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Barn Owl *Tyto alba* prey in Thessaly, and evaluation of Barn Owl diets throughout Greece

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Diet composition of the Barn Owl *Tyto alba* was studied in agricultural landscapes in Thessaly, Greece, for 3 years (2003–05). A total of 852 *Rattus* spp. individuals were identified from 10 065 pellets, which accounted for 2.9% by frequency and 27.4% by biomass of 29 061 prey items. *Rattus* spp. were more numerous in Barn Owl pellets during winter months than in summer. We suggest that this difference was due to a shift in relative prey availability and an increased need for energy by the Barn Owl during the colder months. Comparisons between Thessaly and 15 other areas showed differences in prey availability between islands and mainland Greece. *Microtus* spp. were absent from all island diets except one, and some islands had greater species richness.

Key words: winter, diet, energetics, rats, *Rattus rattus, Rattus norvegicus*

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INTRODUCTION

The diet of the cosmopolitan Barn Owl *Tyto alba* has been well documented because its pellets are easily found, preserved, and analysed (Taylor 1994, Shawyer 1998). While many diet studies have identified seasonal fluctuations in prey frequency (Burton 1984, Taylor 1994), prey biomass also needs to be estimated because it often reveals different patterns of prey use. We conducted a 3-year (2003–05) Barn Owl diet study in Thessaly, central Greece to examine seasonal variation in prey use. The results are compared to published data on Barn Owl diet throughout Greece.

METHODS

Owl pellets were collected from 31 sites in the lowlands (0 to 300 m a.s.l.) comprising 36% of the Thessaly region (5053 km^2; Fig. 1) on four occasions at 6 month intervals (April–September and October–March). Pellets were dissected by the 'dry' method (Marti 1987, Yalden 2003) and prey were identified using reference books (Toschi & Lanza 1959, Toschi 1965, Chaline *et al.* 1974, Lawrence & Brown 1974, Niethammer & Krapp 1977, 1982, 1983). Prey were assigned to five mammal groups: *Crocidura* spp., *Microtus* spp., *Apodemus* spp., *Rattus* spp. and *Mus* spp. A small number of *Rattus* specimens (n = 129) remained unidentified due to cranial damage. Total species biomass in the sample was calculated by multiplying the estimated species-specific biomass by the number of individuals identified from the pellet sample (Perrins 1987, Macdonald & Barret 1993, Chinery 1993). When an adult or sub-adult prey item was identified it was assigned an appropriate biomass estimate, but when a prey's age was not clear, a mean biomass was used.

A meta-analysis was done on all available Barn Owl diet studies in Greece. These included studies from various islands (Böhr 1962, Pieper 1977, Niethammer

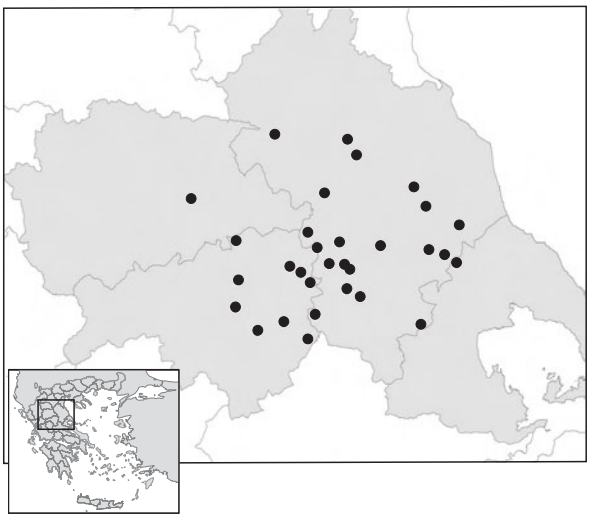

Figure 1. Pellet collection sites in Thessaly, central Greece, where *Rattus* species were present in the Barn Owl diet (2003–05).

1989, Angelici *et al.* 1992), from continental Greece (Tsounis & Dimitropoulos 1992, Alivizatos & Goutner 1999, Vohralik & Sofianidou 2000, Goutner & Alivizatos 2003, Alivizatos *et al.* 2006) and those that compared the owl's diet between island and mainland Greece (Cheylan 1976, Alivizatos *et al.* 2005). The following trophic niche parameters were calculated. Species richness is the number of species in a community or in a sample. Diversity was calculated as

$$H' = -\sum_{i=1}^{s} pi \ln pi,$$

where *pi* is the proportion of species *i* in the entire sample, ln is the natural logarithm, and *s* is the number of species. Evenness was calculated as

$$J' = \frac{Observed\ H'}{Maximum\ possible\ H'},$$

where the numerator H' is the diversity calculated as above and the denominator is the maximum value of H' when all species occur in similar proportions. To avoid bias in the calculation of the above indices due to different pellet sampling effort, the rarefaction method (Sanders 1968, Krebs 1999) was applied to all sites that were included in the present study, with the Software programs Ecosim 7.0 (Gotelli & Entsminger 2001) and Biodiversity Pro version 2.0 (McAleece *et al.* 1997). Since no available software could calculate evenness after rarefying data, evenness was calculated without prior rarefaction.

