COMPARATIVE BEHAVIORAL STUDY BETWEEN JUVENILE AND ADULT *Rumina decollata* (MOLLUSCA, SUBULINIDAE)

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ABSTRACT

Land snails are largely utilized all over the world in several sectors of economy. However, there is a lack of studies about behavioral displays of alien species in the areas of introduction. The aim of the present work was to verify the activity period and the behavioral displays exhibited by individuals of *Rumina decollata* (Linnaeus, 1758). It was utilized 30 young and 30 adult snails, observed during 24 hours by the method *scan sample* at intervals of 20 minutes. It was verified that this snail species presents nocturnal activity and adults were more active than young individuals. The behavioral display “Interact” showed significantly difference during the 24 hours of observation, with more interaction between adults. It was observed difference in the act “Feed” between young and adult snails in two hours during the scotophase (21 and at 3 hours) and in the act “Dislocate” at 21, 23 and 3 hours. The relative air humidity did not influence the snail’s behavior, but there was a positive correlation between the mean temperature and the activity of adult snails. The results demonstrated that *R. decollata* presents activity and rest period alike to other Subulinidae and showed difference in some behavioral displays between juvenile and adult snails, what can be attributed to niche differentiation in order to avoid intraspecific competition. Besides, because this species remains buried most of the time, it cannot be effective in controlling other snail species.

KEY WORDS. Activity period. Biology. Ethogram. Niche differentiation.

RESUMO

Estudo comportamental comparativo entre jovens e adultos de *Rumina decollata* (Mollusca, Subulinidae) Moluscos terrestres são amplamente utilizados em todo o mundo em diversos setores da economia. No entanto, há uma carência de estudos sobre aspectos comportamentais das espécies exóticas nas áreas de introdução. O objetivo do presente trabalho foi verificar o período de atividade e os aspectos comportamentais exibidos por indivíduos de *Rumina decollata* (Linnaeus, 1758). Foram utilizados 30 moluscos jovens e 30 adultos, observados durante 24 horas pelo método de varredura da amostra em intervalos de 20 minutos. Verificou-se que esta espécie de molusco apresenta atividade noturna e que os indivíduos adultos foram mais ativos do que os jovens. O ato comportamental "Interagir" mostrou diferença significativa durante as 24 horas de observação, com mais interação entre os adultos. Observou-se diferença no ato "Alimentar" entre os moluscos jovens e adultos, em dois momentos durante o escotofase (21 e 3 horas) e no ato "Deslocar" em 21, 23 e 3 horas. A umidade relativa do ar não influenciou o comportamento dos moluscos, embora tenha ocorrido correlação positiva entre a temperatura média e a atividade dos moluscos adultos. Os resultados demonstraram que *R. decollata* apresenta períodos de atividade e repouso semelhantes ao de outros subulinídeos e mostrou diferenças em alguns aspectos comportamentais entre os moluscos jovens e adultos, o que pode ser atribuído à diferenciação de nicho, a fim de evitar a competição intraespecífica. Além disso, por esta espécie permanecer enterrada a maior parte do tempo, pode não ser eficaz no controle de outras espécies de moluscos.

PALAVRAS-CHAVE. Biologia. Diferenciação de nicho. Etograma. Período de atividade.

INTRODUCTION

There is a lack of studies about land snails despite its importance, with most of studies realized with aquatic snails. Land snails are utilized in economy sectors, can act as crop pests, intermediate hosts for helminths with medical veterinary importance and transmit plant pathogens, being the damages

mostly due to the widespread of alien species (Leahy, 1980; Roff, 1992; Rao & Singh, 2000; Pigliucci *et al*., 2001; Pardo & Johnson, 2005).

Rumina decollata (Linnaeus, 1758) is a terrestrial gastropod from Subulinidae family native from Mediterranean area, that was introduced in North America and nowadays, is found in other countries such Argentina (Francesco & Lagiglia, 2007), France (Mienis, 2008) and Brazil (Simone, 2006). This species is described as a voracious predator, feeding on other snails and their eggs. Due to its feeding habit, it was introduced in USA in order to control populations of *Helix aspersa* (Müller, 1774) (Helicidae) (Cowie, 2001). There are records that *R. decollata* also eat plants, but with lower damage for them (Batts, 1957; Selander & Hudson, 1976; Fischer *et al*., 1980; Dundee, 1986; El-Wakil *et al.*, 2011) although studies showed that *R. decollata* can cause serious damage in *Citrus sp.* L. plantations (Fisher *et al.*, 1980).

