REPRODUCTIVE CYCLE OF *Hepatus pudibundus* (HERBST, 1785) (CRUSTACEA, DECAPODA, Calappidae) IN UBATUBA, SP, BRAZIL

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ABSTRACT

This study aimed to analyze the reproductive cycle of the crab *Hepatus pudibundus* (Herbst, 1785). The crabs were collected in Ubatuba, SP (23°26'S and 45°02'W) monthly from the July, 1992 to June, 1993. Samplings were performed with an "otter trawl". In the laboratory the crabs were numbered, sexed and measured for their maximum carapace width. The gonad developmental stage and the moult stage were also macroscopically registered. In all sampled months ovigerous females and crabs in both sexes with developed gonad were observed. Moult activity in all size classes was verified. Such fact indicates that this species can suffer moult process after their maturity. In despite of temperature being pointed a one of the most important ecological factor in the reproductive biology of aquatic animals, it was verified any relation between water temperature and ovigerous ratio. The oscillations of the environmental factors in the Ubatuba region sea probably were not enough to alter the continuity of the physiological processes related to *H. pudibundus* reproduction.

Key words: Brachyura, Calappidae, *Hepatus*, repoductive cycle.

RESUMO

Ciclo reprodutivo de *Hepatus pudibundus* (Herbst, 1785) (Crustacea, Decapoda, Calappidae) em Ubatuba, SP, Brasil.

Este estudo visou a análise do ciclo reprodutivo do caranguejo *Hepatus pudibundus* (Herbst, 1785). Os caranguejos foram coletados na região de Ubatuba, SP (23°26'S e 45°02'W), mensalmente no período de junho de 1992 a julho de 1993. As coletas foram realizadas com o auxílio de um barco de pesca equipado com rede do tipo "otter trawl". Em laboratório, os animais foram contados, sexados, mensurados (maior largura da carapaça) e tiveram seu estágio gonad e o de muda macroscopicamente determinados. Além da ocorrência de fêmeas ovígeras em todos os meses de coleta, foi também observada a presença de animais com as gônadas desenvolvidas em ambos os sexos. Em todas as classes de tamanho, para ambos os sexos, foram encontrados caranguejos em processo de muda, isso indica que *H. pudibundus* não apresenta muda terminal e os indivíduos adultos continuam a sofrer ecdise após a maturidade. Não se verificou relação direta entre a porcentagem de fêmeas ovígeras e a temperatura da água. Os fatores ecológicos devem oscilar dentro dos limites de tolerância da espécie, o que favorece a continuidade dos processos fisiológicos, possibilitando a reprodução contínua.

Palavras-chave: Brachyura, Calappidae, *Hepatus*, ciclo reprodutivo.

INTRODUCTION

Crustaceans are a dominant and successful group, represented by a high number of species, exhibiting a great array of life styles and occupying quite dissimilar habitats. This diversity is a result of their life patterns and reproductive strategies (Sastry, 1983).

The study of crab reproduction can be divided in two different aspects: first, the events related to mating, including the processes which precede and continue the copula itself; second, the reproductive cycle of a species, in which the information required (e.g. maturity, egg development, the relationship between reproduction and moult cycle) is usually obtained by means of periodic samples of a given population (González-Gurriarán, 1985).

According to Sastry (*op. cit.*), the reproductive period of brachyurans can be determined through monthly ovigerous ratio recordings during a 1 yr. period. Following the same author, when ovigerous females are recorded in all months, or when similar ovigerous ratios are verified, the designation continuous reproduction can be applied.

In this sense, Sastry (*op. cit.*) defined two different reproduction patterns in crustaceans: continuous breeding in which the reproductive process is not interrupted; and restricted breeding, which is usually correlated with favorable environmental conditions in certain months.

Research on crustacean reproductive biology is demanded due to the need of maintaining natural and fishing stocks (Santos, 1994).

