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Use of tree hollows by a Mediterranean forest carnivore

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ABSTRACT

Although tree hollows seem to be key structures for a wide range of forest mammals, their importance for Mediterranean forest carnivores remain poorly understood. Here we address this issue, by analysing daily resting site use by 21 radio-collared common genets. Tree hollows were used far more frequently during the wet season (October–April; 73.1% of daily locations) than in the dry season (May–September; 47.6%). Nests and underground dens were the second and third most frequently used resting sites, respectively, in both wet (17.5% and 9.4%) and dry (34.1% and 18.3%) seasons. Each individual reused a large percentage of its resting sites (65.7%). Some resting sites (17.3%) were used by more than one individual, but simultaneous sharing was exceedingly rare (0.56% of daily locations). Hollow use probability during the wet season varied little in relation to environmental variables, though there was a tendency to be higher away from riparian habitats (>50 m) and to be lower in sites with very high shrub cover (>80%). Environmental influences were responsible for more variability in the dry season, when hollow usage was highest in hot days, in days with precipitation, far from riparian habitats, close to sources of human disturbance, in landscapes dominated by continuous forest habitats, and in sites with low shrub cover. Results support the importance of tree hollows for Mediterranean forest carnivores, probably because they provide safe shelter against unfavourable weather, predators and human disturbance. However, results also revealed the importance of riparian trees, which offer support for building nests close to sources of water and food during the dry season. Considering home range size and the average number of hollow-bearing trees used by each genet, we recommend that management of cork and holm oak forests should strive to safeguard at least 4.6 hollow-bearing trees per 100 ha, while simultaneously maintaining large riparian trees. This will improve the resting habitat for common genets, while presumably favouring also other Mediterranean carnivores.

1. Introduction

Tree hollows provide shelter for a range of forest mammals and thus appear to be an essential resource for the persistence of many species (Gibbons and Lindenmayer, 2002; Banks et al., 2011). This resource is declining due to modern forestry, which reduces the availability of large and old trees with cavities (Gibbons et al., 2008; Ranius et al., 2009). There is thus increasing interest in understanding how mammals use tree hollows, and how the shortage of hollows can limit their populations (Lindenmayer et al., 2012a). This information is essential for the sustainable management of forests, if these are to maintain habitat conditions for hollow-dependent species (Gibbons et al., 2008; Manning et al., 2013).

Although many mammals are associated with tree hollows in natural forests, in at least some circumstances they may be able to persist despite reductions in hollow availability. For instance, den sharing in social mammals may overcome, at least partly, the shortage of hollows in managed forests (Banks et al., 2013). This strategy may be more difficult for solitary mammals such as most carnivores, where each hollow is generally used by a single individual at a time, with the exception of male and female pairs during the mating season, and of females with its cubs (Zielinski et al., 2004). In forest carnivores it is thus possible that shortage of hollows can be overcome through flexible behaviour allowing animals to use different types of resting sites. At present, however, information is still scarce on the flexibility of rest site use by forest solitary carnivores, and what factors influence such flexibility.

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Forest carnivores normally resting in tree hollows can also use a variety of other structures such as underground dens, green nests, raptor nests, rock piles, and human buildings (e.g. Palomares and Delibes, 1994; Zielinski et al., 2004; Birks et al., 2005; Slauson and Zielinski, 2009; Camps, 2011). However, three major resting site types appear to be used most regularly: (i) tree hollows, (ii) nests and (iii) dens (Zalewski, 1997b; Santos-Reis et al., 2004; Slauson and Zielinski, 2009; Camps, 2011). Nests are structures made by carnivores using plant material, which are often located in large tree branches, and are supported by climbing plants (Palomares and Delibes, 1994; this study). Dens are mainly located on burrows, often in riverbanks and surrounded by high shrub cover (Slauson and Zielinski, 2009). It is uncertain whether these three types of structures, can be used interchangeably, or whether each is associated with a specific set of environmental conditions. Clarifying this issue is important to find out under what circumstances the availability of tree hollows may be limiting for a species.

Several hypotheses may explain variation in resting site use by forest carnivores (Brainerd et al., 1995; Fernández et al., 2002; Birks et al., 2005; Purcell et al., 2009). Tree hollows may be used in more pristine habitats, whereas alternatives may be used in degraded and fragmented forests with few old and large trees (Zielinski et al., 2004, 2006; Manning et al., 2013). Variation may also be related to predation risk, because tree hollows may confer more protection than other rest-site types (Birks et al., 2005; Slauson and Zielinski, 2009). For instance, hollows may be used more frequently where understory shrub cover is lower and so predation risk may be higher, especially from avian predators (Zielinski et al., 2004; Popp et al., 2007; Banks et al., 2011). Seemingly, tree hollows may be used more often where human disturbance is high (Brearley et al., 2010; Banks et al., 2011; Bryant et al., 2012). Another possibility is that variation in rest site use is influenced by their capacity to offer protection against weather extremes such as high (or low) temperatures, and heavy rain events (Taylor and Buskirk, 1994). Tree hollows are judged to provide microclimate stability, and so they may be used more often under harsh conditions. On the other hand, nests may be a good alternative during hot periods, due to convective heat loss at upper canopy layers, while dens may provide fresh temperatures and insulation protection (Buskirk, 1984; Zabala et al., 2007; Lesmeister et al., 2008; Bryant et al., 2012). Finally, it is possible that rest-sites are used in relation to their proximity to critical resources such as mates, food and water, which greatly influence range use by forest carnivores (Brainerd et al., 1995; Purcell et al., 2009; Weir et al., 2012).

