Eder Carvalho da Silva

# Aspectos da Dinâmica Populacional e Biologia Reprodutiva de *Achatina fulica* Bowdich, 1822 (Mollusca, Gastropoda) na Cidade de Salvador - Bahia.

Salvador

2008

Eder Carvalho da Silva

# Aspectos da Dinâmica Populacional e Biologia Reprodutiva de *Achatina fulica* Bowdich, 1822 (Mollusca, Gastropoda) na Cidade de Salvador - Bahia

Dissertação apresentada ao Instituto de Biologia da Universidade Federal da Bahia, para a obtenção de Título de Mestre em Ecologia e Biomonitoramento.

Orientador(a): Elianne Pessoa Omena

Salvador

2008

PROGRAMA DE PÓS-GRADUAÇÃO EM ECOLOGIA E BIOMONITORAMENTO
UNIVERSIDADE FEDERAL DA BAHIA – INSTITUTO DE BIOLOGIA

ECOBIO

# COMISSÃO EXAMINADORA

Título da Dissertação: **"Dinâmica Populacional e Biologia Reprodutiva de Achatina fulica Bowdich, 1822 (Mollusca, Gastropoda) na Cidade de Salvador-Bahia"**

Mestrando: ***Éder Carvalho da Silva***

Orientadora: Dra. Elianne Pessoa Omena

Membro: Dra. Elianne Pessoa Omena
Instituição: Universidade Federal do Rio de Janeiro

Membro: Dra. Silvana Aparecida Rogel Carvalho Thiengo
Instituição: Fundação Oswaldo Cruz

Membro: Dr. Francisco Carlos Rocha de Barros Júnior
Instituição: Universidade Federal da Bahia

**HOMOLOGADA EM / / 200 .**

Biblioteca Central Reitor Macêdo Costa - UFBA

S586 Silva, Eder Carvalho da.
Aspectos da dinâmica populacional e biologia reprodutiva de *Achatina fulica* Bowdich, 1822 (Mollusca, Gastropoda) na cidade de Salvador - Bahia / Eder Carvalho da Silva. - 2008.
72 p. : il.

Inclui apêndice e anexos.
Orientadora : Elianne Pessoa Omena.
Dissertação (mestrado) - Universidade Federal da Bahia, Instituto de Biologia, 2008.

1. Molusco. 2. Molusco - Reprodução (Salvador - BA). 3. Molusco - Fatores climáticos. 4. Glândulas. I. Omena, Elianne Pessoa. II. Universidade Federal da Bahia. Instituto de Biologia. III.Título.

CDD - 594.3
CDU - 594.3

# Agradecimentos

A minha orientadora Prof. Dra. Elianne Pessoa Omena que acompanhou todo o desenvolvimento do trabalho sempre disposta a tirar dúvidas e fazer correções;

A Universidade Católica do Salvador - UCSal que cedeu o espaço físico de seus laboratórios para realização das análises, especialmente a Nelma e Luciano;

Ao Programa de Pós-Graduação em Ecologia e Biomonitoramento da Universidade Federal da Bahia pelo acolhimento durante o tempo de desenvolvimento do trabalho e pelos ensinamentos dados por todos seus professores.

A minhas “estagiárias” Jamile Aquino, Maira Andrade e minha noiva Daniele Silveira que se dispuseram a acordar cedo e me acompanhar nas coletas;

Ao Prof. Dr. Francisco Barros pelas dicas estatísticas;

A todos os colegas de mestrado por todas as revisões e correções deste trabalho.

A todos os anônimos que me auxiliaram durante as coletas, indicando os locais onde os caramujos eram mais freqüentemente encontrados, quando podia encontrá-los com mais facilidade, etc.

# Sumário

# Introdução Geral

A extinção de espécies e sua substituição por outras é um fenômeno normal. Uma estimativa admite que o ritmo de extinção foi, em média, de uma espécie por ano ao longo dos tempos. Porém, atualmente, 100 espécies, talvez 1000, desapareçam diariamente, isso se deve, com exceção de alguns casos, as ações nefastas do homem, seja direta, pela caça, ou indireta, pela destruição de habitat e introdução de espécies exóticas, por exemplo (DAJOZ, 2005).

A distribuição de muitas espécies é limitada por barreiras climáticas e geográficas à sua dispersão, por este motivo os padrões de evolução têm ocorrido de modo diverso em diferentes áreas do mundo (PRIMACK & RODRIGUES, 2001). Porém o homem rapidamente alterou esse padrão transportando espécies intencionalmente ou não (DAJOZ, 2005; TOWSEND *ET AL*, 2006).

Este processo de estabelecimento de espécies animais ou vegetais, vindas de outras regiões em ecossistemas naturais ou manejados pelo homem, e seu posterior alastramento, de forma que passam a dominar o ambiente e a causar danos às espécies originais e ao próprio funcionamento dos ecossistemas é chamado invasões biológicas (ou bioinvasão) (NISC, 2001). Segundo RICKLEFS (2003) durante os últimos 200 anos, a América do Norte foi invadida por mais de 70 espécies de  peixes, 80 de moluscos, 2000 de plantas e 2000 de insetos.

Apesar da grande maioria das espécies exóticas não se estabelecerem nos lugares onde foram introduzidas, uma porcentagem consegue se instalar e muitas delas crescem em abundância as custas das espécies nativas (PRIMACK & RODRIGUES, 2001; DAJOZ, 2005; TOWSEND *ET AL*, 2006). Desta forma, a introdução de espécies exóticas e invasoras é considerada a segunda maior causa de perda de diversidade biológica (USC, 2001; ALOWE *ET AL*, 2004; FISCHER & COLLEY, 2004).

Segundo TELES *ET AL* (2004), o caramujo *Achatina fulica* (BOWDICH, 1822) é uma espécie conhecida pelo seu alto potencial invasor constando como uma das 100 piores espécies da Lista da União para Conservação da Natureza (IUCN).

Originário do continente africano, desde a Abissínia (Etiópia) até Moçambique. Seu primeiro registro fora da África data de 1803 na ilha Maurícia, em seguida em 1821 nas ilhas Reunião, cujo governador havia importado de Madagascar e criava em seu jardim, pois sua esposa apreciava sopa de caramujos, que, segundo se dizia, curava tuberculose. Em 1847, o malacologista W. B. Benson transportou a espécie da ilha Maurícia para a Índia, onde a soltou no jardim da Bengal Asiatic Society. Em seguida se espalhou por várias regiões tropicais do velho mundo (DORST, 1973) (ver Anexo Figura A1).

A introdução desta espécie na América iniciou-se pelo Havaí, por volta de 1936, tendo alcançado a Califórnia no fim da Segunda Guerra Mundial (provavelmente aderidos aos veículos militares repatriados do Pacífico depois da guerra); foi registrada na Flórida no inicio da década de 70 (DORST, 1973; TELES *ET AL*, 1997).

No Brasil a introdução desse molusco ocorreu após uma exposição na cidade de Curitiba-PR e incentivo ao cultivo e comércio de “escargots” para alimentação exótica em restaurantes (TELES *ET AL*, 2004). Seus primeiros registros no país foram descritos em meados de 1988 na cidade de Itariri, estado de São Paulo (TELES *ET AL*, 1997), porém atualmente se encontram animais em vida livre em 23 estados

(Vasconcellos & Pile, 2001; Teles *et al*, 2004) tanto em áreas antrópicas quanto em ambientes naturais, principalmente nas bordas de florestas (até 500m) (Simião & Fischer, 2004; Fischer & Colley, 2005; Thiengo *et al*, 2007). A instalação da espécie exótica invasora no ambiente antrópico e posterior ocupação de áreas nativas, sugere o início de uma saturação da população de *A. fulica* em áreas urbanas, fato preocupante, uma vez que os riscos de impactos ambientais se acentuam e dificultam as ações de controle (Fischer *et al*, 2006). A invasão de *A. fulica* já foi reportado, inclusive, em Unidades de Conservação como a Reserva Biológica do Poço das Antas, estado do Rio de Janeiro, o Parque Nacional da Chapada dos Guimarães estado do Mato Grosso, Parque Estadual Carlos Botelho, estado de São Paulo e a Área de Proteção Ambiental de Guaraqueçaba, estado do Paraná (Fischer & Colley, 2004; Eston *et al*, 2006; Thiengo *et al*, 2007).

Na Bahia o caramujo *A. fulica* já foi registrado em onze cidades (dados baseados em observações dos membros dos Conquiliologistas do Brasil e publicações científicas): Canavieiras, Caravelas, Eunápolis, Ilhéus, Itacaré, Itaparica, Lauro de Freitas, Morro de São Paulo (Gamboa), Paulo Afonso, Porto Seguro, Simões Filho e Salvador (Paiva, 2001; Albuquerque, 2003; Silva, Obs. Pess).

Conhecido como Caramujo Gigante Africano, alcança dimensões consideráveis, em torno de 20 cm de comprimento de concha e chega a pesar 200g (Teles *et al*, 1997; Vasconcellos & Pile 2001), porém no Brasil os registros máximos médios variam em torno de 11 cm e pouco mais de 100 g (Vasconcellos & Pile, 2001; Albuquerque, 2003; Carvalho *et al*, 2003; Simião & Fischer, 2004; Fischer & Colley, 2005; Fischer *et al*, 2006). O sucesso da espécie está relacionado com seu habito generalista, elevado potencial reprodutivo e alta resistência a variáveis ambientais (RAUT & BARKER, 2002).

O potencial reprodutivo é favorecido por se tratar de espécie hermafrodita protândrica com cópula recíproca no qual os caramujos jovens produzem apenas esperma e os adultos mais velhos produzem esperma e óvulos (TOMIYAMA, 1993). A sua estratégia reprodutiva inclui a capacidade de armazenamento de esperma, a longo prazo (cerca de 350 dias) e posterior produção ovos (RAUT & BARKER, 2002). Um animal adulto realiza em média 5 a 6 oviposições por ano, podendo depositar até 400 ovos por postura (TOMIYAMA & MIYASHITA, 1992). A maturidade é alcançada com idade de 4 à 8 meses e o caramujo apresenta uma longevidade de três a cinco anos (TOMIYAMA, 1993; RAUT & BARKER, 2002). Em apenas três anos um só caramujo gera uma descendência de 8 bilhões de indivíduos (DORST, 1973)

Esses animais apresentam uma alta adaptação e resistência a fatores abióticos como temperatura e umidade provavelmente por terem evoluído em borda de florestas, ambiente sujeito a grande variações ambientais (RAUT & GHOSE, 1981), o que lhe confere uma vantagem competitiva com caramujos de tamanhos similares. RAUT & BARKER (2002) confirmam o impacto ambiental sobre a fauna e flora endêmica causado pela invasão deste molusco em diferentes localidades. Nas ilhas Havaianas houve rápida diminuição da diversidade da fauna nativa de caramujos após a introdução de *A. fulica* e outros caramujos exóticos (COWIE, 1995; COWIE, 2001), fato semelhante ocorreu na Ilha de Ogasawara (OHBAYASHI *et al*, 2007).

Segundo a USDA - United States Department of Agriculture - (1966), os problemas reais e os riscos potenciais representados pela espécie exótica *A. fulica* no Brasil tem implicações além do meio ambiente, estendendo-se à agricultura e a saúde.

Herbívora generalista, pode se alimentar de, pelo menos, 500 espécies de plantas de culturas agrícolas de interesse comercial (TELES *ET AL*, 2004) como banana (*Musa*), feijão (*Beta vulgaris*), calêndula (*Tagetes patula*), repolho e couve-flor (*Brassica oleracea v. capitata e Brassica oleracea v. botrytis*), dedo de Senhora (*Abelmoschus esculentus*), cabaço de esponja (*Luffa cylindrica*), abóbora (*Cucurbita pepo*), mamão (*Carica papaya*), pepino (*Cucumis sativus*) e ervilhas (*Pisum sativum*) (VENETTE & LARSON, 2004). Desta forma, nos inúmeros países em que se estabeleceu, *A. fulica* promoveu a devastação de plantações e lavouras comerciais, bem como a destruição de grãos armazenados, além de hortas e jardins em áreas domiciliares (TELES *ET AL*, 1997; VASCONCELLOS & PILE, 2001), tornando-se um sério problema a agricultura local e um transtorno a população. RAO & SINGH (2000) caracterizam a espécie como peste agri-horticultural em quase toda a Índia Oriental, causando danos pesados a colheitas de legumes.

Além disso, a ocorrência de *A. fulica* em vida livre é importante por se tratar de uma espécie envolvida na transmissão de nematódeos como *Angiostrongylus cantonensis* (CHEN, 1935) e *Angiostrongylus costaricensis* (MORERA e CÉSPEDES, 1971). Apesar de alguns experimentos em laboratório mostrarem uma baixa suscetibilidade de *A. fulica* a infecção destes nematódeos (CARVALHO *ET AL,* 2003; NEUHAUSS, 2007) já há casos de transmissão associados a este caramujo (THIENGO *ET AL,* 2007; CALDEIRA *ET AL*, 2007; GRAEFF-TEIXEIRA, 2007).

Os roedores são os seus hospedeiros definitivos, porém a infecção humana causa sérios problemas à saúde pública como: meningite eosinofílica, causada por

*A. cantonensis* e angiostrongilíase abdominal, por *A. costaricensis* (CALDEIRA *ET AL*, 2003; CALDEIRA *ET AL*, 2007; GRAEFF-TEIXEIRA, 2007).

Em *A. cantonensis*, a infecção ocorre após o hospedeiro definitivo ingerir as larvas de terceiro estágio (L3) deixadas nos locais por meio de muco produzido pelo molusco (VASCONCELLOS & PILE, 2001). No homem, as larvas L3 migram para o cérebro onde se desenvolvem em adultos e depois de algum tempo morrem causando uma série de problemas ao sistema nervoso (MALEK, 1985; CALDEIRA *ET AL*, 2007). O *A. costaricensis* tem ciclo semelhante ao do *A. cantonensis* a diferença está no fato de que os adultos (medem de 20 a 32 mm) são encontrados nas arteríolas ileocecal do hospedeiro definitivo (MALEK, 1985; CALDEIRA *ET AL*, 2007). Em ambos os casos as crianças são as mais atingidas (TELES *ET AL*, 2004).

Até pouco tempo não existiam casos registrados de meningite eosinofílica no Brasil, porém CALDEIRA *ET AL* (2007) identificou três casos da doença no estado do Espírito Santo. Já a angiostrongilíase abdominal é uma doença grave com centenas de casos já reportados, sendo encontrados registros nos estados do Paraná, Rio Grande do Sul, Santa Catarina, São Paulo e no Distrito Federal (TELES *ET AL*, 1997; GRAEFF-TEIXEIRA, 1998; BENDER *ET AL*, 2003; SILVA *ET AL*, 2003; CALDEIRA *ET AL*, 2007).

Além de riscos a saúde humana *A. fulica* também está envolvido na transmissão de outras zoonoses. Buscando estágios larvais de *A. cantonensis* e *A. costaricensis* pesquisadores do laboratório de Malacologia do Instituto Oswaldo Cruz/Fiocruz encontraram larvas de outros nematódeos de importância veterinária como o *Aelurostrongylus abstrusus*, parasita de felinos, cães, primatas e texugos, indicando também o seu potencial como hospedeiro intermediário de outros helmintos (nematóides e Trematoda: Digenea) (THIENGO *ET AL*, 2007).

Diante desta situação, a elevada população do molusco africano tem despertado a atenção dos cientistas, da sociedade e das autoridades (FISCHER & COLLEY, 2005). Campanhas de controle devem ser iniciadas na cidade de Salvador com o intuito de evitar possíveis problemas causados pelo caramujo. Assim faz-se necessário uma pesquisa a respeito da dinâmica populacional desta espécie, possibilitando uma melhor estratégia de controle.

Este trabalho tem por objetivo apresentar dados sobre a dinâmica populacional de *A. fulica* na cidade de Salvador, levando em consideração aspectos reprodutivos que poderiam conduzir a campanhas de controle mais eficientes.

# ASPECTS OF POPULATION DYNAMICS AND REPRODUCTIVE BIOLOGY OF *ACHATINA FULICA* BOWDICH, 1822 (MOLLUSCA, GASTROPODA) IN THE CITY OF SALVADOR, BAHIA, BRAZIL.

Eder Carvalho da SILVA[1] & Elianne Pessoa OMENA[2]

1. Integrated Nucleus of Studies in Zoology. Institute of Biological Science of the Catholic University of Salvador. Av. Prof. Pinto de Aguiar, 2589. 41.740-090. Salvador, Bahia, Brazil. E-mail: edercarvalho514@oi.com.br. Telephone: (+55) 71 32857706

2. Department of Sea Biology, Institute of Biology of the Federal University of Rio de Janeiro. Av. Carlos Chagas Filho, 373. Block G. Cidade Universitária. 21.941-902. Rio de Janeiro, Rio de Janeiro, Brazil. E-mail: elianne.omena@yahoo.com.br

ASPECTS OF POPULATION DYNAMICS AND REPRODUCTIVE BIOLOGY OF *ACHATINA FULICA* BOWDICH, 1822 (MOLLUSCA, GASTROPODA) IN THE CITY OF SALVADOR, BAHIA, BRAZIL.

ABSTRACT

The risks of the introduction an invasion species are uncalculated and bigger. Consisting as one of the a hundred species with biggest invade potential, *Achatina fulica* stand out from others pulmonary land snail, especially, because your highest reproductive potential that accelerates the dispersion process increasing the damage related to health, economics and environment. With the objective of investigating the relationship of the african snail with the environment, was made a study by aspects of population dynamics and reproductive biology in the city of Salvador. The experiment consisted of the monthly manual collection of the snail, morfometric analysis in field and laboratory analysis later (reproductive system). The results showed there to be a yearly cycle for *A. fulica* with the period of recruitment at the end of the rainy season and in the dry season, growth in height of the shell and the increase of the sexual activity in the rainy season. In spite of the preference for the rainy station, was found snails in the top of sexual activity for whole period of study. Moreover, it was notice that there is a relationship between the peristome thickness and sexual development, with the increase of this structure as the individual reach the sexual maturity but this relationship isn't precisely and it should be adjust for each area. The eradication becomes impossible because of the invasion levels founded in Salvador, it's recommended the control of the specie, even it can be in a continue way, it should be intensified in rainy periods.

**Key-words:** *A. fulica*, African snail, reproduction, climate factors, protein gland.

# INTRODUCTION

The introduction of one species in a new habitat consist a risk of the environment and economic; free predators, parasites and natural competitors and, in a good environment conditions, these organisms can reach high density populations. One time established, they are rarely eliminated and bringing lost to the local biodiversity (Carlton, 1996; Dajoz, 2005; Towsend et al, 2006). The introduction of invasion species is consider the second biggest cause of the lost of biology diversity in a lot of ecosystem, and can cause change in your structure and function, increasing the biology homogeneous (USC, 2001; Alowe et al, 2004; Fischer and Colley, 2004).