The introduction of this species for biological control is questionable (Fisher *et al*., 1980; Cowie, 2001). Several species, terrestrial and aquatic have been introduced with this purpose; with serious consequences to the environments were the established (Kinzie III, 1992; Pointier, 1993; Pointier, 2001; Cowie *et al*., 2009).

The introduction of alien species can be harmful because they usually show competitive superiority and have no predators in introduced areas, what can lead to the extinction of native snails (Byers, 2000). The distribution of *R. decollata* must be studied in regional scales for the diagnosis of its potential to cause damages and as invasive species (Francesco & Lagiglia, 2007). However, little is known about the ecology and behavior of *R. decollata* in areas where it was introduced (Francesco & Lagiglia, 2007), including in Brazil, which demonstrate necessity of studies about behavioral biology of this species.

The aim of this study was to observe the behavioral displays of juvenile and adult individuals of *R. decollata*, and to determinate its activity period.

MATERIAL AND METHODS

For the assays, it were utilized 30 adult snails, and the same

number of juveniles, obtained from colonies maintained at Museu de Malacologia Prof. Maury Pinto de Oliveira, Universidade Federal de Juiz de Fora, Minas Gerais, Brazil.

To describe the behavioral displays, snails were distributed (10 snails/group, with three repetitions) in plastic terrariums containing moistened and sterilized soil (12° for one hour) and feed according to Bessa & Araújo (1995a,b).

The observations were carried out during the photophase (6:00 to 17:00h) and scotophase (18:00 to 5:00h), using the "*Scan Sample´*" method (Altmann, 1974) every 20 minutes totalizing 24 hours of observation. The behavioral displays observed were adapted from Junqueira *et al*. (2004). The nocturnal observations were realized by using a flashlight wrapped in red cellophane to provide a lower wavelength in order to reduce the interference in snail's behavior.

The work was realized under natural conditions of temperature (23.8 ± 0.5º C) and relative air humidity (70 ± 4%). The temperature and relative air humidity were registered every observation.

The behavioral displays were analyzed as mean frequency (mean number of each act registered ± standard deviation). The activity period was evaluated quantifying activity and rest periods of adult and juvenile snails.

To compare the behavioral parameters observed, it was utilized the ANOVA test, followed by the Tukey test. To evaluate the influence of temperature and relative air humidity in snails displays it was used Multiple Linear Regressions calculated with BioEstat 5.0 software (significance of 0.05).

RESULTS

The results demonstrated that *R. decollata* presented nocturnal activity period (Adults: $Q=16,07$; $p<0,01$ and Juveniles: $Q=20,49$; $p<0,01$) (Figure 1). It was observed that adults and juveniles presented activity and rest period alike during photophase, however, during scotophase, adults were more active ($Q=4,13$; $p<0,01$) (Figure 1).

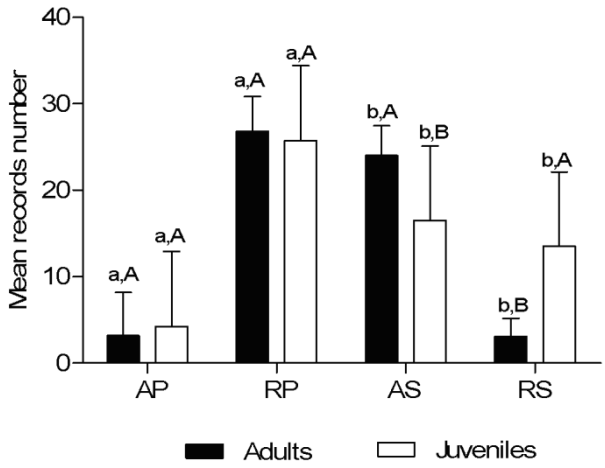

Figure 1: Activity and rest during photophase and scotophase of juvenile and adult individuals of *Rumina decollata* (AP- activity in photophase; RP- rest in photophase; AS- activity in scotophase; RS- rest in scotophase). Minute letters indicates difference between each age (adults and juvenile) during photophase and scotophase and capital letters indicate difference between adult and juveniles.

