# Distribution, feeding behavior and control strategies of the exotic land snail *Achatina fulica* (Gastropoda: Pulmonata) in the northeast of Brazil

*Albuquerque, FS.*[a]*, *Peso-Aguiar, MC.*[b]*, *Assunção-Albuquerque, MJT.*[a]*

[a]Edificio de Ciências, Universidad Alcalá de Henares,
Carretera Madrid-Barcelona, Km 33, 6, 28871 Alcalá de Henares, Madrid, Spain

[b]Campus de Ondina, Universidade Federal da Bahia – UFBA,
Rua Barão de Geremoabo, 147, CEP 40170-290, Salvador, BA, Brazil

*e-mail: fabio.suzart@alu.uah.es, mpeso@ufba.br, mariajose.teixeira@alu.uah.es

Received November 13, 2006 – Accepted May 29, 2007 – Distributed November 30, 2008

(With 3 figures)

## Abstract

The goal of this study was to document the distribution and establishment *A. fulica* such as their feeding preference and behavior in situ. The study was carried out at the city of Lauro de Freitas, Bahia state, Brazil, between November 2001 and November 2002. We used catch per unit effort methods to determine abundance, distribution, habitat choice and food preferences. The abundance and distribution of *A. fulica* was most representative in urban area, mainly near to the coastline. Lots and house gardens were the most preferred sites during active hours. The results indicated that *A. fulica* started their activity at the end of the evening and stopped in mid-morning. Their preferred food were vascular plants such as *Hibiscus syriacus*, *Ricinus communis*, *Carica papaya, Galinsonga coccinea*, *Lippia alba*, *Ixora coccinea*, *Musa parasidisiaca*, *Mentha spicata* and *Cymbopogon citrates*. Our results indicate that *A. fulica* are well adapted and established in this city and modified environments facilitate their establishment and dispersion. However, human perturbation, such as clearance of lots could be limiting for the persistence of *A. fulica* populations.

*Keywords: Achatina fulica*, invasive species, exotic species, Giant African Snail, spatial distribution.

## Ecologia do caracol exótico *Achatina fulica* (Gastropoda:Pulmonata) no nordeste do Brasil

## Resumo

O objetivo deste estudo foi documentar a distribuição e o estabelecimento de *Achatina fulica*, assim como sua preferência alimentar e aspectos comportamentais in situ. Esta pesquisa foi desenvolvida na cidade de Lauro de Freitas, Estado da Bahia, Brasil, durante os meses de novembro de 2001 a novembro de 2002. Usamos o método de esforço de captura determinado por homem/hora para calcular a abundância e distribuição, habitats preferidos, além de preferência alimentar. Vimos que a abundância e distribuição de *A. fulica* foram mais representativas em áreas urbanas, sobretudo cerca da linha de costa. Os terrenos e jardins de casas foram os locais preferidos pelos caracóis quando estavam em atividade. Os resultados indicaram que os caracóis *A. fulica* iniciam sua atividade no final da tarde e hibernam no meio da manhã. A comida preferida destes caracóis foram plantas vasculares como *Hibiscus syriacus*, *Ricinus Communis*, *Carica papaya, Galinsonga coccinea*, *Lippia alba*, *Ixora coccinea*, *Musa parasidisiaca*, *Mentha spicata* and *Cymbopogon citrates*. Nossos dados sugerem que o *A. fulica* está plenamente adaptado e estabelecido nesta cidade e, também, que ambientes modificados facilitam seu estabelecimento e dispersão. Entretanto, a perturbação humana, como a limpeza de terrenos pode ser um fator limitante para a persistência da população de *A. fulica*.

*Palavras-chave: Achatina fullica*, espécies invasoras, espécies exóticas, Caracol Gigante Africano, distribuição espacial.

## 1. Introduction

The Giant African Snail (*Achatina fulica* Bowdich, 1822) promotes substantial ecological and economic impacts in areas where it has been introduced (Rauth and Barker, 2002). This snail is one of the most destructive pests affecting subtropical and tropical areas, causing large damages to farms, commercial plantations and domestic gardens. It can also be found on trees, decaying material in decomposition and next to garbage deposits (Mead, 1995; Vansconcelos and Pile, 1999). Furthermore, *A. fulica* could be an intermediate host of *Angiostrongylus costaricencis* (Morera and Céspedes, 1971), the etiological agent of abdominal angiostrongylosis, and its dispersion could imply a possible risk of transmission of this disease (Teles et al., 1997).