RESULTS

Barn Owl diet in Thessaly, central Greece (2003–05)
A total of 29 061 prey were identified from 10 065 pellets. *Rattus* specimens (n = 852) represented 2.93% by frequency and 27.37% by biomass of the sample as follows: Black Rat *Rattus rattus* 0.77% and 4.46%, Brown Rat *Rattus norvegicus* 1.72% and 19.15%, and unidentified *Rattus* sp. 0.44% and 3.76% (by frequency and biomass, respectively). *Rattus* species were present in 25 of the 31 sites sampled and were found significantly more often (by frequency and biomass) during winter periods (Figs. 1, 2A,B; $\chi^2 = 21.2$, $df = 3$, $P < 0.0005$ and $\chi^2 = 7425.6$, $df = 3$, $P < 0.0005$, respectively). While the frequency of non-rat prey items was similar across seasons (Fig. 2A; $\chi^2 = 0.04$, $df = 3$, $P = 0.998$), the estimated biomass of non-rat items was significantly reduced during winter seasons (Fig. 2B; $\chi^2 = 546.2$, $df = 3$, $P < 0.0005$).

A review of Barn Owl diet throughout Greece
Information on Barn Owl diet in 12 geographic regions in Greece was reviewed as summarized in Table 1, including 6 islands and 6 mainland areas (Fig. 3).

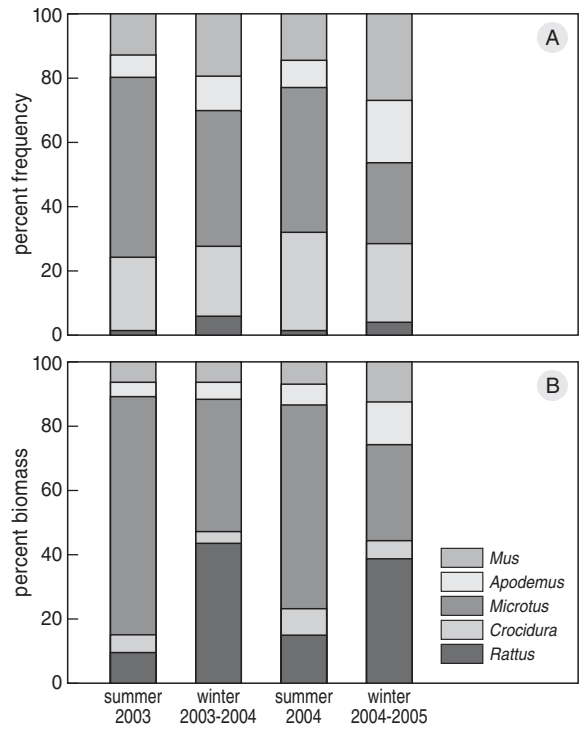

Figure 2. Percentage occurrence of mammal prey groups in the diet of Barn Owl in Thessaly, central Greece. A) By frequency, and B) by biomass.

Mammals dominated in the owl's diet both in frequency (73.58–99.78%) and biomass (85.64–90.25%) (Table 1, Figs 3, 4A,B). Mammals were mainly composed of rodents, but exceptions were Crete and Mitrikou Lake, where insectivores formed 88.24% and 44.92% of the owl's diet in numbers, and 58.37% and 24.49% in biomass (Figs 4A,B).

The ratio of rodent to insectivore prey was >1 in most sites, and ratios generally ranged between 2 and 6, except at Crete and Mitrikou Lake. The highest ratio (77) was found for the island of Antikythera where very few insectivores were eaten. Birds were captured in small percentages in all sites except Mitrikou Lake and the islands of Antikythera and Kos where they formed more than 10% of the diet (Fig. 4A). On the island of Kerkira 17 different species were identified (1.97% by frequency, Fig. 4A), and on the island of Kos, 14 species of birds reflected 21.23% of all prey taken (Fig. 4A).