When compared the frequency of behavioral displays exhibited during 24 hours between adults and juveniles, only the behavior "Interact" showed significant difference ($Q=3.42$; $p<0.05$) with higher interaction among adults (Figure 2). The other behavioral displays did not showed statistical difference ($p>0,01$).

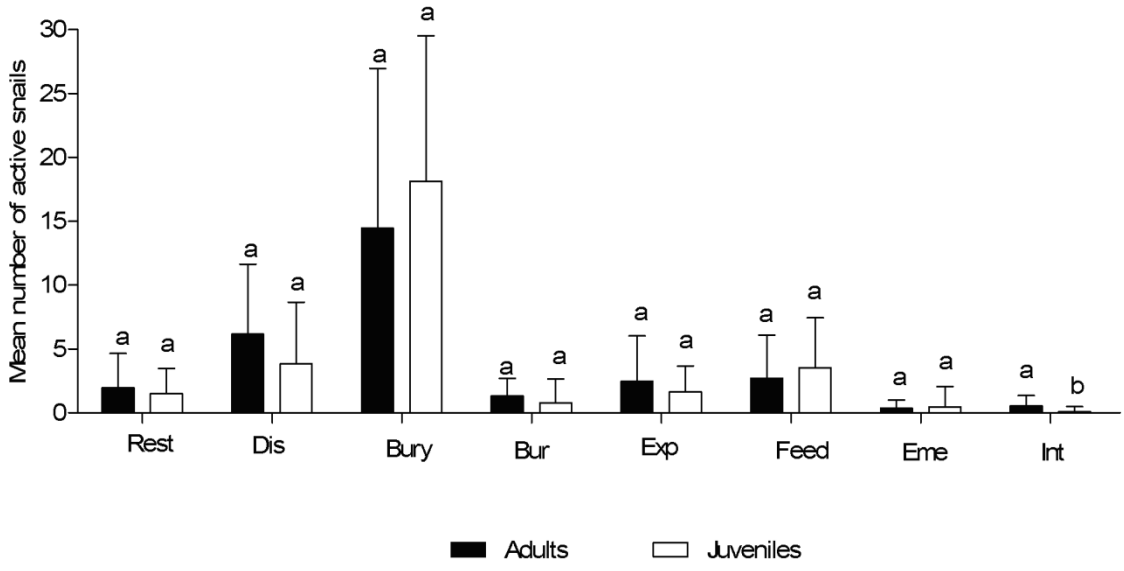

Figure 2: Frequency of behavioral displays of adult and juvenile individuals of *Rumina decollata* observed during 24 hours (Rest- Rest; Dis- Dislocate; Bury- Bury; Bur- Burying; Exp- Explore; Feed- Feed; Eme- Emerge; Int- Interact).

Different letters indicate statistical difference.

It wasn't observed the behavior "Defecate" neither for adult nor for juvenile snails during the observation period. Regarding the behavior "Explore", there was no statistical difference between adult and juveniles ($p>0,01$) during the observation period (Figure 3). This behavior was not observed for both ages from 7:00 to 14:00h (Figure 3).

