Seasonal changes of energy reserves in *Bulimus tenuissimus* (d’Orbigny, 1835) (Mollusca, Bulimulidae)

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Abstract

The objective of this study was to evaluate the variation of energy substrates in different seasons in *Bulimus tenuissimus*. For this evaluation, substrates were collected from the digestive and albumen glands and foot tissues, which were processed to obtain the concentrations of glucose and galactose. There was seasonal variation in energy reserves in both the digestive gland and the foot of *Bulimus tenuissimus*, with a tendency to accumulation from spring to winter. There was greater use of energetic reserves in the spring and summer, being the glycogen stored in the digestive gland the first source consumed. In addition, mobilization of reserves of glycogen in the muscle in summer was observed. The reduction of glycogen coincides with the reproductive cycle of the species, and the expenses generated for the processes of mating and gametogenesis was the cause of this reduction. The concentration of galactogen also varied according to the reproductive period. It was suggested that variations in temperature and photoperiod that occur during the year would act as regulatory mechanisms of energy metabolism of *B. tenuissimus*.

Keywords

Galactogen; glycogen; land snail; seasonality

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Introduction

Environmental conditions directly influence the life history of land snails, and can act as restriction factors of the feeding and reproductive activities (Hyman, 1967; Leahy, 1984; Heller, 2001; Furtado et al., 2004; Ansart et al., 2007).

Many species remain active throughout the seasons with favorable conditions and abundance of food, which also occur in the processes of mating and laying of eggs. In dry and cold seasons, the animals come in a process known as aestivation, remaining inactive until the next favorable season (Gomot et al., 1989; Iglesias et al., 1996). The energy reserves accumulation in the favorable period ensures the survival of these animals during this period of inactivity (Storey, 2002).

In addition, environmental factors such as temperature, humidity and photoperiod, moreover, regulation of the activity may also influence growth rates and fecundity of snails by interfering directly in the metabolism of these animals (Wayne, 2001). So, the reproductive seasonality of land snails is related to changes in the processes of synthesis, degradation or conversion of energy reserves available to the reproduction.

The variation in energy content is related to the reproductive cycle of snails, with accumulation and expenditure of energy for meeting partners, mating and production of eggs (Da Silva and Zancan, 1994; Rosa et al., 2005). The reproductive behavior as well as gametogenesis, is controlled by the neuroendocrine system, which is dependent of external stimuli (Joosse, 1988; Wayne, 2001; De Fraga et al., 2004).

*Bulimulus tenuissimus* is a native land snail widely distributed throughout Brazilian territory (Simone, 2006) and that stands out to act as intermediate host of helminths of veterinary importance and also as an agricultural pest (Thiengo and Amato, 1995). This species is iteroparous and has a long life cycle, with eggs laying occurring during the spring-summer (Silva et al., 2008).

The objective of this work was to evaluate the seasonal variation in the glycogen content in the digestive gland and cephalopedal mass, and galactogen content in the albumen gland of *B. tenuissimus*.

Material and methods

**Snails collection**

The snails used were reared in the Mollusks Biology Laboratory at the Professor Maury Pinto de Oliveira Malacology Museum, Federal University of Juiz de Fora, Juiz de Fora, Minas Gerais, Brazil (21°45′13″/21°46′13″S and 43°21′19″/43°22′15″W).

Five groups of snails, with 20 individuals each, were kept in a transparent plastic terrarium (14 cm diameter × 9 cm deep) sealed with cotton tissue. The substrate was sterilized humus (120°C/1 h), which was moistened with water on alternate days. The snails were fed with a blend of bird ration enriched with calcium carbonate (proportion 3:1) (Bessa and Araújo, 1995). The diet was provided in plastic
recipients (3 cm wide) to avoid contact with the substrate, and it was renewed in alternate days. The study was conducted in natural conditions of temperature (19°C-25°C) and relative air humidity (70%-95%).

The snail groups were kept in these conditions from birth until they reached the age of one year, when the animals are considered adults (Silva et al., 2008).

Seasonal variation of glycogen and galactogen content

To evaluate the seasonal variation in the glycogen and galactogen content, adult snails (average length of the shell of 18 ± 2 mm) were dissected in the months corresponding to the seasons (spring – October 2007; summer – January 2007; autumn – April 2008 and winter – July 2008) to remove digestive and albumen glands and cephalopedal mass tissues. The tissues removed were individually weighed using an analytical balance (Bosch SAE 200) and kept in an ice bath to avoid the enzymatic degradation of carbohydrates.

The glycogen and galactogen were extracted according to Pinheiro and Gomes (1994) and determined by 3,5 DNS technique (Sumner, 1924).

Statistical analysis

To compare the glycogen and galactogen contents at different seasons a Kruskal-Wallis test was used, followed by a Student-Newman-Keuls test. The correlation between fresh weight and tissue concentration of glycogen and galactogen was given by a Pearson correlation coefficient. For both tests, the significance level of 0.05 was used.

Results

In winter, the average weight of the digestive gland was lower than in other seasons ($H = 28.60$, $p = 0.0001$). Similarly, in autumn difference between the average weight of the albumen gland was observed, which was significantly lower ($H = 11.00$, $p = 0.01$). There was no difference between the average weight of the cephalopedal mass in the seasons (table 1). There was no correlation between the weight of the tissues and the glycogen and galactogen contents in the seasons ($p > 0.05$).

There was significant variation in energy reserves in the digestive gland and foot according to the seasons (fig. 1). In spring and summer, greater consumption of glycogen stored in the digestive gland was observed, but the degradation of the foot reserve was reduced. In summer, we also observed mobilization of glycogen from body tissues.

