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DIET OF THE MADAGASCAR HARRIER-HAWK, *POLYBOROIDES RADIATUS*, IN SOUTHEASTERN MADAGASCAR

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ABSTRACT.—We recorded prey deliveries, pellets and food remains of the Madagascar Harrier-Hawk (*Polyboroides radiatus*) from 10 August–5 December 1997 at Berenty and Bealoka private reserves in extreme southeastern Madagascar. The Madagascar Harrier-Hawk had a variable diet, eating at least 16 prey species, including reptiles (2.4% of biomass), birds (11.5%), mammals (85.9%) and insects (0.2%). The largest component of the diet of the harrier-hawk in terms of biomass was Verreaux's Sifaka (*Propithecus verreauxi*), all of which were presented by the male to the female during courtship.

KEY WORDS: *Madagascar Harrier-Hawk*; Polyboroides radiatus; *diet; lemur predation.*

Dieta de *Polyboroides radiatus* en el sureste de Madagascar

RESUMEN.—Registramos las presas, egragópilas y restos de comida de *Polyboroides radiatus* desde Agosto 10 hasta Diciembre 5 de 1997 en las reservas privadas de Berenty y Bealoka en el extremo sureste de Madagascar. *Polyboroides radiatus* tuvo una dieta variable consumiendo por lo menos 16 especies distintas de presas, las cuales incluyen reptiles (2.4% de la biomasa), aves (11.5%), mamíferos (85.9%) e insectos (0.2%). El mayor componente de la dieta en términos de biomasa fue *Propithecus verreauxi*, todos aportados por el macho a la hembra durante el cortejo.

[Traducción de Autor]

Until recently, information on the diets of Malagasy raptors has been limited. Langrand (1990) summarized information based on stomach analyses of Rand (1936). More recent analyses of pellet remains of several owl species (Goodman and Thorstrom 1998, Goodman et al. 1993a, 1993b, Langrand and Goodman 1996) and the Madagascar Buzzard (*Buteo brachypterus*) (Goodman and Langrand 1996) have expanded our knowledge of this group. One endemic species of raptor for which little information is available is the Madagascar Harrier-Hawk (*Polyboroides radiatus*). Despite its abundance in a variety of habitats across the island ranging from montane rainforest to spiny desert scrub, little is known about the ecology of this raptor and there is no quantified information on its diet.

Recently, there has been an increased demand for information on the feeding ecology of Malagasy raptors. Conservationists concerned with protecting what remains of Madagascar's fragmented forests need to understand the ecosystem from the perspective of primary consumers. By focusing efforts on protecting predator populations such as raptors and the habitat containing their often large home ranges, we can more easily preserve organisms existing at all levels of the food chain (Watson and Lewis 1994). Primatologists have also become interested in documenting the diet of Malagasy raptors as they seek to understand the historic and present-day selection pressures on lemur life history characteristics. While predation on diurnal lemurs by the harrier-hawk has rarely been documented (Goodman et al. 1993), laboratory and field studies of lemur vigilance and alarm calls suggest that it may represent an important threat to free-ranging lemurs (Macedonia 1990, Sauther 1989). Wright (1998) demonstrated in a 10-yr be-

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Table 1. Diet of the Madagascar Harrier-Hawk at Berenty and Bealoka Reserves in southeastern Madagascar. Data are combined from the two sites.