Reproductive cycles involve a series of events in a population. This series begins at the end of the juvenile phase, and includes gonad development, gamete differentiation and growth, reproductive behavior related to moult stage, spermatophore transfer during mating in males, egg development, extrusion and incubation in females (Sastry, 1983).

Several authors focus these reproductive processes. Among those contributions, some can be remarked: e.g. Pereyra (1966) on *Chionoecoetes tannaeri*; Lucas & Hodgkin (1970) on *Halicarcinus australis*; Pillay & Nair (1973) on *Portunus pelagicus*; Du Preez & McLachlan (1984) on *Ovalipes punctatus*; Choy (1988) on *Liocarcinus puber* and *L. holsatus*. Ovigerous females of these species are present year-round in their populations, however, peaks of reproduction activity were verified in certain months.

In the other hand, some species present a restricted breeding season. This season length is dependent on certain environmental factors, being temperature one of the most influencing factors (Sastry, *op. cit.*). Jones (1980) observed restricted breeding in the grapsid crab *Helice crassa*, and provided comparisons with similar data obtained in other localities.

The achievement of functional sexual maturity can be noticed by macroscopic observations of gonad size and color (Haefner, 1976; Batoy *et al.*, 1987; Du Preez & McLachlan, 1984).

In some species, gametes are produced rather continuously and the sequential offspring production is only interrupted during the incubation period. In certain occasions, consecutive egg batches are laid within a single intermoult period. Otherwise, egg production is separated by moulting in some cases. Variability in the timing of reproductive events yields different temporal patterns in brachyuran species.

The combination of both gonad development and moult cycle data contributes to a better understanding of the reproductive biology of brachyuran crabs. According to Adiyodi & Adiyodi (1970), these processes are antagonic and their adequate timing minimizes the metabolic competition.

The purpose of the present study is to determine the reproductive cycle of *Hepatus pudibundus* in its natural environment, by means of investigating its gonad development and moult cycle in the wild.

MATERIAL AND METHODS

Samples of *H. pudibundus* were obtained from the coastal region of Ubatuba (SP), (23º26'S e 45º02'W), with the aid of a fishery boat provided with otter-trawl net (15 mm mesh size at the sides and 10 mm at its end). Monthly trawls were conducted during a 1 yr. period, from July 1992 to June 1993.

The carapace width (CW) of all crabs was measured with a vernier caliper at the nearest 0,01 mm. All crabs of both sexes were dissected in order to ascertain their gonad development stage (Tables, 1 and 2). Also, the carapace hardness was tested according to Haefner (1976) and Warner (1977).

TABLE 1

***H. pudibundus* gonadal development in males.**

Stage	Characteristics	Symbol
Immature	Undifferentiated gonad associate to juvenile morphology.	IM
Rudimentary	Non-developed gonad, whitish filament.	RU
Developing	Slight rolled-up whitish gonad.	D
Developed	Fully developed and rolled-up gonad, localized near cardiac region and showing whitish color.	DE

TABLE 2

***H. pudibundus* gonadal development in females.**

Stage	Characteristics	Symbol
Immature	Undifferentiated gonad associate to juvenile morphology.	IM
Rudimentary	Non-developed gonad, yellowish ocre ovary like a thin filament.	RU
Developing	On start of the gonad maturation small light-violet ovary.	D
Intermediary	Dark-violet ovary, occupying a small portion of the thoracic cavity.	INT
Developed	Brigth dark-violet ovary occupying most of the thoracic cavity.	DE

Contrasts between and within multinomial populations (in the present case binomial) were tested by means of a Goodman test (1964 and 1965) in the gonad development, ovigerous condition and moult activity analyses. The results were discussed considering the 5% significance level.

RESULTS

A total of 1944 *H. pudibundus* individuals were obtained; 789 males and 1.155 females.

