

A population assessment and distribution of the endemic Enid snail *Pachnodus fregatensis* on Frégate Island, Seychelles

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Abstract: The Frégate Island Enid snail *Pachnodus fregatensis* is a terrestrial mollusc endemic to an island of 2km² in the Seychelles and is classified as an Endangered species according to the IUCN Red List. Previous assessments revealed a substantial decline in the population following a successful rat eradication programme in 2001 as a result of susceptibility to the poison used. In 2002, the snail population was estimated at 7700 individuals and the latest estimate reveals a significant increase to 63890 individuals as well as dispersal into previously unrecorded habitat.

Key words: Enid snail, terrestrial mollusc, island, population trend, Cerastidae

Introduction

Terrestrial snails, being a major component of oceanic island biota, offer much in terms of answering questions of evolution and biogeography (Holland & Cowie 2009). However, before their value in evolutionary biology can be determined, basic information, such as their conservation status, population size and ecological requirements need to be determined. Most animal conservation efforts are directed at vertebrates, even though these animals represent only about 1% of the extant biodiversity (Ponder & Lunney 1999). This contrasts with the current extinction risk among invertebrates, less than 0.3% of which has been evaluated for cataloguing in the IUCN lists (Baillie *et al.* 2004). Molluscs represent the group with the highest number of recorded extinctions, and terrestrial molluscs are especially prone to disappearance as they include many endemics with restricted distributions and limited dispersal capacity (Lydeard *et al.* 2004).

The Frégate Island Enid Snail *Pachnodus fregatensis* (Van Mol & Coppois, 1980) is no exception. It is a terrestrial species that occupies a single, continuous range of only two square kilometres on Frégate Island in the Seychelles archipelago. *Pachnodus fregatensis* is classified as Endangered on the IUCN Red List of Threatened Species with the population trend being unknown (category A1a) (2011). As with other threatened species, it has been neglected in ecological studies and there have been very limited studies on the biology and distribution of this species. The presence of *Pachnodus fregatensis* was first reported in 1972 (as *Pachnodus ornatus*) (Lionnet 1972) although it was not described as an endemic species until 1980, based on specimens collected in 1972 on banana trees along the Rivière Bambou (Van Mol & Coppois 1980).

During July 1995, brown rats *Rattus norvegicus* were unintentionally introduced and rapidly became established on the island. They are a highly invasive species and known to pose a threat to certain endemic animals (Thorsen & Shorten 1997). In view of this, in 1996 a rescue collection of Enid snails, along with Giant Tenebrionid

Beetle *Polposipus herculeanus*, Giant Millipede *Seychelleptus seychellarum* and Giant Scorpion *Chiromachus ochropus* was sent to the Zoological Society of London as part of an ex-situ captive breeding programme (Lucking & Lucking 1997; Gerlach 1999) in order to safeguard the survival of these vulnerable species of Frégate Island.

In 2000, Gerlach and Florens had raised concerns about the potential impact of rodent eradication on the invertebrates of Frégate and had shown that *Pachnodus* snails are highly vulnerable to poisoning. Rats had been reported on Frégate from at least the 1960's (Dawson 1965), although they appear to have been eliminated from at least 1985 - 1995 (Gerlach 2005).

In 2005, Gerlach revealed that between 1999 and 2001, the population of Frégate Enid snails had declined by a significant 87% and he estimated the population to be approximately 7700 individuals. The result of this decline seems to be the broadcast use of the anti-coagulant Brodifacoum in the successful eradication of brown rats from the island in 2001 (Merton *et al.* 2001).

Being an important component of a healthy functioning ecosystem, snails are considered potential bio-indicators of the impact on climate change (Gerlach 2010). Despite their importance, these molluscs face a number of potential threats on Frégate, including habitat alteration, direct poisoning used in eradication of introduced species (Gerlach 2006), as well as changing weather patterns and possible threats from introduced species. Three, possibly four, snail species have already become extinct in the Seychelles, along with extinctions of at least eight plant species, three tortoise species, one mammal species, one crocodile species, seven bird species and likely many invertebrate species (Nature Seychelles, S.a.). *Conturbatia crenata*, a species described by Gerlach in 2001 from a single specimen found on Frégate in 1999 is likely the fourth snail species to become extinct (Gerlach 2005), even before any data has been collected on its biology and distribution.

