

INFLUENCE OF TEMPERATURE AND PHOTOPERIOD ON THE MATURATION OF THE SEMINAL VESICLE AND ALBUMEN GLAND IN *Oxychilus (Drouetia) atlanticus* (GASTROPODA: PULMONATA)

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TRISTÃO DA CUNHA, R., A.S. RODRIGUES & H. SOUSA. 2001. The influence of temperature and photoperiod on the maturation of the seminal vesicle and albumen gland in *Oxychilus (Drouetia) atlanticus* (Gastropoda: Pulmonata). *Arquipélago. Life and Marine Sciences. Supplement 2 (Part B):* 67-70. Ponta Delgada. ISSN 0873-4704.

The land snail *Oxychilus (Drouetia) atlanticus* is endemic to São Miguel (Azores). In this species, the reproductive system, especially the glandular organs, changes in size and shape during the reproductive cycle. As maturation-diagnostic organs, the seminal vesicle and the albumen gland have complementary interpretations. While the former is appropriate to establish the phase of the pre-copulatory and copulatory periods the latter appears a more accurate way to define pre-egg-laying and egg-laying periods. Concerning the effects of photoperiod and temperature on both organs, it seems that while the former triggers the physiological phenomena related to reproduction, inducing the seminal vesicle and the albumen gland to mature, the latter acts mainly as a regulatory factor for these organs, delimiting the distinct phases of reproduction.

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INTRODUCTION

Oxychilus (Drouetia) atlanticus is a land snail endemic to São Miguel (Azores). In this species, as in *Stylommatophora* in general, the reproductive system changes in size and shape during the reproductive cycle. These changes, which are better seen in glandular organs such as the seminal vesicle and the spermooviduct, may be used to diagnose maturation (RODRIGUES 1995).

Although stylommatophorans are simultaneous hermaphrodites, some species reveal a form of protandry (BAUR 1994) in which the male function reaches maturity before that of the female (SOKOLOVE & MCCRONE 1978). In *Oxychilus atlanticus*, gonadal maturation is characterized by an earlier development of spermatogenesis followed later by vitellogenesis of the oocytes, subsequently showing spermatozoa and oocytes side by side in the same acinus (RODRIGUES 1995).

The albumen gland, which is a female organ, is a compound alveolar gland (TOMPA 1984), very similar in *Stylommatophora* in general (NOYCE 1973) and it is the last part of the reproductive system to develop, changing in size and colour in adult snails (RIGBY 1963; RUNHAM & LARYEA 1968; ELS 1978; TOMPA 1984).

Reproductive development is controlled by endocrine mechanisms, induced by environmental parameters, mainly photoperiod and temperature (TOMPA 1984; BAKER 1988).

According to BECK (1968) photoperiod promotes the synchrony of internal functions that regulate biological systems, as well as affecting every organism in its geographical distribution, seasonal biology, growing, shape, metabolic rates and behaviour.

In Order *Stylommatophora*, PARIVAR (1978) found that temperature affects the gonadal development and the relative proportion of male and female gametes, although it affects spermatogenesis more than oogenesis (SMITH

1966), and it is the key factor to initiate spermatogenesis and egg laying (TOMPA 1984). Life cycles and life spans are also affected by changes in both temperature and photoperiod (UMINSKI 1975; TOMPA 1984; SACCHI 1990).

The aim of this study is i) to test the validity of the albumen gland as a new diagnostic organ of sexual maturity, using the seminal vesicle as the reference organ (RODRIGUES 1995), and ii) to relate the general development of both organs with photoperiod and temperature along the reproductive cycle of the species.

SAMPLING SITE

The climate of the island is of the humid Atlantic type, characterised by prolonged rainy periods in winter and spring, mild temperature (mean 17.5°C), very high air relative humidity (>80%) and soil moisture, even during the summer months (BETTENCOURT 1977). Photophase in the Azores, located between 36°55'N - 39°45'N and 24°45'W - 31°17'W, ranges from around 10 hours in January, to 14h30' in June (Fig. 1A), decreasing at the same rate after July (BECK 1968).