Know as gigantic african snail, the pulmonary land snail *Achatina fulica* (BOWDICH, 1822) reach considerer dimensions, 20cm of length of the shell and reach 200g weigh (Teles et al, 1997; Vasconcellos and Pile, 2001) but in Brazil the maximum middle record change 11cm of length and a little more than 100g of weight (Vasconcellos and Pile, 2001; Carvalho, et al, 2003; Simião and Fischer, 2004; Fischer and Colley, 2005; Fischer et al, 2006).

The specie show off from others pulmonary mollusks because of your higher potential invader (Teles et al, 2004). There is one character that made him on of 100 species with higher potential invader from the World Conservation Union (IUCN) (Alowe et al, 2004), it's your high capacity of reproduction favored because it is a hermaphrodite species with mutual coupling (Tomiyama, 1993), capable of stock sperm for long periods (Raut and Barker, 2002), having one higher number of annual eggs position (5 to 6) and eggs lay (Tomiyama and Miyashita, 1992). In some way, development on the process of grows up and population explosion with succession problems results for the environment, economics and local healthy.

Complex in your morphology and physiology, the reproductive system of *A. fulica* is form by a set of male organs like prostate gland, ducts deferens, penis and the dart sac; female organs, albumin gland (or protein gland), womb, oviduct, sperm theca (bursa copulatrix) and vagina; beyond hermaphrodite organs like ovotestis (hermaphroditic gland), hermaphroditic duct, fecundate complex and atrium (genital pore) (Wanvipa et al, 1989 apud Teixeira et al,2006; Caetano, 2005; Tomiyama, 1993, 2002; Fischer and Colley, 2005).

Studies on the state of Paraná were made by Fischer and Colley (2005) took a supposition that *A. fulica* display seasonal cycle with one or two generations for yearly and with coupling happening in the spring and autumn. The seasonally evidence of *A. fulica* was registered by many authors too (Berry and Chan, 1968; Lai et al., 1982; Raut and Barker, 2002; Fischer and Colley, 2005) that have be show high sexual activity connect environment suitable condition like higher air humidity, mild temperature and plentiful rains.

The higher populations of african mollusk have awaking attention of the scientists, the society and authorities that seen in the exotic specie one potential of predator and competitor of native mollusks, decreasing your populations and provoke species extinction; agriculture plague and possible middle host of nematodes that can provoke eosinophillic meningoencephalitis and abdominal angiostrongiliasis in humans, and others zoonosis in domestic animals (Cowie, 1998; Cowie, 2001; Fischer and

Colley, 2005; Thiengo et al, 2007; Caldeira et al, 2007; Graeff-Teixeira, 2007; Neuhauss et al, 2007).

The studies demonstrate economics losses by introduction of invasion species are value in US$ 42,6 billions the environment  expenses, US$ 6,7 billions the human health expenses, even more difficult estimate, they are huge too (Pimente et al, 2001). Although the tendency described by Simberloff and Gibbons (2004) of the population collapse after some time of invasion, are extreme importance research about population dynamics and reproductive biology of *A. fulica* for comprehension the ecologic relationship and search one better control strategy and manage for decrease the problems cause by the specie.

This way, this work has the objective to present data about population dynamics of *A. fulica* in the city of Salvador, describing aspects of live cycle of the specie with rate growth, size, time of recruitment, age (life time) and reproductive period, characterize the reproductive biology, analyzing the relationship between the peristome thickness and the stage of sexual maturation and between climates factors like precipitation, temperature and air humidity, and sexual activity periods.

## MATERIALS AND METHODS

*Area of study*

The area studied is located in the Metropolitan Region of Salvador, state of Bahia - Brazil, which is located at 12º57’13”S and 38º27’24”W, is hot and humid climate – located between the Tropic of Capricorn and the Line of Ecuador, sunny, with an average temperature of 25.5ºC that varies little over the years. The pluviometer annual rate in the city ranges 2000mm, the humidity of the hair has average of 81% (maximum 83% in May and minimum 79% in February) (INMET, 2008).

*Sampling and experimental design*

According to previous studies (Silva, 2005) for 15 neighborhoods infested by *A. fulica* in the city Salvador (Amaralina, Barra, Barris, Caminho das Árvores, Costa Azul, Itaigara, Itapuã, Jardim Encantamento, Ondina, Piatã, Pituba, Praia do Flamengo, Rio Vermelho, Stella Maris and STIEP). From these data were raffled three neighborhoods for each campaign of monthly sampling. Within each neighborhood was an enclosed area containing $1km^2$ of extension (Fig. 1). Some neighborhood have been hit more than once, a maximum of three, when it occurred to areas of $1km^2$ were moved to new areas that were visited them but remaining within the neighborhoods hit. The idea of the design was representatively sampled the area of study avoiding that spatial variation went a confusion variable influencing the temporal variation, that was sought in this study (Table 1). In order to assist the movement of collectors, were used maps of the areas bounded sampling as well as the route to be followed during the collection.

The procedure was manual collection of snails that were on the streets, squares, gardens and other public places. All samples were collected at the beginning of the morning, when termination of activity of the snail (Tomiyama, 1993; Raut and Barker, 2002; Albuquerque, 2003), by two collectors and lasted approximately one hour. To protect against possible pathogens collectors sent by snail and/or the environment where they were, they wore rubber gloves.

From August 2006 to August 2007, monthly collections were made in the areas of sampling, and the collection August 2006 (collection pilot) was not considered valid by methodological problems have been found in the procedures for collection and analysis. The collections from September 2006 to August 2007 were ordered in chronological order (September 2006 = Collection 01 and so on). In each area of sampling at least 60 snails were collected manually and submitted to morphometric analysis in the field of data for population dynamics. Of these, forty-five (fifteen per area of sampling) were taken in plastic containers to the laboratory of the Catholic University of Salvador (UCSal) to analyze macro-anatomical the reproductive system.

The monthly values of accumulated rainfall (in mm), the mean temperature (°C) and humidity of the air (%) were collected with the Center for Weather Forecasting and Climate Studies - the National Institute for Space Research (CPTEC / INPE) through the database available on the worldwide network of computers at the following address: http://www.cptec.inpe.br/. The values were the thirty days preceding the collections.

*Morphometric analysis*

The animals collected in September 2006 were measured with the help of a caliper (0.05 to 150mm) and heavy with a digital field balance with precision of 0.1g. The dimensions were measured: larger diameter (dm), height of the opening (ha), width of the opening (la), height of the spire (he), height of the shell (h), peristome thickness (pe), number of turns (Fig. 2) and weight (p). In other collections only the height of the shell (h) and total weight (p) were measured.

Work undertaken by Tomiyama and Miyashita (1992) and Tomiyama (1993, 2002) that describe the peristome thickness has a close relationship with sexual maturity, appearing at the beginning of maturity and is developing the extent that the individual becomes old, thus being, it is possible to characterize three stages: "Young-Adult" (peristome < 0.5 mm) portion of the masculine reproductive system in developing or developed, don't have feminine portion; "Intermediate" (0.5 to 0.8 mm): masculine portion of the reproductive system developed, have or don’t have feminine portion, and "Old-Adult" (peristome > 0.8 mm) are both parts of the reproductive system well developed (hermaphrodites).

*Laboratory analyses*

For the analysis of anatomical features of the reproductive system, specimens of different sizes were sacrificed and dissected by heating under a stereo-microscope. The structures of the reproductive apparatus were seen following the illustrations and descriptions of Tomiyama (1993, 2002) Caetano (2005); Fisher and Colley, (2005) and Teixeira et al (2006), for *A. fulica*. (see Anexo Figure A2).

With the help of an analytical digital balance with precision of 10mg (0.01g) was obtained the weight of the protein gland to see if the snail was sexually active or not.

One way of assessing the sexual activity in *A. fulica* is through weight of the gland of albumen. The gland of albumen, also called the gland protein, is responsible for the production and storage of nutrients that will "supply" eggs (Nieland and Goudsmit, 1969 apud Caetano, 2005). Runham and Laryea (1968) showed that this gland fluctuates greatly in size during the different phases of the reproductive cycle, being bigger before ovoposition and dry immediately after ovoposition that, according Tompa (1984) may be the original size of the gland since all the fluid contained there in was transferred to the eggs. The study of Tomiyama (1993) showed that the maximum size for glands of protein in young adults (are not capable of producing eggs) was 650 mg, so that the heavier glands value characterizes sexual activity at that time.

This way our hypothesis of interest is that there is relationship between sexual activity and climatic variables studied (temperature, precipitation and humidity of the air) being expected greater sexual activity during humid period in the city of Salvador – Bahia.

Moreover were quantified, when found, the number of eggs in the uterus of snails.

*Statistical analyses*

First place was a Principal Components Analysis (PCA) using MVSP (Multi-Variety Statistical Package - Statistical Package Multi-Misc) version 3.13l for Windows, in order to extract the first two axes of variation (PC1 and PC2). Later was put PC1 x PC2 to observe the formation of groups.

Because of little variation in temperature and humidity of the air and, consequently little influence on their sexual activity, also linked the biology of the species, only the temperature was used in regression with the variable of interest (sexual activity). The regression was made using SPSS (Statistical Package for the Social Sciences) 13.0 for Windows being considered $\alpha=0.05$. The variable of interest (sexual activity) represented the proportion between the number of sexually active individuals (gland protein> 650 mg) and the sexually inactive (gland <650 mg).

To determine the extent morphometric that best represents the growth of snail, the Pearson correlations between variables morphometric (h, dm, ha, la, he, number of turns) and the weight of each individual were performed using the statistical package SPSS 13.0 for Windows (Statistical Package for the Social Sciences). From this determination was possible to generate a linear equation and define, more precisely, the frequency distribution of the population of the *A. fulica*. It was stipulated that the value of α would be 0.05, however this value was corrected by the correction of Bonferroni (α/n, where α = 0.05 in is the number of tests of hypotheses). This procedure was adopted because he has conducted several tests of hypotheses for the same set of data. The value of α considered in this study was 0.008.

The curve of growth was obtained through the model of von Bertalanffy, given by:

$$Lt = L\infty\ [1-\exp(-k(t-t_0)]$$

Where:

$Lt$ = length of age t;

$L\infty$ = asymptotic maximum length;

$k$ = constant growth;

$t_0$ = "age" with the length zero ($Lt = 0$)

The parameters of growth and the curve of growth were obtained with the help of Microsoft Excel 2002.

The value of the constant growth (k) was estimated from three pairs of values in length and age known in the literature or found in this work. The principle was estimated asymptotic length ($L\infty$) from the largest individual caught (Lmáx), where: $L\infty$= Lmáx/0.95 (Pauly, 1983). The average longevity for *A. fulica* found in the literature is three to five years the snail can live up to nine years in suitable conditions (laboratory for example) (Tomiyama, 1993; Raut and Barker, 2002). This way, with the value of asymptotic length ($L\infty$) found the snail would have approximately six years.

Another feature found in the literature is the time from fertilization until birth (outbreak of the egg), which varies around 13 days (0.036 years) (Raut and Barker, 2002 and Rao and Singh, 2000). As there is a kind likely to grow following this equation since the moment when born until the senility, the curve often cuts the x on the age, a point generally lower than zero (King, 1996). Knowing that length with zero (Lt = 0mm) the snail has -0.036 years (-13 days) and that at birth (t = 0 years) presents approximately 3 mm in length of shell (Silva, personal communication) were unable to estimate the constant growth (k). From there it was only replace the value of t for the Lt.

The longevity for this study defined as the time that the individual takes to achieve 95% of asymptotic length, was estimated based on the formula proposed by Taylor (1958): tmax = to + 2996/k.

## RESULTS

### *Climatic factors and sexual activity*

The average values of temperature and precipitation for the period of study were close to historical values, but the humidity of the air made up, approximately, 14%

higher than the historical average, which did not influence the results already show that is still possible a division between a wet or rainy period (April to September) and a less wet or dry (October to March). It is worth emphasizing the little variation in temperature and humidity of air, both for the historical numbers as for the period of study (Figs. 3 and 4).

It collected a total of 540 snails in 12 collecting, 100 of these were seen to be sexually active, and 318 inactive and 122 could not be determined by not submitting gland of protein. The 418 glands of protein had weighed an average of 430.64mg (standard deviation = 754.37mg) of weight being the maximum value of 5450mg and 10mg less than that was also the most frequent (52 repetitions) (see Apêndice Table A1).

The results of this study show that there is a greater relationship between rainfall and sexual activity of *A. fulica* (Fig. 4), as the temperature and humidity of the air had little variation and therefore little influence.

In the months of highest rainfall was highest percentage of active animals such as the months of May and June 2007 with 180 and 202 mm and 41% and 43% of snails' active, respectively. Already in the months in which rains less than in January and February with 19 and 37 mm and were found only 5% and 9% of assets, respectively. We can highlight, though, the period from March to July 2007 which had accumulated rainfall of 916 mm - 56.5% of rainfall throughout the study period - and average per month, 31% of the animals active while the rest of the year the average of assets was 18%.

The months of December 2006 and April 2007 were exceptions, as presented proportion of assets well below the expected value for heavy rain found in the period.

The principal components analysis drew first two axes of variation (PC1 and PC2) of data. The PC1 accounted for 59.7% of variation and PC2, 32.5% (92.2% of total). Among the variables, the humidity of the air and precipitation were more inversely related to PC1 (as the PC1 increases the humidity of air and precipitation decrease) and temperature, the PC2. The rainfall also was related to PC2 almost with the same intensity with which the PC1 (Table 2).

The plot PC1 x PC2 (Fig. 5) the spatial distribution of points shows the formation of three groups. The first groups formed by the collections of January and February had the lowest values for sexual activity and were related to lower values of air humidity and precipitation, and high temperatures, characteristics of the dry period.

In reverse, the collections of November and December 2006 and March, May and June 2007 which showed the highest value for sexual activity, were related to periods of moisture from the humidity of the air and rainfall higher and more mild temperatures (wet period).

Already the group represented by the collections of September and October 2006 and July 2007 (transition between seasons) had intermediate numbers of air humidity, precipitation and temperature related to average levels of sexual activity.

Only the months of April 2007, which have higher temperature as compared with the numbers of precipitation and humidity of the air presented, and in August of

2007 with higher humidity of the air, that left a bit of expected to average levels of sexual activity.

The regression between the temperature and variable of interest (sexual activity) was shown to be significant (p = 0.002; $F$ = 18.617) (Fig. 6). This, the higher the rainfall increased sexual activity, that is, the greater the number of sexually active individuals.

*The relationship between sexual maturity and peristome*

Totality of 585 snails were collected, of these 54% were "Old-Adult," 34% "Intermediates" and only 12% "Young-Adults" (Table 3). Noting the proportion of monthly "Old-Adult", "Intermediates" and "Young-Adult" which is shown in Figure 7, you can see an increase in "Old-Adult" in the rainy months.

The peristome thickness ranged from 0.1mm to 2.95mm, with the average 0.93mm in thickness but the most frequent was 0.85mm. (see Apêndice Figure A1).

Almost the whole of snails belonging to the stage of sexual development "Old-Adult" presented the portions of the female and male reproductive system (96%). Of the "Intermediates", 65% had both portions of the reproductive system and, among the "Young-Adult", 86% had only the male portion (Fig. 8).

It were seen snails with eggs in November 2006, January, March, May, June and July 2007 and being found more than one snail eggs loading only in collecting March 2007. We counted a total of 560 eggs in just seven *A. fulica* which resulted in an average of 80 eggs per snail. Of these, five were "Old-Adult" and had an average of 78 eggs per snail and two "Intermediates" with an average of 86 eggs per snail. Despite having been found "Young-Adult" with the portion of the female reproductive system, there were no snails with eggs at this stage.

*Aspects of the population dynamics of* *Achatina fulica*

The shell of *A. fulica* has reddish brown color with stripes of variable coloration, until slightly brown, violet. The number of turns between 5 and 8 and increase in diameter quickly and progressively. The general form is bulimuloid (h/dm = 1.58), with elongated spire (he / h = 0.41) and opening ovulate-oblique (ha/la=1.63; ha/dm=0.87; la/dm =0.54). (see Apêndice Figure A2)

It was collected a total of 884 snails in 12 sampling. The average for the entire period of collection was 50.17 mm in height and 17.20 grams of weight. The other variables measured are described in tables 4 and 5.

Aiming to establish the measure morphometric more accurate to estimate the body size of the specie were made correlations between the total weight of the individual and measures morphometric: larger diameter, height of the opening, width of the opening, height of the spire, height of the shell and number of turns (Table 6). All values of correlation were found positive and significant. The height of the shell was the best descriptor of the size, giving highest correlation with the weight (Fig. 9).

Defined the height of the shell (h) as variable morphometric that best represents the growth of *A. fulica*, histograms of high frequencies were made monthly (Fig. 10).

For the analysis of graphs of Figure 10 is unable to verify that there are two different cohorts in almost every month, these two cohorts are more evident in the month of August 2006. Since March 2007 what you see is a gradual growth in average height of the shell and, consequently, a shift to the right of mode featuring an ageing population that is soon offset by the emergence of younger cohorts.

In the months August to December 2006 and February 2007 was recorded greater numbers of young individuals in the population, unlike what occurred in the months of March to July 2007 in which there is a predominance of individuals greater. The month of January 2007 had its histogram of different frequency of the other months because of low quantity of animals collected.

The study of growth of *A. fulica* resulted in numbers of Lmax = 107.6 mm, $L\infty$= 113.3 mm; k = 0.75 and to = -0.036mm.

After replacing these values the expression was as follows:

$$Lt = 113,3 \times [1-\exp(-0,75(t-(-0,036)]$$

The figure 11 shows the curve of growth following the formula of von Bertalanffy focusing on the largest animal collected with 107.6 mm in height of the shell and with about 3 years and 11 months, and the lowest with 23.6 mm and 3 months of age.

The longevity was estimated at 3 years and 11 months, with the snail would reach this age 107.6 mm in height of the shell, same value of the bigger animal collected.

## DISCUSSION

*Climatic factors and sexual activity*

Because of little variation in temperature (3.6 ° C, Min. 23.6°C and Max. 27.2°C) and humidity of the air (4.0%, Min. 92.8% and Max. 96,8%), it is believed that these variables little influence the activities of the snail, since it is a species resistant to environmental variations, probably because they evolved in edge of forests (Raut and Ghose, 1981). Ruat and Ghose (1984) confirmed this statement showing that the activities of African snails are affected only when temperatures remain for a long period of below 10°C or above 30°C and humidity of the air below 80%, when they are in aestivation. These limits numbers of temperature and humidity of the air did not occur during the study period and it's rare to occur.