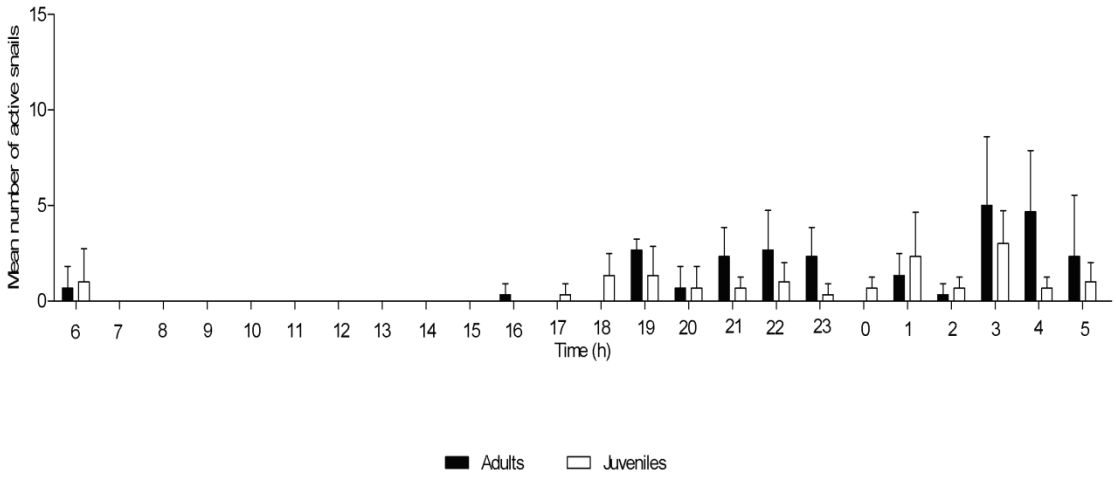

Figure 3: Comparison of the behavioral display "Explore" between adult and juvenile *Rumina decollata* during 24 hours. It was not observed statistical difference (ANOVA, $p<0,05$).

The feed did show significant difference between adult and juveniles only in two hours of scotophase: at 21 o'clock ($Q=4,00$; $p<0,05$), with adults feeding more and at 3 o'clock ($Q= 4,00$; $p< 0,05$) when juveniles feed more (Figure 4).

Adults dislocated more and this act presented significant difference at three different hours in scotophase: at 21 o'clock ($Q=9,89$; $p<0,01$), at 23 o'clock ($Q= 4,47$; $p<0,05$) and at 3 o'clock ($Q= 4,42$; $p< 0,05$) (Figure 5).

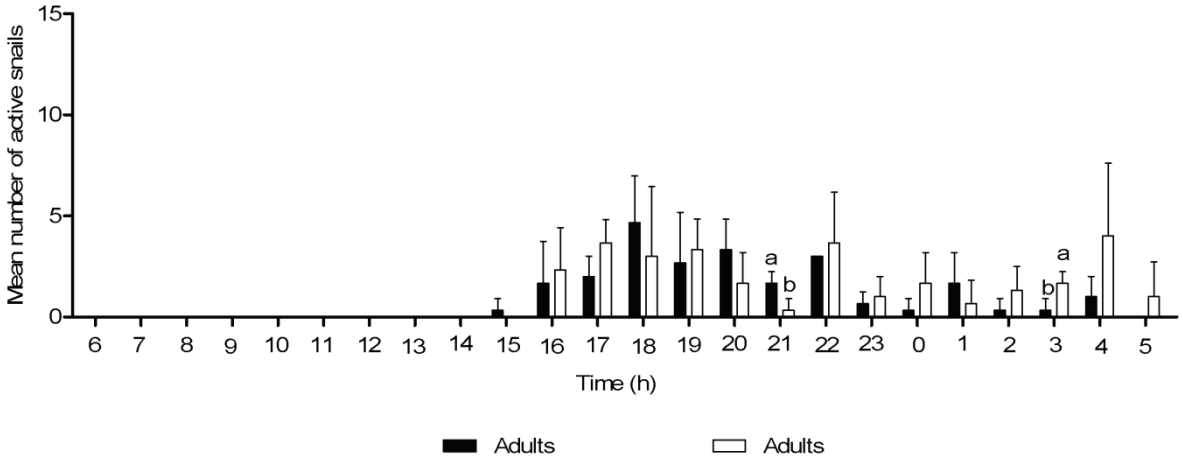

Figure 4: Comparison of the behavioral display “Feed” between adult and juvenile *Rumina decollata* during 24 hours. Different letters indicates statistical difference (ANOVA, p<0,05).

