The diet of two species of *Tyto* in southeastern Madagascar

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Abstract

Although there are many studies across Madagascar on the dietary habits of different species of owls, little is known on this subject in the southeastern region of the island. We present herein an analysis of animal remains recovered from Red Owl (*Tyto soumagnei*) and Barn Owl (*T. alba*) pellets collected in the southeast. For the *T. soumagnei* material collected from Parcel 1 of the Parc National d'Andohahela, 22 individual animals were identified and based on minimum number of individuals, 20 (91%) comprise endemic small mammals of the tenrec family Tenrecidae (*Oryzorictes hova*, *Nesogale dobsoni*, and *Microgale* cf. *cowani*), rodent family Nesomyidae (*Eliurus webbi*), and mouse lemur of the family Cheirogaleidae (*Microcebus tanosi*). One single individual of the introduced rodent, *Rattus rattus* (family Muridae) was identified, as well as an unidentified lizard. In general, the percentage biomass data are in parallel, with 94% of that consumed by *T. soumagnei* being native mammals. In the case of the *T. alba* material collected in the littoral forests of Petriky, 35 individual animals were identified and based on minimum number of individuals, 15 (43%) comprise frogs and 18 (51%) introduced small mammals, mostly *Rattus rattus*. Other prey species included a large-size frog, a medium-sized gecko, a nesomyine rodent (*Macrotarsomys bastardi*), and a mouse lemur (*Microcebus murinus*). With respect to measures of represented biomass, given the small body mass of frogs, introduced small mammals represented over 86% of the total biomass consumed by this owl. Differences in the diet of the two *Tyto* species in southeastern Madagascar are compared to other sites on the island.

Résumé détaillé

Bien qu'il existe de nombreuses études menées à travers Madagascar sur les habitudes alimentaires des différentes espèces de chouettes, on sait peu de choses sur ce sujet provenant de la région du Sud-est de l'île. Nous présentons ici une analyse des restes d'animaux récupérés dans les pelotes de réjection d'Effraie de Soumagne (*Tyto soumagnei*) et d'Effraie des clochers (*T. alba*) collectés dans le Sud-est. Pour le matériel de *T. soumagnei* trouvé dans la Parcelle 1 du Parc National d'Andohahela, 22 animaux différents ont été identifiés et, sur la base du nombre minimal d'individus, 20 (91 %) comprennent des petits mammifères endémiques de la famille des Tenrecidae (*Oryzorictes hova*, *Nesogale dobsoni* et *Microgale* cf. *cowan*i), de la famille des Nesomyidae (*Eliurus webbi*) et de la famille des Cheirogaleidae (*Microcebus tanosi*). Un seul individu du rongeur introduit, *Rattus rattus* (famille des Muridae), a été identifié. En général, les données sur le pourcentage de biomasse sont parallèles, 94 % de celle consommée par *T. soumagnei* étant constituée de mammifères indigènes. Dans le cas du matériel de *T. alba* collecté dans les forêts littorales de Petriky, 35 individus ont été identifiés sur la base d'un nombre minimal d'individus, 15 (43 %) comprennent des grenouilles et 18 (51 %) de petits mammifères introduits, principalement *Rattus rattus*. Les autres proies comprenaient une grenouille de grande taille, un gecko de taille moyenne, un rongeur nesomyine (*Macrotarsomys bastardi*) et un lémurien (*Microcebus murinus*). En ce qui concerne les mesures de biomasse représentée, compte tenu de la faible masse corporelle des grenouilles, les petits mammifères introduits représentaient plus de 86 % de la biomasse totale consommée par cette espèce de chouette. Les différences dans le régime alimentaire de ces deux espèces de *Tyto* dans le Sud-est de Madagascar sont comparées à celles d'autres régions de l'île.