The evidence of seasonality of *A. fulica* was recorded by Lai et al (1982) reported that the dispersion of the specie, namely, the occupation of new areas for new individuals added to the population, occurs throughout the year, but is particularly evident during or after the winter. Raut and Barker (2002), also considers the seasonality, with cycles associated with good times may occur two pronounced peaks in each season as the first soon after the resumption of activity and the completion phase of aestivation and second, 2 to 3 months later. In Malaysia, Berry and Chan (1968) also consider the existence of an apparent annual cycle of *A. fulica*, but related to the dry and rainy seasons.

The results of this study have shown a clear link between environmental conditions, especially the variation of rainfall, and sexual activity for *A. fulica* in the city of Salvador. It is also possible to say that for the period studied, sexual activity was more manifested in the rainy season and the month of March that rains above the expected, confirming the hypothesis of interest. Albuquerque (2003) reached similar results, to observe the sexual behavior of the snail in the city of Lauro de Freitas – Bahia found that the copulate occurred more frequently from April to August and on rainy days.

Regardless of environmental conditions were found sexually active individuals in all sampling months which suggests that *A. fulica* is able to reproduce throughout the year.

*The relationship between sexual maturity and peristome*

Different of presented by Tomiyama (1993), were found some "Old-Adult" without the portion of the female reproductive system. This fact ally the presence of snails showing reproductive system hermaphrodite complete with peristome of only 0.35 mm ("Young-Adult"), and the trend suggested by Tomiyama (1993, 2002) that the species complete their sexual development after the peristome thickness exceed the 0.5 mm ("Intermediates"), suggests an early sexual maturation of the population of *A. fulica* in the city of Salvador. This early ripening of the population may have occurred by the abundance of resources (food, shelter) and/or the favorable climatic conditions found in the city. Fisher and Colley (2005) also found snails with complete reproductive system (performing posture inclusive) with peristome less than 0.5 mm (0.4 mm).

The presence of approximately 75% of the population examined in full sexual development ("Old-Adult" and some “Intermediates"), and characterized by large and vigorous individuals are evidence of the first phase of establishment population suggested by Civeyrel and Simberloff (1996 ) where there is the exponential growth of the population of the species. Although not addressed in this study, increasing the population of *A. fulica* has been reported already made some time in the capital of Bahia.

The increase in the number of "Old-Adult" in the rainy months, found in this study, was also observed by Albuquerque (2003) in Lauro de Freitas. This increase is related to increased observation of sexual activity in the rainy season, because these animals ("Old-Adult") are larger and have full sexual development which make them more suitable for reproduction.

Tomiyama and Miyashita (1992) found in their studies that "Old-Adult" the greatest number of eggs per ovoposition when compared with "Intermediates", these data are conflicting with those found in this study in which the numbers obtained for "Old-Adult" (77.6 eggs per individual) are slightly lower than the value obtained for "Intermediates" (86.0 eggs per individual). The answer to this observation may be the insufficient number of animals with eggs collected (only seven).

Despite not having been found "Young-Adult" producing eggs - a result also found Tomiyama and Miyashita (1992) - the absence of the portion of the female reproductive system as a justification for the fact can not be employed here. The most plausible is considered that these animals had portion of the female reproductive system with incomplete development, impossible, therefore, the production of eggs. We can not discard the possibility that these animals were not sexually active only when collected.

By not having obtained a significant number of snails with eggs can not be any kind of inference regarding the time where it is more frequent or quantity of eggs that each individual can store, requiring future studies to elucidate these points. What can be said is that snails were found with eggs at the height of the dry season (November and January) and the rainy season (March, May, June and July) and that the reason for this has occurred, possibly, either by little variation in annual climate city of Salvador that makes a humid tropical climate propitious to the development of *A. fulica*. In addition, Raut and Barker (2002) argue that the storage capacity of the sperm provides for the species of Achatinídeos ability to produce eggs in any season.

*Aspects of the population dynamics of Achatina fulica*

As was observed in the state of Parana by Fischer and Colley (2005), the population of *A. fulica*, in the city of Salvador is composed of animals from medium to large size and in full sexual activity. Comparing with the data obtained by Caetano (2005) and Ohbayashi and Takeuchi (2007), the average weight and height of the shell were lower than those obtained by this, now when compared to Albuquerque (2003) the means obtained were higher. The presence of individuals great and strong, probably with full sexual development portrays the process of invasion of the species in Salvador, with the occupation of urban ecosystems, not only causing serious ecological and economic problems, as well as possible damage to human health and domestic animals (Teles et al, 1997; Vasconcellos and Pile, 2001; Raut and Barker, 2002; Bender, 2003; Silva et al, 2003; Thiengo et al, 2006; Thiengo *et a*l, 2007).

Although there young snails (recruits) for the whole year, it was evident that the recruitment was more frequent in the months August to December 2006 and February

2007 that characterized the end of the wet season and beginning of the dry season. This result confirms the information obtained on items related to the reproduction of the species. The period of increased sexual activity and the largest proportion of "Old-Adult" (presenting both sides of the reproductive system and developed) occur mainly in the wet period. So the reproduction occurs in the rainy season, in which the animals invest energy in the production of gametes and eggs, and the recruitment occurs in the dry season.

In the vast majority of animals the size of the body is closely related to age, but this increase in size is not constant throughout life and generally describes a kind of exponential curve with a rapid growth in the beginning (young animals) that is slowed to as the animal becomes older. As was observed in the results, the curve of growth of *A. fulica* follows this pattern, with rapid growth up to two years of age (≅ 90 mm) that becoming slower as the animal becomes older.

Gomes et al (2004), in studies with pulmonary gastropods land in Rio Grande do Sul, has concluded that the lifecycle of the population of Simpulopsis ovata (SOWERBY, 1822) is annual and the species is semelpara (a species that has only a reproductive event, namely adults die after the reproductive period), moreover, states that annual cycles have been found among terrestrial pulmonary gastropods (Helicella *(Xerothracia) pappi* (SCHÜTT, 1962), *Salinator takii* (KURODA, 1928) (Lazaridou-Dimitriadou, 1995; Kosuge, 2000). Different these terrestrial pulmonary with life cycles short, *A. fulica* can live, in life-free, more than four years and was playing 15 to 25 times throughout his life this fact, combined with a series of other species that makes an excellent attacker. Another kind of species with life cycle long and that can become invasive because of the time of life and accelerated reproduction, is *Helix aspersa* (MÜLLER, 1774) ( Madec et al, 2000).

The fact that have been found snails with equal ages and value very close for longevity and living almost four years, suggests how well suited environmental conditions in the city of Salvador are. Therefore, the eradication of species would be very difficult, and most indicated the control of population since the eradication was achieved in only incipient populations of *A. fulica* in California (USA), Florida (USA), Queensland (Australia), Fiji, Samoa and Vanuatu (Raut and Barker, 2002; Thiengo et al, 2007).

## CONCLUSIONS

The climate found in the city of Salvador offers the african snail optimal conditions for survival and development leading to the animal to reproduce sooner. Moreover, the little variation in temperature and humidity requires little of the capacity of resistance to major environmental changes that the species has, so to reproduce throughout the year, increasing your activity as the rainfall increases.

The relationship between the thickness of peristome and stage of sexual maturation, as suggested by Tomiyama and Miyashita (1992) and Tomiyama (1993, 2002) is true, but should be adjusted for each region. Although there relationship between the thickness of peristome and sexual maturation, the boundaries between the stages are not well defined and, depending on the place where the study is done, the limits of thickness of peristome  for each sexual stage may vary. In the case of the city of Salvador "Young-Adult" would peristome less than 0.35 mm, "Intermediates" of 0.35 mm to 0.90 mm and "Old-Adult", greater than 0.90 mm.

The eradication becomes impossible for the invasion levels found in Salvador is recommended the control of the species. This control, despite occur continuously, should be intensified in rainy periods, since these are times that animals are just being viewed more sexually active, the demand for sexual partners or areas for breeding. It is suggested that the plan of management and control of A. fulica created by IBAMA, is implemented, since it is giving results in other cities where the snail is pest. (Brazil, 2007)

Studies on the population biology of the species are the key to implementation of programmers for control and eradication of invasive species. Knowledge of the population dynamics of *A. fulica* in Salvador can subsidize future actions to minimize the impacts caused by the spread of this species.

## ACKNOWLEDGEMENTS

I thank the Program of Postgraduate in Ecology and Biomonitoring of the Federal University of Bahia by the host during the development of the work and the lessons given by all their teachers; Catholic University of Salvador that has given physical space of its laboratories to conduct the analysis; and mainly to those who helped me during the collections.

## REFERENCES

Albuquerque, F.S. 2003. Ocorrência, aspectos da dinâmica populacional e comportamental de *Achatina fulica* Bowdich, 1822 (Gastropoda: Pulmonata) em Lauro de Freitas. 101p. *Dissertação (mestrado)* - Universidade Federal da Bahia. Instituto de Biologia. Programa de Pós-Graduação em Ecologia e Biomonitoramento.

Alowe, S., Browne, M. and Boudjelas, S. 2004. 100 of the world's worst invasive alien species. A selection from the global invasive species database. Disponível: www.issg.org/database.

Bender, A.L., Maurer, R.L., Silva, M.C.F., et al. 2003. Ovos e órgãos reprodutores de fêmeas de *Angiostrongylus costaricensis* são reconhecidos mais intensamente por soros humanos de fase aguda na angiostrongilíase abdominal. Revista da Sociedade Brasileira de Medicina Tropical, 36(4): 449-454.

Berry, A.J and Chan, L.C. 1968. Reproductive condition and tentacle extirpation in Malayan Achatina fulica (Pulmonata). Australian Journal of Zoology**, 16:** 849-855.

Brazil. Ministério da Saúde. Séc. de Vigilância em Saúde. Dep. de Vigilância Epidemiológica. 2007. Vigilância e controle de moluscos de importância epidemiológica: diretrizes técnicas: Programa de Vigilância e Controle da Esquistossomose (PCE). 2nd edn. Ministério da Saúde, Brasília. 178 p.

Caetano, F.A.M. 2005. Estudo comparativo do aparelho reprodutor do molusco *Achatina fulica* criado em cativeiro e asselvajado. Pirassununga, 2005. 61p. *Dissertação (mestrado)* - Universidade de São Paulo. Faculdade de Medicina Veterinária e Zootecnia. Departamento de Nutrição e Produção Animal.

Caldeira, R.L., Mendonça, C.L.G.F., Goveia, C.O., et al. 2007. First record of molluscs naturally infected with *Angiostrongylus cantonensis* (Chen, 1935) (Nematoda: Metastrongylidae) in Brazil. Memórias do Instituto Oswaldo Cruz, 102(7): 887-889.

Carlton, J.T. 1996. Biological Invasion and Cryptogenic Species. Ecology, 77(6): 1653-1655.

Carvalho, O.S.; Teles, H.M.S.; Mota, E.M.; et al. 2003. Potentiality of *Achatina fulica* Bowdich, 1822 (Mollusca: Gastropoda) as intermediate host of the *Angiostrongylus costaricensis* Morera & Céspedes 1971. Revista da Sociedade Brasileira de Medicina Tropical, 36: 743-745.

Centro de Previsão de Tempo e Estudos Climáticos - Instituto Nacional de Pesquisas Espaciais (CPTEC/INPE). PCDA - Plataforma de Coleta de Dado. Disponível em: http://www.cptec.inpe.br. Acesso em 04 abr. 2008.

Civeyrel, L. and Simberloff, D. 1996. A tale of two snails: is the cure worse than the disease? Biodiversity and Conservation, 5: 1231-1252.

Cowie, R.H. 1998. Patterns of introduction of non-indigenous non-marine snails and slugs in the Hawaiian Islands. Biodiversity and Conservation, 7: 349-368.

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

Dajoz, R. 2005. Princípios de Ecologia, 7th edn. Artmed, Porto Alegre. 520p.

Fischer, M.L and Colley, E. 2004. Diagnóstico da ocorrência do caramujo gigante africano *Achatina fulica* Bowdich, 1822 na APA de Guaraqueçaba, Paraná, Brasil. Revista Estudos de Biologia, 26(54): 43-50.

Fischer, M.L and Colley, E. 2005. Espécie invasora em reservas naturais: caracterização da população de Achatina fulica Bowdich, 1822 (Mollusca - Achatinidae) na Ilha Rasa, Guaraqueçaba, Paraná. Brasil. Biota Neotropica, 5 (1): http://www.biotaneotropica.org.br/ v5n1/pt/ download?article+BN03305012005+it.

Fischer, M.L.; Simião, M.; Colley, E.; et al. 2006. O caramujo exótico invasor na vegetação nativa em Morretes, PR: diagnóstico da população de *Achatina fulica* Bowdich, 1822 em um fragmento de Floresta Ombrófila Densa aluvial. Biota Neotropica, 6 (2): http://www.biotaneotropica.org.br/v6n2/pt/abstract?short-communication+bn03306022006.

Graeff-Teixeira, C. 2007. Expansion of *Achatina fulica* in Brazil and potential increased risk for angiostrongyliasis. Transactions of the Royal Society of Tropical Medicine and Hygiene, 101: 743-744.

Gomes, S.R.; Silva, R.S.; Gil, G.M and Thomé, J.W. 2004. Ciclo biológico de *Simpulopsis ovata* (Gastropoda, Bulimulidae) em São Francisco de Paula, Rio Grande do Sul, Brasil. Iheringia, Série Zoologia, 94(3):253-259

Instituto Nacional de Meteorologia (INMET). INMET - Clima. Disponível em: http://www.inmet.gov.br/html/clima.php. Acesso em: 04 abr. 2008.

King, M. 1996. Fisheries biology, assessment and management. 9th edn. Ed. Blackwell Science, Oxford. UK. 341 pp

Kosuge, T. 2000. Seasonal aspects in the life history and ecology of the intertidal pulmonate *Salinator takii* Kuroda (Gastropoda: Amphibolidae). Venus: Japanese Journal of Malacology, 59(1): 19-28.

Lai, P.Y, Funasaky, S.Y and Higa, S.Y. 1982. Introduction for biological control in Hawaii: 1979 and 1980. Hawaiian Entomological Society, 24**:** 109 - 113.

Lazaridou-Dimitriadou, M. 1995. The life cycle, demographic analysis, growth and secondary production of the snail *Helicella (Xerothracia) pappi* (Schütt, 1962) (Gastropoda Pulmonata) in E. Macedonia (Greece). Malacologia, 37(1): 1-11.

Madec, L.; Desbuquois, C. and Coutellec-Vreto, M.A. 2000. Phenotypic plasticity in reproductive traits: importance in the life history of *Helix aspersa* (Mollusca: Helicidae) in a recently colonized habitat. Biological Journal of the Linnean Society, 69**:** 25–39.

Neuhauss, E.; Fitarelli, M.; Romanzini, J, et al.. 2007. Low susceptibility of *Achatina fulica* from Brazil to infection with *Angiostrongylus costaricensis* and *A. cantonensis*. Memórias do Instituto Oswaldo Cruz, 102(1): 49-52.

Nieland, M and Goldsmit, E. 1969. Ultrastructure of galactogen in the albumen grand of *Helix pomatia*. Journal of Ultrastructure Research, 29**:** 119-140

Ohbayashi, T. and Takeuchi, K. 2007. Fluctuation of the distribution and population of the giant african snail, *Achatina fulica* Bowdich (Pulmonata Achatinidae) in Chichijima and Hahajima Islands, of the Ogasawara (Bonin) Islands, from the Years 1995 to 2001. Japanese Journal of Applied Entomology and Zoology, 51**:** 221–230

Pauly, D. 1983. Some simple methods for the assessment of tropical fish stocks. FAO Fisheries Technical Paper, 234**:** 52p.

Pimentel, D., Mcnair, S., Janecka, J. et al. 2001. Economic and environmental threats of alien plant, animal, and microbe invasion. Agriculture, Ecosystems & Environment, 84**:** 1-20.

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

Raut, S.K. and Barker, G. 2002. *Achatina fulica* Bowdich and others Achatinidae pest in tropical agriculture. in: Mollusks as croup pest (Barker, G. eds). Molluscs as Crop Pest: CAB Publishing. New Zealand. p.55-114.

Raut, S.K and Ghose, K.C. 1981. Viability of sperms in aestivating *Achatina fulica* Bowdich and *Macrochlamys indica* Godwin-Austen. Journal of Molluscan Studies, 48**:** 87 - 94.

Raut, S.K and Ghose, K.C. 1984. Pestiferous Land Snails of India. Zoological Survey of India n° 11, Bani Press, Calcutta, 151 pp.

Runham, N.W. and Laryea, A.A. 1968. Studies on the maturation of the reproductive system of *Agriolimax reticulatus* (Pulmonata: Limacidae). Malacologia, 7: 93 – 108.

Silva, E.C. Ocorrência de *Achatina fulica* (Bowdich, 1822) (Mollusca, Gastropoda), caramujo hospedeiro intermediário de *Angiostrongylus sp* (Nematoda: Metastrongyloidae), em Salvador - Bahia. Salvador, 2005. 82p. *Monografia de Graduação* - Universidade Católica do Salvador. Instituto de Ciências biológicas.

Silva, A.C.A., Graeff-Teixeira, C. and Zaha, A. 2003. Diagnóstico da angiostrongilíase abdominal utilizando PCR em soro de pacientes. Revista do Instituto de Medicina Tropopical de São Paulo, 45(5) 295-297.

Simberloff, D. and Gibbons, L. 2004. Now you see them, now you don’t! - population crashes of established introduced species. Biological Invasions, 6**:** 161-172.

Simião, M.S. and Fischer, M.L. 2004. Estimativa e inferências do método de controle do molusco exótico *Achatina fulica* Bowdich 1822 (Stylommatophora; Achatinidae) em Pontal do Paraná, litoral do Estado do Paraná. Caderno de Biodiversidade, 4**:** 74-82.

Taylor, C.C. 1958. Cod growth and temperature. Journal of Marine Science. 23(3): 366-370.

Teixeira, D.G.; Martins, M.F.; Guerra, J.L. et al. 2006. Descrição histológica da via genital masculina e hermafrodita de escargots das espécies *Achatina fulica* e *Achatina monochromatica*. Veterinária e Zootecnia, 13(1): 44-54.

Teles, H.M.S.; Vaz, J.F.; Fontes, L.R. and Domingos, M.D. 1997. Registro de *Achatina fulica* Bowdich, 1822 (Mollusca, Gastropoda) no Brasil: Caramujo hospedeiro intermediário da angiostrongilíase. Revista de Saúde Pública, 31: 310-312.

Teles, H.M.S.; Fontes, L.R.; Amaral, W. 2004. Pesquisa nacional de opinião pública sobre a espécie do caramujo *Achatina fulica*. Instituto Brasileiro de Helicicultura - IBH/CEDIC; 01-24.

Thiengo, S.C., Barbosa, A.F., Coelho, P.M. et al. 2006. Moluscos exóticos com importância médica no Brasil. Disponível em: <http://www.mma.gov.br/invasoras/capa/docs/co/silvana_carvalho.pdf> Acesso em: abr. 2008.

