Chapter

A Review of European Owls as Predators of Bats

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Abstract

Fossil evidence indicates that owls have been preying on bats from as far back as the Pleistocene. Overall, bats form quite small portions (i.e. trace to 0.2%) of the diets (by prey frequency) of European owls. An assessment of dietary studies and anecdotal accounts reveals that five species of European owls, the Eurasian scops owl *Otus scops*, Pygmy owl *Glaucidium passerinum*, Tengmalm's owl *Aegolius funereus*, little owl *Athene noctua* and Ural owl *Strix uralensis*, rarely feed on bats (with less than 0.1–0.4%) and a further two species, short-eared owl *Asio flammeus* and eagle owl *Bubo bubo*, may only take bats occasionally, while three species, long-eared owl *Asio otus*, barn owl *Tyto alba* and tawny owl *Strix aluco*, feed on bats more frequently. In this study, a total of 19,864 recorded bats have been preyed upon by these owls, with as many as 48 bat species being identified. Barn and tawny owls have captured most of this total (47.1 and 41.9%), followed by the long-eared owl (7.6%), while short-eared and eagle owls take similar amounts of bats (1.1 and 1.7%, respectively). Owl predation on bats deserves future research because it may help contribute to our knowledge on bat biodiversity and distribution and possibly identify an additional risk for small populations of endangered bats.

Keywords: European owls, bats, predation

1. Introduction

Bats are the only mammals capable of self-powered flight yet constitute some 20% of all living mammal species, with as many as 110 separate bat species coexisting within the same ecological community, a number that far exceeds that of any other mammalian group [1, 2]. Bats diversified in the Early Eocene in response to an increase in prey diversity, and Eocene bat fossils have been found on most continents leaving the geographic origin a source of debate [1]. Despite their taxonomic and ecological diversity, modern bats (order: Chiroptera) are almost exclusively nocturnal. Rydell and Speakman [3] think that predation risk could have been a significant factor preventing early bats from becoming diurnal. The only other vertebrates that exploit niches for nocturnal flying predators are the owls and nightjars. Fossil evidence indicates that owls have been predating on bats from as far back as the Pleistocene [4, 5]. Since bats are very fast in flight, predation pressure on bat populations is likely to be a minor cause of mortality. Indeed, in the owl diets from North America (23,888 prey items) and temperate Europe, plus Iraq, reviewed by Marti [6], bats did not occur. In later reviews, Mikkola [7] found that bats accounted for 0.04% of prey items of barn *Tyto alba*, tawny *Strix aluco* and long-eared owls *Asio otus* in the British Isles (67,405 prey items) with the same percentage

for short-eared *Asio flammeus* and Tengmalm's owls *Aegolius funereus* (15,147 prey items) in Europe and Finland. For the Eurasian eagle owls *Bubo bubo* (17,615 prey items), bats accounted for 0.03% of prey taken in Fennoscandia.

In this paper, we examine the ecological relationships between owls and bats and see if the larger owl species take larger bats as they tend to do with other prey [8].

2. Methods

We conducted a literature review examining bats as prey in the diets of European owls. The literature examined was published between 1886 and 2018 and covered the ecological timeframe of the Pleistocene to current day. A total of 1680 publications were examined, and a synthesis of the findings is reported here. Utmost effort has been made to avoid duplication in the counting of the same bats mentioned in the review papers and/or multiple papers by the same author. The collection of the data was limited to Eurasia and one particular case study in North Africa (short-eared owl—Algeria). Only 8 European owl species had more than 10 bats in their diet studies, namely, barn owl, tawny owl, long-eared owl, short-eared owl, Eurasian eagle owl, Tengmalm's owl, Ural owl *Strix uralensis* and little owl *Athene noctua*.

Bat weights are drawn from [9–13] as an average of values given. Species weight is the average of the species of that family. Owl weights from [14] are an average of extremes for females and males combined. Our analysis is focused on the frequency of bats in the diet of owls; we also compare the weights of the bat species to the weights of the owl species which ate them. We did not assess bats in terms of their role in the collective biomass of prey taken by the owls.

3. Results

3.1 How owls capture bats

Bats are captured by owls mainly during the periods of emergence or return from roosts, but owls are in general not well adapted for catching bats [15]. The relative benefits of capturing substandard individuals are greatest just when a predator is attacking a species of prey which is typically difficult to capture and kill [16].

Some authors have indicated that barn owls frequently capture young bats that are not yet able to fly [17] and that bats seem to be rarely captured in flight [18]. In Vickery Bat Cave, Oklahoma, barn owls were observed using a wholly unique technique to capture adult Mexican free-tailed bats *Tadarida brasiliensis*. Appearing at dusk when the bat flight from the cave was at its height, the owls dropped from a ledge only 3 m or so above the bats and moved swiftly along with them, often making a capture. Each owl appeared to select one bat before starting the chase, and the bats were caught with 'unerring precision'. Looney [19] witnessed on one September evening the capture of seven bats by one or more owls within a 45-minute period.

