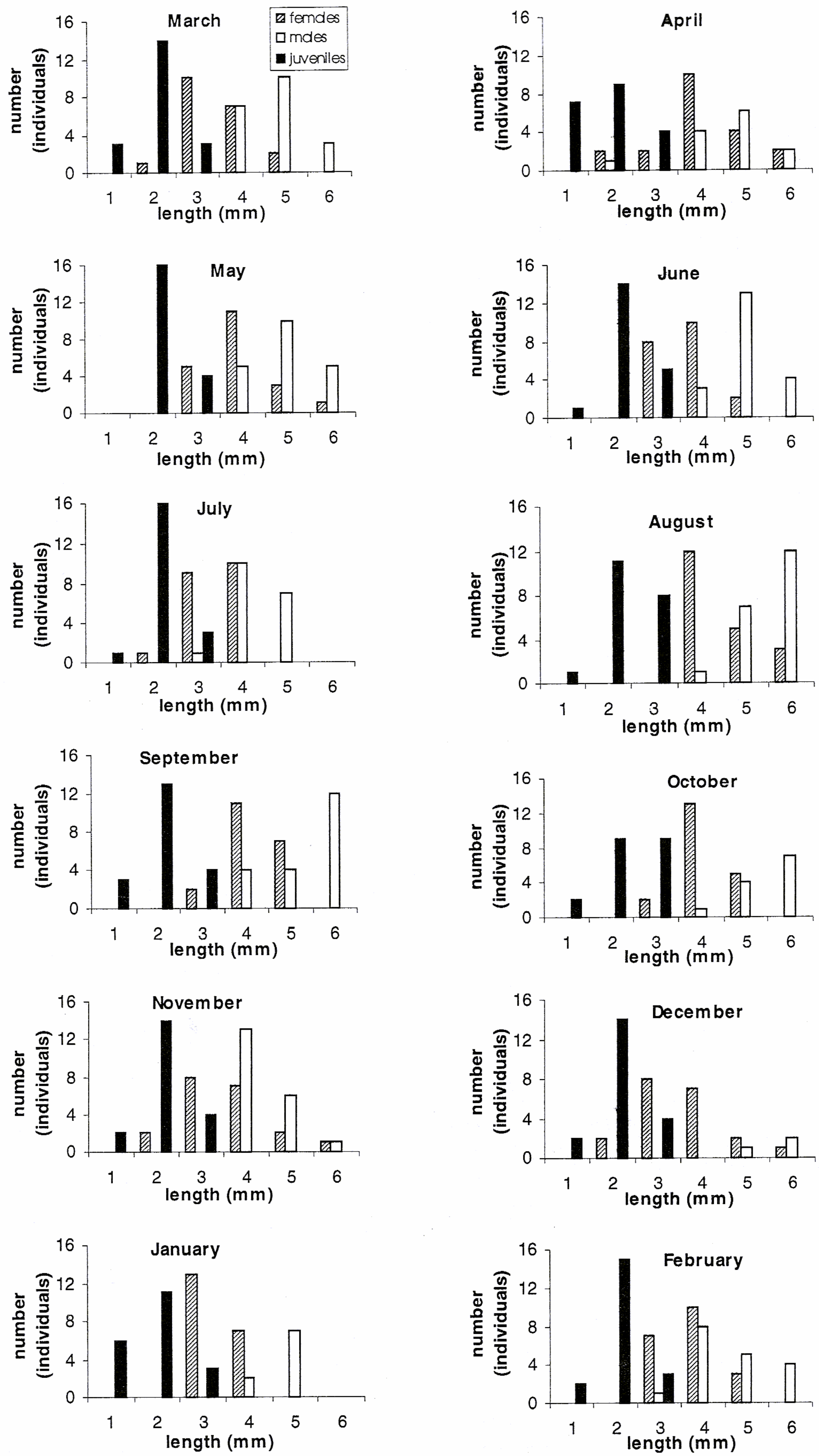

Figure 3: Length-frequency distribution of males, females and juveniles, grouped into 6 size classes.