In the decade since 2001, no thorough population assessments have been undertaken to determine the population trend of Enid snails and it was unknown whether the population had recovered since the eradication of rats. The purpose of this study was to establish whether there has been a recovery of the population and if so, to what extent. The vegetation on Frégate has also changed during this period and this study served to determine the distribution of the species. With limited historical data on *P. fregatensis* and with small, isolated populations being vulnerable to extinction, optimal conservation decisions need to be made to ensure the continued survival of this species. To do so effectively, up to date information is necessary and population trends are essential.

Study area

Frégate is a privately owned island of 219 hectares, forming part of the inner granitic group of the Seychelles archipelago. The island lies at 04°35'19''S and 55°56'55''E, with its highest point being Mont Signal situated 125 m above sea level. Deposits on the plateau are associated with guano; forming phosphate cemented sandstones and phosphatised granite. The low-lying areas were swampy in the past and characterized by sediments of fine clay and quartz (Braithwaite 1984). These swampy areas have been replaced by agricultural fields, manicured lawns and a marina development. Frégate, as the seventh largest granitic island, was probably isolated from the rest of the Seychelles islands approximately 12,000 years ago following the break-

up of Gondwanaland (Gerlach 2005).

The vegetation of Frégate has been significantly altered by man's activities and little is known of the island's original vegetation structure (Ferguson & Pearce-Kelly 2005). A description of Frégate in 1787 describes low trees and scrub (Fauvel 1909). Continuous human occupation of the island is thought to have commenced in the early 19th century with a resultant clearing of native vegetation for the establishment of plantations, particularly coconut *Cocos nucifera* (Robertson & Todd 1983). During the early 1900's the island was used for spice and copra production (Merton *et al.* 2001). At present, the vegetation on the island comprises of diminutive patches of native woodland that have either persisted or been replanted, along with exotic species such as cashew *Anacardium occidentale*, banyan *Ficus benghalensis*, cinnamon *Cinnamomum verum* and cocoplum *Chrysobalanus icaco*, amongst others. A large portion of the island was set aside for a vanilla plantation in the early 1900's with sandragon trees *Pterocarpus indicus* being used to support the vines. This area provided habitat for the snails in the past (Gerlach 2005), however these trees were affected by a fungal disease in 2001 that has since destroyed them (Boa & Kirkendall 2004). This area has regenerated naturally and provides potential habitat for the Enid snail and other species.

Methods

Fieldwork was conducted in August 2011 when the snails are active and the probability of underestimation is reduced. The island was stratified into vegetation types based on maps from Gerlach (2005) and Henriette & Rocamora (2009) and updated by Canning (2011). Updated vegetation distribution is based on changes that have occurred as a result of habitat restoration and natural vegetation regeneration. A repeatable pilot study of the entire island determined the presence or absence of snails in each vegetation type.

Surveys were carried out in the mornings between 07:00 and 10:00 before snails retreated into crevices or other hideaways. The vegetation types in which the snails were present were assessed for substrate preference and population distribution. An estimate of the population is based on methodology previously used by Gerlach in 1999 and 2002 to allow for the comparison of results and determination of trends.

A system of random quadrats was used. In each vegetation type surveyed, ten quadrats of 5 x 5m (25m²) were randomly placed and GPS co-ordinates were recorded. The use of randomized quadrats allows the molluscs to be studied regularly without requiring sophisticated marking of location techniques and over-sampling of small areas. Surveyed sample sites were marked using a frame of four steel poles of 25m². In each quadrat a total count of live snails was conducted. Snails were exhaustively searched for by lifting all litter and searching as well as by inspecting the trunks of trees found within the quadrats. The population was estimated by multiplying the estimated mean per square metre, for the surveyed area, by the area over the entire island that is available for the species to occupy. The area available to be occupied by these snails was determined by using Google Earth Pro, version 6.0.3.2197.

All substrates used by the snails were recorded. These substrates were divided into "coconut palm", which consist of live coconut palms, "coconut leaf litter", "soil", "other species" which included *Cinnamomum verum*, *Terminalia catappa*, *Panicum maximum*, *Alstonia macrophylla*, *Premna obtusifolia*, *Chrysobalanus icaco*, *Anacardium occidentale* and an agave species. Substrate, described as "other substrate", is terrestrial

and includes rocks, unidentified leaves, branches and coconuts.

