THE ROLE OF FIRE REGIMES AND DISPERSAL PATTERNS ON THE COMPOSITION OF ROCK RINGTAIL POSSUM GROUPS

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Abstract

Controlled burning is done across much of the Top End of Australia. The intensity and frequency of these fires has been shown to shape habitats. When a fire regime is changed a corresponding shift in the composition of plants and animals in that area is observed. This change is of concern as it may cause habitat fragmentation and isolation of groups from the population. Rock Ringtail Possum, *Petropseudes dahli*, habitat may be altered by varying fire regimes. In order to ascertain their susceptibility to local extinctions due to habitat fragmentation, it is necessary to understand their population ecology especially in terms of movement and relatedness. This study seeks to examine genetic variation in *P. dahli* at three different scales: throughout its range, within a given fire regime, and within an outcrop. Rock Ringtail Possum feces are distinct and can be used to sample the microsatellite DNA of individuals at a given outcrop. Additionally, the variation in plant types and abundance will be compared within and between each fire regime type. This research has the potential to provide invaluable data on the impact of fire regimes on a small, rock dwelling marsupial and thus aid in future fire management decisions.

Additional Keywords
Habitat fragmentation, genetic diversity, non-invasive techniques

Introduction

One major problem facing ecologists is being able to understand and predict how species will respond to habitat disturbance. Numerous models have been created in an attempt to describe how biodiversity will respond to environmental change (Newell 1999). In Australia, there has been a wide-spread loss of biodiversity. The major reasons for this are considered to be land use changes, feral animals and fire regime changes. In northern Australia, where the population is sparse, much of the landscape has been left only minimally altered by land use changes. There, fire regime changes have been pointed to as the primary factor in the decline of biodiversity. The goals of this research are 1) to test the effect of variable fire regimes on biodiversity, 2) to determine the impact environmental perturbations caused by fire have on the distribution and abundance of Rock Ringtail Possums, *Petropseudes dahli*, and 3) to investigate the phylogeography of *P. dahli* on a variety of scales. Specific objectives are to investigate the assumption that variable fire regimes influence the vegetation composition that *P. dahli* depends on, to determine if these variable fire regimes have an effect on the abundance, group composition, and dispersal patterns of Rock Ringtail Possums, to examine the genetic diversity and isolation risk of *P. dahli* and to suggest possible management strategies.

1 Fire Ecology

Traditionally, Aboriginal people of Australia systematically burnt patches of land at specific times for approximately 10 months of the year (Braithwaite 1991). Burning at the very beginning of the dry season (March or April) was done to clear campsites. They did not burn other areas because burning green grass was considered to be an ecologically destructive practice. The smoke from the fires could make the animals sick (Bowman et al 2001; Yibarbuk et al 2001). During the dry season, as the strong southeast winds dried out the grass over large areas, the grass was burnt for a variety of reasons such as clearing the country for walking and hunting. In the late dry season (late September to early October), large fires were lit to prepare the bush for the onset of rain and to bring the rain. These fires were used to make the bush fruit trees healthy and productive (Bowman et al 2001). The effect of these fires being lit at different times of the year for different purposes was to create a mosaic of burned areas in various stages of post fire recovery. This mosaic pattern increases biodiversity in an area compared to more homogenous burn patterns (Bowman 2003).

As Europeans spread throughout Australia, the fire regimes changed dramatically for a variety of reasons. Currently, there is a diversity of viewpoints on fire management with a resulting high variation in fire regimes throughout northern Australia. Some managers (Braithwaite 1990; Bowman et al 2001; Yibarbuk et al 2001) attempt to replicate traditional Aboriginal fire regimes by burning small patches every year throughout the whole year. Rangers with the Bushfires Council Northern Territory (NT) burn certain areas every year at the beginning of the dry season. In Western Australia, Australian Wildlife Conservancy managers are implementing a fire regime of burning the area every five years at the beginning of the wet season. Finally, due to the sparse population and limited funding in the region, many areas are left unmanaged. Fires in those areas are usually large, intense fires at the end of the dry season caused either by anthropogenic factors or by lightening strikes.

The habitat change over the past 200 years has resulted in fragmented populations as well as a decline of vertebrate populations throughout Australia (Lindenmayer and Possingham 1996; Eldridge et al 1999; Newell 1999; Vernes 2000). Changes in fire management have been indicated as one of the major causes of this decline. Rock Ringtail Possums, *Petropseudes dahli,* may potentially be affected by both the habitat changes and the management strategies currently in place. Its range appears to be declining in northwestern Australia; however, only a few studies have been done on the Rock Ringtail Possum and its life history is not well known. I predict that the decline in their range is due to a loss of heterogeneity of habitat and isolation caused by the change in fire regimes.

Rock Ringtail Possums live in rock outcrops that are distributed in patches throughout the Northwestern portion of Australia, including Arnhem Land in the Northern Territory and the Kimberley in Western Australia (Kerle and Winter 1995). Unlike most possums, *P. dahli* lives exclusively in these rocky outcrops and has evolved several adaptations indicative of its more terrestrial lifestyle as compared to other possums. *P. dahli* does not build a nest, but rather it has been observed sleeping in rock crevices. It has a longer snout, shorter tail, shorter legs, and shorter claws when compared to its more arboreal relatives (Kerle and Winter 1995). Runcie (2002) found that *P. dahli* is a generalist folivore which primarily consumes *Acacia difficilis, Eucalyptus miniata, Terminalia carpentaria,* and *Erythophleum chlorostachys.* Mature leaves of the food plant species which were relatively abundant in the area were primarily selected. Rock Ringtail Possums occasionally supplement their diet with fruits and flowers (Runcie 2002). Anecdotal observations also suggest that *P. dahli* preferentially feeds upon several species of figs.