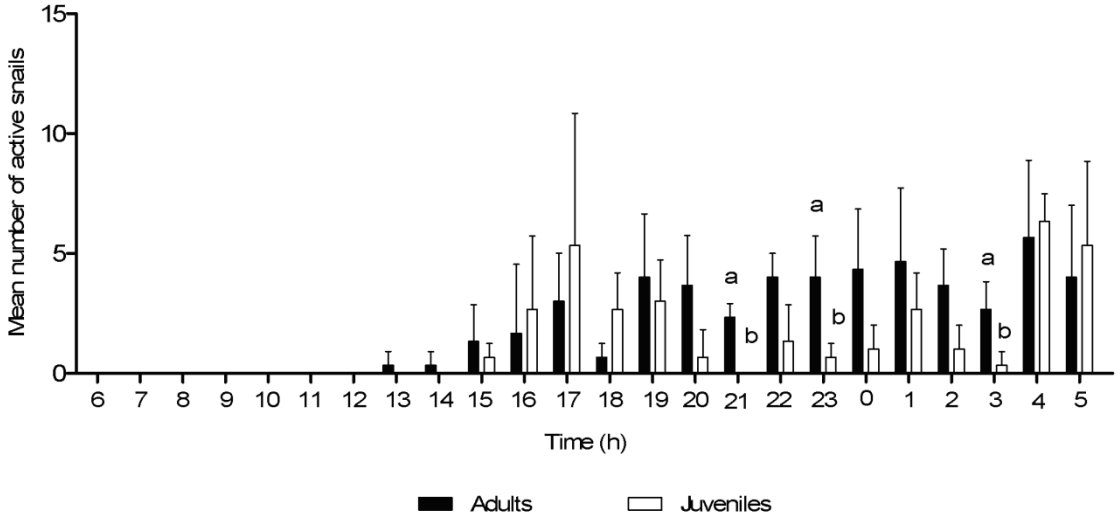

Figure 5: Comparison of the behavioral display “Dislocate” between adult and juvenile *Rumina decollata* during 24 hours. Different letters indicates statistical difference (ANOVA, p<0,05).

It was observed a correlation between the mean temperature and the activity of adults (F=6,11; p=0,02; R^2=0,22) and juveniles (F=14,14; p<0,01; R^2=0,39) (Figure 6).

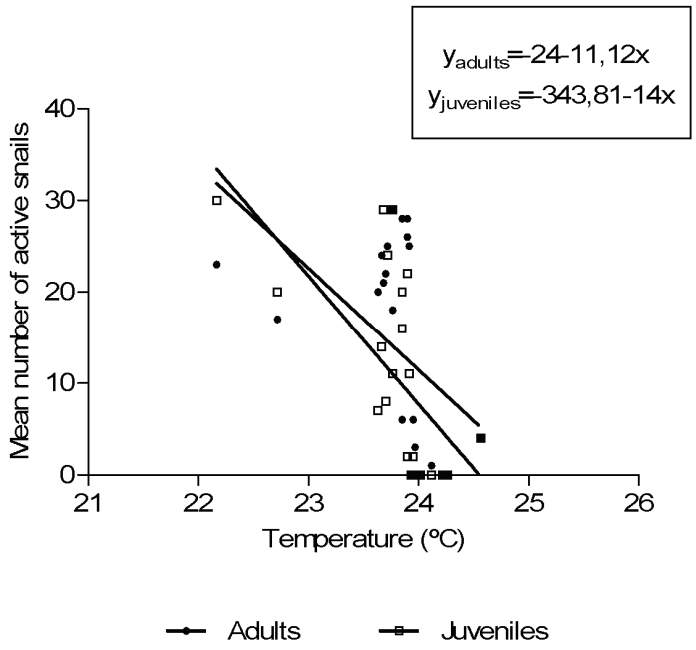

Figure 6: Correlation between mean temperature and activity of adult and juvenile *Rumina decollata* observed during 24 hours.

However, there was no correlation between relative air humidity for juveniles (F=0,91; p=0,35; R^2=0,04) and adults (F=0,1088; p=0,74; R^2=0,01).

DISCUSSION

It was observed that adult and juveniles remained buried during the most part of the observation period, which corroborates the studies of El-Wakil *et al*. (2011) that described this snail species as ground dwellers that live basically buried. Batts (1957) in field observations described individuals of *R. decollata* moving (exploring) while others where completely covered or only with the shell apex visible, as observed in the present study. Selander & Kaufman (1973) stated that *R. decollata* in comparison to other snail species is remarkably sedentary. This species restrict its movements to small areas and usually is not found far from aestivation sites, even in rainy periods or when the conditions are favorable for activity.

According to Pieri & Jurberg (1981) burying is a common response to adverse environmental conditions. This behavior is widespread among molluscs, including other Subulinidae such as *Leptinaria unilamellata* (Orbigny, 1835) that is a soil dweller, remaining hidden in dried interlaced

of gramineae and roots, being found until 15cm deep in soil (Dutra, 1988). The same was observed to *Beckianum beckianum* (Pfeiffer, 1846) (Almeida & Mota, 2011).