Results

Snails were encountered in five vegetation types; these being *Alstonia* dominated mixed exotic woodland, coastal woodland, exotic scrub planted with natives, coconut plantation and mixed exotic scrub (Fig. 1). These sites ranged from 13m to 105m above sea level. These vegetation types differ greatly in terms of species composition, vegetation densities and microhabitat availability. The results of these differences are reflected in the distribution and densities of snails with the snails found in habitats dominated by exotic species. 124 individuals were enumerated from the 50 surveyed quadrats.

P. fregatensis unevenly distributed on the island and is found in densities varying between 0.268 /m² in *Alstonia* dominated mixed exotic woodland, 0.032 /m² in mixed exotic woodland, 0.016 /m² in coastal woodland, 0.084 /m² in exotic scrub planted with natives and 0.096 /m² in coconut plantation with the mean density across habitat types being 0.0992/m² (Table 1).

The area available across all vegetation types in which this species is found was determined to be 644,054 m². Using the mean density multiplied by the area available to

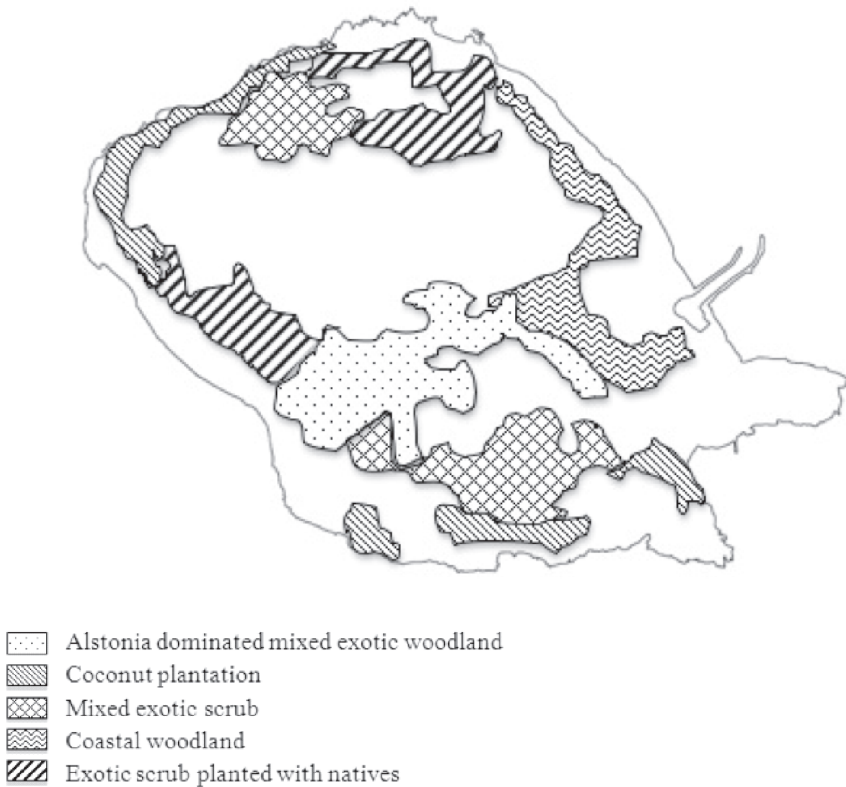


Figure 1. Spatial distribution of *Pachnodus fregatensis* on Frégate Island

these snails, the population was estimated at $63,890 \pm 11,361$ individuals. These results indicate a significant increase from the results of the 2002 assessment (Table 2).

One way ANOVA determined that the distribution of snails between habitats is statistically significant ($F = 2.9713$, $P < 0.05$) with the majority of snails (54%) being found in *Alstonia* dominated mixed exotic woodland, despite this vegetation type accounting for only 21.5% of available habitat. Coastal woodland accounted for the lowest percentage of snails with only 3.2% of observed snails occupying this vegetation type. Exotic scrub accounted for 17%, coconut plantation for 19.3% and mixed exotic scrub for 6.4%.

The substrates on which snails are found in each vegetation types are determined largely by the species composition of the vegetation in that particular habitat. Non-native species dominate all habitat types in which snails are found with the presence of *C. nucifera* appearing to be advantageous to the species. In all habitats, living *C. nucifera* and their decaying leaves were utilized as a substrate. The leaves form dense carpets on the ground and moisture retention amongst these leaves is high, providing a suitable microhabitat for snails. In determining the substrate usage by the snails, a Chi² test indicated a significant association with certain substrate types. $X^2 = 50.93$, $P < 0.01$ at 16df indicating a statistically significant difference between substrates (Table 3).