Thiengo, S.C., Faraco, F.A., Salgado, N.C. et al. 2007. Rapid spread of an invasive snail in South America: the giant African snail, *Achatina fulica*, in Brazil. Biological Invasions, 9: 693-702.

Thiengo, S.C.; Fernandez, M.A.; Torres, E.J.L. et al. 2007. First record of a nematode Metastrongyloidea (*Aelurostrongylus abstrusus* larvae) in *Achatina (Lissachatina) fulica* (Mollusca, Achatinidae) in Brazil. Journal of Invertebrate Pathology. Article in Press.

Tomiyama, K. and Miyashita, K. 1992. Variation of egg clutches in the Giant African snail, *Achatina fulica* (Ferussac) (Stylomatophpra; Achatinidae). Venus: Japanese Journal of Malacology, 51(4): 293-301.

Tomiyama, K. 1993. Growth and maturation pattern in the African giant snail, *Achatina fulica* (Férussac) (Stylommatophora: Achatinidae). Venus: Japanese Journal of Malacology, 52: 87-100.

Tomiyama, K. 2002. Age dependency of sexual role and reproductive ecology in a simultaneously hermaphroditic land snail, Achatina fulica (Stylommatophora: Achatinidae). Venus: Japanese Journal of Malacology, 60: 273-283.

Tompa, A.S. 1984. Land snails (Stylommatophora). In The Mollusca Reproduction, (ed. A. S. Tompa, N. H. Verdonk and J. A. M. van den Biggelaar), 7: 47–140. London: Academic Press.

Townsend, C. R.; Begon, M. and Harper, J. L. 2006. Fundamentos em Ecologia, 2nd edn. Artmed, Porto Alegre. 592p.

USC - Union Concerned Scientists. The science of invasive species. 2001.Disponível em http://www.ucsusa.org/global_environment/invasive_species/index.cfm. Acesso em: 02 Mai. 2008

Vasconcellos, M.C. and Pile, E. 2001. Ocorrência de *Achatina fulica* no Vale do Paraíba, Estado do Rio de Janeiro, Brasil. Revista de Saúde Pública, 35(6): 582-584.

Wanvipa, K; Kruatrachue, M; Suchaet, E.U. et al. 1989. Comparative Studies on reproductive system of *Achatina fulica*, *Hemiplecta distincta* and *Cyclophorus aurantiacus*. Journal of the Science Society of Thailand, 15: 71-107.

# Figure and Tables

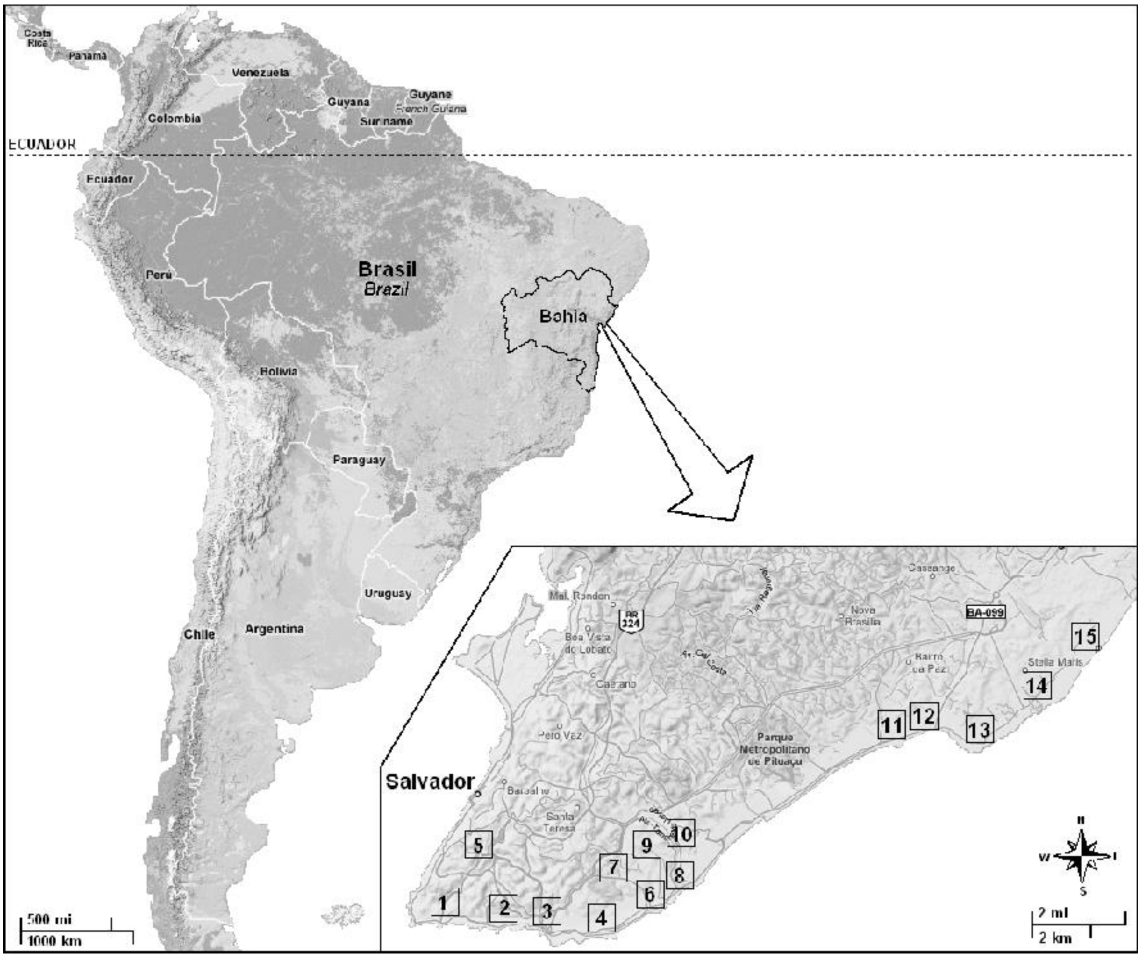



Figure 1: City of Salvador - Bahia with the scheme of the sample area was visited during of the study period. Areas (visited). 1. Barra (2); 2. Ondina (1); 3. Rio Vermelho (3); 4. Amaralina (1); 5. Barris (3); 6. Pituba (3); 7. Itaigara (3); 8. Costa Azul (2); 9. Caminho das Árvores (2); 10. STIEP (2); 11. Piatã (3); 12. Itapuã (3); 13. Jardim Encantamento (3); 14. Stella Maris (2); 15. Praia do Flamengo (3).

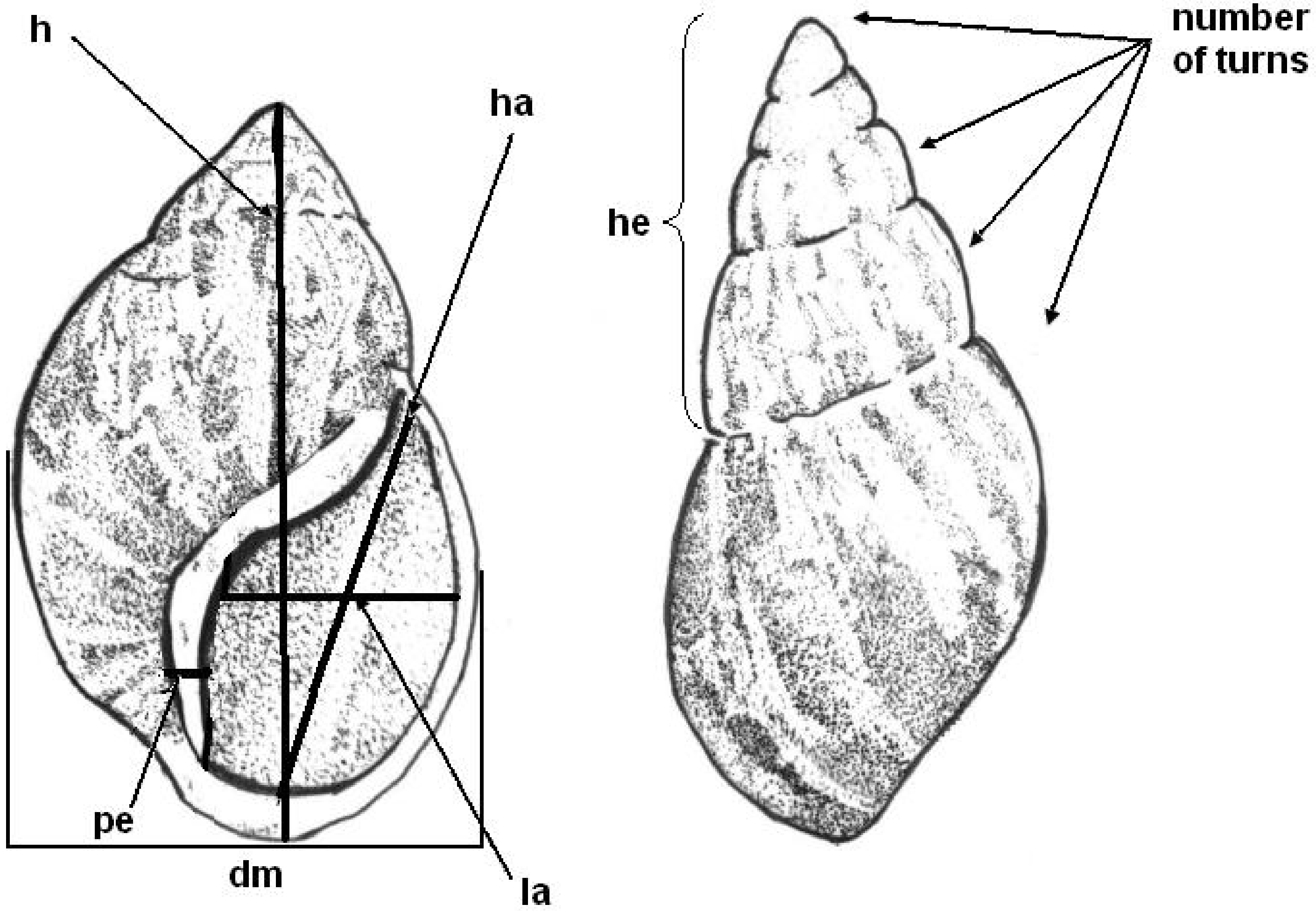



Figure 2: Scheme of the *A. fulica* shell with indication of morphometrics measure (dm, larger diameter; h, height of the shell; ha, height of the opening; la, width of the opening; he, height of the spire; pe, peristome thickness). Illustration: Fischer, M. L.

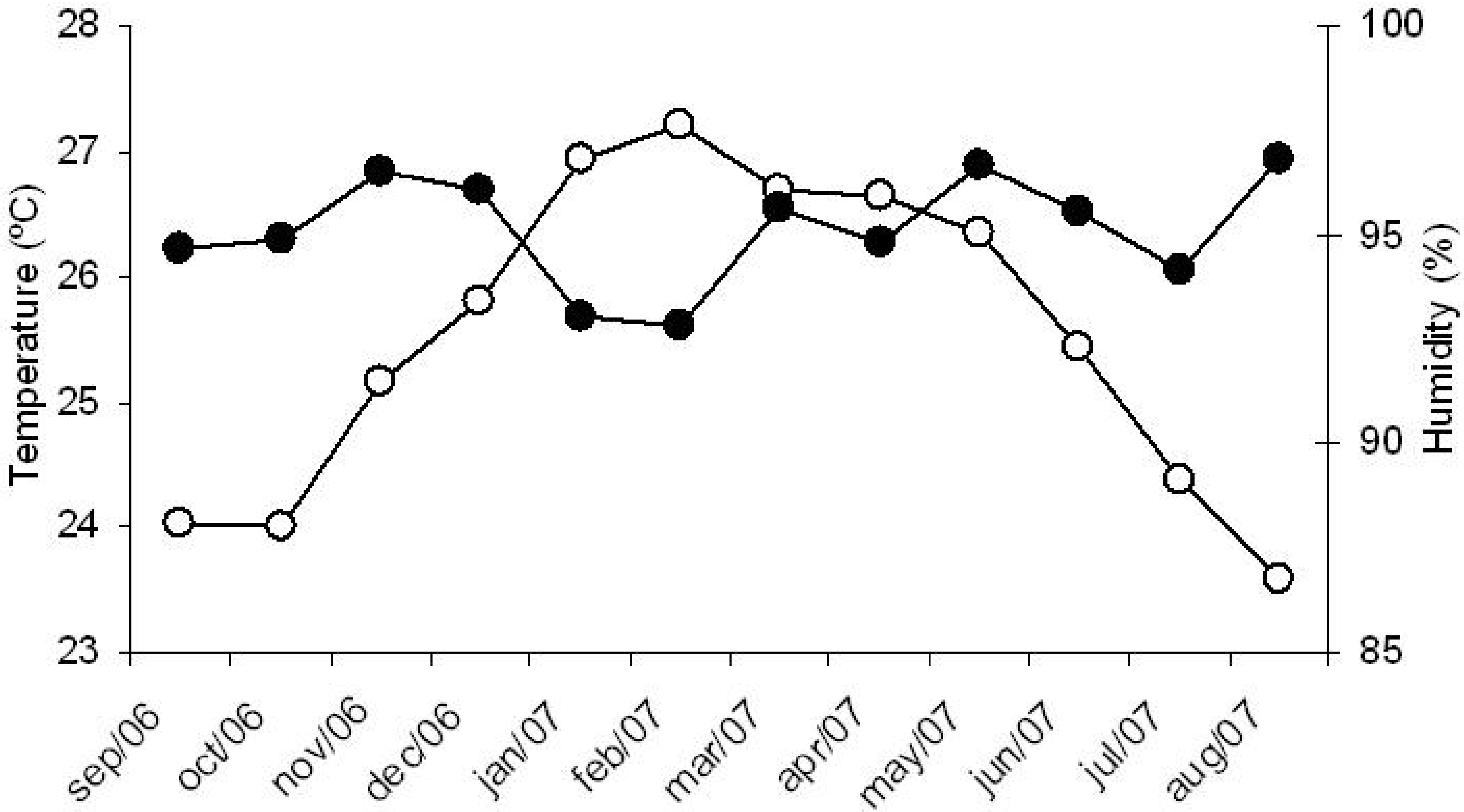



Figure 3: Average monthly of temperature (○) and humidity of air (●) for the city of Salvador during the study period (September of 2006 to August de 2007). Font: CPTEC/INPE, 2008

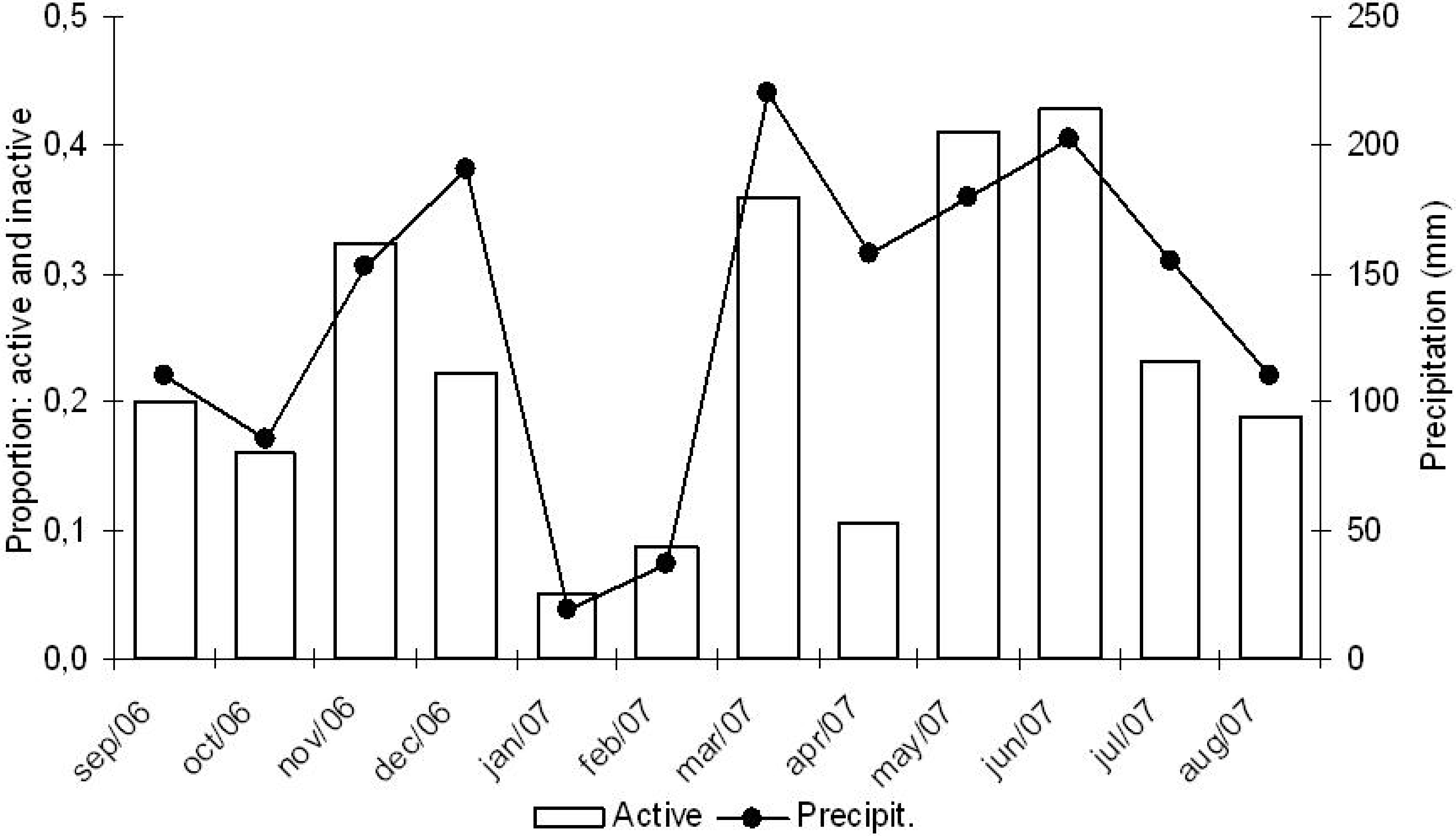



Figure 4: Proportion between active snail and relationship with the precipitation in the period of September of 2006 to August of 2007 for the city of Salvador.