During scotophase, adult snails were more active than juvenile, showed more interaction and explored more at certain times. This can be attributed to the fact that adult snails are searching partners to copulate. Junqueira *et al.* (2004) evidenced the nocturnal habit of *Sarasinula linguaeformis* (Semper, 1885) (Veronicellidae) which presented higher activity during the night and at early morning. According to these authors, the most frequent behavioral displays exhibited during scotophase were dislocate and feed, and during photophase, dislocate and bury. To *L. unilamellata* the preferable period for all activities was the nocturnal. During the day, snails were inactive, buried or under the ration recipient or lettuce leaves, always aggregated (Almeida & Bessa, 2001).

The behavioral differences observed among juvenile and adult snails can be due to a niche differentiation between individuals of different ages. Intraspecific comparisons between individuals size are useful and enhance the environmental variables that motivate certain behaviors and can change the development of the organism (Byers, 2000).

Cruz (2002) considered that niche assembles a set of interactions established between individuals and the surrouding environment, and observed two groups of essential and independent variables that influences all the rest. This autor classifies this variables in: structural division, that include all the dimensions related to habitat utilization and temporal division, which group the time dimensions such as anual and circadian cycle. In the present study, juveniles rested more than adults during scotophase, which showed higer activity, this can indicate behavioral adjustments to avoid competition during the utilization of resources. Besides, a temporal division in the act “Feed” can be observed, which presented statistical difference in two distinct hours with a bigger part of the adult snails feeding more at 9 pm and most of juveniles feeding at 3 am.

The division of rest sites among juvenile and adults of the same species was observed to

Arianta arbustorum (Linnaeus, 1758) (Helicidae) in field (Ledergerber *et al*., 1997). These authors argue that this niche differentiation enable the coexistence of individuals from different species and from the same species in different ages.

Conner *et al.* (2008) realized assays manipulating adult and juvenile *Pomacea paludosa* (Say, 1829) (Ampullariidae), and juveniles of *P. paludosa* in the presence of adults from an alien species. It was observed that juveniles presented a decrease in growth when raised in the presence of one or a small number of adults *P. paludosa* in tanks. Regarding the survival, the authors verified that it was higher for juveniles created in the absence of adults of the same species. The opposite was observed when juveniles were put with an exotic adult or four adults of the same species, in other words, the survival of juveniles diminished with the increasing of adults density, especially from the alien species. Pearce (1997) observed a similar pattern for *Mesodon thyroidus* (Say, 1816) (Polygyridae) and *Neohelix albolabris* (Say, 1817) (Polygiridae) in experiments realized in field and in laboratory conditions, where juveniles from both species competed for resources with adults from the same species and the growth of juveniles was affected by the presence of adults. Thus, it was evidenced the importance of niche differentiation among adult and juvenile snails, which can explain the differences found in some activities at different hours.

Adults dislocated more than juveniles in three distinct hours (21, 23 pm e 3 am), interacted and presented higher activity (during scotophase), this difference can bedue to the fact of adults being searching partners.

The temperature influenced the activity of snails but not humidity, despite the last one being a factor with strong influence in snails, as stated for several authors (Batts, 1957). It is worth highlighting the incidence of microclimate variations; since it was proved that they can cause intraspecific variations in activity (Potts, 1975).

Maltz (2003) observed that the climate conditions influenced the activity of individuals of *Helicodonta obvoluta* (Müller, 1774) (Helicidae) that were more active at the begining or the ending of April.

Under constant conditions of temperature and humidity in field and in laboratory conditions, adult snails exhibited two activity peaks: at the end of the evening (twilight) and in the early morning, with a rest period during the day. Immature individuals were more active, with high and constant activity from the afternoon until early morning, with several individuals remaining active during the day.

In favorable conditions of temperature and humidity (in field) and in laboratory conditions, the activity in all ages depended on temperature and humidity. The authors also registered that immature snails were more active (Maltz, 2003). Individuals of *R. decollata* utilized in the present work were evaluated in two phases: photophase and scotophase. The activity of adult and juvenile snails presented significant difference only during scotophase, unlike the observed to the terrestrial gastropod *H. obvoluta*. The same was observed to *Arion lusitanicus* (Mabille, 1868) (Arionidade) (Grim & Schaumberger, 2002).