The sampling site, Abelheira, lies about 4 km north-east of Ponta Delgada, 130 m above sea level. Data on temperature from the meteorological station Afonso de Chaves, was used to characterize Abelheira during the sampling period.

MATERIALS AND METHODS

Sampling of *Oxychilus atlanticus* at Abelheira started in November 1993 and lasted until December 1995. For the study of the seminal vesicle and the albumen gland, 10 individuals with the highest shell diameter were selected from each monthly sample, since this parameter is considered to be the most reliable estimator of age (CHARRIER & DAGUZAN 1978).

In order to examine the correlation between abiotic parameters and the seminal vesicle and albumen gland, data were organized in four sampling periods, winter 1993-spring 1994, summer-autumn 1994, winter 1994-spring 1995, and summer-autumn 1995.

The seminal vesicle was classified according to one of the three degrees of development established by RODRIGUES (1995), based on external morphology: 1) narrow and straight; 2) of intermediate thickness and slightly folded (coiled); 3) thick and heavily coiled.

The albumen gland was measured with EDUSKAN-3.1, a program developed by BELLIDO (1993). Monthly values of the albumen gland were divided into four size classes: 1) small [$<5.0 \times 10^5 \mu^2$]; 2) of intermediate size [$5.0 \times 10^5 - 10.0 \times 10^5 \mu^2$]; 3) large [$10.01 \times 10^5 - 20.0 \times 10^5 \mu^2$], and 4) very large [$>20.01 \times 10^5 \mu^2$]. These size classes were considered to reflect the sequence of physiological changes exhibited by the albumen gland during growing.

RESULTS

In the individuals of *Oxychilus atlanticus* studied, the maximum shell diameter (SD) ranged from 5-6 mm in January-February to 8-8.5 mm in late autumn and early winter. The pattern of growing was very similar from year to year, indicating an annual life cycle with a maximum longevity of 18 months (TRISTÃO DA CUNHA 1995).

According to the degree of maturity shown by the seminal vesicle, individuals were immature or undergoing maturation between January and May and mature between June and November-December (Fig. 1B).

Measurements of the area (size) of the albumen gland (Fig. 1B) show that the organ was not developed between January and June, slowly began to increase between June and October, and reached the highest area in November-December.

PHOTOPHASE VS. SEMINAL VESICLE AND ALBUMEN GLAND

There is a strong correlation ($r^2=0.942$, $P=0.01$, $N=260$) between photophase and the degree of maturity exhibited by the seminal vesicle. The organ is fully developed in June, when photophase is at its maximum (14h30'), and remains mature until November-December, despite the decrease of photophase (Fig. 1A and B).