Fig. 1 shows the rates of males with developed gonads throughout the study period. It can be noticed that developed gonads were present in a high proportion of males in all months. Higher rates were recorded in August/1992 and February/1993, which were only significantly different from those registered in September/1992 and November/1992. Moult activity in males (Fig. 2) was observed in all size classes except the 11^{th} ($p < 0.05$). As in males, high proportions of females with developed gonads were verified in all months. Higher rates were recorded in March/1993 and June/1993 (Fig.3).

Females moult activity per size is represented in Fig. 4. Moult activity was observed in all size classes, but did not differ statistically between sizes ($p < 0.05$).

Ovigerous females were present in all months in low proportions (20% to 35%), being the observed in July/1992, September/1992, October/1992, November/1992, December/1992 and February/1993 (Fig. 5).

In ovigerous females Iit was observed that the development gonad closely follows the development of embryos (Fig. 6). Monthly water temperature means recorded in this region was not correlated with monthly ovigerous ratio (Fig. 7).

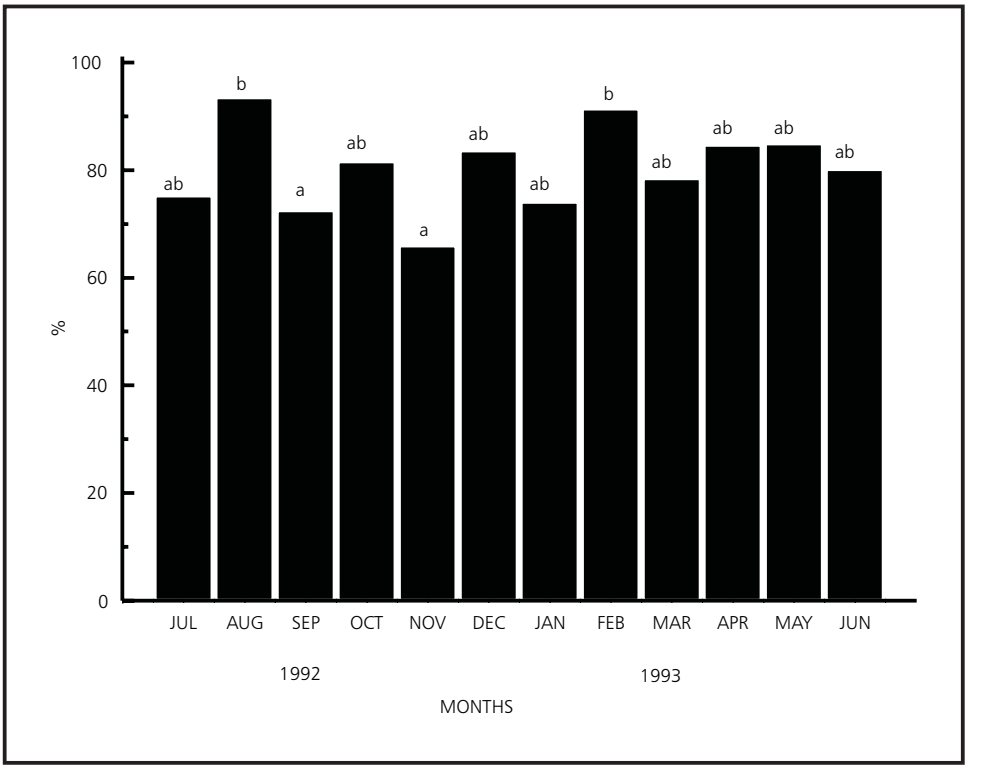

Fig. 1 — *H. pudibundus*: Bar graph showing monthly frequencies of males with developed gonads (bars with same letters do not differ significantly; $p < 0.05$).

DISCUSSION

Continuous reproduction is common in tropical and subtropical brachyurans. Nevertheless, the reproductive pattern of a single species may vary in geographically isolated populations. This source of variation is observed in the calappid *M. lunaris*.

In India, Pillay & Nair (1976) verified a seasonal reproduction in this species, while Perez (1990) found that *M. lunaris* breeds continuously in an Australian population.

