

Long-term monitoring of nocturnal lemur populations in the littoral forests of Sainte Luce, southeast Madagascar

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INTRODUCTION

Approximately one-fifth (113) of the world's 504 recognised primate species are endemic to the island of Madagascar (Estrada et al, 2017). Of these, 98% of species are considered threatened with extinction by the International Union for Conservation of Nature (IUCN, 2019). Furthermore 100 species are reported as undergoing population declines. In order to properly understand population dynamics, and how animals are responding to fragmentation and anthropogenic pressures over time, it is crucial to obtain estimates of population size and population density for threatened species (Buckland et al, 2001). From a conservation perspective, such parameters can provide valuable monitoring tools and early diagnosis of declines in vulnerable populations.

Sainte Luce represents one of the last examples of intact southern littoral forest in Madagascar (Consiglio et al, 2006). It currently comprises of 17 forest fragments (Fig.1.), each of which are degraded and harvested for natural resources to various extents (Fig.2.). The littoral forests represent a useful model for monitoring population dynamics, as they are well studied taxonomically and their highly fragmented nature allows for the effect of forest size and human impacts to be explored. This ongoing study is conducted in the forest fragments S7, S8 and S9, three of the most intact remaining fragments. Furthermore in 2015, fragments S8 and S9 were designated IUCN Category IV protected forests, whilst S7 was selected as a community resource forest.

RESEARCH QUESTIONS

- Has the nocturnal lemur population in Sainte Luce shown significant change over the past 8 years?
 - Do lemurs exhibit species-specific demographic trends across the fragmented landscape?
- Has local forest policy impacted the population of nocturnal lemurs across three study fragments?

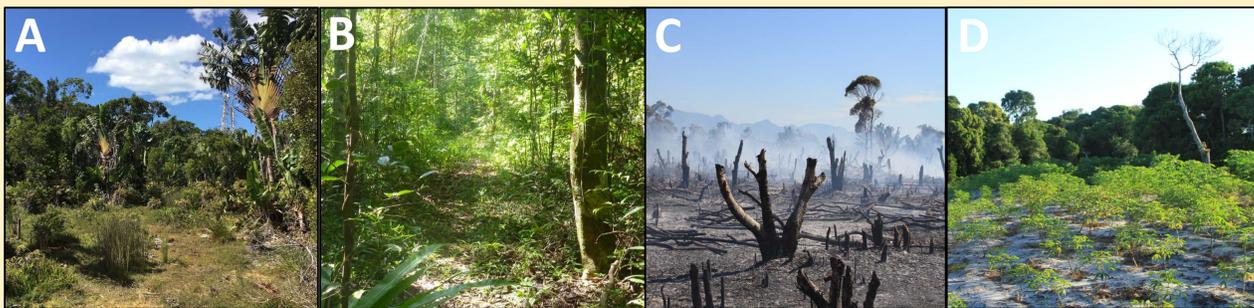


Fig.2. Sainte Luce habitat: (A) Open marsh area in S7, (B) Forest interior in S9, (C) Burning (tavy) on the forest edge of S9, (D) Cassava plantation on the edge of S8. The expansion of agriculture represents a major threat to the remaining littoral forests (Bollen & Donati, 2006).

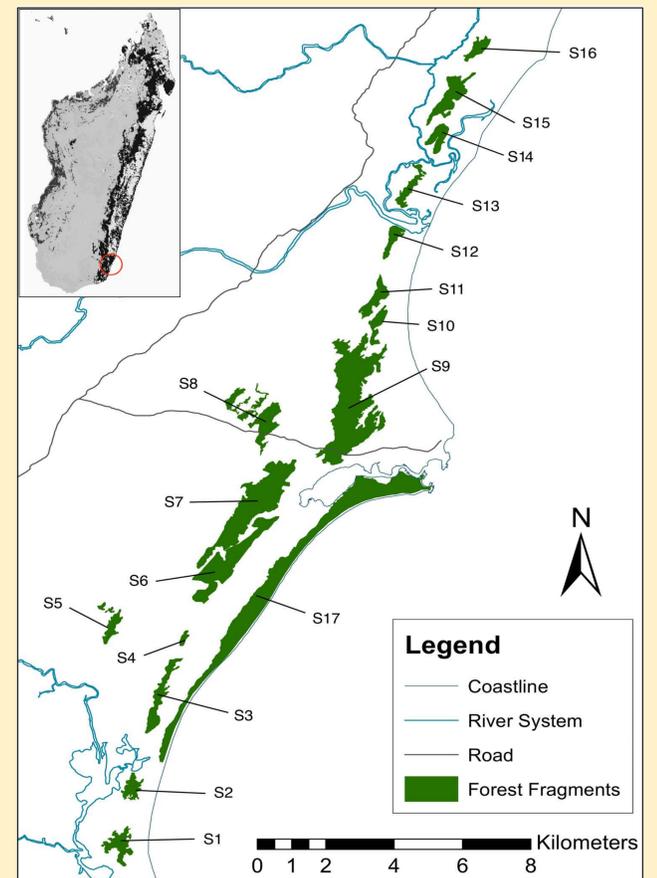


Fig.1. Map showing the forest fragments of Sainte Luce (shaded green) and the study site in relation to Madagascar.