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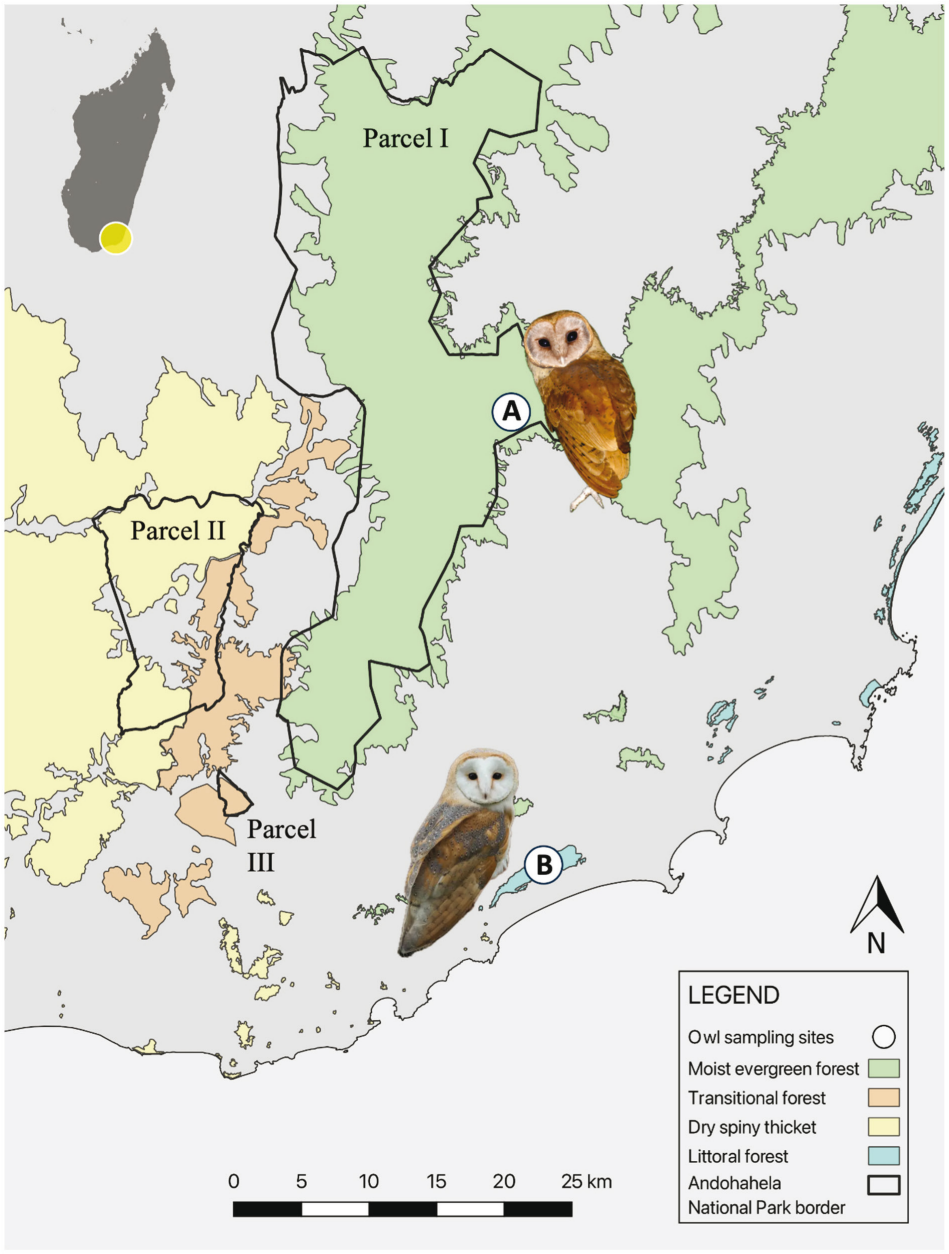

Figure 1. Owl sample collection sites from southeastern Madagascar. The three parcels of the Parc National d'Andohahela are delineated. **A**) Manangotry lowland moist evergreen forest associated with a Red Owl (*Tyto soumagnei*) roost and **B**) Petriky littoral forest and the pellet material deposited by Barn Owl (*T. alba*).

Introduction

Over the past decades, a number of studies have been published on the diet of different birds of prey on Madagascar, including diurnal raptors (orders Accipitriformes and Falconiformes; e.g. Goodman *et al.*, 1998, 2015; Karpanty & Goodman, 1999; Karpanty & Wright, 2007; Rasoma & Goodman, 2007; Razafimanjato *et al.*, 2007; Razakaratrimo *et al.*, 2019) and owls (order Strigiformes; e.g., Goodman *et al.*, 1993a, 1993b; Goodman & Thorstrom, 1998; Karpanty & Wright, 2007). While these studies for the most part cover an important portion of the geographic regions of the island, the southeastern area, with one exception concerning Madagascar Long-eared Owl *Asio madagascariensis* (Goodman *et al.*, 1991), has little such published data. Herein we provide new information on the dietary habits of two other owl species from southeastern Madagascar based on the contents of regurgitated pellets and associated prey remains. The species involved are the two members of the family Tytonidae that are present in Madagascar – Red Owl (*Tyto soumagnei*) and Barn Owl (*T. alba*).