The presence of crabs of both sex with developed gonads along the study period, suggests that *H. pudibundus* can breed all year-round, not being verified reproductive peaks.

Recent studies on portunid crabs living in the same region, e.g. the reproductive cycle of *Portunus spinimanus* (Santos, 1994) and *Callinectes danae* (Costa & Negreiros-Fransozo, 1998), have also shown a continuous reproductive pattern. However, other swimming crabs in the same area, i.e. *C. ornatus* and *Arenaeus cribrarius*, exhibit reproductive peaks in certain months (Mantelatto *et al.*, 1995; Pinheiro, 1995).

In spite of being previously verified a discontinuous reproduction in *H. pudibundus* (Rieger, 1986; Sampaio, 1989), the present results and those obtained by Mantelatto (1991), confirm that this species can breed continuously. But that research, there were not attempt into de samples systematically month by month.

There are evidence that brachyuran females can extrude more than one egg-batch in a single intermoult period, leading to multiple spawning (Santos, 1994). In *H. pudibundus*, the observations revealed that gonad and embryonic development in ovigerous females are closely related. Developed ovaries in ovigerous females have been observed in different brachyuran species (Pillay & Nair, 1973; Du Preez & McLachlan, 1984; Choy, 1988; Perez, 1990; Santos, 1994).

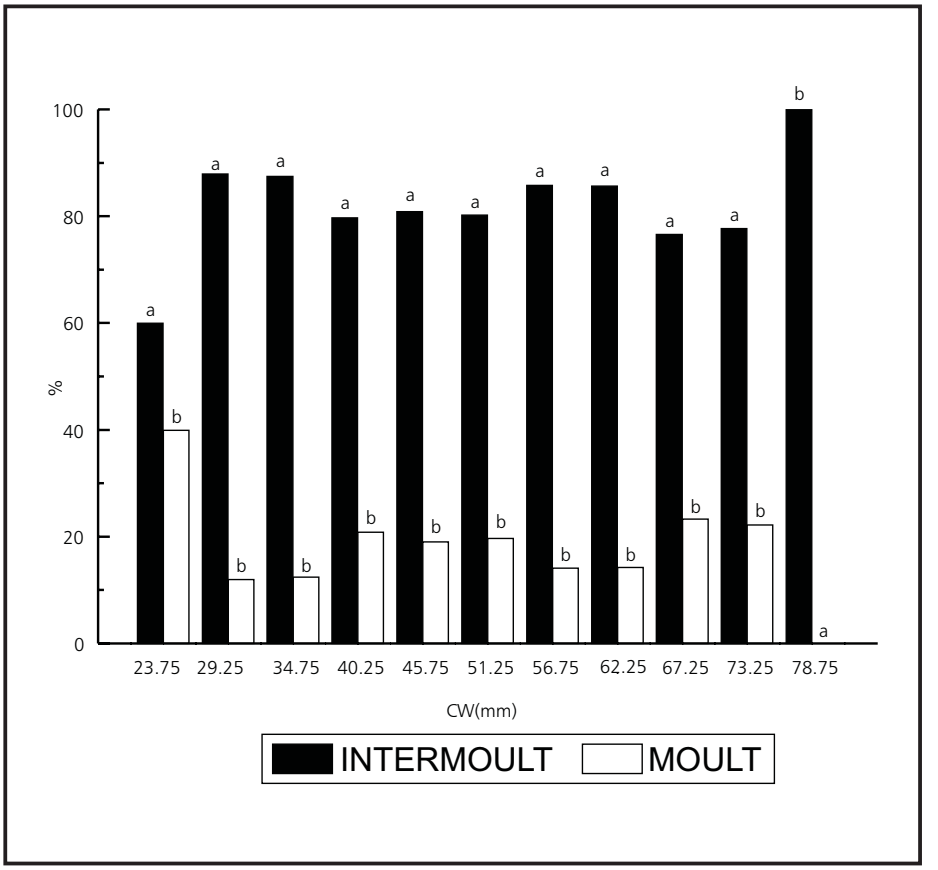

Fig. 2 — *H. pudibundus*: Bar graph showing the monthly frequency of males in molt activity per size class (bars with same letters do not differ significantly; $p < 0.05$).

