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Population assessment of the Fregate Island giant tenebrionid beetle *Polposipus herculeanus*

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Abstract: *Polposipus herculeanus* Solier, 1848 is a critically endangered member of the Tenebrionidae and is endemic to a single island of approximately 2 km² in Seychelles. Vegetation changes have occurred on the island over the years and continue to occur, both naturally and as a result of habitat restoration. Vegetation that was considered important habitat for this beetle has changed as a result of a fungal disease that affected the dominant tree species in this habitat. Surveys of the population have occurred previously; prior to rat eradication and shortly thereafter. This assessment was conducted to compare results with these previous assessments to determine whether vegetation changes have had an effect on the population. Comparison of results indicates that the population is stable and that vegetation changes have not necessarily had an adverse effect on the population.

Key words: *Polposipus*, endemic, changes, assessment, stable

Introduction

Polposipus herculeanus Solier, 1848 is a large, flightless tenebrionid beetle that is Critically Endangered - category B1 + 2c (IUCN 2010) and endemic to Fregate Island in the Seychelles islands. There is limited information on its ecology in the wild and disputed claims as to its historical distribution (Marshall 1982). Assessments of the population have been carried out in the past by, amongst others, Lloyd (1971), Lucking & Lucking (1999), Mellor (2002) and Gerlach (1999, 2002). These beetles were found to occur in specific habitat types and to avoid others. Habitat types have changed in size and composition since 2002 as a result of habitat restoration as well as natural vegetation regeneration. Along with vegetation change, it has been over 10 years since the successful eradication of rats from the island (Shah 2001). Brown rats *Rattus norvegicus* colonized Fregate in 1995 and were considered to be predators of these beetles (Parr 1999). Along with rats the common myna *Arcidotheres tristis* was seen as a possible predator of these beetles (Sachse as quoted by Ferguson & Pearce-Kelly 2004). The myna has been successfully eradicated (Canning 2011) and this may have an influence on beetle numbers in the future, although it is too early to determine this as these birds have only recently been eradicated. It would also be difficult to prove this as there is no data to substantiate this claim.

The impact of alien species on native species is well documented and Fregate has not escaped the negative consequences of these introductions. The vegetation of Fregate has been significantly altered by the activities of man, with alien species dominating. The introduction and establishment of alien species has the potential to displace or

exterminate native species and species with small populations and limited range, such as *P. herculeanus* are especially vulnerable (Van Dyke 2003). These alien species have undoubtedly had an impact on the native fauna of Fregate, including *P. herculeanus* and the absence of *P. herculeanus* from large areas of the island is almost certainly largely due to the predominantly unnatural state of the vegetation. *P. herculeanus* has a limited distribution on Fregate, although the potential exists for an expanded distribution into areas of suitable habitat. Areas of suitable habitat are however severely fragmented and isolated from one another. This fragmentation of habitats is a grave threat to species survival (Laurance 2010). The isolation of individuals between habitat types is of concern as it may have negative consequences such as the inability to supplement numbers, decreased gene flow and decreased possibility of recolonization in suitably restored habitats as well as increased chance of mortality during dispersal in poorly connected areas (Bennett & Saunders 2010). The expansion of natural and fragmented habitats is a critical priority in increasing animal assemblages (Bennett & Saunders 2010) and for this reason habitat restoration is an important conservation activity on Fregate. Assessment of the effect that habitat restoration has had on various species has never taken place and the fact that this beetle is restricted to Fregate and is critically endangered makes it imperative that current restoration activity has no negative impact on this species. These beetles are seen as having low powers of dispersal due to their large size and their inability to fly (Ferguson & Pearce-Kelly 2004) and all future restoration needs to ensure that the dispersal of this species into suitable habitat is not in any way restricted.