The forested areas of the southeastern corner of Madagascar form a zone in which the local biota shows high beta-diversity turnover along an east-west gradient. This remarkable cline begins in the east

coastal littoral forests, extends westwards over the lowland and medium altitude moist evergreen forests of the Vohimena and Anosyenne Mountains, on to the transitional habitats between moist evergreen and dry spiny thicket, ending in the spiny thicket. This complete transition occurs over a distance of about 50 km, with the eastern portion of the zone receiving an annual rainfall approaching 1340 mm and the western limit about 830 mm. The central area of this zone, the Parc National d'Andohahela is composed of three disconnected parcels (Figure 1), and contains considerable plant and animal species diversity, including many site-level endemics (Goodman *et al*., 2018).

The prey remains reported on herein were collected at two sites representing two of the regional forest types: one in littoral forest (Petriky) and the other within the Parc National d'Andohahela (Parcel 1), specifically lowland moist evergreen forest (Manangotry). The data presented herein provides new information on the diet of these two congeneric owl species across this zone.

Materials and methods

Pellet collection sites

Petriky

The Petriky Forest, of about 800 ha and occurring at low elevation (<40 m), represents the southernmost littoral forest block on Madagascar (Figure 1). Some 280 ha constitutes a protected area known as Paysage Harmonieux Protégé de la Forêt Naturelle de Petriky. The local natural forest vegetation is a slightly deciduous and low stature littoral forest growing on a sandy, mineralized substrate, with some transitional floristic elements of dry spiny thicket. The vertebrate fauna shows similar intermediate biogeographic affinities between the dry spiny thicket and moist evergreen forest (Temple *et al*., 2012; Goodman *et al*., 2018). This unique combination of vegetation and faunal characteristics gives Petriky a distinct biota as compared to other regional forests. Average rainfall is approximately 1075 mm per year, falling mostly between November and April (Goodman *et al*., 2018).

A collection of *Tyto alba* pellets and miscellaneous associated remains were obtained from a roost site within the protected area (Figure 1) situated in disturbed littoral forest (-25.058740°S, 46.869830°E, and at about 13 m), in a relatively large *Intsia bijuga* (family Fabaceae) tree. The collection contained an estimated 18 pellets, several being slightly broken. The identification of the predator was made by direct observation at the roost site and recovered diagnostic feathers.

Manangotry

The Manangotry moist evergreen forests are within Parcel 1 of the Parc National d'Andohahela. The site has hilly terrain and is located between the flanks of the Anosyenne and Vohimena mountain ranges and spans an elevational range from 250 to 1250 m. The natural habitat at lower areas (250-500 m) is floristically diverse lowland moist evergreen forest, with a canopy height of 15-20 m, and emergent trees reaching 30 m. The area receives an annual rainfall of approximately 1360 mm, with no pronounced dry season (Goodman *et al*., 2018).

Material was collected from a single roost site (Figure 1) situated deep in the forest and an area with steep terrain (-24.755490°S, 46.848263°E, 415 m). The roost was located near the source of several small unnamed tributaries, the nearest being some 500 m away, and draining into the Manampanihy River. The roost tree, which overhung a small cave, is alleged to have fallen during a cyclone event in 2021. A variety of material, including four pellets and feather remains of *Tyto soumagnei*, was collected on 21 August 2023.