Another technique witnessed at a different location [20] was when a barn owl flew into a column of bats head-on from above, stalled, with head up, feet down and wings spread wide, catching a bat that struck it in the chest. It was assumed that the bats were not using their echolocation apparatus while flying in such a dense mass. The owl was observed to make four successful captures using this technique.

Research of Petrželková et al. [15] indicates that barn owls most probably prefer to prey on volant inexperienced yearling bats which are easier to catch while

reaching almost adult size. Yearling bats lack flying skills, they are conspicuous during the emergence, and they often concentrate near the roost during their early practice flights, making them more vulnerable to owl predation than adults.

Spitzenberger et al. [21] recorded, with an infrared camera and an automatic registration device, tawny owl attacks on bats entering an attic roost through an access window. At least 333 *Myotis emarginatus* bats entered the roost by flying over or past the owl which attacked 252 times but with only 31 strikes being successful. During a successful attack, the owl extended its legs, jumped upwards with raised wings and snatched and killed the entering bat with the talons of the foot, tore it apart and ate it on the spot or carried it away. The owl killed 5.3% of the maximum number of female bats roosting in the attic during 12 nights. By restricting its attacks to the period of late pregnancy, the owl took advantage of the state of highest vulnerability of the female bats in this maternity colony.

The observations of [19–21] would suggest that individual owls develop their own unique techniques for capturing bats on the wing.

Bats also seem able to avoid predation to some extent during their evening emergence and morning return to and from the roost. Güttinger [22] noted that *Myotis myotis* changed their emergence exit from a roost to avoid the attacks from tawny owls. Petrželková and Zukal [23] have shown with the use of a trained barn owl that *Eptesicus serotinus* bats are using clustering during emergence as an important anti-predation strategy although the owl presence did not induce any major changes in other measured parameters (like onset, end, rate or duration of emergence).

Boratyński [24] made an interesting observation in Poland on how a tawny owl was attempting to catch a *Nyctalus noctula* in the air, but the bat 'hid in the predator's shadow' by flying very close behind it and waiting until the owl gave up hunting. Finally, the bat flew away safely after the owl ceased searching for the lost prey.

Forest-dwelling owls may experience difficulties in capturing any bats that are present, as bats tend to fly close to the trees, as the study by Russo et al. [25] suggests. This may explain why both the great grey owl *Strix nebulosa* and the hawk owl *Surnia ulula* have so far had no bats in their diet lists; and the extremely well studied Eurasian Pygmy owl *Glaucidium passerinum* has so far been recorded preying on only one *Myotis daubentoni* and one unidentified Vespertilionidae bat in Finland [26] and another in Russia [27]. Scherzinger [28] was wondering why *Plecotus auratus* is not found in the diet of the Pygmy owl as both species are known to use old *Dendrocopos major* holes.

3.2 Owl species and bat diversity

At least 48 bat species have been identified in the diet of eight Eurasian owl species (**Table 1**). A total of 19,864 bats have been preyed upon by these owls. The barn owl has captured 47.1% of all recorded bats in this review, but the tawny owl comes a close second with almost as high a percentage (41.9%), although its food samples have been studied much less than those of the barn owl (well over 5 million prey items). The long-eared owl comes far behind these two with just 7.6%. The short-eared owl and the eagle owl take similar amounts of bats (1.1 and 1.7% from this material, respectively). With only trace amounts of bats in their diets (i.e. 0.4 to 0.1%), we still list the little owl, Tengmalm's owl and Ural owl in **Table 1** but the scops owl only in **Table 2**.

It has been said that larger owl species take larger prey [8]. This study shows, however, that all sizes of bats are widely represented in the diet of the studied owls (**Table 1**). However, there is a statistically significant correlation in the weight of eaten bats and the weight of the owl (0.736, $p < 0.05$). The heaviest owl *Bubo bubo* takes bats with an average weight of 21.5 g, while the smallest owl *Aegolius funereus*