Despite a limited distribution these beetles have been found to occupy a number of different tree species, both native and non-native. *Pterocarpus indicus*, an introduced species, was used by these beetles. It was considered an important habitat type (Lloyd 1971, Mellor 2002) and *P. herculeanus* was found on this species in relatively high densities (Lloyd 1971). *P. indicus* no longer exists on the island as a result of sandragon wilt with reports of the first death of this tree from 2001 (Boa & Kirkendall 2004) and the last tree dying in approximately 2004 (Goza, pers. comm.). This assessment determined that these beetles are still found in the areas where *P. indicus* occurred although their densities vary significantly between these sites, depending on the size and age of the trees that have replaced *P. indicus*. The area of Au Salon has been allowed to regenerate naturally with little interference and at this site beetles prefer decaying *P.indicus* rather than living trees of other species that have replaced the *P. indicus*. *P. indicus* woodland in the Anse Parc area has been restored and replanted with indigenous species. This assessment included the entire island, covering all habitat types and a comparison of results from previous assessments indicates that the population is stable.

Study area

Fregate Island lies at 04°35´19´´S and 55°56´55´´E and is a privately owned granitic island of 219 ha lying 55 km East of Mahé (Merton *et al*. 2002). It is a granitic island overlying oceanic basalt. Deposits on the plateau are associated with guano; forming phosphate cemented sandstones and phosphatised granite. The low-lying areas were marshy in the past and characterized by sediments of fine clay and

quartz. (Braithwaite 1984). These marshy areas have since been replaced by cultivated fields, gardens and a marina development. Fregate is largely covered in introduced species, with patches of native woodland that have either persisted or been replanted. Rainfall records on the island are inconsistent and unreliable. Rainfall records from 1972–2001 in Mahé give an average annual rainfall of 2319.8 mm (Seychelles National Meteorological Services, S.a.).

Methods

The assessment was carried out in March 2011 during the wet Northwest monsoon when beetle abundance was previously determined to be at the highest (Lucking & Lucking 1999). The survey assessed only the adult population found on trees and was carried out in the early mornings when beetles tended to be more visible and individuals were not yet sheltering in cracks and crevices. Surveys were not carried out during heavy rain as beetles were less visible and appeared to seek cover under these conditions.

Protocols and methods used by Gerlach in 1999 and 2002 were adapted and used to ensure consistency and a standardized method to allow for comparison of results. The entire island was assessed based on a habitat approach to determine which habitats are important for the cohort. The island was stratified into vegetation types and each vegetation type was determined using maps from Gerlach (2003) and Henriette & Rocamora (2010) and adapted based on vegetation changes that have occurred since these maps were produced. Differentiation of vegetation types is easily determined in the field as there are clear boundaries, largely as a result of the unnatural state of the vegetation of the island. Google Earth was used to produce a map of vegetation types after ground-truthing. In each habitat type 20 trees were randomly selected, marked and inspected on different occasions for the presence or absence of beetles. Trees were marked with plastic marker tape, numbered and their G.P.S. co-ordinates were recorded to ensure the same tree was surveyed on each occasion. The height of the beetles was recorded as well as the species of tree. Trees less than 2 m tall were excluded from the random selection. This was done as Mellor (2002) determined that beetles preferred trees with a larger diameter at breast height. Personal observations also determined that beetles appeared to avoid smaller trees. All visible beetles were marked using a non-toxic over-all multi- purpose correction fluid pen. Beetles were marked on the tree with minimal disturbance. Generally the beetles did not move during or after marking. A single mark of approximately two to three millimetres in diameter was placed randomly on the elytra. Beetles were reached and marked using a 5 m long ladder and by climbing the tree. This mark-resighting was used to obtain a mean of beetles per tree and to determine whether there was a recurring absence or presence of individual beetles on the randomly selected trees. A pilot survey was conducted in all vegetation types to determine the presence or absence of beetles within each stratum. Those strata that were found to contain no beetles were excluded from the survey. In regenerated native woodland, decaying logs (both on the ground and still standing), were included in the survey as beetles were found on these logs in the pilot study. In all other vegetation types only living trees were included in the survey.

Vegetation types

Vegetation types are described based on dominant species and relative homogeneity. They are determined to allow for repeatability of surveys. In the individual descriptions below, only dominant species and those species that were included in the random selection of trees were included. Tree densities were determined per vegetation type by using a belt transect method. Transects of 100 m by two metres were used and all woody species above two metres were included in the survey. At least five transects were included in each vegetation type.