TAXA	MNI[a]	% TOTAL INDIVIDUALS	% TOTAL BIOMASS
Reptilia[b]			
Furcifer lateralis	1	1.6	0.1
Tracheloptychus madagascariensis	4	6.3	0.5
Chalarodon madagascariensis	1	1.6	0.1
Dromicodryas quadrilineatus	1	1.6	1.7
Aves[c]			
Bubulcus ibis (nestlings)	3	4.8	0.3
Numida meleagris[d]	1	1.6	4.3
Streptopelia picturata	1	1.6	0.8
Coracopsis nigra	3	4.8	2.8
Coracopsis vasa	2	3.2	2.4
Acridotheres tristis[e]	1	1.6	0.6
Dicrurus forficatus (nestlings)	4	6.3	0.3
Mammalia[f]			
Propithecus verreauxi verreauxi (adult)	2	3.2	29.1
Propithecus verreauxi verreauxi (young)	3	4.8	19.3
Microcebus murinus (adult)	3	4.8	0.6
Microcebus murinus (young)	1	1.6	0.1
Tenrec ecaudatus	4	6.3	33.4
Rattus rattus[e] (adult)	7	11.1	3.3
Rattus rattus (subadult)	1	1.6	0.2
Insecta (Orthoptera, Coleoptera, Lepidoptera)	20	31.7	0.2
Total	63	100	100

[a] MNI = Minimum number of individuals.
[b] Reptile biomass estimates provided by C. Raxworthy (pers. comm.).
[c] Avian biomass from Goodman et al. (1997) and Telfair (1994).
[d] Probably introduced to Madagascar (Langrand 1990).
[e] Introduced to Madagascar.
[f] Mammal biomass estimates from Mittermeier et al. (1994) and fieldwork by S.M. Goodman (pers. comm.).

havioral study that the large-bodied, diurnal rainforest Milne-Edward's Sifaka (*Propithecus diadema edwardsi*) responds to aerial predators such as the harrier-hawk by giving loud alarm calls, dropping low in the canopy and choosing daytime resting sites lower than feeding sites. The purpose of this study was to describe the diet of the Madagascar Harrier-Hawk.

STUDY AREA AND METHODS

Research was conducted between 10 August–5 December 1997 at the privately-owned Berenty and Bealoka Reserves in southeastern Madagascar (25°00′S; 46°18′E, elevation 100 m) near Amboasary-Sud, 80 km west of Tolagnaro (Fort Dauphin). Together, these two reserves compose approximately 200 ha of gallery and spiny forest on the banks of the Mandrare River and are dominated by *Tamarindus indica*, a characteristic tree of this semiarid thorn-scrub habitat. The climate of southern Madagascar is characterized by a distinct dry season (March–November) and highly variable amounts of annual rainfall in the wet season (December–February). The forest fragments of Berenty and Bealoka are separated by 10 km of sisal plantations and small fragments of spiny forest; thus, there is no migration of primates between reserves. The land vertebrate faunal composition of the two reserves is essentially identical.

One occupied Madagascar Harrier-Hawk nest was found in each reserve in early August 1997 during the courtship stage of the breeding cycle. Birds were individually identified by key features. Species-specific vocalizations were used to assist in nest location. A blind was constructed adjacent to the nest tree within Berenty. Using 10 × 40 binoculars and a 30× spotting telescope, continuous observations of this nest were performed at half-day intervals in conjunction with lemur observations Focal hours totaled 134 at this nest. Behavioral observations were not performed on the Bealoka nest.

Prey items brought to incubating or brooding parents were identified. Pellets and prey remains were also col-

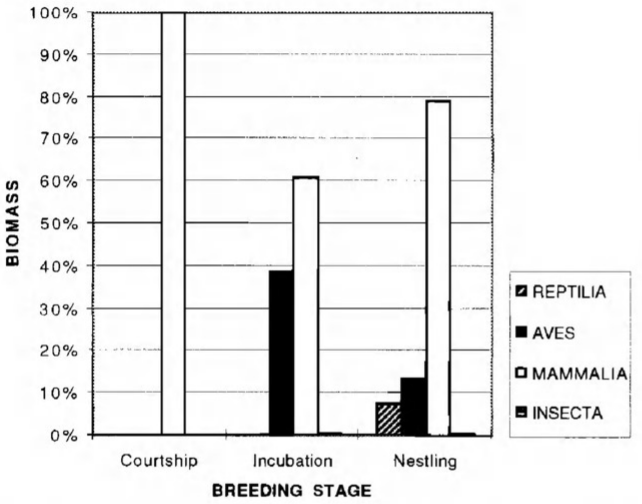

Figure 1. Percentage biomass of reptilian, avian, mammalian and insect prey of the Madagascar Harrier-Hawk during courtship, incubation and nestling stages of the breeding cycle based on direct observation of prey brought to the nest.

