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PREY PARTITIONING BETWEEN MATES IN BREEDING BOOTED EAGLES (*HIERAAETUS PENNATUS*)

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KEY WORDS: *Booted Eagle*; Hieraaetus pennatus; *food partitioning*; *forest*; *prey provisioning*; *reversed size dimorphism (RSD)*.

Reversed sexual-size dimorphism (RSD) is widespread in raptors and owls, with females being larger than males (Newton 1979). Several researchers have proposed that this trait is driven by different selective forces acting on breeding adults (Mueller and Meyer 1985, Massemin et al. 2000, Simmons 2000). However, no explanation has gained universal acceptance (Bildstein 1992). One of the most popular explanations is the prey-partitioning hypothesis or female supplementary feeding hypothesis (Reynolds 1972, Korpimäki 1985), which suggests that RSD is advantageous because it allows females to hunt larger prey, widening the prey base available for the pair and reducing intersexual competition for food (Snyder and Wiley 1976, Andersson and Norberg 1981, Massemin et al. 2000). Several authors (e.g., Snyder and Wiley 1976,

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Newton 1979, Simmons 2000) have noted that the degree of RSD among raptor species shows a strong relationship with the proportion of birds in the diet. Nonetheless, studies addressing differential prey-size choice between sexes have been equivocal (Opdam 1975, Collopy 1984, Kennedy and Johnson 1986, Boal and Mannan 1996).

Between 1998 and 2000, we conducted a study on a breeding population of Booted Eagles (*Hieraaetus pennatus*) in southeastern Spain. This species is a medium-sized raptor showing a moderate degree of reversed size dimorphism ($\bar{x}$ male body mass = 709 g, female = 975 g; del Hoyo et al. 1994, Balbontín et al. 2001). Although the Booted Eagle is a common bird of prey of the forests and woodland areas of the Iberian Peninsula (Veiga and Viñuela 1994), little is known about its diet. Earlier studies in Europe and South Africa describe it as a small- and medium-sized bird hunter, also preying on lizards and mammals (Steyn and Grobler 1985, Veiga 1986, Martínez et al. 2004).

Here, our objective was to analyze the prey items delivered to the nest by male and female Booted Eagles, examining differences in the kind and body mass of prey between the genders.

METHODS

We carried out the study between 1998–2000 in central Murcia (southeastern Spain; 38°00'N, 1°45'W). The study area included about 10 000 ha and ranges from 550–1521 m above sea level, with a topography characterized by rugged slopes dominated by pine forests (*Pinus halepensis*) interspersed with traditional agroecosystems (cereal plots, vineyards, and olive and almond groves).

Dietary differences between males and females were assessed from observations of prey deliveries at five different nests. Prey items were identified from blinds located 30–50 m away from the nests using a spotting scope and binoculars. One nest was observed in 1998, two in 1999, and other two in 2000. Observations were conducted every 4–8 d from the early nestling stages (late May) until 5–7 d after fledging (early August). Nest observations started at 1100 H, lasted until 1900 H, and continued the following day from 0700–1100 H. In total, 509 hr of direct observation were made, during which we recorded visually all prey deliveries. A prey item was assumed to have been captured by the male when: (1) we observed the male delivered prey to the nest or (2) the prey captured by the male was delivered to the nest by the female after a food transfer involving characteristic vocalizations. A prey item was assumed to have been captured by the female when she delivered it and no food transfer was observed.

Biomass of prey was estimated based on data reported by Van den Brick and Barruel (1972) and Mañosa (1994). Mass data was log transformed for analysis. Prey items were also assigned to the following categories: mammals, large adult birds (≥200 g), small adult birds (<200 g), nestlings (<100 g) and reptiles. We also considered two nesting periods (early, until the chicks were ca. 30 d old, and late, until the end of observations), to assess temporal differences in the type and mass of the prey captured.

We used Morisita's index (Krebs 1999) to assess overlap in the prey species caught by male and female eagles. A linear mixed-effects model was employed to evaluate differences in the mean mass of prey captured by each mate. Nest was considered as a random factor to avoid pseudoreplication and the temporal factor was included as a fixed effect. The proportions of each prey type and size were also assessed by the analysis of four-way contingency tables using Poisson log-linear models and likelihood ratio test (Venables and Ripley 2002) to examine the effects of sex, nest, and nesting period as explanatory factors. Statistical analyses were performed with the R statistical package (Maindonald and Braun 2002).