Here we examine factors influencing rest site use by the common genet (*Genetta genetta*) in Mediterranean oak forests. This species is considered a useful model for Mediterranean forest carnivores, because it is abundant within its range in south-western Europe, and it is relatively easy to trap and track using telemetry (Pereira and Rodríguez, 2010). Moreover, their predominantly arboreal habits and climbing skills make them suitable to study the importance of tree hollows as resting sites. The genet has a slender body shape, and so it may be affected by energetic constraints under climatic stress similar to those faced by other forest carnivores (Zielinski, 2000; Camps and Alldredge, 2013). Also, the genet occupies landscapes with a wide range of forest composition and fragmentation levels, making it particularly suited for analysing the effects of habitat conditions on rest-site use. Therefore, we carried out a detailed examination of rest-site use based on intensive radio-tracking of genets, aiming to: (i) identify the main types of resting sites; (ii) estimate seasonal variation in resting site use and (iii) quantify variation in tree hollow use in relation to forest composition and fragmentation, resource distribution, predation risk, human disturbance, and weather conditions. Results were used to discuss Mediterranean forest management favouring the availability of resting sites for genets and other forest carnivores.

2. Materials and methods

2.1. Study area and species

The study was conducted in southern Portugal (38°32′24″ to 38°47′33″N, 08°13′33″ to −07°55′45″W), in an area of about 50,000 ha (Fig. 1). Climate is Mediterranean, with mean daily temperature ranging from 5.8 °C to 12.8 °C in winter, and from 16.3 °C to 30.2 °C in summer; annual rainfall averages 609.4 mm and is concentrated in October–March (Évora 1971–2000; IPMA, 2012). The relief is undulating (150–430 m above sea level) and the landscape is largely dominated (≈50%) by open to closed cork oak (*Quercus suber*) and holm oak (*Q. rotundifolia*) forests, where the understory may be herbaceous or shrubby depending primarily on grazing pressure. Understory shrubs are also frequently removed mechanically to reduce fire risk and for providing easy access to livestock. Agricultural areas are also important (≈45%), comprising mainly dry arable land and pastureland, with or without sparse oaks trees, and olive orchards and vineyards.

Common genets (*Genetta genetta*), (mean adult weight ± SE: 1765.8 ± 34.8 g; this study) are widespread and abundant throughout the study area, though they are mainly associated with forested areas and riparian galleries (Zabala et al., 2001; Matos et al., 2009; Santos et al., 2011). They exhibit nocturnal activity, forage both on the ground and in the tree canopy, and select dense cover for breeding and resting (Palomares and Delibes, 1994; Santos-Reis et al., 2004; Camps and Llobet, 2004; Galantinho and Mira, 2009; Pereira and Rodríguez, 2010). Genets feed mainly on small vertebrates, mostly mammals (Virgós et al., 1999; Rosalino and Santos-Reis, 2002). The species is considered of least conservation concern in Portugal (Cabral et al., 2005).

2.2. Trapping and handling

Trapping was performed from May 2010 to December 2011, except in February–April 2011 and August–September 2011 due to logistic constraints and low capture success (Zabala et al., 2001). Trapping was carried out using 10–15 home-made box-traps (30W × 30H × 90L cm) groups, set at >500 m apart from each other, and baited with sardines in oil, fresh chicken eggs, and road-killed small mammals and passerines. Trap groups were spread all over the study area, in potential genet habitats (e.g. forest areas, riparian areas and shrubland areas; e.g. Zabala et al., 2001; Galantinho and Mira, 2009; Santos et al., 2011). Traps were checked every morning after sunrise to minimize animal stress, and bait was replaced whenever needed. Mean ± SE sampling effort in the wet season (October–April) was 33.9 ± 0.8 trap nights (696 total operative trap nights), and in the dry season (May–September) it was 123.0 ± 4.4 trap nights (1190 total operative trap nights).

Once an animal was captured, it was immediately carried to a nearby veterinarian hospital, where the animal was removed from the box, immobilised, and injected intramuscularly with a mix of ketamine hydrochloride (100 mg mL^{-1}) (Imalgene 1000, Lyon, France) and medetomidine hydrochloride (1 mg mL^{-1}) (Domitor, Pfizer, New York, NY, USA) (ratio of 2:1 by volume) at a dosage of 0.12 mL kg^{-1} (Herr et al., 2010). Animals were weighted, sexed, and checked for sanitary disorders (e.g., parasites). Individuals were classified as juveniles, sub-adults or adults by analysing a combination of morphological traits such as tooth wear, body size, sexual development and overall body condition (Rodriguez-Refojos et al., 2011). All animals were marked with PIT (Passive integrated transponders) tags (model: TXP148511B, 8.5 mm × 2.12 mm,