*A. fulica* originated in Africa (Bequaert, 1950; Mead, 1995; Simberloff, 1995) and is currently widely distributed in Japan (Mead, 1961; Koyano et. al., 1989), the Indian Islands, Australia, Southeast Asia (AFFA, 2001; Paiva, 2001; Graeff-Teixeira et al., 1995; Shah, 1992; Godan, 1983) and in the American continent (Godan, 1983). In Brazil, the first occurrence of *A. fulica* was described in the state of São Paulo in April 1996, next to a rural school (Teles et al., 1997). Later, Paiva (2001) described that *A. fulica* was widely distributed in Brazil and has been found at the states of Amazonas, Bahia, Espirito Santo, Goiás, Maranhão, Minas Gerais, Pará, Paraíba, Paraná, Pernambuco, Piauí, Rio de Janeiro, Rondônia, Santa Catarina and São Paulo.

One of the most important factors for the establishment and dispersion of *A. fulica* is human presence (De-Winter, 1989). In general, this snail is most abundant in sites with high human density (Takeda, 1988). Another important factor that may condition *A. fulica* population dynamics, growth rate, survival and fecundity is food preference (Ahmed and Rauth, 1991). Achatinidae species are generally regarded as herbivorous, feeding primarily on vascular plants (Rauth and Barker, 2002). Previous studies support that *A. fulica* is an important agricultural plague and causes substantial environmental loss (Hodashi, 1979; Egonmwan, 1991; Otchoumou et al., 1990). However, most of these studies deal with agricultural plant species.

Physical, biological and chemical strategies have been used to eradicate and manage *A. fulica* populations (Raut and Baker, 2002). Physical control strategies were used to collect and destruct snails and their eggs (Peterson 1957, Olson 1973). Invertebrate predators of terrestrial gastropods have also been used for biological control of *A. fulica* (Griffihs et al., 1993; Simberloff and Stiling, 1996; Takeuchi, 1997). Finally, a large number of toxicants have been used against *A. fulica* (Nair et al., 1968, Raut and Ghose, 1984; Panigrahi and Raut, 1994).

It has been widely documented that *A. fulica* is well-adapted and distributed around the world. However, information about *A. fulica* feeding preferences and behavior is still scarce in Brazil. Our main purpose was to describe *A. fulica* distribution in an area where it has been recently introduced, and identify its habitat and food preferences. We also examined the effects of scrub clearance on *A. fulica* abundance. To fulfill these goals, we addressed three basic questions: 1) what is the *A. fulica* distribution in areas where they have been recently introduced? 2) what are the main aspects of their behavior and feeding? and 3) what is the effect of lot clearance on their abundance?

## 2. Material and Methods

Distribution and abundance of *Achatina fulica* were recorded in a tropical area, Lauro de Freitas City (12° 54' S and 38° 19' W), Brazil. The study area covers of 60 Km$^2$ and was divided into urban area (residential and industrial areas) and forested area. The urban area presented a population of 113,543 inhabitants (1,892.4 hab/km$^2$) (IBGE, 2000). During the study, the annual average temperature was 25.7 °C, annual mean humidity was 78.6 and the annual precipitation was 2,000 mm (SEI, 2002). The map of Lauro de Freitas was digitalized and processed using ArcGIS 9.2 in a grid and comprised 60 quadrates of 1,000 x 1,000 m (Figure 1).

We carefully searched for *A. fulica* from November 2001 until November 2002 during different periods, including rainy days, to identify and quantify the occurrence of this snail in the city. Samples were taken monthly from forest and urban areas using catch per unit effort method (CPUE/hour) to collect the snails. The mean monthly abundance was then calculated. To identify the preferred sites into the urban areas, five 1.0 x 1.0 m quadrates were randomly thrown and the density of this snail was calculated.