METHODS

This study was conducted between January 2011 and December 2018, and is based on a line transect methodology (Buckland et al, 2001). Established transects in S7 (4), S8 (north 3, south 3) and S9 (5) were selected to limit further forest destruction. Transect lengths vary (1,007m max, 220m min) as a result of fragment size and shape. The study focuses on the three nocturnal species present in the area; *Avahi meridionalis* (EN), *Cheirogaleus thomasi* (CR*) and *Microcebus tanosi* (EN*) (Fig.3.). * denotes preliminary IUCN Red List assessments (C. Schwitzer pers. comm.). Pop. estimates were calculated using DISTANCE v7.3 and statistical analysis was conducted using Generalised Linear Mixed Models (GLMM). During analysis, all observations >50m were removed as outliers and the hibernation period for *C. thomasi* (the dry season; May-September) was excluded. Years were combined into pairs to ensure estimates were robust.

RESULTS 483 transects conducted / 283km surveyed / 1923 lemur observations

GLMM analysis indicates that no individual species shows statistically significant total population change over the past 8 years but that fragment has a strong influence on population dynamics (Supplementary Table 1.). DISTANCE results also indicate a differentiated species-specific trend (Fig.3.) and it is apparent that the lemur communities vary greatly between study fragments. Fig.3 reveals the comparative abundance of the three species in Sainte Luce, and shows the relative trends of the 3 species across each of the study fragments.

DISCUSSION

All three nocturnal species were observed in each study fragment, yet the differentiated trends underscore the complexity of the situation and the need for considered conservation management strategies. Recent protection of forest fragments S8 and S9 (IUCN category IV) appear to have benefitted *Cheirogaleus thomasi*, particularly in S8, however the population appears to be increasing also in the heavily logged fragment S7. Further data is required to properly assess the impact of the new protected areas. In contrast *Avahi meridionalis* numbers appear to have undergone a large decline in S9 between 2011 and 2014. The species is also in serious trouble in S7 and likely on the verge of extirpation in this fragment. The drivers of this decline are unknown but it is plausible that this species has been impacted by hunting. *Microcebus tanosi* observations are comparatively low, making accurate population modelling difficult, however populations appear stable in all study fragments. It is widely acknowledged that some species are more resilient to fragmentation and habitat degradation than others, responding differently, with species-specific traits (dispersal capability, rarity, trophic status, dietary requirements etc.) mediating the effects (Estrada et al, 2017). However, the long-term survival of lemurs in such small fragments is uncertain (Ganzhorn et al, 2001).

It is therefore crucial to continue to monitor the Sainte Luce lemur community in order to assess the impact of the protected areas and to inform future conservation strategy.

Fig.3.

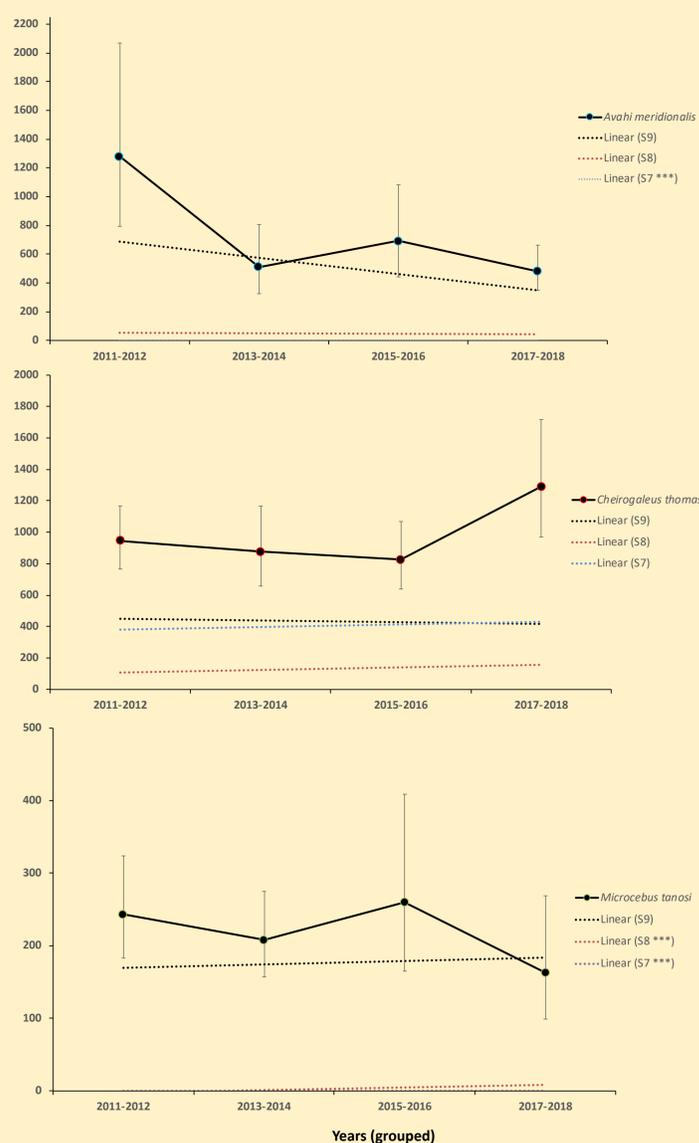


Fig.3. Modelled population estimates for the nocturnal lemurs of Sainte Luce (S7, S8 and S9 combined). Linear trendlines indicate the proportional abundances of species per fragment. *** represent estimates based on limited data.



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