Rock outcrops inhabited by *P. dahli* are typically sandstone and vary in size and resource quality. The outcrops lie within the surrounding flat lowlands and were formed by the erosion of plateaus during the Tertiary period (Runcie 2002). The rock outcrops provide a number of microclimates, have increased water retention, and have a decreased susceptibility to fire. These features allow for the tree species associated with them to be relatively diverse and abundant, with a long period in which fruits are available. Jeremy Russell-Smith et al (1998) found that many rocky escarpments are being burned more frequently than is required for regeneration of these fire sensitive communities, which require protection from fire throughout the time between seedling establishment and reproductive age. This increase in burning frequency has been attributed to a general increase in size and intensity of fires. These larger, more intense fires are able to burn the vegetation on rock outcrops that formally would have been shielded by the surrounding rocks and wetter conditions. Additionally, the density and composition of the undergrowth depends upon the timing and intensity of burning (Russell-Smith et al 1998). *Spinifex* grass tends to be replaced by dense swards of *Sorghum* spp. when exposed to a very high frequency of late dry season fires. Generally, the low lying area between rock outcrops is burnt more often by large fires. This fire pattern tends to homogenize the landscape surrounding outcrops. I predict that the community level biodiversity of the vegetation should show significant differences between areas with different levels of fire disturbance when compared to the habitat diversity within a fire regime type and show the highest diversity in intermediate levels of disturbance.

2 Metapopulation Dynamics

Together with reduction in habitat area and quality, reduction in habitat connectivity is one of the major factors influencing species' persistence in fragmented landscapes. When the rate of migration is reduced, remnant populations may become isolated and have a higher extinction risk due to environmental, demographic and genetic influences (Stacey and Taper 1992; Mills and Smouse 1994; Eldridge et al 1999). In simulation models of metapopulation persistence for Leadbeater's possum, habitat patchiness and dispersal capability significantly influenced the probability of extinction (Lindenmayer and Possingham 1996). In another study, it was shown that the dispersal capability of *Antechinus agilis*, a small marsupial carnivore, was restricted by the geographical isolation of the habitat patch (Banks et al 2005). Therefore, I predict that habitat patchiness and dispersal capability will significantly influence the persistence of possum groups on rock outcrops.

Rock Ringtail Possums are dependent upon rock crevices for shelter. Additionally, Runcie (2002) found that they selectively fed upon certain tree species that are associated with rock outcrops. The presence of these elements is an indicator of *P. dahli* habitat quality. The probability of a habitat patch being occupied is typically correlated with the size of the habitat patch and its distance to occupied patches. Finally, the dispersal capability of an animal has been found to influence the likelihood that a habitat patch will be occupied. I predict that the percentage of occupied outcrops will be dependent upon habitat quality, proximity to occupied outcrops and possum dispersal ability.

3 Population Genetics

Rock Ringtail Possums are distributed in two distinct areas in northwestern Australia, one in Western Australia (WA) and the other in the Northern Territory (NT) extending slightly into Queensland. The geographic distribution of *Petropseudes dahli* appears to have been restricted in the past 20 years. They are no longer able to be found in areas where they were previously reported. Rock Ringtail Possums are protected in both the NT and WA, as are all native species. Due to its non-threatened status though, it is does not have any further special protection that is accorded to listed threatened species. It has, however, been targeted for research and conservation efforts based on the limited life history and distribution information available. Unfortunately, their cryptic, nocturnal behavior has made observations difficult. Additionally, the low trap success rate of *P. dahli* has made investigations of their population biology complicated. Studies have revealed that *P. dahli* is socially monogamous and can be found living in groups ranging from two to ten individuals (Kerle 2001). The typical number of individuals is four; adult male, adult female, subadult offspring and juvenile offspring. Young disperse after they reach eight months, though dispersal is asynchronous and can occur at later ages. However, little is known about their distribution and genetic structure. I am interested in the genetic variation in *P. dahli* at three different scales; throughout its range, within a given fire regime, and within an outcrop. Recent advances in non-invasive genetic sampling techniques have made population genetic studies of this elusive species more feasible. Rock Ringtail Possum feces is distinct and can be used to sample the microsatellite DNA of possum individuals at a given outcrop.

Methods

Initially, I worked with the NT Department of Natural Resources, Environment and the Arts and the WA Department of Conservation and Land Management to identify potential study sites with various fire regimes. The five study sites chosen were located from west to east at Windjana Gorge, King Leopold Range, Mornington Wilderness Station, Mary River Station, and Kulgnuki. Approximately 2000 fecal samples were collected and stored for further DNA analysis from these five sites. Additionally, the variation in plant types and abundance will be compared within each fire regime type and between the types. I will search all the outcrops in an area of 1km^2 for the presence of possum groups, rock crevices, and food trees. The presence of possum groups will be determined by locating fecal samples. I will then measure the undergrowth density and calculate the distance to the nearest occupied outcrop. I am currently testing the applicability of the microsatellite DNA markers that were previously developed for other possum species (Clinchy et al 2004, Hansen et al 2005). By sequencing and then comparing the amplified products of the individuals for each of the markers, it will be possible to determine the genetic variability. I plan to determine the genetic variation within and between areas. This information should help to determine the dispersal capability and isolation risk for Rock Ringtail Possums and thus, aid in fire management decisions.

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