R. decollata, at two ages, remained most of the time resting, so as was verified to *A. lusitanicus* that spend 68% of 24 hours resting, mainly in photophase. The feeding showed difference in two distinct hours, at 9 pm with adults feeding more and at 3 pm, with juveniles feeding more, wich corroborate the observations realized with *Limax valentianus* (Ferussac, 1821) (Limacidade) that also presented a peak in feeding at 9 pm (Hommay *et al*., 1998), and *H. aspersa* that fed preferably in the period between 1 and 2:30 pm (Grim & Schaumberger, 2002).

CONCLUSIONS

It was evidenced that *R. decollata* has an activity period alike other molluscs as described before, that they basically remain buried and dislocate too few which can indicate that the utilization of this species as biological control is not viable, specially in controlling species with climbing behavior such *H. aspersa*.

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REFERENCES

Almeida, M.N. & E.C.A. Bessa. 2001. Estudo do crescimento e da reprodução de *Leptinaria unilamellata* (D'orbigny) (Mollusca, Subulinidae) em laboratório. Revista Brasileira de Zoologia, Curitiba, 18: 1107-1113.

Almeida, M.N. & G.G. Mota. 2011. Ecologia, reprodução e crescimento da concha de *Beckianum beckianum* Pfeiffer, 1846 (Pulmonata, Subulinidae) em condições naturais. BioFar − Revista de Biologia e Farmácia, Campina Grande, 6: 75-85.

Altmann, J. 1974. Observational study of behavior: sampling methods. Behavior, 48: 227-265.

Batts, J.H. 1957. Anatomy and life cycle of the snail *Rumina decollata* (Pulmonata: Achatinidae). The Southwestern Naturalist, 2: 74-82.

Bessa, E.C.A. & J.L.B. Araújo. 1995a. Oviposição, tamanho de ovos e medida do comprimento da concha em diferentes fases do desenvolvimento de *Subulina octona* (Brugüière) (Pulmonata, Subulinidae) em condições de laboratório. Revista Brasileira de Zoologia, Curitiba, 12: 647-654.

Bessa, E.C.A. & J.L.B. Araújo. 1995b. Ocorrência de autofecundação em *Subulina octona* (Brugüière) (Pulmonata, Subulinidae) em condições de laboratório. Revista Brasileira de Zoologia, Curitiba, 12: 719-723.

Byers, J.E. 2000. Effects of body size and resource availability on dispersal in a native and a non-native estuarine snail. Journal of Experimental Marine Biology and Ecology, 248: 133-150.

Conner, S.L.; C.M. Pomory & P.C. Darby. 2008. Density effects of native and exotic snails on growth in juvenile apple snails *Pomacea paludosa* (Gastropoda: Ampullariidae): a laboratory experiment. Journal of Molluscan Studies, 74: 355-362.

Cowie, R.H. 2001. Can snails ever be effective and safe biocontrol agents? International Journal of Pest Management, 47: 23-40.

Cowie, R.H.; R.T. Dillon; D.G. Robinson & J.W. Smith. 2009. Alien

non-marine snails and slugs of priority quarantine importance in the United States: a preliminary risk assessment. American Malacological Bulletin, 27: 113-132.

Cruz, M.A. 2002. Nicho y evolución. Revista Biología (La Habana), 16 (1): 3-7.

Dundee, D.S. 1986. Notes on the habits and anatomy of the introduced land snails *Rumina* and *Lamellaxis* (Subulinidae). The Nautilus, 100: 32-40.

Dutra, A.V.C. 1988. Aspectos da ecologia e da reprodução de *Leptinaria unilamellata* (Orbigny, 1835) (Gastropoda, Subulinidae). Revista Brasileira de Zoologia, Curitiba, 5: 581-591.

El-wakil, H.B.; A.E.A. Banaja & S.A.M. Amer. 2011. Morphometric and genetic insights for three terrestrial snails in Taif province of Saudi Arabia. World of Applied sciences Journal, 14: 546-551.

Fischer, T.W.; R.E. Orth & S.C. Swansson. 1980. Snail against snail. California Agriculture, 34: 18-20.

Francesco, C.G. & H. Lagiglia. 2007. A predatory land snail invades central-western Argentina. Biological Invasions, 9: 795-798.