Habitat type 1 - Coconut dominated. Predominantly *Cocos nucifera* with abundant *Anacardium occidentale* and *Cinnamomum verum* and very low densities of *Premna obtusifolia* and *Ficus* spp.

Habitat type 2 - Exotic scrub planted with natives. Dominated by *Chrysobalanus icaco* and *Panicum maximum*. Common indigenous species are *Terminalia catappa, Premna* and *Mimusops seychellarum*. Exotic species include *Cinnamomum, Manguifera indica* and *Anacardium.*

Habitat type 3 - Mixed woodland. This vegetation type consists of replanted indigenous species such as *Ficus* spp., *Premna* and *Terminalia* and exotic species are dominated by *Manguifera*, *Cinnamomum* and *Paraserinathes falcataria*

Habitat type 4 - *Pisonia* woodland. This vegetation type is a monospecific stand of mature *Pisonia grandis*. It is the smallest vegetation type and the only monospecific stand of *P. grandis* on the island.

Habitat type 5 - Coastal woodland. This area is dominated by replanted indigenous species. It includes *T. catappa*, *Heriteria littoralis*, *Calophylum inophyllum*, *Hernandia nymphaefolia* and *Ochrosia oppositifolia*

Habitat type 6 - Native regenerated woodland. This area historically consisted of a stand of *Pterocarpus indicus* and has been allowed to regenerate naturally after die off of *P. indicus* .The trees in this vegetation type are still small and consist mostly of indigenous species. This area has not been extensively replanted and the majority of trees have naturally regenerated (Goza pers. comm.). This area is dominated by *Premna* and *Dracaena* spp. and includes *Calophyllum* and *Terminalia*. *Cinnamomum* is the most abundant alien species. This vegetation type has high tree densities due to the fact that the area has not yet progressed to a climax state.

Habitat type 7 - Native planted woodland. As with habitat number 6, this area consisted of a *Pterocarpus indicus* stand and has been replanted with indigenous species after die off of *P. indicus.* Many of the replanted trees were already large when replanted and this habitat is dominated by *Ficus* spp., *Premna* and *Pisonia*.

Habitat type 8 - *Alstonia* dominated mixed exotic woodland. This habitat type dominates the central southern section of the island and extends from inland of the marina almost to Grand Anse. It is dominated by mature *Alstonia macrophylla* and *Cocos nucifera*, interspersed with *Hevea brasiliensis*, *Cinnamomum* and *Anacardium*. Few indigenous species are found in this vegetation type.

Habitat type 9 - Mixed exotic scrub. This vegetation type is dominated by *Chrysobalanus* interspersed with *Anacardium* and *Cinnamomum*. It extends from the plateau into lower-

lying areas. The plateau is sparser than the lower lying areas. Other species include *Manguifera*, *Ficus benghalensis* and *Casuarina equisetifolia*.

Habitat type 10 - Open grassland with natives. This area is dominated by open grassland with sedges. Species that have been planted include *Calophyllum, Terminalia, Ochrosia* and *Cordia subcordata*. *Cocos* is common in the open areas where indigenous species have not been planted.

Habitat type 11 - Bamboo. This monospecific vegetation type dominates the central section of the island and has outcompeted all other vegetation along the Rivière Bambou.

Habitat type 12 - Coconut plantation. These areas are monospecific stands of *Cocos* and dominate the coastal areas, although they do extend inland.

Habitat type 13 - Glacis. These open, exposed rocky areas are mostly on the plateau and dominated by *Chrysobalanus* and *Panicum maximum*.

Habitat type 14 - *Ficus benghalensis.* This species is found over a wide area of the island. Thick stands occur within *Alstonia* dominated mixed exotic woodland, as well as in coastal areas and around the hotel and villas. Stands are also found on other areas

Figure 1. Habitat types occupied by P*olposipus herculeanus*.
Key: 1. Coconut dominated, 2. Exotic scrub planted with natives, 3. Mixed woodland, 4. *Pisonia* woodland, 5. Coastal woodland, 6. Native regenerated woodland, 7. Native planted woodland, 8. *Alstonia* dominated mixed exotic woodland, 9. Mixed exotic scrub, 10. Open grassland with natives

of the island. It can be considered a separate vegetation type due to the size of area they cover and due to their ability to outcompete other vegetation.