RESULTS

We identified to the species level 117 of 127 prey items delivered to nests (Table 1). Birds made the bulk of the Booted Eagle diet (65.35%), followed by ocellated lizards (*Lacerta lepida*; 26.77%), and mammals (7.87%). Females brought 40 prey items (31.50%) and males 87 (68.70%). Of these, 54 were delivered directly by the male, and 33 were previously transferred and then delivered by the female. The prey-provisioning rate was 0.24 prey items/hr (0.08 for females and 0.16 for females).

A moderate degree of dietary similarity between the sexes was found (Morisita's index = 0.67). However, the mean mass of prey captured by males and females differed significantly ($F_{1,119}$ = 11.50, P < 0.001). The temporal factor and its interaction with the gender were not significant ($F_{1,119}$ = 0.20, P = 0.66 and $F_{1,119}$ = 0.19, P = 0.59, respectively).

The analysis of the prey-type contingency table revealed that sex, nesting period, and nest factors significantly influenced prey type (sex: χ^2 = 25.42, P < 0.001; nesting period: χ^2 = 23.79, P < 0.001; nest: χ^2 = 72.40, P < 0.001;). Based on the Poisson model, males delivered greater proportions of small birds, nestlings, and reptiles than females (Table 2). Both sexes captured similar proportions of large adult birds and mammals.

DISCUSSION

Our results show that differences in provisioning rates between sexes was moderate and similar to those reported by Simmons (1986), Mañosa (1994), and Gronnesby and Nygard (2000) for a variety of small and medium-sized forest raptors. The Morisita's index points to a moderate dietary similarity between sexes, a finding which differs from those of Kennedy and Johnson (1986) and Boal and Mannan (1996) for Cooper's Hawk (*Accipiter cooperii*) and Northern Goshawk (*Accipiter gentilis*), respectively. These workers found extensive niche overlap between the sexes in these species that also exhibit substantial sexual dimorphism.

Our study suggests prey-size partitioning between pair members of Booted Eagles during the chick-rearing stage. Previous studies have reported a similar tendency

Table 1. Prey delivered to nest by male and female Booted Eagles in Murcia, southeastern Spain (1998–2000).

		MALES			FEMALES		
	MEAN MASS (G)	NO. OF INDIVIDUALS	PERCENT INDIVIDUAL	PERCENT BIOMASS	NO. OF INDIVIDUALS	PERCENT INDIVIDUAL	PERCENT BIOMASS
Mammals							
European Rabbit (*Oryctolagus cuniculus*)	1000	2	2.3	12.9	2	5.0	15.8
European Rabbit[a] (*Oryctolagus cuniculus*)	250	1	1.1	1.6	0	0.0	0.0
Black Rat (*Rattus rattus*)	150	2	2.3	1.9	1	2.5	1.2
Red Squirrel (*Sciurus algirus*)	250	0	0.0	0.0	2	5.0	3.9
Subtotal mammals		5	5.7	16.5	5	12.5	20.9
Birds							
Chicken (*Gallus domesticus*)	2000	0	0.0	0.0	1	2.5	15.8
Wood Pigeon (*Columba palumbus*)	400	0	0.0	0.0	3	7.5	9.5
Wood Pigeon[a] (*Columba palumbus*)	70	3	3.4	1.4	0	0.0	0.0
Feral Pigeon (*Columba livia*)	300	16	18.4	31.0	15	37.5	35.5
Red-legged Partridge (*Alectoris rufa*)	450	1	1.1	2.9	1	2.5	3.5
Red-legged Partridge[a] (*Alectoris rufa*)	75	5	5.7	2.4	0	0.0	0.0
Eurasian Kestrel (*Falco tinnunculus*)	200	4	4.6	5.2	2	5.0	3.2
Jay (*Garrulus glandarius*)	190	0	0.0	0.0	2	5.0	3.0
Mistle Thrush (*Turdus viscivorus*)	115	2	2.3	1.5	0	0.0	0.0
Unidentified adult[b]	100	0	0.0	0.0	4	10.0	3.2
Unidentified nestling[b]	100	2	2.3	1.3	0	0.0	0.0
Unidentified nestling[b]	70	1	1.1	0.5	1	2.5	0.6
Stone Curlew[c] (*Burhinus oedicnemus*)	70	1	1.1	0.5	0	0.0	0.0
Turtle Dove (*Streptopelia turtur*)	140	2	2.3	1.8	0	0.0	0.0
Turtle Dove[c] (*Streptopelia turtur*)	40	3	3.4	0.8	1	2.5	0.3
Blackbird (*Turdus merula*)	90	3	3.4	1.7	1	2.5	0.7
Green Woodpecker[c] (*Picus viridis*)	55	2	2.3	0.7	0	0.0	0.0
Crested Lark (*Galerida cristata*)	43	2	2.3	0.6	0	0.0	0.0
Corn Bunting (*Miliaria calandra*)	50	0	0.0	0.0	1	2.5	0.4
European Starling (*Sturnus vulgaris*)	90	2	2.3	1.2	0	0.0	0.0
Unidentified passerines	20	2	2.3	0.3	0	0.0	0.0
Subtotal birds		51	58.6	53.5	32	80.0	75.6
Reptiles							
Ocellated Lizard (*Lacerta lepida*)	150	31	35.6	30.0	3	7.5	3.5
Subtotal reptiles		31	35.6	30.0	3	7.5	3.5
Total		87			40		
Mean biomass (g)		178 ± 17			317 ± 53		