Grimm, B. & K. Schaumberger. 2002. Daily activity of the pest slug *Arion lusitanicus* under laboratory conditions. Annals of Applied Biology, 141: 35-44.

Hommay, G.; F. Jacky & M.F. Ritz. 1998. Feeding activity of *Limax valentianus* Ferussac: nocturnal rhythm and alimentary competition. Journal of Molluscan Studies, 64: 137-146.

Junqueira, F.O.; F. Prezoto; E.C.A. Bessa & S. D'ávila. 2004. Horário de atividade e etograma básico de *Sarasinula linguaeformis* Semper, 1885 (Mollusca, Veronicellidae), em condições de laboratório. Revista Brasileira de Zoociências, Juiz de Fora, 6: 237-247.

Kinzie III, R.A. 1992. Predation by the introduced carnivorous snail *Euglandina rosea* (Ferussac) on endemic aquatic lymnaeid snails in Hawaii. Biological Conservation, 60: 149-155.

Leahy, W. 1980. Aspectos adaptativos de *Bradybaena similaris* Férussac, 1821 (Mollusca, Gastropoda, Pulmonata) submetido ao jejum e dessecação. Boletim de Fisiologia Animal, São Paulo, 5: 47-55.

Ledergerber, S.; H. Baminger; A. Bisenberger; D. Kleewein; H. Sattmann & B. Baur. 1997. Differences in resting-site preference in two coexisting land snails, *Arianta arbustorum* and *Arianta chamaeleon* (helicidae), on alpine slopes. Journal of Molluscan Studies, 63: 1-8.

Maltz, T.K. 2003. Life cycle and population dynamics of *Helicodonta obvoluta* (O. F. Müller, 1774) (Gastropoda: Pulmonata: Helicidae). Folia Malacologica, 11: 63-88.

Mienis, H.K. 2008. Does *Rumina saharica* Pallary, 1901 occur in France? MalaCo, 5: 228-229.

Pardo, L.M. & L.E. Johnson. 2005. Explaining variation in life-history traits: growth rate, size, and fecundity in a marine snail across an environmental gradient lacking predators. Marine Ecology Progress Series, 296: 229-239.

Pearce, T.A. 1997. Interference and resource competition in two land snails: adults inhibit conspecific juvenile growth in field and laboratory. Journal of Molluscan Studies, 63: 389-399.

Pieri, O.S. & P. Jurberg. 1981. Aspectos etológicos na sobrevivência dos caramujos vetores da xistosomose ao tratamento com moluscicidas. Memórias do Instituto Oswaldo Cruz, Rio de Janeiro, 76: 47-55.

Pigliucci, M.; C.J. Murren & C.D. Schlichting. 2001. Phenotypic plasticity and evolution by genetic assimilation. Journal of Experimental Biology, 209: 2362-2367.

Pointier, J.P. 1993. The introduction of *Melanoides tuberculata* (Mollusca, Thiaridae) to the island of Saint Lucia (West Indies) and its role in the decline of *Biomphalaria glabrata*, the snail intermediate host of *Schistosoma mansoni*. Acta Tropica, 54: 13-18.

Pointier, J.P. 2001. Invading freshwater snails and biological control in Martinique Island, French West Indies. Memórias do Instituto Oswaldo Cruz, Rio de Janeiro, 96: 67-74.

Potts, D.C. 1975. Persistence and extinction of local populations of the garden snail *Helix aspersa* in unfavorable environments. Oecologia, 21: 313-334.

Rao, I.G. & D.K. Singh. 2000. Effect of single and binary combinations of plabt-derived molluscicides on reproduction and survival of the snail *Achatina fulica.* Archives of Environmental Contamination and Toxicology, 39: 486-493.

Roff, D.A. 1992. The evolution of life histories. London, Chapman & Hall.

Selander, R.K. & D.W. Kaufman. 1973. Self-fertilization and genetic population structure in a colonizing land snail. Proceedings of the Academy of Natural Sciences of Philadelphia, 70: 1186-1190.

Selander, R.K. & R.O. Hudson. 1976. Animal population structure under close inbreeding: the land snail *Rumina* in southern France. American Naturalist, 110: 695-718.

Simone, L.R.L. 2006. Land and freshwater molluscs of Brazil. São Paulo, EGB/FAPESP.