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The impacts of forest clearance on lizard, small mammal and bird communities in the arid spiny forest, southern Madagascar

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ABSTRACT

Madagascar is a global biodiversity hotspot threatened by forest loss, degradation and fragmentation, all of which are detrimental to the future survival of forest-dwelling organisms. For conservation purposes it is essential to determine how species respond to habitat disturbance, specifically deforestation. In this study we investigated the impacts of deforestation on three vertebrate communities, lizards, small mammals and birds, in an area of spiny forest subjected to anthropogenic forest clearance. Spiny forest has high levels of endemism, but conservation in this unique ecosystem is hindered by the lack of research. We undertook standardised trapping, time-constrained and timed species searches to assess species richness, species abundance and community composition of lizards, small mammals and birds in six areas of 'forest' and six 'cleared' areas. From surveys and opportunistic sightings we recorded a total of 70 species of birds, 14 species of mammals and 38 species of reptiles and amphibians. We found forest clearing to have a negative effect on species richness and community structure of all groups and identified loss of canopy cover as a driving factor behind this. However, the response and sensitivity to clearing varied between groups and species. Lizards (50%) and small mammals (40%) had the greatest decline in species richness in response to clearing as compared to birds (26%), although birds showed the greatest shift in community structure. The community in cleared areas contained more generalist and introduced species that have wider geographic ranges and habitat preferences, than those unique to the spiny forest. We found the first suite of species to suffer from forest clearance were those of high conservation priority due to their restricted geographic range. Our findings are discussed in relation to future spiny forest conservation and management.

1. Introduction

Madagascar has been designated a global biodiversity hotspot, due to its high number of island endemic species (Myers et al., 2000; Ganzhorn et al., 2001), 90% of which are forest dwelling (Dufils, 2003). Myers et al. (2000) suggests that Madagascar is 'the single highest biodiversity conservation priority in the world'. However, conflict exists between conserving Madagascar's biodiversity and anthropogenic land use. Madagascar has one of the world's highest rates of human population increase (Green and Sussman, 1990), resulting in an intensification of forest product exploitation

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(Jolly and Jolly, 1984; Green and Sussman, 1990; Kull, 2002; Vallan, 2002; Watson et al., 2004a). Due to direct and indirect causes, it is reported that forests have been cleared at an accelerating rate (Green and Sussman, 1990; Casse et al., 2004), although differences in reported estimates and descriptions of the dynamic nature of vegetation change has lead to conflicting evidence and more recent attempts at quantification (Ingram and Dawson, 2005). No Malagasy forest escapes anthropogenic pressures (Goodman and Raherilalao, 2003). Current estimates suggest only 10–20% of Madagascar's natural forests remain largely intact (Du Puy and Moat, 1998; Myers et al., 2000), all of which is under varying degrees of threat (Dufils, 2003).

Deforestation is currently one of the greatest threats to global biodiversity (Primack, 2004). It has been widely demonstrated that deforestation resulting in habitat loss, degradation and fragmentation has detrimental effects on species diversity in Madagascar (Goodman, 1993; Smith et al., 1997; Vallan, 2002; Watson et al., 2004b). The impact of deforestation on communities depends on the forest type, the size and shape of the deforested patch (Goodman and Rakotondravony, 2000;Ramanamanjato and Ganzhorn, 2001; Vallan, 2002; Watson et al., 2004b), the type of clearance (Stephenson, 1993) and the landscape context (Saunders et al., 1991; Watson et al., 2004a). The impact of deforestation is not uniform across species (Vallan, 2002; Watson et al., 2004a). The ability of species to tolerate or exploit modified conditions, or to disperse to alternative sites, will determine their persistence and future survival. To attempt to mitigate the effects of deforestation it is essential for conservation purposes to identify susceptible species. Additionally we need to understand the processes behind how different species and communities respond to different levels and types of forest use (Goodman and Raherilalao, 2003). This information will help to determine species for conservation priority and to develop and implement potentially effective land use and management practices to aid a resolution to conflict between conservation and anthropogenic needs.