[a] Young.
[b] Estimated body mass from recovered prey
[c] Nestlings

Table 2. Estimated probabilities from the main effects log-linear model applied to the prey-type frequency table. Probabilities from the five nests are summed.

Prey Type	Early Nestling Period		Late Nestling Period	
	Males	Females	Males	Females
Mammals	0.43	0.27	0.07	0.22
Large adult birds (≥200 g)	0.20	0.10	0.28	0.44
Small adult birds (<200 g)	0.53	0.22	0.16	0.11
Nestlings (<100 g)	0.67	0.07	0.22	0.05
Reptiles	0.69	0.04	0.22	0.04

in raptors and owls (Simmons 1986, Mañosa and Cordero 1992, Overskaug et al. 1995), although several authors found only weak evidence of prey partitioning between sexes during the nestling period (Widén 1984, Toyne 1998, Delannoy and Cruz 1999). Males in our study, on average, delivered smaller prey items than females. The taking of smaller prey by males could be related to their smaller body size and greater agility, which would favor the search, pursuit, and hunting of such prey (Temeles 1985) and reduce the costs of handling prey (Villarán 2000). Females may reduce competition for food with males by taking larger prey; Booted Eagle females weigh 27% more than males on average (del Hoyo et al. 1994), which is consistent with theories concerning the selective advantage of RSD (Andersson and Norberg 1981, Temeles 1985). In summary, our findings suggest that intersexual prey-size partitioning may be related to the sexual dimorphism of this species.

CAPTURA DIFERENCIAL DE PRESAS POR MACHOS Y HEMBRAS DE *HIERAAETUS PENNATUS*

RESUMEN.—Entre 1998 y 2000 estudiamos la dieta de machos y hembras de *Hieraaetus pennatus,* mediante el control visual de cinco nidos en una zona forestal del sureste de España. Machos y hembras capturaron respectivamente el 69% y el 31% del total de las presas aportadas a los nidos. La tasa de aporte fue de 0.24 presas/hora, siendo las aves la dieta predominante de los pollos (65%). Encontramos un moderado nivel de similitud entre las capturas de machos y hembras, pero la biomasa media y las frecuencias de los diferentes tipos de presas capturados fueron significativamente distintos entre ambos sexos. Nuestros resultados sugieren la existencia de diferencias entre la dieta de ambos sexos, probablemente relacionadas con el dimorfismo de tamaño.

[Traducción de los autores]

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PREDATION OF SMALL MAMMALS BY RUFOUS-LEGGED OWL, BARN OWL, AND MAGELLANIC HORNED OWL IN ARGENTINEAN PATAGONIA FORESTS

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KEY WORDS: *Magellanic Horned Owl;* Bubo magellanicus; *Rufous-legged Owl;* Strix rufipes; *Barn Owl;* Tyto alba; *diet; sigmodontine rodents.*

Despite the large number of forest owls in the Neotropics, there are few data available on their diets that reflect foraging inside forested habitats. For the southern cone of South America, including Argentina and Chile, only a few contributions have addressed this topic (Martínez and Jaksic 1996, 1997, Ramírez-Llorens 2003, Trejo and Ojeda 2004).

The Rufous-legged Owl (*Strix rufipes*) inhabits dense and old-growth temperate forests in southern Argentina and Chile (Straneck and Vidoz 1995, Martínez and Jaksic

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