Habitat type 15 - Native planted woodland type 2. This vegetation type occurs in coastal areas and is recently restored. It is found within coconut plantations. Replanted species includes, *Premna*, *Terminalia, Calophyllum* and *Ficus* spp.

Results

Of the fifteen primary vegetation types identified, ten were found to contain populations of beetles. Those habitats that did not have beetles were bamboo, coconut plantation, glacis, native planted woodland type 2 and *Ficus benghalensis*. These habitat types were excluded from the assessment and in the analysis of the data and are considered unsuitable potential habitat. The absence of beetles in coconut plantations and *F. benghalensis* is corroborated by Ferguson & Pearce-Kelly (2004).

The distribution of the population between habitat types was found to be greatly skewed. After data transformation the results from one-way ANOVA indicates that there is a statistically significant difference between choice of habitat type ($F = 3.1814$, $P < 0.05$). Dispersal of beetles between vegetation types was found not to be random and their distribution is clumped which is in agreement with the results of Mellor (2002).

The highest densities of beetles were found in *Pisonia* woodland (habitat type 4) and mature native planted woodland (habitat type 7). Native regenerated woodland (habitat type 6) had one of the lowest densities of beetles. This low density may be explained by the fact that this habitat type is not yet mature after die off of *Pterocarpus*

Figure 2. Comparison of population of *P. herculaneus*. 1999 and 2002 estimates as determined by Gerlach (2003).

Year	Estimate	Upper limit	Lower limit
1999	57,060	66,098	48,022
2002	50,390	53,678	47,102
2011	54,351	67,879	43,511

Figure 3. Surveyed habitat types

Habitat type	Area surveyed in m²	Tree densities per hectare	Beetle densities per tree
Coconut dominated	191,690.4	1,225	0.475
Exotic scrub planted with natives	41,751.62	700	0.975
Mixed woodland	57,450.98	1,050	1.075
Pisonia woodland	6,293.38	2,800	1.225
Coastal woodland	54,350.72	1,400	0.625
Native regenerated woodland	18,871.54	2,340	0.35
Native planted woodland	6,672.34	1,100	1.3
Alstonia dominated mixed exotic	211,339.92	1,120	0.575
Mixed exotic scrub	119,813.33	1,140	0.75
Open grassland with natives	45,212.71	425	0.3

indicus. Beetles found in this habitat were for the most part found on decaying *P. indicus* logs that were both lying and still standing. The native planted woodland has mature trees and beetles were found on these trees. No beetles were found on the decaying logs of *P. indicus* that are still found in this habitat type.

A population estimate was obtained by determining the means of beetles observed on the 20 trees per vegetation type in conjunction with tree densities over area of habitat. Data obtained indicated a skewed distribution of the population between habitat types. This skewed data was partially as a result of unexpectedly low densities of beetles in regenerated native woodland. Data was transformed using a logarithmic transformation to give an estimate of μ. The result was then multiplied by the number of sampling units to give an estimate of the population.

Population estimate of *Pulposipus herculaneus* on Fregate was determined to be 54,351 with an upper limit of 67,879 and a lower limit of 43,511. No beetles were found in seemingly suitable habitat on the southwestern side of the island and most lower lying areas appeared to have lower densities of beetles which is in agreement with results of Lucking & Lucking (1997). *Pisonia* woodland is an anomaly in this respect, although this may be explained by the protection against the elements afforded by this vegetation type. Further surveys would be needed to explain this.

Discussion

The population of this beetle appears stable when Gerlach's estimates from 1999 and 2002 (Gerlach 2003) are compared with 2011 estimates. The population has increased since the assessment in 2002 after a decrease from the assessment in 1999 and this is probably as a result of a population increase after the eradication of rats.

These beetles appear to choose specific tree species and avoid others; however the reason for this is unclear. They are found on smooth barked trees, such as *Alstonia macrophylla* (corroborated by Mellor 2002) and *Pisonia grandis* that offer few cracks and minimal or no peeling bark for sheltering purposes, as well as on *Manguifera indica*, *Anacardium occidentale* and others that are fissured and flaky and offer much shelter. They avoid *Ficus benghalensis* and *Cocos nucifera* that have similar characteristics to those species that are utilized and some other factor must determine their avoidance of these tree species.