Many studies on the impacts of deforestation on animal communities in Madagascar have focused on tropical rainforest (Stephenson, 1993, 1994b; Raxworthy and Nussbaum, 1994; Vallan, 2000) or littoral forests (Lehtinen et al., 2003; Watson et al., 2005), and until recently have mainly focused on protected areas, such as in eastern and highland forests (Stephenson, 1993; Goodman and Rakotondravony, 2000; Vallan, 2000). In comparison there is relatively little research undertaken in the dry spiny forests, and as a result they are recognised as a high research priority (Goodman and Raherilalao, 2003; Ganzhorn et al., 2003). Additionally, research tends to focus on a single taxonomic group, such as vegetation (Cadotte et al., 2002; Brown and Gurevitch, 2004), birds (Goodman and Raherilalao, 2003; Watson et al., 2004a), reptiles (Lehtinen et al., 2003), amphibians (Vallan, 2000), invertebrates (Benstead et al., 2003), large mammals (Smith et al., 1997) and/or small mammals (Stephenson, 1993; Goodman and Rakotondravony, 2000; Ganzhorn et al., 2003), but few have looked across communities to investigate patterns of response (Hawkins et al., 1990).

The 'Southern Domain' also known as the arid xerophytic spiny forest or 'spiny thicket', (Gautier and Goodman, 2003) extends across the extreme south and southwest area of Madagascar covering approximately five million hectares (Wells, 2003). It is restricted to elevations under 400 m and runs southwards from Morombe along the coast to the western slopes of the Anosyennes Mountains in the southeast (Gautier and Goodman, 2003). It is the oldest biome of Madagascar (Wells, 2003) and most arid (Gautier and Goodman, 2003), with an average annual rainfall of approximately 300 mm. The spiny forest is subjected to 'slash and burn' agriculture for cultivation and livestock grazing, charcoal making, selective logging, collection of wood for construction and fuel, and collection of food and medicinal plants (Fenn, 2003).

The Southern Domain has the highest proportion of endemic plants on Madagascar; between 90% and 95% of the documented 336 plant species are endemic (Philipson, 1996; Gautier and Goodman, 2003). Plant families characteristic of this region include the xerophytic Didiereaceae, Euphorbiaceae and baobabs (*Adansonia* spp.). Nine species of birds are restricted solely to spiny forest (Sinclair and Langrand, 1998), two are classified as 'Vulnerable' and two 'Near-threatened' (Birdlife International, 2000). Consequentially, spiny forest is classified as an 'Endemic Bird Area' (Stattersfield et al., 1988). It is also home to three endemic rodent species and six endemic species of tenrec (Goodman, pers. commun.). All nine lemur species occurring in spiny forest are threatened (IUCN, 2003). Reptile fauna is relatively diverse in the spiny forest (Nussbaum et al., 1999) with several habitat specialists (Henkel and Schmidt, 2000). Due to high endemism and species conservation status it is essential to incorporate this unique ecosystem in any National and International biodiversity conservation efforts.

In this paper we investigate the impact of spiny forest deforestation on three selected vertebrate communities commonly used as bio-indicators; small mammals, reptiles and birds (Raxworthy and Nussbaum, 1994; Watson et al., 2004a). We compared species presence and abundance in six 'forested' sites of low-level forest exploitation, and six heavily exploited 'cleared' areas. We hypothesized that anthropogenic forest 'clearance' will have a detrimental effect on species richness, however the impact will be species specific and not all communities will respond in the same manner. To test this our study comprised three aims: (i) assess the impacts of forest clearance on community composition by comparing changes in species presence and abundance; (ii) determine which environmental factors are affecting community shifts in different vertebrate groups; and (iii) within each group assess the sensitivity of each species to deforestation. Findings can then be discussed in relation to current and future spiny forest conservation and management.

2. Methods

2.1. *Study area*

The study was undertaken between September and December 2003, during the austral summer when most species are active (Goodman, 1999). Studies were conducted around the village