The Pearson's correlation coefficient showed that there is no significant association between percentage of ovigerous females and seawater temperature in the studied region. Similar results were obtained by Santos (*op. cit.*). It is probable that temperature is not directly influencing oviposition in this species.

As a general rule, the moult process in crustaceans does not cease after sexual maturity. Yet, the so-called terminal anecdysis occur in a number of brachyurans, e.g. majids by Vernet-Cornubert (1958) and Hartnoll (1963); *Ebalia* by Schembri (1982); *Ovalipes punctatus* by Du Preez & McLachlan (1984), in which moulting is suspended once maturity is achieved.

In *H. pudibundus* moult activity was observed in almost all size classes, which indicates that this species does not undergone a terminal anecdysis, but continues moulting even though at longer intermoult intervals.

Information on the moult cycle is important for the understanding of crab reproduction, since mating may involve a male in intermoult and a females in the recent post-moult stage. In the Calappidae, the only available data concerns to the species *M. lunaris*, whose reproductive behavior was investigated by Perez & Belwood (1989). In that case, the most common mating pattern occur, that is, a hard shell male copulates with a recently moulted female.

In *H. pudibundus*, it is likely that mating may occur more than once after the puberty moult. This suggestion is supported by the presence of large adult females in recent post-moult stage.

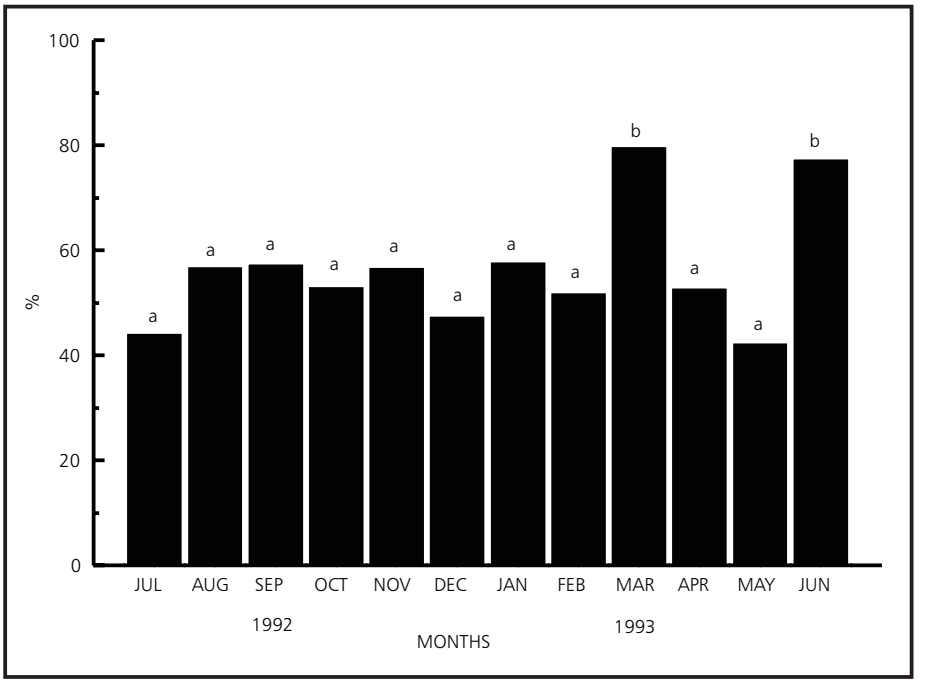

Fig. 3 — *H. pudibundus*: Bar graph showing monthly frequencies of females with developed gonads (bars with same letters do not differ significantly; $p < 0.05$).