Territorial and feeding behavior were monitored during December 2001 and November 2002. Observations were carried out during day and night times, recording location and behavior (Iglesias and Castillejo, 1998; Hatziioannou, et al., 1994; Lorenzi and Souza, 2001). For food plant preferences, 50 snails were placed in plastic jars (50 x 25 x 15 cm), with a screw cap and a small hole to allow respiration. Detached leaves of plant species presented in the study area (*Hibiscus syriacus* L., *Ricinus communis* L., *Carica papaya* L., *Galinsonga coccinea*, *Lippia alba* (P. Mill.), *Ixora coccinea* L., *Musa parasidisiaca* L., *Mentha spicata* L. and *Cymbopogon citrates* (DC. ex Nees)) were placed into these jars and observations of feeding behavior were performed at irregular intervals (Molgaard, 1986).

To identify possible control strategies, we monitored *A. fulica* abundance during August 2002 in 20 lots (10 cleared and 10 non-cleared) of approximately 500 m$^2$, when Lauro de Freitas City Hall promoted the clearance of lots in the urban area. For this, we calculated the mean

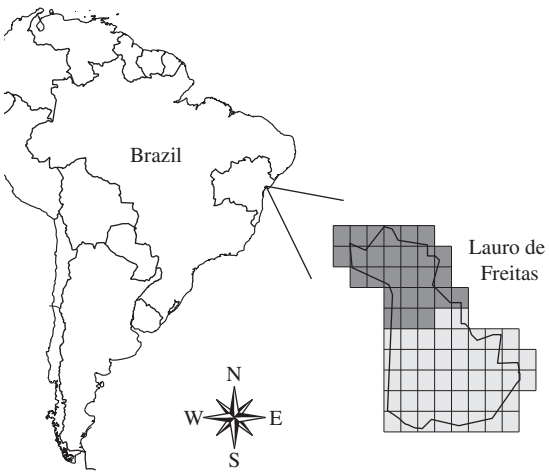


**Figure 1.** The 1,000 x 1,000 m grid covering the surface of Lauro de Freitas. Every Grid pixel is identified according to its use as urban area (dark gray) or forest area (light gray).

abundance before and after the clearance, using the catch per unit effort method. We also calculated the difference between these means, using the Student's *t*-test with a 95% confidence interval.

## 3. Results

*Achatina fulica* was mainly found in the urban area. The results show a different abundance pattern with distance from the coast line (see Figure 2). Mean monthly mean abundance value for forest and urban area is shown in Table 1.The distribution of *A. fulica* in the city showed different preferences among urban areas. High snail abundances were found outside houses. *A. fulica* was most abundant in lots. Also, 31.5% of the snails were also found inside stone walls, linear boundaries of houses and lots. As expected, only a low proportion (7.86%) was present on garden furniture and crawling on external house walls. No snails were found inside houses, although many specimens were found creeping onto windows (as shown in Table 2).

*Achatina fulica* is most active at dusk and dawn (Table 3), but on some cloudy and rainy days it was possible to observe them all day long. In general, *A. fulica* activity in Lauro de Freitas starts around 06:00 PM and the mean time for ceasing activities is 08:00 AM.

We found differences in food preferences. The preferred food were vascular plants such as *Hibiscus syriacus*, *Ricinus communis*, *Carica papaya, Galinsonga coccinea*, *Lippia alba*, *Ixora coccinea*, *Musa parasidisiaca*, *Mentha spicata* L and *Cymbopogon citrates*. Despite preferring herbaceous vegetation, we found saprophytic habits. *A. fulica* was found feeding on horse and bull feces.

We calculated the mean August abundance of *A. fulica* after and before the lot clearances. We noted that before clearance, abundance was 1,274 and at the end of the month, it was 378 snails. The mean snail abundance in non-cleared (3.2) and cleared lots (34.6) were significantly different with $P < 0.001$ (Figure 3).

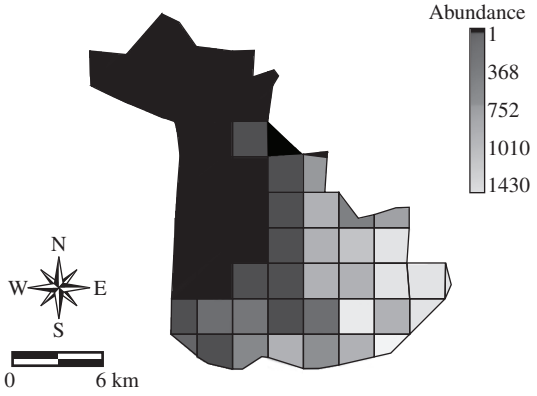


**Figure 2.** A map of mean abundance of *Achatina fulica* per 1,000 x 1,000 m in Lauro de Freitas during the sampling.

**Table 1.** Abundance of *Achatina fulica* in Forest and Urban areas of Lauro de Freitas from November (2001) until November (2002).