Discussion

Pimm (1988) notes that the problem of extinction should be seen primarily as the problem of endemism and that endemic species need to receive priority in protection. As an endemic species, the extinction risk for Enid snails is high and with changing weather patterns and possible future changes in land use this species still faces threats to its survival. Habitat alteration is considered the single biggest threat to species worldwide (Soule 1991) and the anthropogenically induced fragmentation and transformation of Frégate's natural vegetation has undoubtedly had an impact on the

Table 1. Density and numbers of *Pachnodus fregatensis* per vegetation types in which they were found

Vegetation type	Area (m ²)	No. Snails	Density (m ⁻²)
<i>Alstonia</i> dominated mixed exotic woodland	138,973	67	0.268
Coastal woodland	100,519	4	0.016
Exotic scrub planted with natives	132,092	21	0.084
Coconut plantation	111,753	24	0.096
Mixed exotic scrub	160,717	8	0.032
TOTAL	644,054	124	

Table 2. Population trend of *Pachnodus fregatensis*

1999	2002	2011
57,910 \pm 5,407	7,730 \pm 880	63,890 \pm 11,361

Table 3. Observed and expected frequencies for substrate use by *Pachnodus fregatensis* on Frégate Island in each vegetation type generated by a Chi-square test ($n=124$, $P \leq 0.01$).

	<i>Alstonia</i> dominated	Coastal woodland	Exotic scrub planted with natives	Coconut plantation	Mixed exotic scrub	Total
Observed:						
Coconut palm	10	3	6	14	7	40
Coconut leaf-litter	26	0	12	10	0	48
Soil substrate	11	1	1	0	0	13
Other species	6	0	2	0	1	9
Other substrate	14	0	0	0	0	14
<i>Total</i>	<i>67</i>	<i>4</i>	<i>21</i>	<i>24</i>	<i>8</i>	<i>124</i>
Expected:						
Coconut palm	21.6	1.29	6.7	7.74	2.58	
Coconut leaf-litter	25.94	1.55	8.1	9.2	3.1	
Soil substrate	7.02	0.42	2.2	2.52	0.84	
Other species	4.86	0.29	1.52	1.74	0.58	
Other substrate	7.56	0.45	2.37	2.71	0.9	

distribution and abundance of its native fauna. *P. fregatensis* occurs in these disturbed habitats, although with limited historical data it is difficult to conclude whether or not the population size is anywhere near pre-habitation by man and any further fragmentation may pose a very real threat to the continued survival of the Enid snail.

The distribution of snails is clumped in suitable habitats with individuals being isolated from each other due to their low powers of dispersal. Historically snails have been found along the Rivière Bambou and the agricultural plateau within coastal and mixed woodland as well as in exotic *Pterocarpus* woodland (Gerlach 2005). *Pterocarpus* woodland has been replaced by mostly native species that have naturally regenerated. No snails were found in this habitat type, probably due to this regenerated habitat type being less than a decade old and with these snails having poor powers of dispersal, they are likely to disperse into this area over time. The thick leaf litter that is found in this habitat should provide a suitable microclimate for the species.

Dispersal of Enid snails into previously unrecorded areas around the hotel and villas was first reported by Pearce during a field trip by the Zoological Society of London in March 2011 and corroborated in the latest assessment. Significant amounts of both native species and non-native species have been planted in this area since the development of a hotel and further habitat restoration and the creation of suitable corridors on the island would facilitate the dispersal of this species into new and suitable habitats on the island.

The eradication of rats from Frégate Island is justifiably considered a success in terms of conservation intervention. This action was a factor in the survival of the Seychelles Magpie Robin *Copsychus sechellarum* as well as contributing to the welfare of other native species. Despite the impact this intervention had on the snails, the significant increase in the size of the population between 2002 and 2011 indicates a strong resilience and ability to recover rapidly from a depleted population size; provided suitable habitat is available and external risk factors are excluded or reduced. The increase in the population can be attributed to the cessation of the use of poison in snail habitat since the eradication of the rats as well as the change in vegetation structure for both habitat restoration and ornamental purposes.

With limited historical records of the vegetation of Frégate, it is difficult to accurately determine the natural distribution and abundance of Enid snails in particular habitats and the lack of regular monitoring of the species provides only limited data on population trends. However, now that a baseline has been determined both post and prior to conservation interventions, it is important to maintain a monitoring protocol for the Enid snail. The conservation of this species and others on the island lies in the conservation and correct management of the habitat.

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