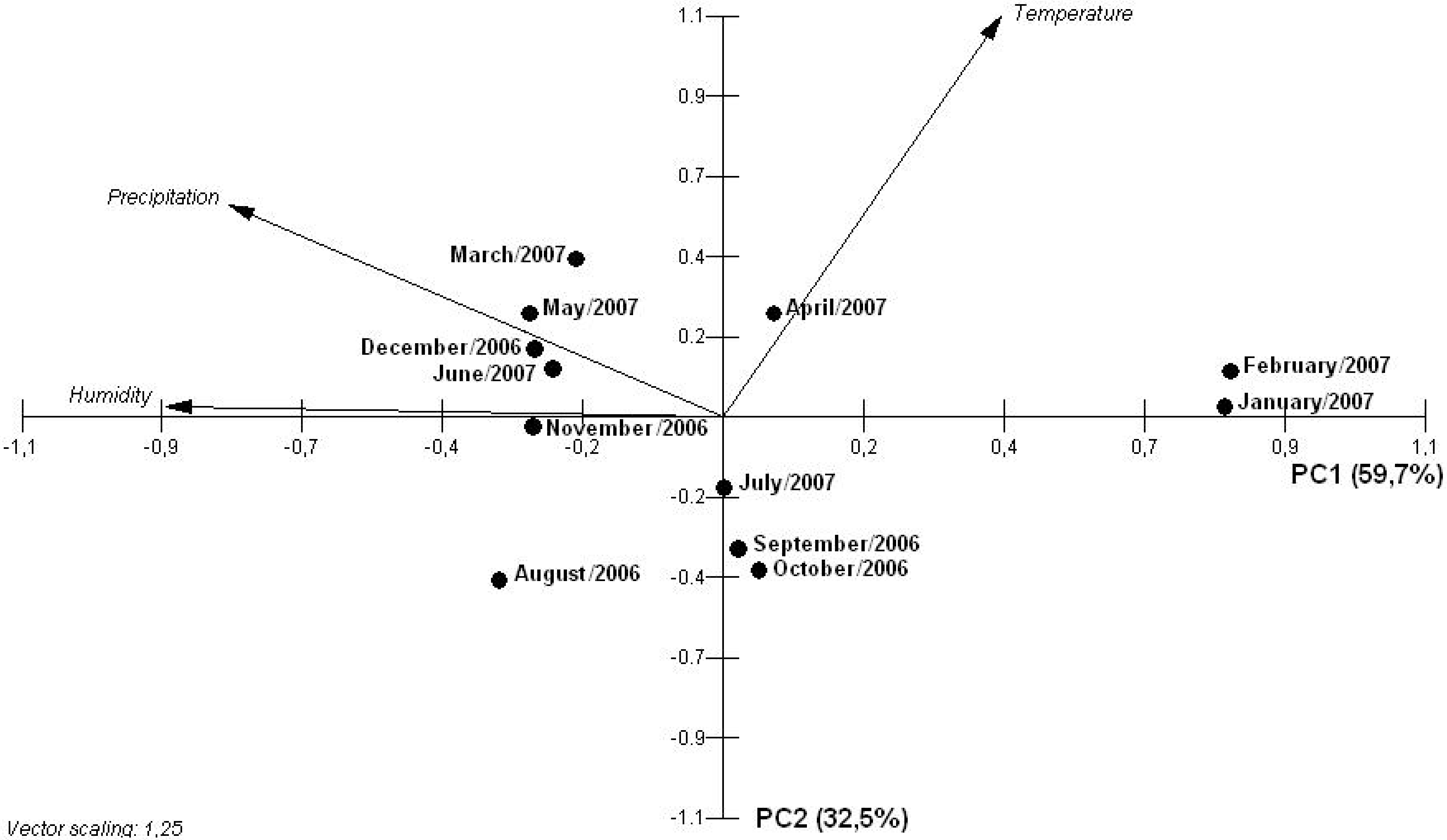



Figure 5: Graph of the Principal Component Analysis with plot of PC1 x PC2.

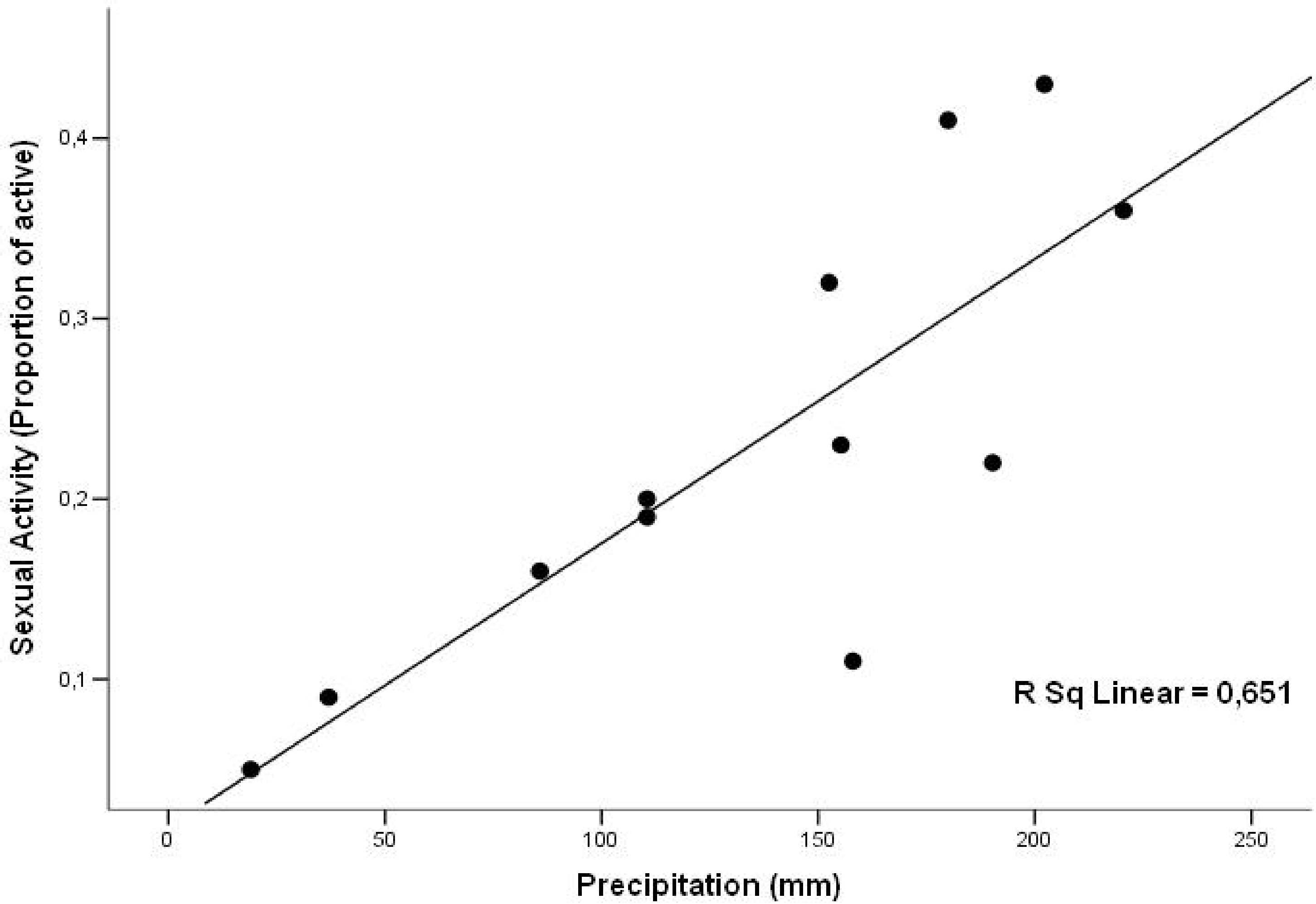



Figure 6: Regression between temperature and the measure of the Sexual Activity (proportion of actives). $F = 18.617$; $p = 0.002$; $R^2 = 0.651$

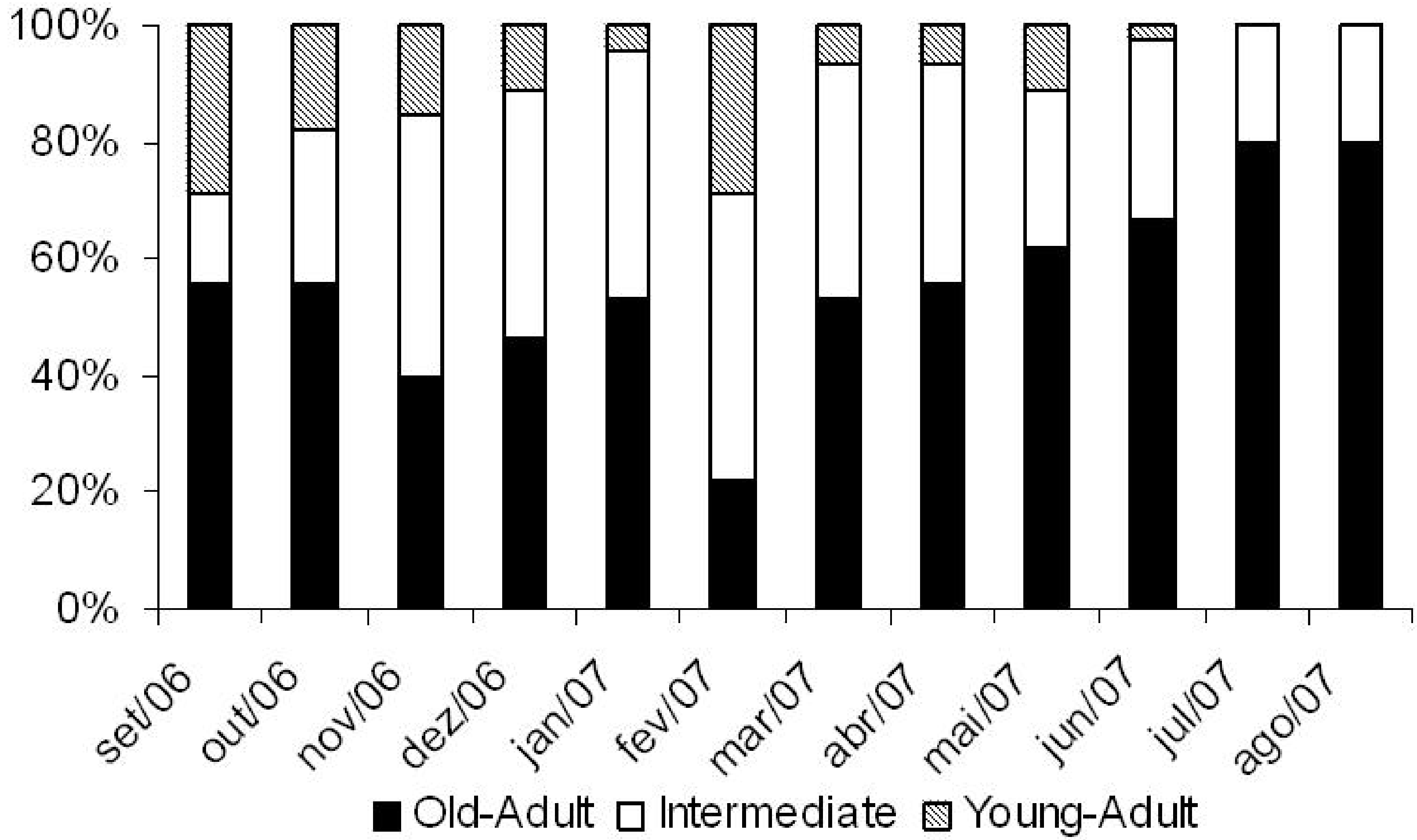



Figure 7: Monthly proportion of the “Old-Adult”, “Intermediate” e “Young-Adult” of the *A. fulica* in the city of Salvador (n = 45 monthly)

Figure 8: Graphic of proportion the *A. fulica* with and without P.F.S.R. (Portion Female of System Reproductive) for stage of sexual maturation.

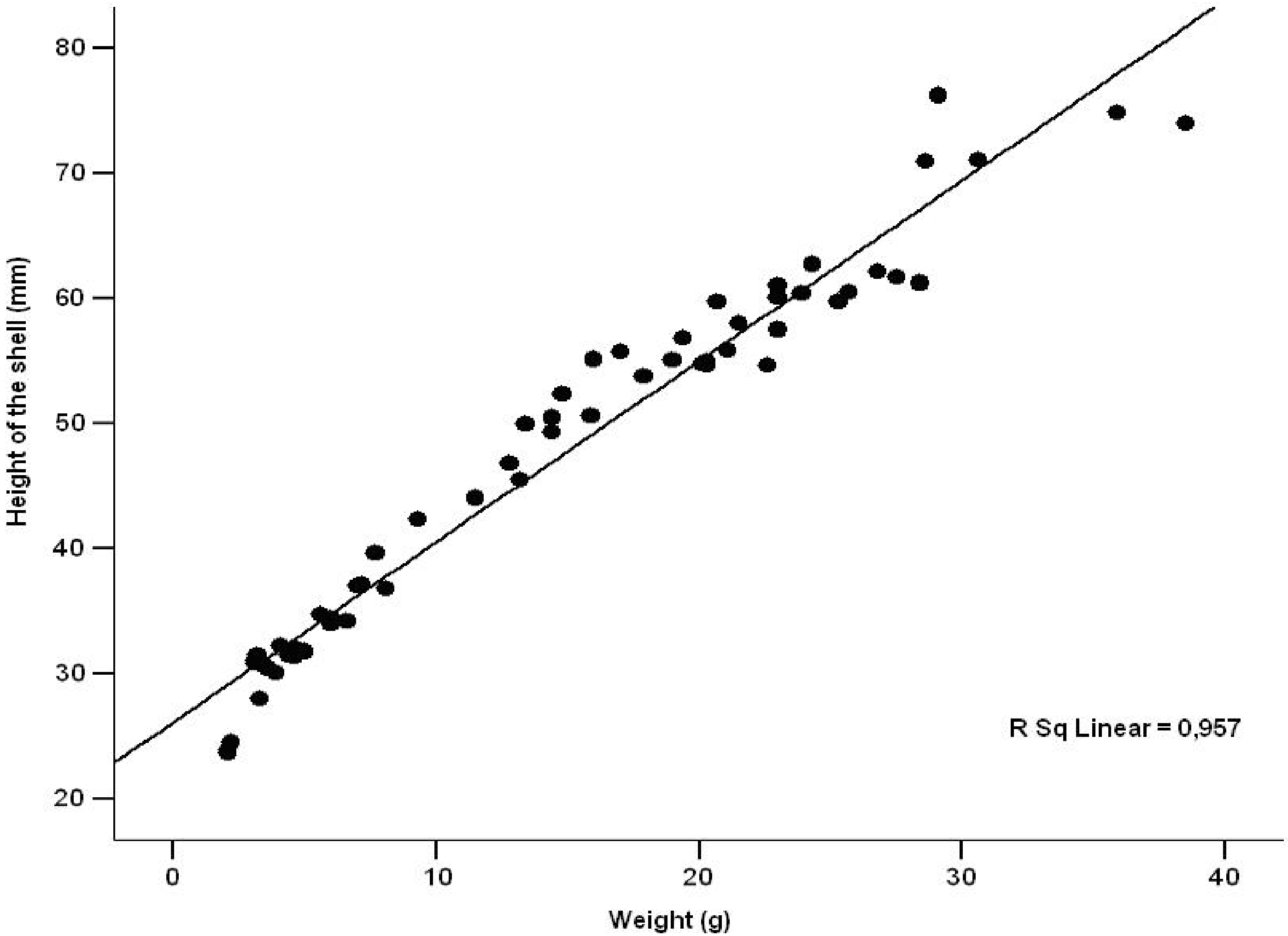



Figure 9 - Graphic of correlation between weight (g) and the height of the shell (mm) of *A. fulica* in September de 2006 in the city of Salvador.

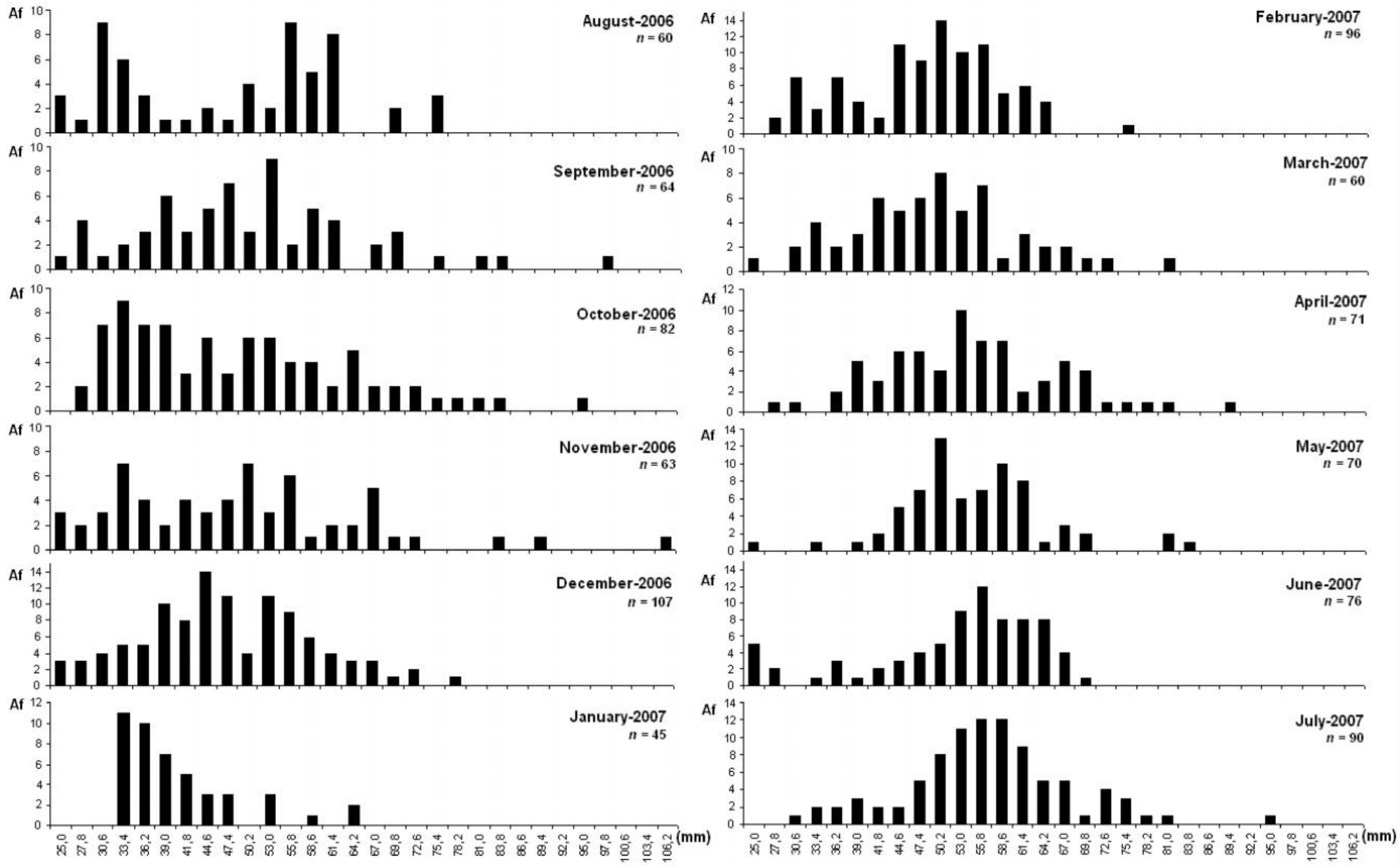



Figure 10: Monthly histograms frequency of the *A. fulica* height of the shell in 12 campaign of sample. Af = Absolute frequency.