Pellet preparation and identification of contents

Bone remains were removed from pellets after being immersed in soapy water for about 24 hours and identified using the comparative osteology collections at the Université d'Antananarivo, Mention Zoologie et Biodiversité Animale. Age classes for mammals are based on the ossification of the basisphenoid suture and molar eruption patterns: juveniles – suture non-fused and distal molars non-erupted and adults – suture fused and cheek teeth fully erupted. The minimum number of individuals (MNI) per taxon for each of the two collections was tallied for mammals based on cranial-maxillary/mandible counts and the number of unique bilateral elements and for other vertebrate groups by the unique number of unique bilateral bones. We report the MNI figure as a percentage of total individuals identified in a given pellet collection. To calculate percent biomass, we used mean body mass data from different sources, largely those collected in southern Madagascar (Table 1). Invertebrate remains were few and are not figured in the analyses herein. Reptile bones were uncommon and amphibian remains were notably

Table 1. Mean body mass of vertebrates identified from owl remains reported on herein. Non-native species are identified with an asterisk (*).

Taxa	Mean mass (g)
AMPHIBIANS[1]	
Large-size frog (cf. large *Boophis* or *Laliostoma*)	9.5
Medium-size frog (cf. *Ptychadena*)	4.9
REPTILES[1]	
Medium-size gecko (cf. *Paroedura*)	6.3
MAMMALS	
Tenrecidae[3,4]	
Medium-size *Microgale* (cf. *Microgale cowani*)	13.3
Nesogale dobsoni	32.2
Oryzorictes hova	42.5
Soricidae[3]	
**Suncus etruscus*	1.7
Nesomyidae[3]	
Eliurus webbi	88.3
Macrotarsomys bastardi	23.4
Muridae[1,3]	
**Mus musculus*	10.3
**Rattus rattus*-subadult	26.1
**Rattus rattus*-adult	66.0
PRIMATES	
Microcebus murinus[5]	59.4
Microcebus tanosi[6]	54.7

[1] Mean body mass taken from Goodman *et al*. (1993a).
[2] Mean body mass taken from Faliarivola *et al*. (2022).
[3] Mean body mass taken from Soarimalala and Goodman (2011).
[4] Mean body mass taken from Goodman *et al*. (1999).
[5] Mean body mass based on unpublished data of Jörg Ganzhorn and colleagues from animals captured at Petriky. The species identification follows Van Elst *et al*. (2025).
[6] Mean body mass taken from Hyde Roberts (2021).

present, but due to an associated lack of comparative osteological material the identifications to genus level are tentative, as is the associated inferred body mass.

Results

Tyto soumagnei

In the pellet collection of this species collected in the Manangotry Forest, on the basis of the MNI, 22 different prey animals were identified, of which 20 (91%) comprise endemic small mammals (Table 2). These include 11 individuals of the tenrec family Tenrecidae (*Oryzorictes hova*, *Nesogale dobsoni*, and *Microgale* cf. *cowani*), eight individuals of the rodent family Nesomyidae (*Eliurus webbi*), and one mouse lemur of the family Cheirogaleidae (*Microcebus tanosi*). One single individual of the introduced rodent, *Rattus rattus* (family Muridae) was identified, as was an undentified gecko. Hence, the local diet of this species is largely composed of native mammal prey. With respect to measures of represented biomass, the same pattern was found, with 94% of that consumed by *T. soumagnei* being native mammals. With regards to the total consumed biomass, the three most commonly consumed endemic mammals were *E. webbi* (57%), *O. hova* (21%), and *N. dobsoni* (11%). *Rattus rattus* represented 5% of the consumed biomass.

Tyto alba

In the pellets of this species collected in the Petriky Forest, 35 individuals were identified, of which based on MNI, 15 (43%) comprised frogs and 18 (51%) introduced small mammals, almost exclusively *Rattus rattus* (Table 2). The balance of the prey items, with

Table 2. Prey remains identified from pellets of two different owl species collected from four different sites in southeastern Madagascar. Non-native species are identified with an asterisk. Unless otherwise noted all individuals are adult. Total minimum number of individuals (MNI) and other percentage values are presented for each site.

Site and taxa	MNI	% total individuals	% total biomass
***Tyto soumagnei* - Manangotry**			
REPTILES			
Medium-sized gecko	1	5	1
Tenrecidae			
Oryzorictes hova	6	27	21
Nesogale dobsoni	4	18	11
Microgale cf. *cowani*	1	5	1
Rodentia			
Eliurus webbi	8	36	57
**Rattus rattus* - adult	1	5	5
PRIMATES			
Microcebus tanosi	1	5	4
Total	**22**	**101**	**100**
***Tyto alba* - Petriky**			
AMPHIBIANS			
Medium-sized frog	14	40	6
Large-sized frog	1	3	1
REPTILES			
Medium-sized gecko	1	3	0.5
Shrew			
**Suncus etruscus*	1	3	0.2
Rodentia			
Macrotarsomys bastardi	1	3	2
**Mus musculus*	1	3	1
**Rattus rattus* - adult	15	43	83
**Rattus rattus* - subadult	1	3	2
PRIMATES			
Microcebus murinus	1	3	5
Total	**35**	**104**	**101**