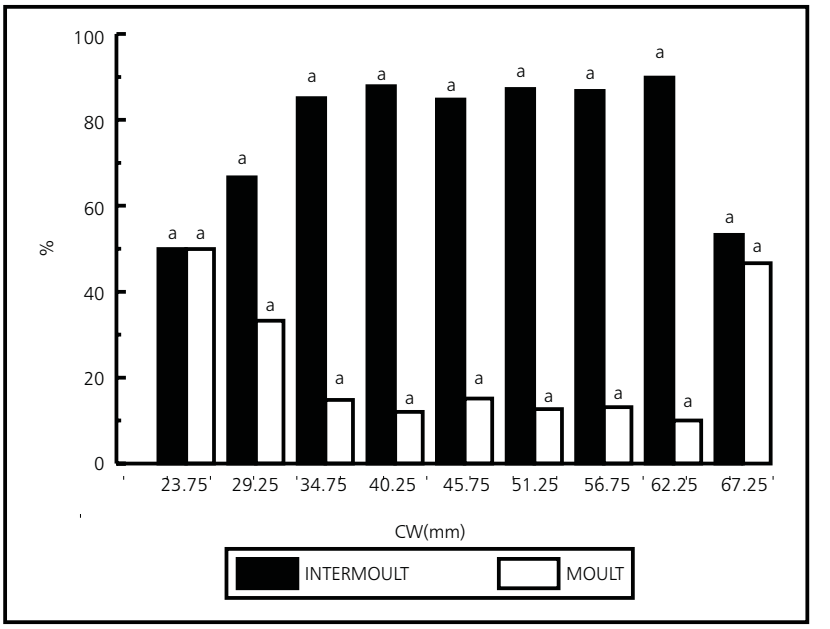

Fig. 4 — *H. pudibundus*: Bar graph showing the monthly frequency of females in molt activity per size class (bars with same letters do not differ significantly; $p < 0.05$).

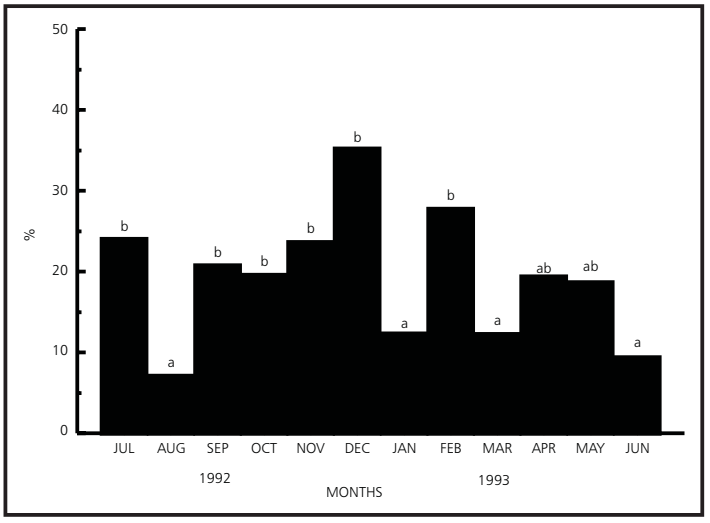

Fig. 5 — *H.pudibundus*: Bar graph showing the monthly frequency of ovigerous females (bars with same letters do not differ significantly; $p < 0.05$).