| Months | Abundance | |
|---|---|---|
| | Forest area | Urban area |
| November | 12 | 1309 |
| December | 4 | 758 |
| January | 1 | 104 |
| February | 0 | 0 |
| March | 3 | 839 |
| April | 7 | 1014 |
| May | 6 | 1194 |
| June | 6 | 796 |
| July | 13 | 1274 |
| August | 5 | 378 |
| September | 2 | 744 |
| October | 1 | 0 |
| November | 0 | 60 |

**Table 2.** Distribution, density and relative frequencies of *Achatina fulica* in urban sites in Lauro de Freitas city.

| Sites | Density/ $m^2$ | Relative Frequency % |
|---|---|---|
| Lots | 8 | 50.80 |
| Garden | 5 | 31.80 |
| Plazas | 0.20 | 1.27 |
| Roads | 0.06 | 0.38 |
| Stone walls | 1.23 | 7.81 |
| External house walls | 0.45 | 2.84 |
| Garden furniture | 0.80 | 5.10 |

**Table 3.** Activity of *Achatina fulica* in Lauro de Freitas City. Data is represented by the start time of the activity of *A. fulica* such the last hour that this snail was found crawling elsewhere. During February and October, no snails were found in the field.

| Month | *Achatina fulica* Activity | |
|---|---|---|
| | Start | End |
| November | 05:45 PM | 12:10 AM |
| December | 05:50 PM | 06:45 AM |
| January | 07:00 PM | 06:27 AM |
| February | - | - |
| March | 05:50 PM | 07:51 AM |
| April | 06:00 PM | 08:00 AM |
| May | 05:43 PM | 08:15 AM |
| June | 05:55 PM | 10:35 AM |
| July | 06:00 PM | 06:50 AM |
| August | 05:41 PM | 06:56 AM |
| September | 05:30 PM | 07:30 AM |
| October | - | - |
| November | 05:00 PM | 06:45 AM |
| Mean | 06:01 PM | 08:00 AM |

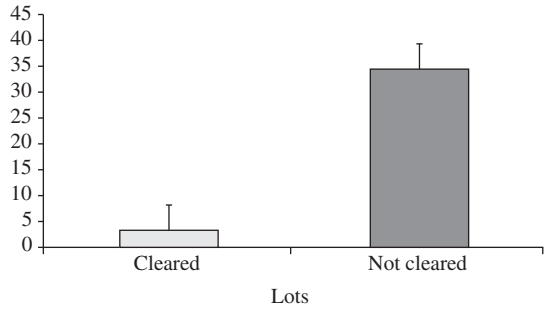


**Figure 3.** Abundance of *Achatina fulica* during August 2002. Data is represented by the abundance in cleared (dark gray) and uncleared (light gray) lots in the urban areas.

## 4. Discussion

The data suggest that *Achatina fulica* is well-adapted and widely distributed in Lauro de Freitas City, and its population density was highest in the urban areas. Because of its low potential for active dispersal, Giant African Snail occupation is restricted to a few areas, but they can reach high densities (Aoki, 1978; De Winter, 1989; Takeuchi et al., 1991; Tomiyama, 1992). However, locally, this snail has a great potential to extend its distribution beyond the colonized area (Frankiel, 1989; Schotmamm, 1990). This pattern has also been observed in Rio de Janeiro (Brazil), around residential houses (Vasconcelos and Pile, 2001). In general, there is a tendency for this species to thrive in the presence of man, especially in urban sites (Barquet, 1950; Wolfenbarger, 1971; Takeuchi et al., 1991) and farms (Ahmed and Raut, 1991). Results show large fluctuations in snail population during September and November 2002. During August 2002 a notable decrease of this snail abundance was found. Also, there was a significant difference between cleared and uncleared lots. This may be a response to scrub clearance in lots. Such human perturbation can be a limiting factor for snail population growth. Similar oscillations in density due to human perturbation were found in Africa (Duah and Monney, 1999).