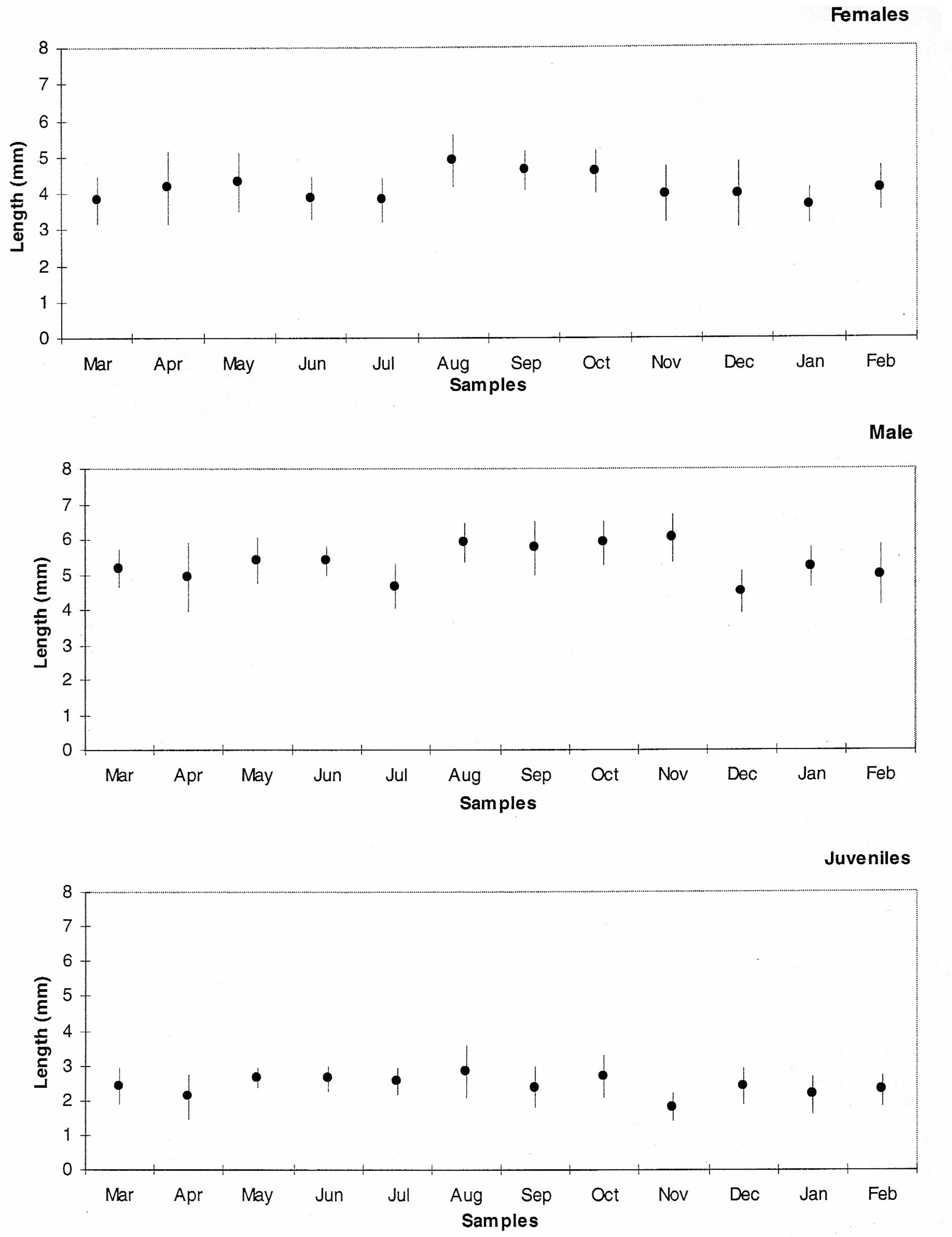

Figure 4: Temporal variations in average body length (solid circles) and standart deviations (vertical bars) of females, males and juveniles.

It has been suggested (Cardoso and Veloso, 2001) that for *Pseudorchestia brasiliensis* (Dana, 1853) the reproductive strategy to compensate low fecundity (2.8 embryos per brood) may be associated with the higher proportion of females in the population (1 male:3.38 females). Others amphipod species with skewed sex ratio in favour of females also have low fecundity (Williams, 1978; Van Senus, 1988).

Table II: Mean body length and body length range of males, females and juveniles.

	sex	Mean (mm)	Length range	Standart Deviation	Number of specimens measured
	females	3.80	2.68 - 5.36	0.65	20
March	males	5.17	4.35 - 6.03	0.53	20
	juveniles	2.41	1.34 - 3.35	0.52	20
	females	4.17	2.01 - 6.36	1.01	20
April	males	4.94	2.3 - 6.03	0.99	20
	juveniles	2.12	1.34 - 3.35	0.64	20
	females	4.32	3.35 - 6.7	0.81	20
May	males	5.41	4.35 - 6.7	0.65	20
	juveniles	2.66	2.34 - 3.35	0.28	20
	females	3.87	3.35 - 5.02	0.60	20
June	males	5.39	4.69 - 6.03	0.43	20
	juveniles	2.63	1.67 - 3.35	0.36	20
	females	3.8	2.68 - 4.69	0.60	20
July	males	4,67	3.01 - 5.69	0.63	20
	juveniles	2.56	1.67 - 3.35	0.38	20
	females	4.89	4.02 - 6.03	0.72	20
August	males	5.91	4.69 - 6.7	0.55	20
	juveniles	2.84	1.67 - 4.09	0.75	20
	females	4.62	3.68 - 5.36	0.53	20
September	males	5.76	4.35 - 6.7	0.77	20
	juveniles	2.39	1.34 - 3.68	0.57	20
	females	4.60	3.68 - 5.36	058	20
October	males	5.89	4.69 - 6.7	063	20
	juveniles	2.68	1.67 - 3.68	061	20
	females	3.94	2.68 - 4.69	0.76	20
November	males	6.03	5.36 - 6.7	0.67	20
	juveniles	1.81	1.01 - 2.34	0.41	20
	females	3.97	2.68 - 6.03	0.90	20
December	males	4.52	4.02 - 6.03	0.59	20
	juveniles	2.41	1.34 - 3.35	0.53	20
	females	3.63	3.01 - 4.69	0.49	20
January	males	5.21	4.69 - 5.69	0.56	20
	juveniles	2.16	1.34 - 3.01	0.53	20
	females	4.10	3.35 - 5.36	0.60	20
February	males	5.00	3.68 - 6.67	0.86	20
	juveniles	2.31	1.67 - 3.35	0.45	20