lected from beneath the nests. Prey collections at Berenty were made daily and at Bealoka weekly. Remains were sorted, dried and stored in plastic bags. Identification of prey remains was made to genus and species levels at the Université d'Antananarivo. Paired parts of any taxon were separated and the largest number of parts of either the left or right side was considered the minimum number of individuals (MNI). Data from the two nests were combined as data from the Bealoka nest were limited by the weekly collection schedule. The composition of the prey communities were identical between the two reserves.

RESULTS

Reptiles accounted for 11.1% of total individuals and 2.4% of total biomass, birds for 23.9% of individuals and 11.5% of biomass, mammals for 33.4% of individuals and 85.9% of biomass, and insects for 31.7% of individuals and 0.2% biomass of the diet during the nesting season (Table 1). The harrier-hawks had a generalist diet eating at least 16 different prey species, ranging from cockroaches (*Gromphadorhaima portentosa*) to mouse lemurs (*Microcebus murinus*) and chameleons (*Furcifer lateralis*). One explanation for the relatively high diversity of prey types is the tendency for harrier-hawks to forage on the ground and probe tree holes and cavities as well as to hunt in flight and from perches.

Perhaps the most interesting result of our study is the heavy reliance of the harrier-hawks on mammalian prey. The harrier-hawks ate two adult (3.4 kg/individual) and three young (1.5 kg/individual) Verreaux's Sifakas making this diurnal lemur the most important prey item for the hawks in terms of biomass (48.4%). All of the sifakas were taken during the courtship stage of the breeding season (Fig. 1). The large lipotyphlan tenrec (*Tenrec ecaudatus*), which weighs up to 1.95 kg, was the second most important prey item at 33.4% of total biomass. A small portion of the harrier-hawk's diet, either by numbers or biomass, consisted of introduced species (*Numida meleagris, Acridotheres tristis* and *Rattus rattus*).

DISCUSSION

Our study presents the first detailed analysis of the diet of the Madagascar Harrier-Hawk. Goodman and Pidgeon (1991) previously documented the consumption of a flying fox (*Pteropus rufus*) by harrier-hawks at Berenty and suggested that harrier-hawks may nest near and exploit concentrated food resources. Our study supports this finding. Not only did harrier-hawks eat sifakas, which are two to three times their body mass, but they also nested within 500 m of a heronry and consistently exploited this resource during the nestling stage of their breeding cycle. Rand (1936) reported remains of insects, spiders, lizards, frogs and small mammals in the digestive system of the Madagascar Harrier-Hawk. Our study demonstrates the diet of the harrier-hawk to be extremely variable, containing at least 16 vertebrate and invertebrate prey species. The continued success of this hawk in the fragmented forests of southern Madagascar will likely be due to its ability to exploit such a wide variety of prey.

One of the more striking findings of our study was the predation of harrier-hawks on large, diurnal lemurs. Evidently, harrier-hawks prey on both adult and infant Verreaux's sifakas and they can become seasonally the most important part of this raptor's diet in terms of biomass. Such predation might be detrimental for sifakas which typically produce one young per troop (7–8 individuals) per year. Our findings support the work of Rasoanindrainy (1985) who found that the main cause of sifaka mortality was predation by the Madagascar Harrier-Hawk. These findings should prompt primatologists to reconsider the importance of present-day predation pressure on lemur life-history characteristics (Csermely 1996). All predation by harrier-hawks on sifakas occurred during the courtship stage of the nesting cycle. Although data are limited, temporal variation in prey consumption

suggests that the sifaka may be difficult for this raptor to subdue, yet it is a valuable resource in the initial stages of nesting. Future research on the diet of the Madagascar Harrier-Hawk is needed to explore these seasonal differences in diet.

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