Another important aspect of the management of *A. fulica* pests is its cost. The cost of the eradication of *A. fulica* can be very expensive. In the USA, the elimination of this pest represented a very expensive process, varying from US$ 60,000 to US$ 700,000 (Muniappan 1987, Smith and Fowler 2003). According to Lauro de Freitas City Hall, lot clearance cost is around US$ 3,300 per month. Consequently, we believe that lot clearance could be a good solution to eradicate *A. fulica* invasion in areas where its relative abundance was greater in lots, squares and streets.

Our results showed that *A. fulica* was most active from the beginning of the evening until the mid-morning. This result is similar to those obtained by Raut (1984) and Raut and Baker (2002). They found that *A. fulica* is a nocturnal snail and during the daytime it is quiescent and its activity begins at the end of the evening. Other important factors that affect the circadian cycle of these snails are sunlight and their physiological conditions (Takeda, 1986).

The feeding of *A. fulica* is dependent on plant community composition (Waterhouse and Noris, 1987), and varies according to quality and quantity (Rauth and Barker, 2002). Some studies suggest that this snail may be a generalist (Vinci et al., 1988). Similar feeding behavior was found in Lauro de Freitas, in that *A. fulica* fed on species such as *Hibiscus spp.*, *Hemigraphis colorata* (Blume), *Cymbopogon citratus*, *Carica papaya*, *Mentha* spp. The location of food by *A. fulica* is powered by its sense of smell, being mainly attracted to garden crops (Farkas and Shorey, 1976; Gallois and Daguzan, 1989) and *Urtica dióica* L., a species typically used as refuge needs (Grimes and Blyte, 1969). We also found *A. fulica* feeding on bull feces. Many infections are spread by fresh water and terrestrial snails (Teles et al., 1997; Carvalho et al., 2003). Bearing in mind that this snail presents a possible public health risk regarding the spread of diseases, and even though we quantify the risk represented by its saprophytic habit, we believe that *A. fulica* could represent a threat to human health and its population must be controlled or eradicated. We also believe that further studies are still necessary to measure the degree of risk posed by *A. fulica*.

To conclude, although this species is a recent introduction to Brazil, and particularly in Lauro de Freitas City, *A. fulica* has become established successfully in this area because it presents favorable conditions. Our results suggest that human action could be an important population regulator, by influencing local distribution, or by increasing or decreasing its abundance. We believe that scrub clearance may represent a good and inexpensive solution to eradicate this pest on a small scale.

## References

AHMED, M. and RAUT, SK., 1991. Influence of temperature on the growth of the pestiferous land snail *Achatina fulica* (Gastropoda: Achatinidae). *Walkerana,* vol. 5, no. 3, p. 33-62.

AFFA, 2001. *Giant African Snail – Agriculture, Fisheries and Forestry*. Australia. (Fact Sheet no. 03).

AOKI, J., 1978. Investigation on soil fauna on the Bonin Islands. II Ecological Distribution of the Agate Snail, *Achatina fulica,* and some possibilities of its ecological control. *Edaphologia,* vol. 18, no. 1, p. 21-29.

BEQUAERT, JC., 1950. Studies on the achatinidae, a group of African Land Snail. Bulleting of the Museum of Comparative Zoology. *Bull Mus Comp Zool. Havard,* vol. 105, p. 1-216.

CARVALHO, OS., TELES, HMS., MOTA, EM., MENDONÇA, CLGF., LENZI, HL., 2003. Potentiality of *Achatina fulica* Bowdich, 1822 (Mollusca: Gastropoda) as intermediate host of the *Angiostrongylus costaricensis* Morera and Céspedes 1971. *Rev. Soc. Bras. Med. Trop.,* vol. 36, no. 6, p. 743-745.

De WINTER, AJ., 1989. New records of *Achatina fulica* Bowdich from the Côte d'Ivoire. *Basteria,* vol. 53, p. 71-72.

DUAH, AO. and MONNEY, KA., 1999. Population density and feeding ecology of the giant African Snail *Achatina achatina. Afr. j. ecol*., vol. 37, no.3, p. 366-368.

EGONMAWAN, RI., 1991. Food selection in the land Snail *Limicolaria flammea* Muller (Pulmonata: Achatinidae). *J. molluscan stud,* vol. 58, no. 1, p. 49-55.