From the 6 mammal genera which form the Barn Owl diet in Greece (Figs 5A,B), only *Mus* was preyed upon at all sites. *Crocidura* was captured in important numbers in various cases but contributed minimally to the biomass. On Crete, however, the relatively few numbers of *Rattus* represented a higher proportionate

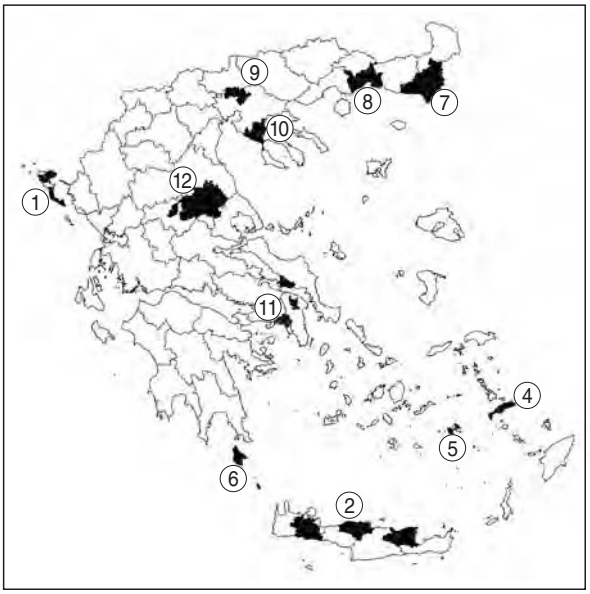

Figure 3. Geographical regions of Greece, where the Barn Owl diet has been studied. 1 Kerkira, 2 Crete, 3 Evoia, 4 Kos, 5 Astipalaia, 6 Antikythera, 7 Evros Delta, 8 Lakes of Mitrikou, Porto Lagos & Lafres, 9 Parthenio, 10 Potidea, 11 Attica, 12 Thessaly.

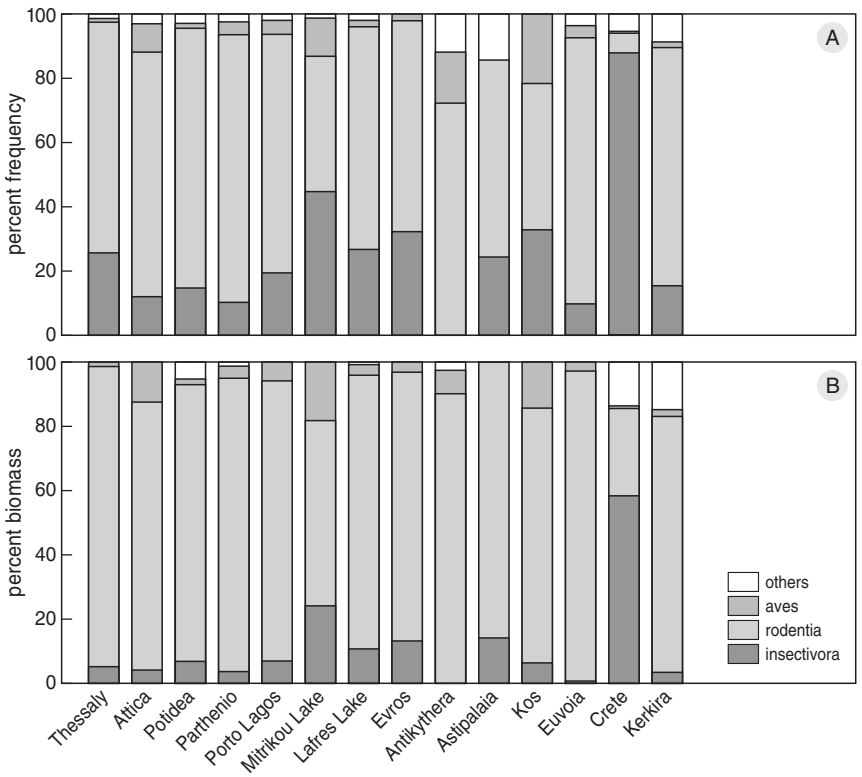

Figure 4. Percentage occurrence of mammal orders and other taxa in the Barn Owl diet in Greek study sites. A) By frequency, and B) by biomass.

Table 1. Geographical regions in Greece where the Barn Owl diet has been studied, year of study, prey percentages, niche values and indexes.