In autumn, the glycogen content in the digestive gland increases considerably, reaching the maximum level in winter. In the foot, accumulation of reserves occurs similarly, but the levels of glycogen are lower than in the digestive gland (fig. 1).
Table 1.
Mean weight, expressed in grams of fresh tissue, of digestive gland, albumen gland and cephalopedal mass of *Bulimulus tenuissimus* in different seasons. SD: standard deviation.

<table>
<thead>
<tr>
<th>Seasons</th>
<th>Digestive gland (mean ± SD)</th>
<th>Albumen gland (mean ± SD)</th>
<th>Foot (mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring (n = 14)</td>
<td>165.00 ± 60.00 a</td>
<td>40.1 ± 16.00 a</td>
<td>69.50 ± 16.60 a</td>
</tr>
<tr>
<td>Summer (n = 17)</td>
<td>130.10 ± 42.00 a</td>
<td>42.30 ± 15.00 a</td>
<td>52.40 ± 21.40 a</td>
</tr>
<tr>
<td>Autumn (n = 15)</td>
<td>161.20 ± 39.00 a</td>
<td>30.50 ± 9.50 a</td>
<td>65.00 ± 22.20 a</td>
</tr>
<tr>
<td>Winter (n = 24)</td>
<td>93.86 ± 34.00 b</td>
<td>25.20 ± 12.85 b</td>
<td>55.00 ± 18.00 a</td>
</tr>
</tbody>
</table>

Different letters indicate significant difference between mean values.

Figure 1. Glycogen content, expressed as mg glucose/g tissue, fresh weight, in digestive gland and cephalopedal mass tissues of adult snails *Bulimulus tenuissimus* in spring, summer, autumn and winter. Different letters indicate significant difference between mean values.

The galactogen content reduced from spring to winter. The highest rate of polysaccharide was observed in spring, followed by summer and autumn. The minimum concentration was found in winter ($H = 17.35$, $p = 0.0006$) (fig. 2).

Discussion

In land snails, processes such as gametogenesis and mating behavior may be influenced by temperature, humidity and photoperiod (Leahy, 1984; Azevedo et al., 1996; D’ávila et al., 2004; D’ávila and Bessa, 2005; Junqueira et al., 2008; Silva et
Figure 2. Galactogen content, expressed as mg of galactose/g tissue, fresh weight, in albumen gland of *Bulimulus tenuissimus* in spring, summer, autumn and winter. Different letters indicate significant difference between mean values.

al., 2009) because these factors can act as regulators of metabolic processes (South, 1992).

In *B. tenuissimus*, there was reduction and accumulation of glycogen during the periods of oviposition and absence of reproductive activity, respectively. The galactogen content was higher during the reproductive period. The energetic change was similar to the reproductive cycle of this species (Silva et al., 2008). According to these authors, *B. tenuissimus* shows a marked seasonal reproductive cycle with a significant increase in egg production in the months of higher temperature and relative humidity, while in cold and dry months a decrease of reproductive activity.

Influence of seasonality on energetic substrates content was recorded for other species of land snails such as *Megalobulimus oblongus* (Da Silva and Zancan, 1994) and *M. abbreviatus* (Horn et al., 2005). This variation may be related to metabolic changes caused by environmental variations and the mobilization of energy during the reproductive cycle (Wayne, 2001; Nowakowska, 2006).

Many studies on different species of snails demonstrated the deposition of glycogen in tissues in the autumn, the period previous to hibernation/aestivation, during which it was reduced (Joosse, 1988; Da Silva and Zancan, 1994). However, in *B. tenuissimus* the concentration of glycogen in digestive gland and cepahalopedal mass tissues remained high in the winter period. It suggests that stored energy was available for reproduction, increasing the reproductive success.

There was mobilization of reserves from the digestive gland and cepahalopedal mass in spring. These results are similar to those ones observed for other species and can be related to energy investment for reproduction and aestivation (Da Silva and Zancan, 1994).
The galactogen content varied according to the reproductive period of *B. tenuissimus*, being high in reproductive seasons (spring and summer) and low in other periods. The high concentration of polysaccharide in the months of spring-summer shows the availability for the production of nutrients to the embryo development (Stickler, 1975). The reduction in glycogen content and the concomitant increase in the galactogen content suggest an increase in interconversion of glucose to galactose (Needhan, 1933; Brooks and Storey, 1990; Pinheiro, 1996).

Reduction in the weight of the digestive gland tissue in *B. tenuissimus* was also observed in *M. oblongus*, and this reduction is related to the inactivity period of these species (Da Silva and Zancan, 1994).

The albumen gland of snails shows more development in the reproductive period, and indicates the maturity of the female system (Da Silva and Zancan, 1994; Horn et al., 2005). This explains the increase in the average weight of albumen gland tissue during spring-summer. Moreover, it suggests that the reduction of glycogen in these periods is directly related to the synthesis of galactogen and oogenesis in this species.

Glycogen and galactogen content may be influenced by environmental variations, being photoperiod a determining factor in the glycogen synthesis. The short days (autumn-winter) tend to stimulate the synthesis, whereas long days (spring-summer) tend to inhibit it (Joosse and Geraerts, 1983; Wayne, 2001; De Fraga et al., 2004; Garcia and Pinheiro, 2007).

According to Gomot et al. (1989), the effects of photoperiod on reproduction are mainly due to the inhibition of gametes maturation and synthesis of albumen from the albumen gland. These authors suggested that this occurs due to hormonal inhibition. Similar results were also observed in *Lymnaea stagnalis* to which the increase in the length of the day caused an increase of glucose to galactose conversion of, and consequently the levels of galactogen in albumen gland decreased (Van Elk and Joosse, 1981).

The results of this study show that environmental seasonality influenced the energetic metabolism of mollusks. These metabolic alterations can reflect directly in seasonal reproduction already recorded for the species (Silva et al., 2008).

References