FARKAS, SR. and SHOREY, HH., 1976. Anemotaxis and odourtrail foolowing by the rerrestrial snail, *Helix aspersa* Müller. *Anim Behav*, vol. 24, no.2, p. 686-689.

FRANKIEL, L., 1989. The Achatines in the Antilles. France. Circular. In GALLOIS, L and DAGUZAN, J. Recherches écophysiologiques sur le régime alimentaire de l'escargot petit-gris (*Helix aspersa* Müller) (Mollusque Gasteropode Pulmoné Stylommatophore). *Haliotis,* vol. 19, p. 77-86.

GODAN, D., 1983. *Pest Slugs and Snail.* Berlin: Springer-Verlag. 445 p.

GRAEFF-TEIXEIRA, C., THOMÉ, JW., PINTO, SCC., CAMILLO-COURA, L. and LENZI, HL., 1995. *Phylocaullis variegatus* - an intermediate host of *Angiostrongylus costaricensis* in South Brazil. *Mem. Inst. Oswaldo Cruz,* vol. 90, no. 3, p. 707-709.

GRIFFITHS, O., COOK, A. and WELLS, SM., 1993. The diet of introduced carnivorous snail *Euglandina rosea* in Mauritius and its implication for threatened island gastropod faunas. *J. zool.*, vol. 229, no. 1, p. 79-89.

GRIMES, JP. and BLYTE, GM., 1969. An investigation of the relationships between snails and vegetation at the winnats pass. *J. ecol*., vol. 57, no. 1, p. 45-66.

HATZIIOANNOU, H., ELEUTHERIADIS, N. and LAZARIDOU0DIM ITRIADOU, M. 1994. Food preferences of dietary overlap by terrestrial snail in Logos area (Edessa, Macedonia, Northern Greece). *J. molluscan stud*, vol. 60, no. 3, p. 331-341.

HODASI, JKM., 1979. Life history studies of *Achatina Achatina. J. molluscan stud,* vol. 45, no. 3, p. 328-339.

IBGE, 2000. *Base de informações municipais*. 2 ed. Brasília.

IGLESIAS, J, CASTILLEJO, J., 1998. Field observation on feeding of land snail *Helix apersa* Muller. *J. molluscan stud*, vol. 64, no. 4, p. 411-423.

KOYANO, S., NUMAZAWA, K. and TAKEUCHI, K., 1989. Ecology of Giant African Snail in Japan. *Plant Protection (Shokubutsu Boeki)*, vol. 43, no. 3, p. 53-56.

LORENZI, H. and SOUZA, HM., 2001. *Plantas ornamentais do Brasil*: arbustivas, herbáceas e trepadeiras. 3 ed. Instituto Platarum.1088 p.

MUNIAPPAN, R., 1987. Biological control of giant African Snail, *Achatina fulica* Bowdich, in Maldives. *FAO plant prot. bull.,* vol. 35, no. 4, p. 127-133.

MEAD, AR., 1961. *The Giant African Snail:* a problem in Economic Malacology. Chicago, USA: The University Chicago Press.

-, 1995. Anatomy, phylogeny and zoogeography in African Land Snail family Achatinidae. In *Proceedings of the 12th International Malacological Congress*, Vigo, Spain. p. 422-423.

MOLGAARD, P., 1986. Food preferences by Slugs and Snails: A simple method to evaluate the relative palatability of the food plants. Great Britain. *Biochem Syst Ecol*, vol. 14, no. 1, p. 113-121.

NAIR, MRGK., DAS, NM. and JACOB, A., 1968. Use of metaldehyde as duts and sprays to control the giant African snail Achatina fulica Bowdich. *Indian j. entomol,* vol. 30, no. 2, p. 58- 60.

OLSON, FJ., 1973. *The screening of candidate molluscicides against the giant African snail, Achatina fulica Bowdich (Stylommatophora: Achatinidae).* Hawaii: University of Hawaii. [Thesis].

OTCHOUMOU, A., ZONGO D. and DOSSO H., 1990. Contribution a l´estude de l´escargot géant *Achatina Achatina* (Linné). *Annales d'Ecologie*, vol. 21, p. 31-58.

PAIVA, CL., 2001. *Achatina fulica (Moluscos) nova praga agrícola e ameaça à saúde pública no Brasil.* Campinas: Centro de Memória da UNICAMP (GEHT/CMU).