	Study sites (see Fig. 3)	Year of study	Prey items (n)	Mammals (% by number)	Species richness (N)		Diversity (H')		Evenness (J')	Rodentia/ Insectivora	Mean weight of mammal prey (g)
					Before rarefaction	After rarefaction	Before rarefaction	After rarefaction			
1	Kerkira	1962	3097	90.12	40	13.24	1.81	1.7	0.493	4.83	25.43
2	Crete	1972, 1975	3180	99.78	24	9.1	1.19	1.12	0.376	0.07	9.93
3	Evoia	1981	125	92.80	14	13.99	1.95	1.93	0.73	8.67	98.32
4	Kos	1978	942	78.45	23	12.17	2	1.91	0.638	1.39	43.44
5	Astipalaia	1990	128	85.94	6	5.97	1.13	1.13	0.634	2.55	18.27
6	Antikythera	1998	106	73.58	13	13	1.62	1.62	0.634	77	153.67
7	Evros Delta	1987,1998, 2006	1931	98.08	26	10.4	1.84	1.76	0.567	2.05	20.17
8a	Lafres Lake	1987	692	96.10	15	9.11	1.67	1.62	0.62	2.59	21.40
8b	Mitrikou Lake	1987	236	86.86	10	9.62	1.93	1.9	0.839	0.93	14.55
8c	Porto Lagos	1987, 2006	785	94.14	19	11.96	1.81	1.74	0.616	3.82	22.61
9	Parthenio	1998	463	93.95	19	12.64	1.82	1.75	0.619	8.26	35.21
10	Potidea	1998	296	96.28	11	8.03	0.92	0.88	0.385	5.63	15.7
11	Attica	1972, 1989,1998	489	88.34	19	12.8	2.12	2.06	0.72	6.45	22.67
12	Thessaly	1998, 2003–05	30074	97.88	40	14	2.21	2.1	0.616	2.82	36.87

biomass. *Rattus* was the main biomass source for owls in Greek islands, and *Microtus* on the mainland.

Barn Owl diet composition was more diverse in the region of Thessaly than it was on the islands and in the rest of continental Greece (ANOVA, $F_{2,41} = 8.43$, $P < 0.001$), but the diet was not more evenly distributed ($F_{2,41} = 2.84$, $P = 0.07$). The owl diet in the region of Thessaly presented a higher prey species richness in comparison to island and other continental Barn Owl diets ($F_{2,41} = 19.10$, $P < 0.001$). Similarly, differences occurred in proportions of mammalian prey biomass in islands, mainland Greece and the Thessaly region ($F_{2,41} = 3.87$, $P = 0.028$).

DISCUSSION

The diet of Barn Owl was composed of prey from a large variety of taxa, including bats Chiroptera, lagomorphs, dormice Gliridae and mustelids, insects, reptiles, and birds. Nonetheless, the owl's diet was dominated by mammalian species, especially rodents. Five main mammal genera (*Crocidura, Microtus, Apodemus, Rattus* and *Mus*) formed the bulk of the Barn Owl's diet. Even in cases where insectivore species were captured at a high rate (Crete island, Mitrikou Lake, Evros Delta & Kos island), they offered a relatively limited amount of biomass. The dominance of insectivores in Crete might be related to the absence of *Microtus* species (Pieper 1990, Reumer 1986) which are replaced by the endemic Cretan White-toothed Shrew *Crocidura zimmermanni*, and the common Lesser White-toothed Shrew *Crocidura suaveolens*.

We can only speculate which factors influenced Barn Owl prey availability and use. The larger proportion in the diet of Brown Rats compared to Black Rats might be explained by differences in relative abundance and interspecific aggression, i.e. Brown Rats are dominant over the Black Rat wherever their ranges overlap (Grizmek 1975, Medway 1978, Handley 1980). Another possibility may be the Black Rat's limited breeding season (March–November) compared to the Brown Rat, which reproduces all year (MacDonald & Barret 1993, Jabir *et al.* 1985). Also, dispersing young Brown Rats are easy prey for the Barn Owl (Taylor 1994).

Changes in vegetation cover and prey vulnerability may explain why more *Rattus* was present in the Barn Owl diet during winter months, while the opposite was true for *Microtus*, which are reportedly optimal prey for the Barn Owl (Shawyer 1998, Marks & Marti 1984). In Thessaly, cereal crops are harvested in June and cotton is harvested in October, with reseeding beginning in