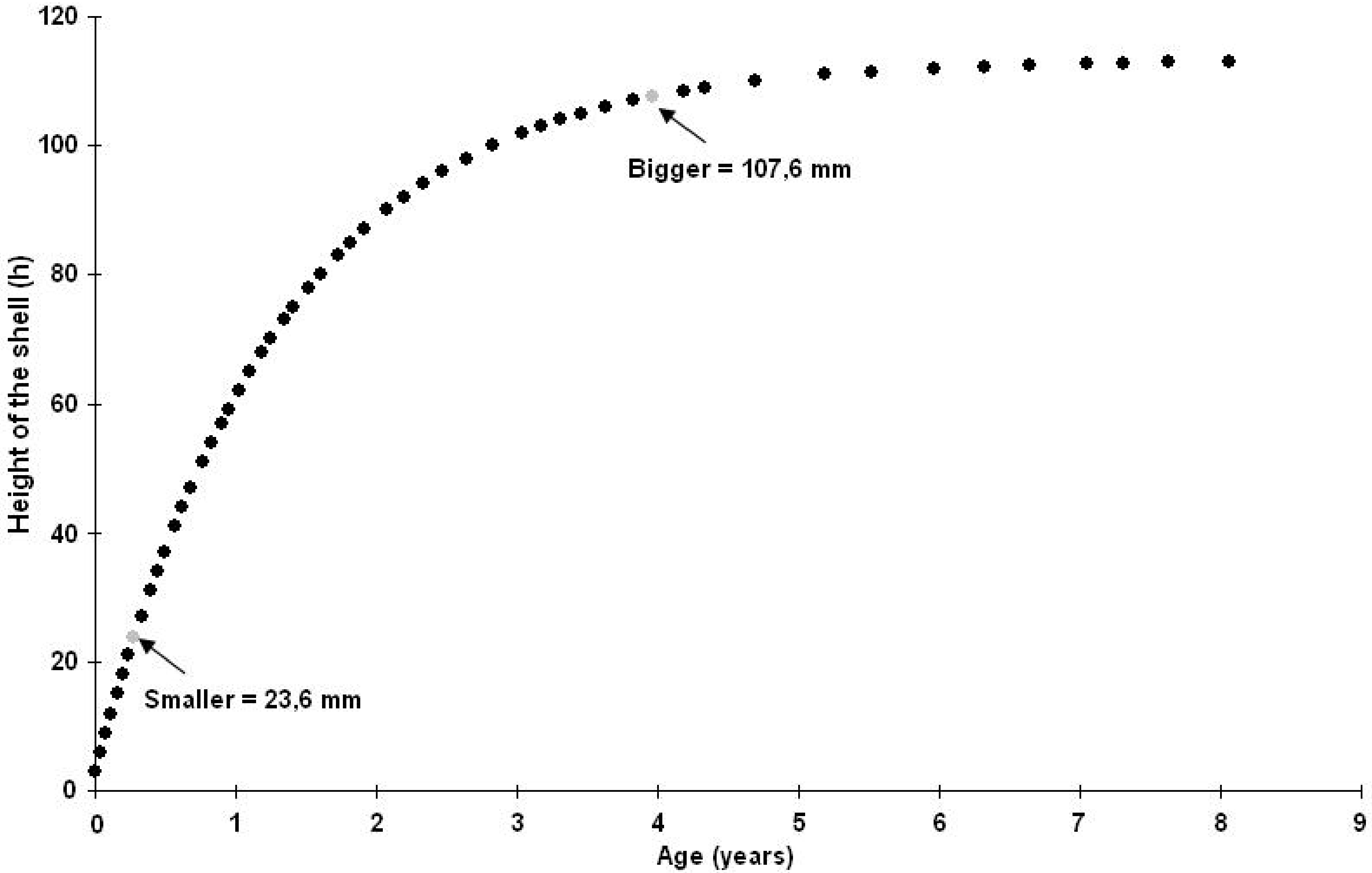


Figure 11: Curve of growth for *A. fulica* in the city of Salvador achieve through the mathematician expression of von Bertalanffy - $L_t = L_\infty [1-\exp(-k(t-t_0)]$ where: $L_\infty = 113.3$ mm; $k = 0.75$ e $t_o = -0.036$)

Table 1: Collections, dates and neighborhoods sampled monthly during the study in the city of Salvador – Bahia.

| **Neighborhoods** | **Collections** | **Neighborhoods** | **Collections** |
|---|---|---|---|
| Amaralina | 11. | Ondina | 06. |
| Barra | 08, 10. | Piatã | 01, 10, 12. |
| Barris | 07, 09, 12. | Pituba | 02, 07, 11. |
| Caminho das Árvores | 01, 08. | Praia do Flamengo | 03, 04, 07. |
| Costa Azul | 04, 12. | Rio Vermelho | 02, 04, 09. |
| Itaigara | 05, 06, 09. | Stella Maris | 01, 03. |
| Itapuã | 03, 06, 11. | STIEP | 05, 10. |
| Jardim Encantamento | 02, 05, 08. | | |

Table 2: Representativeness of each variable in each of the extracted axes for the Principal Component Analysis (PCA).

| | PC1 | PC2 |
|---|---|---|
| Temperature | 0,348 | **0,883** |
| Humidity of air | **-0,701** | 0,023 |
| Precipitation | **-0,623** | 0,468 |

Table 3: Number of *A. fulica* with P.F.S.R without P.F.S.R. and total within the stages of sexual development. P.F.S.R: Portion Female of System Reproductive.

| **Stage** | **With P.F.S.R.** | | **Without P.F.S.R.** | | **Total** | |
|---|---|---|---|---|---|---|
| | **Absolute** | **Relative** | **Absolute** | **Relative** | **Absolute** | **Relative** |
| **Old-Adult** | 305 | 96% | 12 | 4% | 317 | 54% |
| **Intermediate** | 127 | 64% | 70 | 36% | 197 | 34% |
| **Young-Adult** | 10 | 14% | 61 | 86% | 71 | 12% |
| **Total** | 442 | 76% | 143 | 24% | 585 | 100% |

Table 4 - Descriptive statistics the morphometric variables of 60 snails collected in September of 2006. h = height of the shell (mm); dm = larger diameter (mm); ha = height of the opening (mm), la = width of the opening (mm); he = height of the spire (mm); Perist. = peristome thickness (mm).

| | **Weight(g)** | **h** | **dm** | **ha** | **la** | **he** | **Turns** | **Perist.** |
|---|---|---|---|---|---|---|---|---|
| **Mean** | 14,96 | 47,70 | 30,27 | 26,37 | 16,21 | 19,68 | 6,25 | 1,01 |
| **Median** | 14,60 | 50,50 | 32,45 | 27,75 | 16,90 | 20,45 | 6,00 | 0,95 |
| **Mode** | 23,0 | 54,6 | 30,7 | 33,6 | 20,8 | 25,7 | 6,0 | 1,9 |
| **Std. deviation** | 9,748 | 14,403 | 7,666 | 7,052 | 4,245 | 6,772 | 0,875 | 0,637 |
| **Std. error** | 1,258 | 1,859 | 0,989 | 0,910 | 0,548 | 0,874 | 0,113 | 0,095 |
| **Variance** | 95,037 | 207,449 | 58,772 | 49,737 | 18,021 | 45,863 | 0,766 | 0,406 |
| **Minimum** | 2,1 | 23,6 | 17,4 | 14 | 9,4 | 9,4 | 5 | 0,2 |
| **Maximum** | 38,5 | 76,2 | 43,9 | 41,1 | 25,4 | 35 | 8 | 2,4 |

Table 5 - Descriptive statistics of the weight and height of 884 snails collected in 12 samples.

| | **Weight (g)** | **Height (mm)** |
|---|---|---|
| **Mean** | 17,20 | 50,17 |
| **Median** | 15,6 | 50,7 |
| **Mode** | 11,2 | 56,8 |
| **Std. deviation** | 11,750 | 12,760 |
| **Std. error** | 0,395 | 0,429 |
| **Variance** | 138,078 | 162,833 |
| **Minimum** | 1,9 | 23,6 |
| **Maximum** | 104,2 | 107,6 |

Table 6 - Correlations between the weight and the other morphometrics variables for *A. fulica* in September of 2006. h = height of the shell (mm); dm = larger diameter (mm); ha = height of the opening (mm), la = width of the opening (mm); he = height of the spire (mm). n = 60.

| | | Weight | **h** | dm | ha | la | he | Turns |
|---|---|---|---|---|---|---|---|---|
| **weight** | Pearson correlation | 1 | **,978(**)** | ,962(**) | ,960(**) | ,933(**) | ,953(**) | ,767(**) |
| | Sig.(1-tailed) | | $p < 0{,}001$ | $p < 0{,}001$ | $p < 0{,}001$ | $p < 0{,}001$ | $p < 0{,}001$ | $p < 0{,}001$ |

** Significant correlation < 0,01 (1-tailed).

# Conclusão Geral

Em Salvador, assim como em outras cidades do país, a presença de *A. fulica* provavelmente está ligada à criação e comércio desses animais para alimentação exótica em restaurantes especializados. Porém a cultura não prosperou comercialmente, a principio, apenas por se tratar de um hábito pouco difundido na região e, posteriormente, pela abolição da atividade de criação no país imposta pelo IBAMA (Instituto Brasileiro do Meio Ambiente). O alto potencial reprodutivo dessa espécie gerou um crescimento descontrolado da população, fugindo ao controle dos criadores e originando fuga ou liberação intencional de alguns exemplares que passaram a viver livremente e causar problemas.

O clima favorável encontrado na cidade de Salvador proporciona ao caramujo africano ótimas condições de sobrevivência e desenvolvimento passando, assim, a se reproduzir mais cedo. Além disso, a pouca variação de temperatura e umidade exige muito pouco da capacidade de resistir a grandes variações ambientais que a espécie possui, podendo assim se reproduzir por todo o ano, incrementando sua atividade à medida que a pluviometria aumenta e diminuir seu gasto energético na produção de ovos reduzindo o número de ovos por postura.

Hoje, podemos observar em Salvador um crescimento acentuado da população de *A. fulica* com presença de indivíduos grandes e vigorosos com desenvolvimento sexual completo que, segundo CIVEYREL & SIMBERLOFF (1996), são indícios da primeira fase de estabelecimento populacional caracterizada pelo crescimento acentuado da população. No nível de infestação em que se encontra a cidade de Salvador, a erradicação da espécie se torna impossível sendo mais viável o controle, porém as tentativas de controle demandam altos custos e, em sua maioria, resultaram em fracasso (THIENGO *ET AL*, 2006) .

Tem-se tentado o controle biológico para *A. fulica*, no entanto está prática levou, principalmente em ilhas do Pacífico, ao declínio e, em alguns casos, a extinção de espécies nativas de caramujos, sem o controle efetivo de *A. fulica.* Tentou-se, também, o uso de pesticidas e métodos mecânicos (coleta manual) para controle *A. fulica*, só que neste caso com mais eficiência e sem afetar espécies nativas (CIVEYREL & SIMBERLOFF, 1996; COWIE, 1998; COWIE, 2001; OHBAYASHI & TAKEUCHI, 2007). Um aliado do método mecânico é o uso de atrativos, que foi testado por RAVIKUMARA *et al* (2007) tendo obtido sucesso com iscas de talos de mamão.

Desde 2004 vem sendo implementado o plano de manejo e controle de *A. fulica* criado pelo IBAMA. O plano já foi executado em Parnamirim estado do Rio Grande do Norte, Manaus estado do Amazônas e em seis municípios do estado de São Paulo, dois do estado do Rio de Janeiro e dois no estado de Mato Grosso com relativo sucesso. O plano de manejo e controle foi elaborado baseado nas recomendações da Sociedade Brasileira de Malacologia (2001) e consiste no correto reconhecimento e catação manual dos espécimes para posterior eliminação, preferencialmente por incineração. O uso de sal ou produtos químicos para matar os moluscos deve ser visto com ressalvas, pois pode contaminar o solo, lençóis d’água e afetar crianças e animais domésticos (THIENGO *ET AL*, 2006; BRASIL, 2007; THIENGO *ET AL*, 2007).

A diminuição da população de *A. fulica* como resultado do plano de manejo e controle pode acelerar a entrada da população no processo de colapso descrito por

SIMBERLOFF & GIBBONS (2004), no qual há uma queda rápida no tamanho da população levando-a a níveis críticos e extinção local. Segundo os autores este fenômeno ocorre naturalmente e sem motivo aparente na maioria dos casos de invasões, porém antes de ocorrer os estragos já foram feitos.

Assim, devido às implicações sanitárias à saúde humana e de animais domésticos, com transmissão de patógenos; a destruição de habitat naturais e ecossistemas, que ameaçam a biodiversidade devido a extinção de espécies nativas e a todos os danos econômicos (devastação de lavouras, plantações e hortas, destruição de grãos) causados pela espécie invasora *A. fulica* e por todos os outros problemas que ela venha causar, deve-se dar continuidade a campanhas de combate e erradicação da espécie, assim como ocorre em alguns estados em que a espécie é praga. Apenas desta forma será possível preservar a malacofauna nativa, evitar possíveis prejuízos que o molusco possa impor a agricultura e minimizar os riscos a saúde da população local e de visitantes.

# Referências


ALBUQUERQUE, F.S. 2003. Ocorrência, aspectos da dinâmica populacional e comportamental de *Achatina fulica* Bowdich, 1822 (Gastropoda: Pulmonata) em Lauro de Freitas. 101p. **Dissertação (mestrado) -** Universidade Federal da Bahia. Instituto de Biologia. Programa de Pós-Graduação em Ecologia e Biomonitoramento.

ALOWE, S., BROWNE, M. & BOUDJELAS, S. 2004. 100 of the world's worst invasive alien species. A selection from the global invasive species database. Disponível: **www.issg.org/database** (último acesso em: 12/08/2007).

BENDER, A. L., MAURER, R. L., SILVA, M. C. F., *et al*. 2003. Ovos e órgãos reprodutores de fêmeas de *Angiostrongylus costaricensis* são reconhecidos mais intensamente por soros humanos de fase aguda na angiostrongilíase abdominal. **Rev. Soc. Bras. Med. Trop**. vol.36, no.4, p.449-454.

BRASIL. Ministério da Saúde. Séc. de Vigilância em Saúde. Dep. de Vigilância Epidemiológica. 2007. Vigilância e controle de moluscos de importância epidemiológica: diretrizes técnicas: Programa de Vigilância e Controle da Esquistossomose (PCE). 2ª ed. - Brasília: **Editora do Ministério da Saúde**. 178 p.

CALDEIRA, R. L., CARVALHO, O. S, MENDONCA, C.L.F.G *et al*. 2003. Molecular differentiation of *Angiostrongylus costaricensis, A. cantonensis,* and *A. vasorum* by polymerase chain reaction- restriction fragment length polymorphism. **Mem. Inst. Oswaldo Cruz**, vol.98, no.8, p.1039-1043.

CALDEIRA, R.L., MENDONÇA, C.L.G.F., GOVEIA, C.O., *et al*. 2007. First record of molluscs naturally infected with *Angiostrongylus cantonensis* (Chen, 1935) (Nematoda: Metastrongylidae) in Brazil. **Mem. Inst. Oswaldo Cruz.** 102(7): 887-889.

CARVALHO, O.S.; TELES, H.M.S.; MOTA, E.M. *et al*. 2003. Potentiality of *Achatina fulica* Bowdich, 1822 (Mollusca: Gastropoda) as intermediate host of the *Angiostrongylus costaricensis* Morera & Céspedes 1971. **Revista da Sociedade Brasileira de Medicina Tropical** 36:743-745.

CIVEYREL, L. & SIMBERLOFF, D. 1996. A tale of two snails: is the cure worse than the disease? **Biodivers. Conserv**. 5:1231-1252.

COWIE, R.H. 1995. Identity, distribution, and impacts of introduced Ampullariidae and Viviparidae in Hawaiian Islands. **Journal of Applied Malacology**. 5:61-7.

COWIE, R.H. 1998. Patterns of introduction of non-indigenous non-marine snails and slugs in the Hawaiian Islands. **Biodiversity and Conservation** 7:349-368.

COWIE, R.H. 2001. Can snail ever be effective and safe biocontrol agent? **International Journal of Pest Management**. 47:23-40.

DAJOZ, R. 2005. **Princípios de Ecologia.** 7ª ed. Porto Alegre: Editora Artmed. 520p.

DORST, Jean. 1973. **Antes que a natureza Morra.** São Paulo: Editora Edgard Blucher. 394p.

ESTON, M.R., MENEZES, G.V.; ANTUNES, A.Z., *et al.* 2006. Espécie Invasora em Unidade de Conservação Achatina Fulica (Bowdich, 1822) no Parque Estadual Carlos Botelho, Sete Barras, SP, Brasil (Nota Científica). **Revista do Instituto Florestal.** 18:173-179,

FISCHER, M.L & COLLEY, E. 2004. Diagnóstico da ocorrência do caramujo gigante africano Achatina fulica Bowdich, 1822 na APA de Guaraqueçaba, Paraná, Brasil. **Revista Estudos de Biologia.** 26(54): 43-50.

FISCHER, M.L & COLLEY, E. 2005. Espécie invasora em reservas naturais: caracterização da população de Achatina fulica Bowdich, 1822 (Mollusca – Achatinidae) na Ilha Rasa, Guaraqueçaba, Paraná. Brasil. **Biota Neotropica** 5 (1): http://www.biotaneotropica.org.br/v5n1/pt/download?article+BN03305012005+item (último acesso em: 22/08/2007)

FISCHER, M.L.; SIMIÃO,M.; COLLEY, E.; *et al*. 2006. O caramujo exótico invasor na vegetação nativa em Morretes, PR: diagnóstico da população de *Achatina fulica* Bowdich, 1822 em um fragmento de Floresta Ombrófila Densa aluvial. **Biota Neotropica**, 6 (2): http://www.biotaneotropica.org.br/v6n2/pt/abstract?short-communication+ bn03306022006 (ultimo acesso em: 16/08/2007)

GRAEFF-TEIXEIRA, C. 1998. Epidemiology of Abdominal Angiostrongylosis in Southern Brazil. *Parasitology International*. 47 23-48.

GRAEFF-TEIXEIRA, C. 2007. Expansion of *Achatina fulica* in Brazil and potential increased risk for angiostrongyliasis. **Transactions of the Royal Society of Tropical Medicine and Hygiene.** 101 743-744

MALEK E. 1985. Snail hosts of schistosomiasis and other snail-transmitted diaseases in tripocal America: a manual. Washington (DC): Pan American Health Organization: [**PAHO- Scientific Publication**, 478].