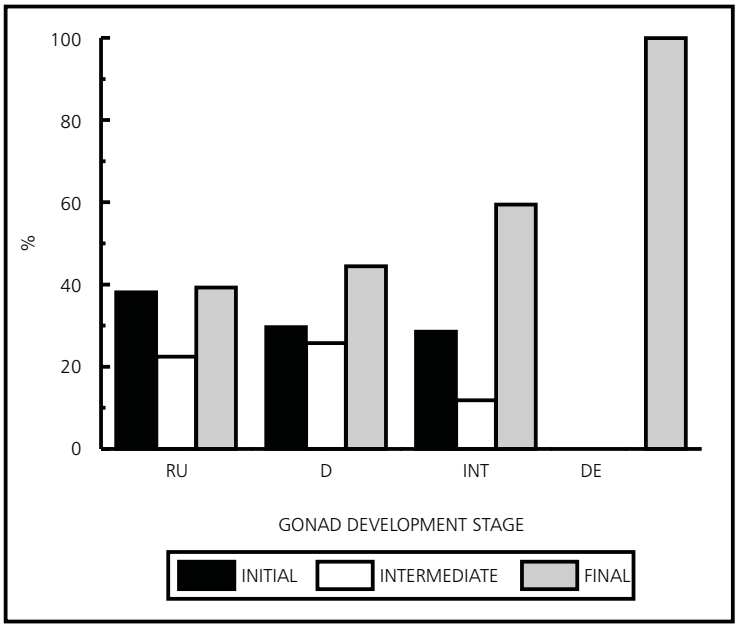

Fig. 6 — *H. pudibundus*: Frequency histogram of embryonic stages per gonad development stage (RU = rudimentary, D = developing, INT = intermediate, DE = developed).

It is known that gonad development and moulting are antagonic processes. In *H. pudibundus*, individuals in pre-moult stage present rudimentary gonads, a fact related to the unfeasibility of maintaining at same time both reproductive and moulting processes (Adiyodi & Adiyodi, 1970).

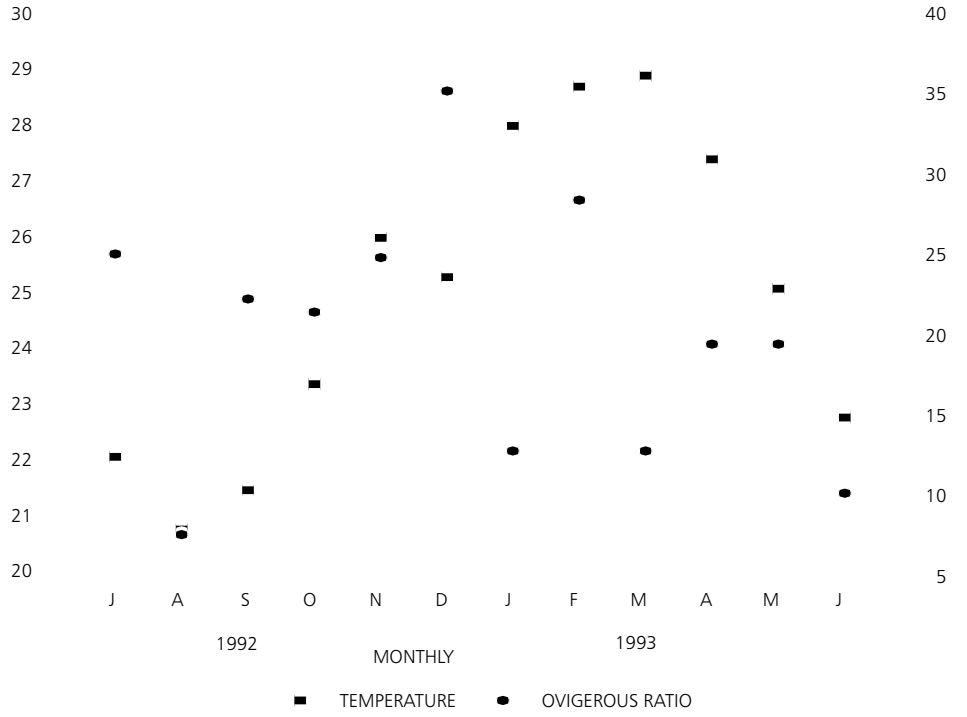

Fig. 7 — *H. pudibundus*: Line graph showing the relation of temperature monthly frequency of ovigerous females.

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