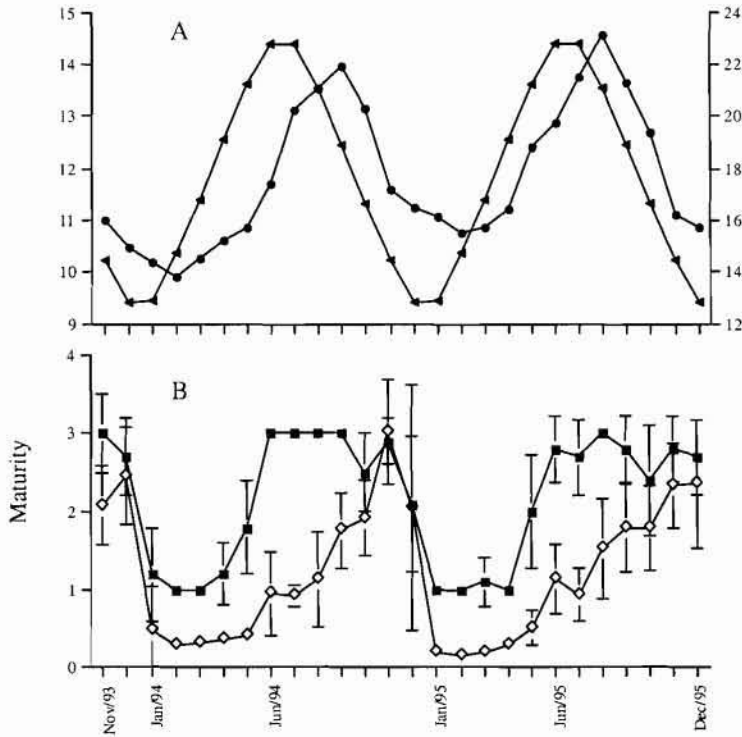


Fig. 1. A) Photophase (hr) (—▲—) for the Azores latitude and Temperature ($^{\circ}\text{C}$) (—●—) at Abelheira, between November 1993 and December 1995; B) Degrees of maturity of the Seminal Vesicle (average \pm sd) (—■—) and size (μ^2) of the Albumen Gland (average \pm sd) (—◇—) of *O. atlanticus*, between November 1993 and December 1995, at Abelheira.

Photophase and albumen gland exhibit a similar general pattern but the highest values of the former anticipate those of the latter by 6 months. The correlation between them is low ($r^2=0.523$, $P=0.10$, $N=260$). In June when photophase is at its maximum, the albumen gland starts to develop, reaching the highest size in December, despite the decrease in photophase (Fig. 1A and B).

TEMPERATURE VS. SEMINAL VESICLE AND ALBUMEN GLAND

There is a strong correlation between temperature and seminal vesicle ($r^2=0.95$, $P=0.01$, $N=260$). The organ is immature when temperature is lower than 16°C and fully developed when temperature is higher than 18°C (Fig. 1A and B).

The correlation between temperature and albumen gland development is high ($r^2=0.847$, $P=0.01$, $N=260$). Maximum values of temperature

exhibit a delay of two months relative to the highest measured area of the albumen gland (Fig. 1A and B).

DISCUSSION

i) IS THE ALBUMEN GLAND A NEW DIAGNOSTIC ORGAN OF SEXUAL MATURITY?

From data on shell diameter, seminal vesicle maturity and albumen gland size, it is possible to establish that the reproductive system of *Oxychilus atlanticus* develops gradually as the animal grows and it appears to be fully developed when it reaches around 7.5 mm diameter, between June and November.

However, the pattern of maturation in both organs is distinct. The seminal vesicle is mature between June and November, which is in accordance with RODRIGUES (1995), with specimens immature the rest of the year. The

albumen gland starts to develop by June but the rapid enlargement only occurs in October - November, signaling final maturation and vitellogenesis of the oocytes in the gonad. A similar general pattern was also observed by RIGBY (1963), in *O. helveticus*, and by SOKOLOVE & MCCRONE (1978), in *Limax maximus*.

As maturation-diagnostic organs of sexual maturity, the albumen gland and seminal vesicle have complementary interpretations. The seminal vesicle may be used to establish the phase of the pre-copulatory and copulatory periods, the albumen gland seems more accurate to define pre-egg-laying and egg-laying periods.

ii) EFFECTS OF PHOTOPHASE AND TEMPERATURE ON THE SEMINAL VESICLE AND ALBUMEN GLAND

According to the data presented, photophase correlates with and probably triggers the physiological phenomena related to reproduction, inducing the seminal vesicle and the albumen gland to increase in size, while temperature acts mainly as a regulatory factor for these organs, making a clear demarcation between the distinct phases of reproduction. Further work will be needed to test these hypotheses among.

ACKNOWLEDGEMENTS

The authors thank Professor Frias Martins for helpful discussions and comments. The present work was supported by the project PRAXIS/2/2.1/BIA/169/94 - Biodiversidade.

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Accepted 12 June 2000.