National Invasive Species Council (NISC). 2001. Meeting the Invasive Species Challenge: National Invasive Species Management Plan. 80 pp.

NEUHAUSS, E.; FITARELLI, M.; ROMANZINI, J. & GRAEFF-TEIXEIRA, C. 2007. Low susceptibility of *Achatina fulica* from Brazil to infection with *Angiostrongylus costaricensis* and *A. cantonensis*. **Mem. Inst. Oswaldo Cruz**. 102(1): 49-52.

OHBAYASHI, T. & TAKEUCHI, K. 2007. Fluctuation of the distribution and population of the giant african snail, *Achatina fulica* Bowdich (Pulmonata Achatinidae) in Chichijima and Hahajima Islands, of the Ogasawara (Bonin) Islands, from the Years 1995 to 2001. **Jpn. J. Appl. Entomol. Zool**. 51: 221–230

OHBAYASHI, T., OKOCHI, I., SATO, H. *et al*. 2007. Rapid decline of endemic snails in the Ogasawara Islands, Western Pacific Ocean. **Appl. Entomol. Zool**. 42 (3): 479-485.

PAIVA, C.L. 2001. *Achatina fulica* (Moluscos) nova praga agrícola e ameaça a saúde no Brasil. **Centro de Memória da UNICAMP** (GEHT/CMU).

PRIMACK, R. B. e RODRIGUES, E. 2001. **Biologia da Conservação**. 1ª ed. Londrina: Editora Planta. 327 p.

RAO, I. G., & SINGH, D. K. 2000. Effect of single and binary combinations of plant-derived molluscicides on reproduction and survival of the snail *Achatina fulica.* **Arch. Environ. Contam. Toxicol**. 39, 486-493.

RAUT, S.K. & BARKER, G. 2002. *Achatina fulica* Bowdich and others Achatinidae pest in tropical agriculture. in: Mollusks as croup pest (Barker, G. eds). **CAB Publishing**, New Zealand. p.55-114.

RAUT, S.K & GHOSE, K.C. 1981. Viability of sperms in aestivating *Achatina fulica* Bowdich and *Macrochlamys indica* Godwin-Austen. **Journal of Molluscs Studies**. 48: 87 - 94.

RAVIKUMARA, M.I.N.; MANJUNATHA M. & PRADEEP, S. 2007. Evaluation of Attractant Waste Material and Bait for the Management of Giant African Snail, *Achatina fulica* Bowdich. **Karnataka Journal of Agricultural Sciences.** 20(2): 288-290.

RICKLEFS, R. E. 2003. **A economia da Natureza**. 5ª ed. Rio de Janeiro: Guanabara Koogan, 503p.

SILVA, A.C.A., GRAEFF-TEIXEIRA, C. e ZAHA, A. 2003. Diagnóstico da angiostrongilíase abdominal utilizando PCR em soro de pacientes. **Rev. Inst. Med. trop. S. Paulo,** 45(5) 295-297.

SIMBERLOFF, D. & GIBBONS, L. 2004. Now you see them, now you don't! - population crashes of established introduced species. **Biological Invasions** 6: 161-172.

SIMIÃO, M.S. & FISCHER, M.L. 2004. Estimativa e inferências do método de controle do molusco exótico *Achatina fulica* Bowdich 1822 (Stylommatophora; Achatinidae) em Pontal do Paraná, litoral do Estado do Paraná. **Cad. Biodivers**. 4: 74-82.

TELES, H.M.S.; FONTES, L.R.; AMARAL, W. 2004. Pesquisa nacional de opinião pública sobre a espécie do caramujo Achatina fulica. **Instituto Brasileiro de Helicicultura** – IBH/CEDIC; 01-24.

TELES, H.M.S.; VAZ, J.F.; FONTES, L.R.; DOMINGOS, M.D. 1997. Registro de A*chatina fulica* Bowdich, 1822 (Mollusca, Gastropoda) no Brasil: Caramujo hospedeiro intermediário da angiostrongilíase. **Rev Saúde Pública**; 31:310-2.

THIENGO, S.C., BARBOSA, A.F., COELHO, P.M. & FERNANDEZ, M.A. 2006. Moluscos exóticos com importância médica no Brasil. Disponível em: <http://www.mma.gov.br/invasoras/capa/docs/co/silvana_carvalho.pdf> Acesso em: abr. 2008.

THIENGO, S.C., FARACO, F.A., SALGADO, N.C., *et al*. 2007. Rapid spread of an invasive snail in South America: the giant African snail, *Achatina fulica*, in Brazil. **Biological Invasions** 9:693-702.

THIENGO, S.C.; FERNANDEZ, M.A.; TORRES, E.J.L.; *et al.* 2007. First record of a nematode Metastrongyloidea (*Aelurostrongylus abstrusus* larvae) in *Achatina (Lissachatina) fulica* (Mollusca, Achatinidae) in Brazil. **Journal of Invertebrate Pathology**. Article in Press.

TOMIYAMA, K. & MIYASHITA, K.; 1992.Variation of egg clutches in the Giant African snail, *Achatina fulica* (Ferussac) (Stylomatophpra; Achatinidae). **Venus,** 51(4): 293-301.

TOMIYAMA, K. 1993. Growth and maturation pattern in the African giant snail, *Achatina fulica* (Férussac) (Stylommatophora: Achatinidae). **Venus,** 52: 87-100.

TOWNSEND, C. R.; BEGON, M. & HARPER, J. L. 2006. **Fundamentos em Ecologia**. 2ª ed. Porto Alegre: Artmed. 592p.

USC - Union Concerned Scientists. The science of invasive species. 2001.Disponível em http://www.ucsusa.org/global_environment/invasive_species/index.cfm. Acesso em: 02 Mai. 2008

USDA - United States Department of Agriculture. 1966. **Animal Welfare Act**. 7 USC: 2131-2156. Disponível em: <http://warp.nal.usda.gov:80/awic/legislat/usdaleg1.htm> Acesso em: ,15 mai 2005.

VASCONCELLOS, M.C. & PILE, E. 2001. Ocorrência de *Achatina fulica* no Vale do Paraíba, Estado do Rio de Janeiro, Brasil. **Rev Saúde Pública**, 35(6):582-4.

VENETTE, R.C. & LARSON, M. 2004. Mini Risk Assessment Giant African Snail, *Achatina fulica* Bowdich (Gastropoda: Achatinidae). **CAPS PRA**. 1-30.

# APÊNDICE
# FIGURAS E TABELAS

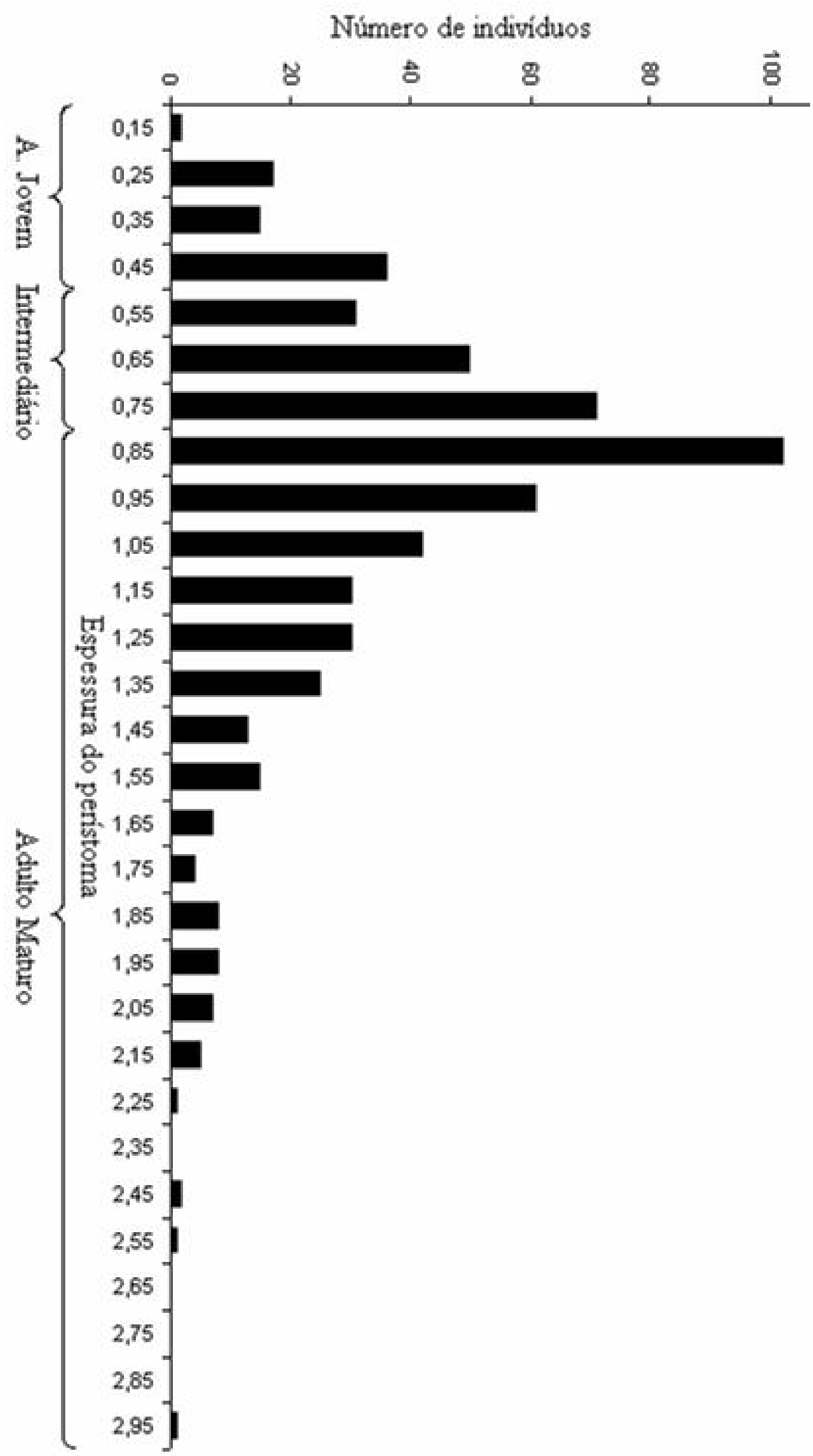



Figura A1: Gráfico da freqüência de classes de espessura do perístoma (mm) e divisão estágio de desenvolvimento sexual.


Figura A2 - *Achatina fulica*. A. espécime vivo; B. concha.

Tabela A1: Média e desvio padrão mensal do peso da glândula de proteína (mg) e total de glândulas pesadas de *A. fulica* na cidade de Salvador - BA. (n = 418)

| | **Set. 2006** | **Out. 2006** | **Nov. 2006** | **Dez. 2006** | **Jan. 2007** | **Fev. 2007** |
|---|---|---|---|---|---|---|
| **Média** | 273,70 | 277,32 | 754,24 | 488,15 | 178,75 | 90,87 |
| **Desvio Padrão** | 411,59 | 427,10 | 1272,71 | 1070,86 | 247,72 | 222,67 |
| **Glândulas (n)** | 30 | 25 | 34 | 27 | 41 | 23 |

| | **Mar. 2007** | **Abr. 2007** | **Mai. 2007** | **Jun. 2007** | **Jul. 2007** | **Ago. 2007** |
|---|---|---|---|---|---|---|
| **Média** | 472,43 | 184,21 | 735,53 | 795,61 | 447,86 | 288,11 |
| **Desvio Padrão** | 735,69 | 216,95 | 941,07 | 1119,38 | 463,99 | 324,03 |
| **Glândulas (n)** | 39 | 38 | 39 | 42 | 43 | 37 |

# ANEXO A - FIGURAS

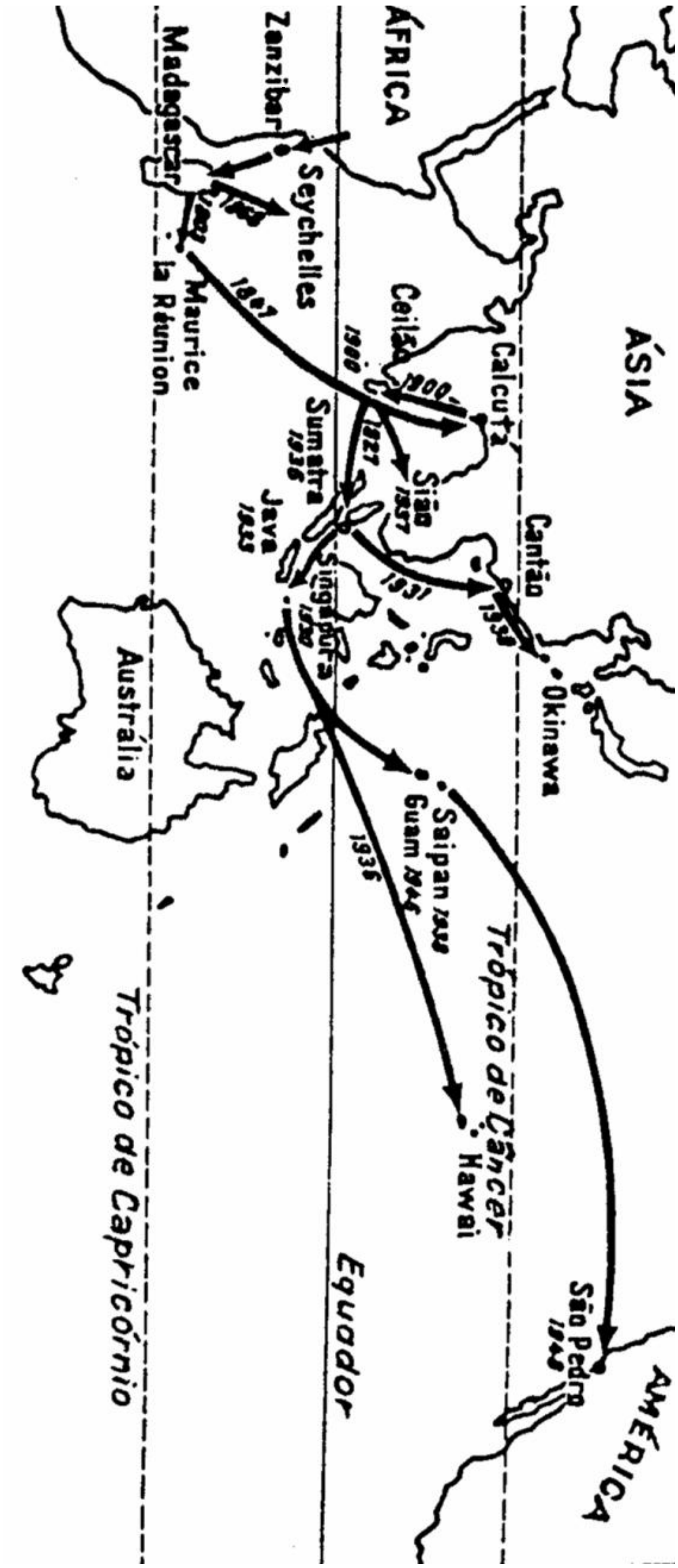
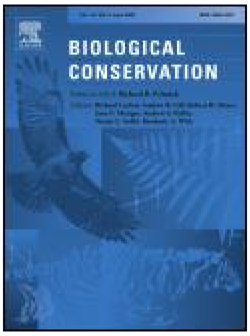



Figura A1: Rota de dispersão de *A. Fulica* partindo da África até sua chegada as Américas.


Figura A2: Sistema reprodutor hermafrodita de *Achatina fulica*. Fonte: CAETANO, 2005.

# ANEXO B
# NORMAS: BIOLOGICAL CONSERVATION




Editor-in-Chief:
R.B. Primack
See editorial board for all editors information

An affiliate publication of the Society for Conservation Biology (SCB). SCB member can obtain a personal subscription to this journal through the Society.

Editorial of the Editor-in-Chief, Richard Primack

Description

Biological Conservation publishes the leading research in the discipline of conservation biology. The journal is globally relevant and international in scope. It publishes articles spanning a diverse range of fields that contribute to the biological, sociological, and economic dimensions of conservation and natural resource management. Biological Conservation has as its primary aim the publication of high-quality papers that advance the science and practice of conservation, or which demonstrate the application of conservation principles for natural resource management and policy, and which therefore will be of interest to a broad international readership. Biological Conservation invites the submission of research articles, reviews (including systematic reviews), short communications and letters dealing with all aspects of conservation science, including theoretical and empirical investigations into the consequences of human actions for the diversity, structure and function of terrestrial, aquatic or marine ecosystems. Such papers may include quantitative assessments of extinction risk, fragmentation effects, spread of invasive organisms, conservation genetics, conservation management, global change effects on biodiversity, landscape or reserve design and management, restoration ecology, or resource economics. Although the journal's coverage of interdisciplinary topics within conservation biology is highly relevant to scientists at academic, research and non-governmental institutions, the emphasis on the practical applications of conservation research also provide essential information for land/resource managers and policy makers charged with protecting biological diversity and ultimately implementing conservation science into conservation practice.

Bibliographic & ordering information
ISSN: 0006-3207
Imprint: ELSEVIER
Commenced publication 1969

Subscriptions for the year 2008, Volume 141, 12 issues
To subscribe as a BES member contact the society at http://www.britishecologicalsociety.org
Institutional online access: ScienceDirect eSelect
For purchase of online access to this journal on ScienceDirect.

Institutional price: Order form
USD 2,948 for all countries except Europe, Japan and Iran
JPY 349,500 for Japan
EUR 2,634 for European countries and Iran

Conditions of sale & ordering procedures, and links to our regional sales offices.
For an overview of recently-dispatched issues, see the Journal issue dispatch dates
Audience
Environmentalists, conservationists, botanists, marine scientists, ecologists, biologists, zoologists.
Impact factor of this journal
2007: 3.296
© Journal Citation Reports 2008, published by Thomson Reuters

## Guide for Authors

Please read all information carefully and follow the instructions in detail when preparing your manuscript.

Manuscripts that are not prepared according to our guidelines will be sent back to authors without review. A checklist for manuscript submission can be found at the end of the Guide for Authors.

Biological Conservation encourages the submission of high-quality manuscripts that advance the science and practice of conservation, or which demonstrate the application of conservation principles for natural resource management and policy. Given the broad international readership of the journal, published articles should have global relevance in terms of the topics or issues addressed, and thus demonstrate applications for conservation or resource management beyond the specific system or species studied.

Types of Contributions

1. Full length articles (Research papers)

Research papers report the results of original research. The material must not have been previously published elsewhere. Full length articles are usually up to 8,000 words.

2. Review articles

Reviews should address topics or issues of current interest. They may be submitted or invited. Review articles are usually up to 12,000 words.

3. Systematic reviews

Systematic review is a methodology used to summarize, appraise and communicate the results and implications of a large quantity of research and information. Although the manuscript should report the main outcomes of the systematic review, it is expected that the full review and associated data will be made available online. The length of a systematic review should not exceed 8,000 words.