PANIGRAHI, A., RAUT, SK., 1994. Thevetia peruviana (Family; Apocynaceae) in the control of slug and snail pests. *Mem. Inst. Oswaldo Cruz*, vol. 89, no. 2, p. 247-250.

PETERSON, GD, 1957. Studies on control of the giant African snail on Guam. *Hilgardia,* vol. 26, no. 16, p. 643-658.

RAUT, SG. and GOSHE, KC., 1984. *Pestiferous land snails of India*. Zoological Survey of India N° 11. Calcuta: Bani Press. 151 p.

RAUTH, SK. and BARKER, GM., 2002. *Achatina fulica Bowdich and other achatinidae as a pest in tropicultural agriculture. Mollusks as Crop Pest.* New Zealand: Ed. By Landscare Research Hamilton. 472 p.

SCHOTMAMM, CYL., 1990. *Circular Letter* Port-of-Spain, Trinidad and Tobago: FAO Caribbean plant Commission PL.

SEI, 2002. *Estatísticas dos Municípios Baianos.* Bahia: Governo do Estado da Bahia. n° 06, p. 31-50.

SHAH, NK., 1992. Management of the Giant African Snail. *Indian Farming*, vol. 21, no. 5, p. 41.

SIMBERLOFF, D., 1995. Why introduced species appear to devaste islands more the mainland areas. Pas. sci., vol. 49, no. 1, p. 87-97.

SIMBERLOFF, D. and STILING, P., 1996. Risks of species introduced for biological control. *Biol. Conserv,* vol. 78, no. 2, p. 185-192.

SMITH, JW. and FOWLER, G., 2003. *Pathway Risk Assessment for Achatinidae with emphasis on the Giant African Land Snail Achatina fulica (Bowdich) and Limicolaria aurora (Jay) from the Caribbean and Brazil, with comments on related taxa Achatina achatina (Linne), and Archachatina marginata (Swainson) intercepted by PPQ.* Raleigh, NC.: USDA-APHIS, Center for Plant Health Science and Technology (Internal Report).

TAKEDA, N. and HIROSHI, T., 1988. Distribution and abundance of the Giant African Snail *Achatina fulica* (Fèrrusac) (Pulmonata: Achatnidae), in two islands, Chichijima e Hahajima, of the Ogasawara Islands. *Jpn. J. Appl. Entomol. Zool,* vol. 32, no. 4, p. 176-178.

TAKEUCHI, K., KOYANO, S. and NUMAZAWA, K., 1991. Occurrence of the Giant African Snail in Ogasawara Islands, Japan. *Micronesica*, vol. 3, p. 109-116.

TELES, HMS., VAZ, JS., FONTES, LR. and DOMINGOS, FM., 1997. Registro de *Achatina fulica* (Mollusca: Gastropoda) no Brazil: caramujo hospedeiro intermediário da Angiostrongilíase. *Rev. saude publica,* vol. 31, no. 3, p. 310-312.

TOMIYAMA, K. 1992. Homing Behavior of the giant African snail, *Achatina fulica* Fèrrusac (Gastopoda: Pulmonata). *Journal of Ethology,* vol. 10, no. 2, p. 139-147.

VASCONCELOS, MC. and PILE, E., 2001. Ocorrência de *Achatina fulica* no Vale do Paraíba, Estado do Rio de Janeiro, Brasil. *Rev. saude publica,* vol. 35, no. 6, p. 582-584.

VINCI, GK., UNNITHAN, VK. and SUGUNAN, VV., 1988. Farming of the Giant African Snail, *Achatina fulica*. *Central Inland Capture Fisheries Research Institute*, vol. 56, no. 1, p. 1-24.

WATERHOUSE, DF. and NORIS, KR., 1987. *Achatina fulica* Bowdich, Mollusca: Achatinidae. Giant African Snail. In WATERHOUSE, DF. and NORIS, KR. (Eds.). *Biological Control – Pacific Prospects*. Melbourne: Inkata Press. p. 265-273.

WOLFENBARGER, DO., 1971. Dispersion of the Giant African Snail, *Achatina fulica*. Quarterly Journal of the Florida Academy Sciences, vol. 34, no. 1, p. 48-52.