one identified individual each, included a large-sized frog, a medium-sized gecko, an endemic rodent (*Macrotarsomys bastardi*), and an endemic mouse lemur (*Microcebus murinus*). Hence, the vast majority of this species' diet at Petriky and based on MNI, are frogs and introduced small mammals. With respect to measures of represented biomass and given the small body mass of frogs, a very different pattern was found. Introduced small mammals represented over 86% of the total biomass consumed by this owl. All of the other prey types together represented less than 14% of the remaining represented biomass.

Discussion

On the basis of details on the diets of two species of the genus *Tyto* reported herein, they have notably different diets. Even though the number of pellets for each species is different (*T. soumagnei*, four intact pellets and scattered prey remains and *T. alba*, about 18 pellets), some general conclusions can be made in a comparative sense of the animal prey they consume.

Tyto soumagnei

Our results show that this species, which occurs locally in moist evergreen forest, feeds almost exclusively on endemic small mammals, representing close to 90% of the total number of individuals and biomass within the sample. Prey species ranged in size from 6.3 g for a medium-sized gecko to 66.6 g for adult *Rattus rattus.*

The pattern of the overall prevalence of endemic species in the diet of *T. soumagnei* in Andohahela is similar to that found for this species in the extensive lowland forests of Masoala, in the far northeast of Madagascar, where all prey species, with the exception of *R. rattus* are endemic to the island, and at least at the genus level are largely those consumed at Andohahela (Goodman & Thorstrom, 1998). This is notably in contrast to the more montane humid forests of the Bemanevika Protected area in the

northwest of Madagascar, where *R. rattus* was the most common prey taken, representing a 45% by minimum number of individuals (Ramamonjisoa *et al*., 2021). We propose that this difference can be explained by two aspects, 1) the higher elevational forests of Bemanevika have been fragmented to a greater degree by human actions, as compared to Andohahela and Masoala, providing the means for *R. rattus* to colonize the area, and 2) *R. rattus* has higher densities in more upland areas as compared to lowland moist evergreen forests of Andohahela (Parcel 1) and the Masoala.

Tyto alba (Petriky)

We found that the diet of *T. alba* at Petriky based on MNI is composed of more than 50% introduced small mammals, mostly rodents, and 40% frogs. In contrast, when diet composition is examined using biomass, 86% comprises introduced rodents, of which 85% being *Rattus rattus.* Prey species ranged in size from 4.9 g medium-sized frogs to 59.5 g *Microcebus murinus*.

Several studies on the diet of *T. alba* in different forest formations on Madagascar have found results similar to those presented herein with reference to the large proportion of introduced small mammals in the diet of this forest-edge or open-area dwelling species, for example in the dry spiny thicket and gallery forests near Bezà Mahafaly (Goodman *et al*., 1993a). The observation that this owl feeds extensively on introduced and often invasive mammal species, is directly associated with its utilization of open habitats or highly degraded forests. The presence of frogs in the diet of this species is presumably cyclic, and most common during periods of notable precipitation, and we assume that a portion of the pellets collected at Petriky were deposited during the rainy season.

New records for the Parc National d'Andohahela

Accumulated pellet samples reported on herein originated from two Strigiformes species (*Tyto alba* and *T. soumagnei*); an additional three other owl species occur in the region (Goodman *et al*., 2018). This work provides new range records for both Tytonidae species. Although expected based on its regional distribution, *T. alba* was previously unknown from Petriky. Further, *T. soumagnei* was unrecorded in the Parc National d'Andohahela. The geographic distribution of *T. soumagnei* was previously very poorly known and until the 1990s the species was recorded from only a few sites on the island. Subsequently it has been documented in several protected areas surrounding Andohahela, including Tsitongambarika, Kalambatritra, and Befotaka-Midongy du Sud (Irwin & Samonds, 2002; Goodman *et al*., 2018).

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