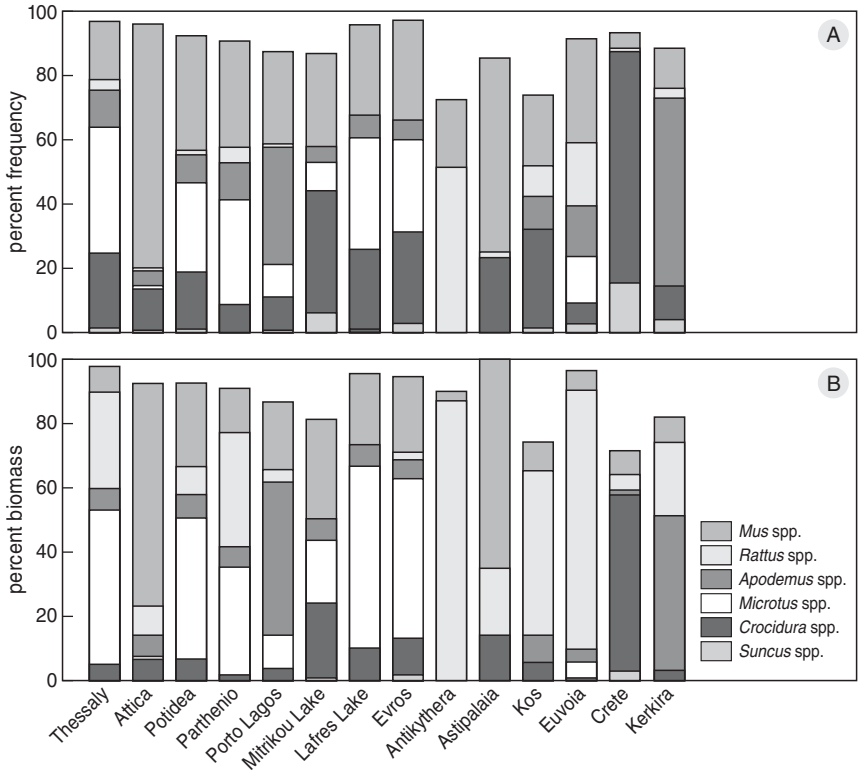

Figure 5. Percentage occurrence of mammal genera in the Barn Owl diet in Greek study sites. A) By frequency, and B) by biomass.

January and April, respectively. Therefore, during winter, the Barn Owl can forage over fallow land, which likely increases its hunting success for larger prey such as rats.

The optimal prey for the Barn Owl in most parts of its wide distribution are *Microtus* species (Mikkola 1983, Taylor 1994, Shawyer 1998). In Greece, voles are present only in mainland areas, and when present they dominate the owl's diet in terms of numbers and biomass. Exceptions to this rule are Potidea, Attica and Mitrikou, where *Mus, Apodemus* and *Crocidura*, dominate the diet in terms of biomass. Voles are completely absent from all Greek islands, except Evoia, which is connected to the mainland with a bridge. The absence of voles from Greek islands corresponds to a predominance of rats in all Greek islands except Crete, where *Crocidura* species are the dominant prey.

Although the Barn Owl diet in Greek islands includes many bird species (e.g. Kerkira & Kos) and other types of prey, it is significantly less diverse with lower evenness than on mainland Greece. The Greek region with the highest diversity, evenness and species richness is Thessaly (Bontzorlos *et al.* 2005, 2007a,b).

In interpreting our results, it is important to consider the amount of energy spent on hunting relative to energy obtained, especially during winter when Barn Owls need more energy for thermoregulation. During the study winters, Barn Owls captured 5985 and 6744 non-rat prey which reflected 55% and 60% of each winters' total biomass, respectively. The much lower number of *Rattus* prey caught in these winters (389 and 279, respectively) represented no less than 40% and 35% of the winters' total biomass. It thus seems that little effort was invested to catch *Rattus*, which, in turn, covered a high percentage of the owls' energy needs. Year-round studies on Barn Owl predation (species-specific), capture success rates, seasonal energetics, and prey use vs. availability are needed to further examine these results.

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SAMENVATTING

Gedurende de jaren 2003–05 werd de samenstelling van het voedsel van de Kerkuil *Tyto alba* onderzocht in het cultuurlandschap van Thessalië, Griekenland. Er werden 852 ratten *Rattus* spp. geïdentificeerd in 10 065 braakballen, wat 2,9% naar frequentie en 27,4% naar biomassa van de 29 061 prooidieren betekende. Ratten waren in de winter talrijker in de braakballen aanwezig dan in de zomer. We veronderstellen dat dit verschil een gevolg is geweest van een verschuiving in het voedselaanbod en een hogere energiebehoefte gedurende het koudste deel van het jaar. Door de braakbalsamenstelling uit 16 onderzoeksgebieden verspreid over Griekenland naast elkaar te zetten kwamen opmerkelijke regionale verschillen naar voren in voorkomen van kleine zoogdieren. Zo werden woelmuizen *Microtus* veel aangetroffen in braakballen op het vasteland, maar ontbraken vrijwel volledig op de eilanden. Daarnaast lieten sommige eilanden een opmerkelijke soortendiversiteit in het voedsel zien.

ARDEA

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