Pisonia woodland was found to have one of the highest densities of beetles. In previous assessments, no mention is made of this. It is unlikely that these beetles have only recently dispersed into this habitat type as it is a mature stand. It is more likely that this habitat was previously overlooked or has been included in other habitat types in previous surveys and not assessed separately, due to its small size and the fact that is situated on the periphery of coastal woodland and mixed woodland. This site is of conservation concern, as not only does it have high densities of adult beetles, but larvae of the beetle have also been found here by Pearce (*pers comm*. 2011). There is also a high density of millipedes (*Seychelleptus seychellarum)* and other invertebrates as well as skinks (*Mabuya wrightii* and *M. sechellensis*) and snakes (*Lamprophis geometricus* and *Lycognathophis seychellensis*). It is also inhabited by Seychelles magpie robins (*Copsychus sechellarum*) and is an important nesting area for lesser noddies (*Anous*

tenuirostris) with very high densities of these birds during the nesting season. This small habitat type needs to be conserved at all costs. It has been suggested, as a conservation measure, that *P. herculaneus* could be translocated to other islands in their possible former range. Their presence and apparent thriving in *Pisonia* woodland lends itself to the establishment of translocated populations on islands with this type of habitat.

Habitat types 6 and 7 have changed from *Pterocarpus indicus* woodland as a result of sangdragon wilt which caused the die off of these trees by 2004. The beetles do not utilize the small trees in habitat number 6, yet utilize mature trees of the same species in habitat number 7. This indicates that these beetles prefer larger, mature trees and this is corroborated by Mellor (2002). In habitat number 6 they may be using decaying logs as habitat due to lack of larger trees. The high density of beetles in habitat number 7 indicates rapid dispersal into suitable habitat and shows the value of habitat restoration for this species. It is likely that these beetles will increase in numbers in habitat 6 over time, as the trees mature. The loss of *P. indicus* as a habitat type is not seen as being of any concern for the continued well being of the beetle. In contrast, it should be seen in a positive light as native species now replace what was an introduced species.

The absence of beetles in habitat number 15 is likely due to isolation and the inability to disperse as a result of adjacent coconut woodland. As is shown by the presence of beetles in mature restored habitat this habitat type should be of value to the beetle and the continued restoration of habitat on the island is strongly recommended, as long as it is carried out in a scientifically and ecologically sound manner. There is however concern that the use of *F. benghalensis* for restoration is detrimental not only to *P. herculeanus* but for the general diversity of the island. It is strongly recommended that this practice be discontinued. Large areas of potential habitat are available for restoration work for the benefit of this and other species. Bamboo has been found to be of extremely low density and diversity for birds (Gane 2011) and spiders (Canning 2010) and is probably true of other species as well. This habitat is detrimental to biodiversity on the island and offers the possibility of substantially increasing available habitat should it be restored to native vegetation.

The method used to assess the population is not considered ideal as beetles present on the trees are likely to be missed. Those beetles that are high up the tree and sheltering out of sight, as well as those individuals that are on the top of branches are likely to be missed, giving an underestimation of the population. Weather conditions were also found to play a role in the abundance of beetles. In hot weather fewer beetles were visible, although surveying early in the morning nullified this problem. Heavy rain also reduces the abundance of visible beetles. The fact that these beetles are nocturnal (Ferguson & Pearce-Kelly 2004) may also bias the results of surveys carried out during the day, although their behaviour in the wild needs to be studied further to determine the best time for surveys. This method was chosen as it does lend itself to repeatability and allows for comparison of results from previous assessments. Regular monitoring of this species is needed to assess temporal population trends to ensure that continued vegetation and other changes do not negatively impact this species.

Although the population is stable and fairly significant, there is potentially far more habitat on the island available to support a larger population. With its' globally

restricted range and population size all efforts need to be taken to ensure the continued well being and expansion of the population. Fragmented habitats need to be connected to allow for dispersal and range expansion. The use of corridors is recommended where habitat types cannot be completely linked. These expanded areas of habitat will not only benefit this species, but other threatened species as well.

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