For a more elaborate explanation of systematic reviews, please check the following link: http://www.cebc.bangor.ac.uk/introSR.php. Authors who intend to write a systematic review are kindly asked to contact Andrew Pullin first.

4. Short communications

Short communications are meant to highlight important research that is novel or represents highly significant preliminary findings, and should be less than 4,000 words.

5. Book Reviews

Book reviews will be included in the journal on a range of relevant titles that are not more than two years old. These are usually less than 2,000 words.

6. Letters to the Editor.

Letters to the editor are written in response to a recent article appearing in the journal. Letters should be less than 1,600 words.

Editorial Process

Publishing space in the journal is limited, such that many manuscripts must be rejected. To expedite the processing of manuscripts, the journal has adopted a two-tier review process. During the first stage of review, the handling editor evaluates the manuscript for appropriateness and scientific content, taking advice where appropriate from members of the editorial board. Criteria for rejection at this stage include:

Manuscript lacks a strong conservation focus or theme, or management implications not well-developed. Please note that research on a rare or endangered species or ecosystem is not sufficient justification to merit publication in Biological Conservation. Published research must also advance the science and practice of conservation biology, and thus have broader application for a wide international audience.

Manuscript subject matter more appropriate for another journal. Natural history or biodiversity surveys, including site descriptions, are usually better suited for other outlets, such as a regional or taxon-specific journal. Similarly, manuscripts with a primarily behavioral, genetic or ecological focus are more appropriate for journals in those fields. For example, studies reporting on disturbance effects, species interactions (e.g., predator-prey, competitive, or pollinator-host plant interactions), species-habitat relationships, descriptive genetics (e.g., assays of genetic variation within or between populations), or behavioral responses to disturbance will be referred elsewhere if they lack a clear conservation message. Authors are advised to contact an Editor prior to submission if there are any questions regarding the appropriateness of a manuscript for the journal.

Study primarily of local or regional interest. Biological Conservation is international in scope, and thus research published in the journal should have global relevance, in terms of the topics or issues addressed.

Study poorly designed or executed. Research lacks spatial or temporal replication, has insufficient sample sizes, or inadequate data analysis. Such obvious indications of poor-quality science will be cause for immediate rejection.

Manuscript poorly written. Poor writing interferes with the effective communication of science. Authors for whom English is not the first language are advised to consult with a technical language editor before submission.

Conservation research ethics violated. Research was unnecessarily destructive, was conducted for the express purpose of causing harm/mortality (e.g., simulation of treatment or disturbance effects on survivorship), or violated ethics in the treatment and handling of animals. Where appropriate, authors must provide a statement and supporting documentation that research was approved by the authors' institutional animal care and use committee(s).

Manuscripts that pass this first stage of editorial review are then subjected to a second stage of formal peer review. This involves evaluation of the manuscript by at least two specialists within the field of study, which may include one or more members of the editorial board. Beyond a critical assessment of the scientific content and overall presentation, referees are asked to evaluate the originality, likely impact and global relevance of the research. Referees make a recommendation to the handling editor, but note that it is ultimately the decision of the handling editor as to whether a manuscript is accepted for publication in Biological Conservation.

Manuscript submission

Biological Conservation uses an online, electronic submission system. By accessing the website http://ees.elsevier.com/bioc you will be guided stepwise through the creation and uploading of the various files. When submitting a manuscript to Elsevier Editorial System (EES), authors need to provide an electronic version of their manuscript. For this purpose, original source files, not PDF files, are preferred. The author should specify a category designation for the manuscript (full length article, review article, short communications, letters, book reviews), choose a set of classifications from the prescribed list provided online, and select a preferred editor. Choice of editor cannot be guaranteed, as allocation depends on editor's workload and availability.

a) Original work

Submission of an article implies that it is original research that is not being considered simultaneously for publication elsewhere. Submission of multi-authored manuscripts must be with the consent of all the participating authors.

b) Cover letter

Submission of a manuscript must be accompanied by a cover letter that includes the following statements or acknowledgements:

The work is all original research carried out by the authors.

All authors agree with the contents of the manuscript and its submission to the journal.

No part of the research has been published in any form elsewhere, unless it is fully acknowledged in the manuscript. Authors should disclose how the research featured in the manuscript relates to any other manuscript of a similar nature that they have published, in press, submitted or will soon submit to Biological Conservation or elsewhere.

The manuscript is not being considered for publication elsewhere while it is being considered for publication in this journal.

Any research in the paper not carried out by the authors is fully acknowledged in the manuscript.

All sources of funding are acknowledged in the manuscript, and authors have declared any direct financial benefits that could result from publication.

All appropriate ethics and other approvals were obtained for the research. Where appropriate, authors should state that their research protocols have been approved by an authorized animal care or ethics committee, and include a reference to the code of practice adopted for the reported experimentation or methodology. The Editor will take account of animal welfare issues and reserves the right not to publish, especially if the research involves protocols that are inconsistent with commonly accepted norms of animal research.

c) Confirmation of submission

After the editorial office has received your submission, you will receive a confirmation, and information about the further proceeding. The handling editor will carry out a light review and decide whether a paper falls within the scope of the journal and is of sufficient standard to be sent for independent peer-review. Any manuscript not being sent for independent peer-review will be returned to the author(s) as soon as possible.

d) Conflicts of Interest

To allow scientists, the public, and policy makers to make more informed judgements about published research, Biological Conservation adopts a strong policy on conflicts of interest and disclosure. Authors should acknowledge all sources of funding and any direct financial benefits that could result from publication. Editors likewise require reviewers to disclose current or recent association with authors and other special interest in this work.

e) Potential reviewers

Authors are at liberty to suggest the names of up to three potential reviewers (with full contact details). Potential reviewers should not include anyone with whom the authors have collaborated during the research being submitted.

III. Setting up and formatting your manuscript

1. General information

Set up your document one-sided, using double spacing and wide (3 cm) margins. Use continuous line numbering throughout the document. Avoid full justification, i.e., do not use a constant right-hand margin. Ensure that each new paragraph is clearly indicated. Number every page of the manuscript, including the title page, references tables, etc. Present tables and figure legends on separate pages at the end of the manuscript. Layout and conventions must conform with those given in this guide to authors. Journal style has changed over time so do not use old issues as a guide.

Number all pages consecutively. Italics are not to be used for expressions of Latin origin, for example, in vivo, et al., per se. Use decimal points (not commas); use a space for thousands (10 000 and above).

2. Preparation of illustrations

We urge you to visit the Elsevier Electronic Artwork Guide at http://www.elsevier.com/artworkinstructions

3. Language

Please assure your manuscript is written in excellent English (American or British usage is accepted, but not a mixture of these). Authors whose first language is not English are encouraged to have the paper edited by a native English speaker prior to submission. Authors who require information about language editing and copyediting services pre- and post-submission please visit http://www.elsevier.com/wps/find/authorshome.authors/languagepolishing or contact authorsupport@elsevier.com for more information. Please note Elsevier neither endorses nor takes responsibility for any products, goods or services offered by outside vendors through our services or in any advertising. For more information please refer to our Terms & Conditions http://www.elsevier.com/wps/find/termsconditions.cws_home/termsconditions.

IV. Structure of the manuscript

1. Title page

a) Title of manuscript

State the title of the manuscript. The title should be concise and informative. Titles are often used in information-retrieval systems. Avoid abbreviations and formulae where possible.

b) Author(s) names and affiliation(s)

State the authors' first and family names (put family name in capitals) and affiliations. Where the family name may be ambiguous (e.g., a double name), please indicate this clearly. Present the authors' affiliation addresses (where the actual work was done) below the names and only in English. Indicate all affiliations with a lower-case superscript letter immediately after the author's name and also in front of the appropriate address. Provide the full postal address of each affiliation, including the country name, and e-mail address of each author.

Once a manuscript is submitted, authorship cannot be changed. In case a change in authorship is requested, the manuscript must be withdrawn and be resubmitted as new submission.

c) Corresponding author

Clearly indicate who is the corresponding author, willing to handle correspondence at all stages of reviewing and publication, also post-publication. Ensure the corresponding author's telephone and fax numbers (with country and area code) are provided in addition to the e-mail address and the complete postal address.

d) Present address

If an author has moved since the work described in the article was done, or was visiting at the time, a 'Present address' (or 'Permanent address') may be indicated as a footnote to that author's name. The address at which the author actually did the work must be retained as the main, affiliation address. Superscript Arabic numerals are used for such footnotes.

e) Abstract

Provide a concise and factual abstract (maximum length of 250 words). The abstract should state briefly the purpose of the research, the methods, the principal results, major points of discussion, and conclusions. An abstract is often presented separate from the article, so it must be able to stand alone. References should therefore be avoided, but if essential, they must be cited in full, without reference to the reference list. Non-standard or uncommon abbreviations should be avoided.

f) Keywords

Immediately after the abstract, provide a maximum of 6 keywords, avoiding general and plural terms and multiple concepts (avoid, for example, 'and', 'of'). Avoid the use of entire phrases as keywords and do not repeat words that were already used in the title. Be sparing with abbreviations: only abbreviations firmly established in the field may be eligible. These keywords will be used for indexing purposes.

2. Introduction

State the objectives of the work and provide an adequate background to the international context in which the research is carried out.

3. Materials and methods

Provide sufficient detail to allow the work to be reproduced. Methods already published should be indicated by a reference: only relevant modifications should be described.

4. Results

Provide your main results in a concise manner. Avoid overlap between figures, tables, and text.

5. Discussions and Conclusions

Indicate significant contributions of your findings, their limitations, advantages and possible applications. Discuss your own results in the light of other international research and draw out the conservation implications.

6. Acknowledgements

Place acknowledgements as a separate section after the discussion and before the references. Include information on grants received and all appropriate ethics and other approvals obtained for the research.

7. Appendices

If there is more than one appendix, they should be identified as A, B, etc. Formulae and equations in appendices should be given separate numbering: (Eq. A.1), (Eq. A.2), etc.; in a subsequent appendix, (Eq. B.1) and so forth.

8. References

Assertions made in the paper that are not supported by your research must be justified by appropriate references. Follow the journal format for references precisely (see section V. below for more detailed information). Ensure all references cited in the text are in the reference list (and vice versa).

9. Captions, tables, and figures

Present these, in this order, at the end of the manuscript. They are described in more detail below (see section VI.). High-resolution graphics files must always be provided separate from the main text file in the final version accepted for publication.

Colour diagrams can be printed (see below).

Ensure that each illustration has a caption. Supply captions on a separate page, not attached to the figure. A caption should comprise a brief title (not on the figure itself) and a description of the illustration or table. Keep text in the illustrations and tables themselves to a minimum but explain all symbols and abbreviations used.

10. Footnotes

Footnotes should not be used.

11. Nomenclature and units

Follow internationally accepted rules and conventions: use the international system of units (SI) for all scientific and laboratory data. If other quantities are mentioned, give their equivalent in SI.

Common names must be in lower-case except proper nouns. All common names must be followed by a scientific name in parentheses in italics. For example, bottlenose dolphin (Tursiops aduncus). Where scientific names are used in preference to common names they should be in italics and the genus should be reduced to the first letter after the first mention. For example, the first mention is given as Tursiops aduncus and subsequent mentions are given as T. aduncus.

12. Preparation of supplementary data

Elsevier now accepts electronic supplementary material to support and enhance your scientific research. Supplementary files offer the author additional possibilities to publish supporting applications, movies, animation sequences, high-resolution images, large tables, background datasets, sound clips, stellar diagrams and more. Supplementary files supplied will be published online alongside the electronic version of your article in Elsevier web products, including ScienceDirect: http://www.sciencedirect.com. In order to ensure that your submitted material is directly usable, please ensure that data are provided in one of our recommended file formats. Authors should submit the material in electronic format together with the article and supply a concise and descriptive caption for each file. For more detailed instructions please visit o http://www.elsevier.com. Supplementary data must be supplied at submission so that it can be refereed.

V. Referencing

1. Citations in the text

Please ensure that every reference cited in the text is also present in the reference list (and vice versa). Unpublished results and personal communications should not be in the reference list, but may be mentioned in the text. Conference proceedings, abstracts and grey literature (research reports and limited circulation documents) are not acceptable citations. Citation of a reference as 'in press' means that the item has been accepted for publication.

2. Citing and listing of web references

As a minimum, the full URL and last access date should be given. Any further information, if known (author names, dates, reference to a source publication, etc.), should also be given. Web references can be listed separately (e.g., after the reference list) under a different heading if desired, or can be included in the reference list.

3. Citing in the text

Citations in the text should be:

Single author: the author's name (without initials, unless there is ambiguity), the year of publication;

Two authors: both authors' names, the year of publication; use 'and' between names not '&'. Three or more authors: first author's name followed by et al., the year of publication. Citations may be made directly (or parenthetically). Groups of references should be given chronologically with the earliest first and if several from the same year then they should be given alphabetically. If there are several from the same author in the same year then they are given as author, yeara, b (eg 1996a,b] (not yeara, yearb)

Examples: "as demonstrated (Allan and Jones, 1995; Smith et al., 1995; Woodbridge, 1995; Allan, 1996a, b, 1999). Kramer et al. (2000) have recently shown ...."

4. List of references

References should be arranged first alphabetically and then further sorted chronologically if necessary. More than one reference from the same author(s) in the same year must be identified by the letters "a", "b", "c", etc., placed after the year of publication. You may use the DOI (Digital Object Identifier) and the full journal reference to cite articles in press. The format for listing references is given below and must be followed precisely.

Examples:

Reference to a journal publication. Give the journal title in full:

Moseby, K.E., Read, J.L., 2006. The efficacy of feral cat, fox and rabbit exclusion fence designs for threatened species protection. Biological Conservation 127, 429-437.

Reference to a book:

Strunk Jr., W., White, E.B., 1979. The Elements of Style, 3rd edn. Macmillan, New York.

Reference to a chapter in an edited book:

Mettam, G.R., Adams, L.B., 1999. How to prepare an electronic version of your article, in: Jones, B.S., Smith , R.Z. (Eds.), Introduction to the Electronic Age. E-Publishing Inc., New York, pp. 281-304.

5. Digital Object Identifier (DOI):

In addition to regular bibliographic information, the digital object identifier (DOI) may be used to cite and link to electronic documents. The DOI consists of a unique alpha-numeric character string which is assigned to a document by the publisher upon the initial electronic publication. The assigned DOI never changes. Therefore, it is an ideal medium for citing a document, particularly 'Articles in press' because they have not yet received their full bibliographic information. The correct format for citing a DOI is shown as follows (example taken from a document in the journal Physics Letters B): doi:10.1016/j.physletb.2003.10.071

NB: Please give as much bibliographic information as possible with the DOI. Please give the name(s) of the author(s), title of the paper, journal name and if possible year of publication.

When you use the DOI to create URL hyperlinks to documents on the web, they are guaranteed never to change.

VI. Manuscript handling after acceptance

1. Copyright

Upon acceptance of an article, authors will be asked to transfer copyright (for more information on copyright see http://www.elsevier.com/authorsrights). This transfer will ensure the widest possible dissemination of information. A letter will be sent to the corresponding author confirming receipt of the manuscript. A form facilitating transfer of copyright will be provided.

If excerpts from other copyrighted works are included, the author(s) must obtain written permission from the copyright owners and credit the source(s) in the article. Elsevier has pre-printed forms for use by authors in these cases: contact ES Global Rights Department, P.O. Box 800, Oxford, OX5 1DX, UK; phone: (+44) 1865 843830, fax: (+44) 1865 853333, e-mail: permissions@elsevier.com

2. Costs for colour prints

a) Colour illustrations in print

Colour illustrations in print will be charged to the author. Illustration costs are EURO 350 for every first page. All subsequent pages cost EURO 175.

b) Colour illustrations on the web (ScienceDirect)

Colour illustrations in the web (ScienceDirect) are free of charge. If you want a colour illustration on the web and the same illustration in black and white in the print version of the journal, please note that you will then have to submit two different illustration files, one colour and one black and white version.

3. Proofs

When your manuscript is received by the Publisher it is considered to be in its final form. Proofs are not to be regarded as 'drafts'.

One set of page proofs in PDF format will be sent by e-mail to the corresponding author, to be checked for typesetting/editing and should be returned within 2 days of receipt, preferably be email. No changes in, or additions to, the accepted (and subsequently edited) manuscript will be allowed at this stage. Any amendments may be charged to the author. Proofreading is solely the author's responsibility.

Should you choose to mail your corrections, please return them to: Log-in Department, Elsevier, Stover Court, Bampfylde Street, Exeter, Devon EX1 2AH, UK.

A form with queries from the copyeditor may accompany your proofs. Please answer all queries and make any corrections or additions required. The Publisher reserves the right to proceed with publication if corrections are not communicated. Return corrections within 2 days of receipt of the proofs. Should there be no corrections, please confirm this.

Elsevier will do everything possible to get your article corrected and published as quickly and accurately as possible. In order to do this we need your help. When you receive the (PDF) proof of your article for correction, it is important to ensure that all of your corrections are sent back to us in one communication. Subsequent corrections will not be possible, so please ensure your first sending is complete. Note that this does not mean you have any less time to make your corrections, just that only one set of corrections will be accepted.

4. Tracking your article

Authors can keep a track on the progress of their accepted article, and set up e-mail alerts informing them of changes to their manuscript's status, by using the "Track a Paper" feature, which can be obtained at:: http://www.elsevier.com/. Contact details for questions arising after acceptance of an article, especially those relating to proofs, are provided when an article is accepted for publication.

5. Offprints

The corresponding author, at no cost, will be provided with a PDF file of the article via e-mail or, alternatively, 25 free paper offprints. The PDF file is a watermarked version of the published article and includes a cover sheet with the journal cover image and a disclaimer outlining the terms and conditions of use.

VII. Submission Checklist

It is hoped that this list will be useful during the final checking of an article prior to sending it to the journal's editor for review. Please consult this Guide for Authors for further details of any item.

Ensure that the following items are present for submission:

One author designated as corresponding author.

Full contact addresses of all author(s).

Covering letter stating that the manuscript is original work, that it is not being submitted elsewhere, that all authors agree with the content and to the submission, any research in the paper not carried out by the authors is fully acknowledged in the manuscript and where necessary all appropriate ethics and other approvals were obtained for the research.

The names and contacts of three potential reviewers are provided.

The manuscript is one-sided, double spaced, page numbered and line-numbered throughout.

The name and address of the author(s) is only stated on the first title page and nowhere else in the manuscript, except for quoting own work.

The second title page contains the title, abstract and keywords.

All tables (including title, description and caption) are included.

All illustrations (including title, description and caption) are included.

Manuscript has been "spellchecked", and checked by someone fluent in English who understands the subject material of the manuscript.

References are in the correct format for the journal (see above).

All references mentioned in the Reference list are cited in the text, and vice versa

All tables and figures have been referred to in the text.

Permission has been obtained for use of copyrighted material from other sources (including the Web)