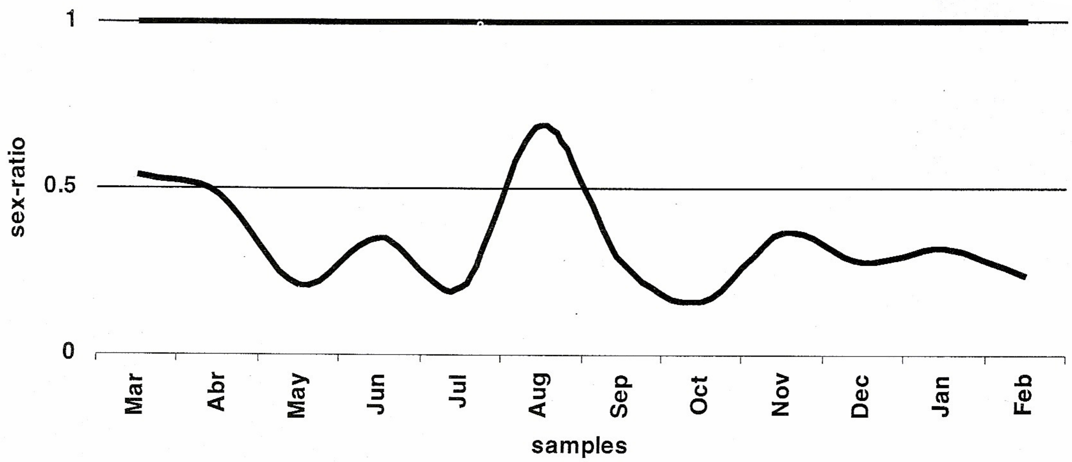

Figure 5: Temporal variation of sex-ratio.

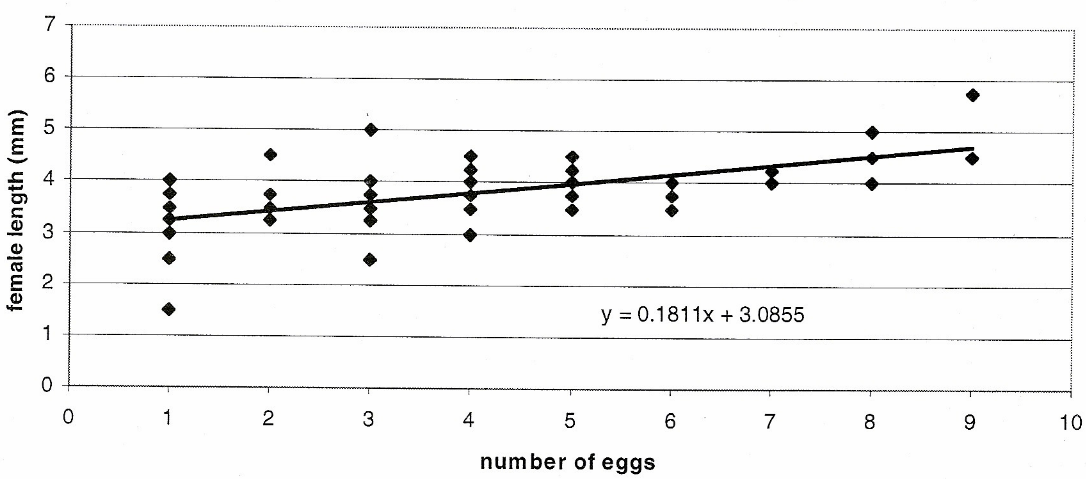

Figure 6: Linear regression between the mean of eggs per brood and the body length of ovigerous female.

Wildish (1979, 1982) speculated that females-biased populations develop in the early stages of adaptation to land. He suggested that this type of sex ratio would maximize reproductive potencials and would be specialy adaptive in case of short breeding seasons. However, the length of breeding season is not critical in the evolution of this bias, as Morino (1978) reported a significantly female-biased sex ratio year round in species with continuos reproduction as *P. platensis*.

The reproductive strategies of *H. nigra* appears to fit others species for which the production of a small number of eggs per brood is compensated by a decrease in the maturation size of females, which in turn allows the production of more than one brood, therefore increasing the number of generations and consequently increasing the intrinsic growth rate of the population, associated to multivoltism and continuous reproduction (Cardoso and Veloso, 1996; 2001).

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