Bat species and weight in grams	***T.a.***	***S.a.***	***S.u.***	***A.o.***	***A.fl.***	***B.b.***	***A.fu.***	***A.n.***	**Total**
Pipistrellus pygmaeus 5.1	50								50
P. pygmaeus or *P. pipistrellus* 5.3	36								36
Pipistrellus pipistrellus 5.5	661	2415		5	1	10		8	3100
Myotis mystacinus 6.1	69	205	1	2		8	5	2	292
Myotis brandtii 6.5	16	151				1			168
Pipistrellus abramus 6.5			1	658					659
Murina huttoni 6.7		1							1
Rhinolophus hipposideros 6.9	69	135		1		2			207
Pipistrellus sp. 6.9	145	1		144	7			7	304
Murina hilgendorfi 7.0				4					4
Pipistrellus kuhlii 7.3	2146	21		113				12	2292
Hypsugo savii 7.5	16	3						1	20
Asellia tridens 8.0	36			13		3			52
Myotis nattereri 8.3	523	71		13		4	3	1	615
Myotis emarginatus 8.7	54	46				1			101
Myotis capaccinii 8.8	36					1			37
Plecotus auritus 9.3	375	228		5		5	3	1	618
Myotis petax 9.5						2			2
Myotis annectans 9.7		2							2
Barbastella barbastellus 9.7	50	418				8			476
Plecotus sp. 9.8	45						2	2	49
Rhinopoma microphyllum 10.0	3					7			10
Pipistrellus nathusii 10.2	133	22				2		1	158

Bat species and weight in grams	***T.a.***	***S.a.***	***S.u.***	***A.o.***	***A.fl.***	***B.b.***	***A.fu.***	***A.n.***	**Total**
Myotis bechsteinii 10.2	38	125		1		4			168
Plecotus austriacus 10.3	272	11		11					294
Myotis daubentonii 10.9	115	85	5	18			4		227
Nycteris thebaica 11.5	3								3
Eptesicus nilssoni 11.6	17	65	3		2	3	2		92
Miniopterus schreibersii 11.9	55	39				1		1	97
Myotis sp. 12.1	69	1		2	195	4			271
Rhinolophus blasii 12.5	3								3
Rhinolophus euryale 12.9	10	36				6			52
Myotis dasycneme 13.2	33	16							49
Rhinolophus sp. 14.6	2							1	3
Rhinolophus bocharicus 15.1								6	6
Nyctalus leisleri 16.0	24	7							31
Vespertilio murinus 16.6	119	1725			2	51		3	1900
Vespertilio sp. 16.8						1			1
Vespertilio sinensis 17.0				12					12
Rhinolophus mehelyi 17.6	2								2
Eptesicus sp. 18.5		1							1
Hesperoptenus sp. 18.8		1							1
Otonycteris hemprichii 19.0	56					16		5	77
Eptesicus bottae 20.5	19	13				1			33
Myotis blythii 21.3	199	75		1		41		1	317
Eptesicus serotinus 23.4	985	281		120		28		1	1415

Bat species and weight in grams	*T.a.*	*S.a.*	*S.u.*	*A.o.*	*A.fl.*	*B.b.*	*A.fu.*	*A.n.*	Total
Rhinolophus ferrumequinum 23.5	135	35				10			180
Taphozous nudiventris 28.0	37	2			2	3			44
Nyctalus sp. 28.1	1								1
Nyctalus noctula 28.3	425	1033		274		19		10	1761
Myotis myotis 32.8	1981	916	1	3		46		2	2949
Tadarida teniotis 38.0	9	3		1					13
Nyctalus lasiopterus 40.1	2	1							3
Cynopterus sphinx 46.0	1								1
Scotophilus heathi 50.0		1							1
Rousettus leschenaulti 60.0	1								1
Rousettus aegyptiacus 135.0	90					4			94
Chiroptera (unidentified)	191	121	1	114	11	54	3	21	515
Total	9356	8312	12	1510	220	346	22	86	19,864
Percentage of the total	47.1	41.9	0.1	7.6	1.1	1.7	0.1	0.4	100.0

T.a. = Tyto alba: [29–58], S.a. = Strix aluco: [7, 59–90]; S.u. = Strix uralensis: [61, 91–96]; A.o. = Asio otus: [38, 42, 43, 60, 61, 81, 92, 97–127]; A.fl. = Asio flammeus: [46, 92, 128–133]; B.b. = Bubo bubo: [37, 60, 61, 92, 134–154]; A.fu. = Aegolius funereus: [60, 61, 86, 155–161]; A.n. = Athene noctua: [45, 60, 61, 74, 103, 162–177].

Table 1.
Numerical occurrence of bat species in increasing order of weight and unidentified bats in the diet of the most studied owl species in Eurasia.

has taken bats with the average weight of only 8.9 g (**Table 3**). Bat sizes range from 5.1 g, species like *Pipistrellus pygmaeus*, to 135 g species like *Rousettus aegyptiacus* (**Figure 1**). In the diet of owls, an average of 18.5 species of bats was found: barn owl 40, tawny owl 33, eagle owl 27, long-eared owl 18 and little owl 15 (**Table 3**). The remaining three species, short-eared, Tengmalm's and Ural owls had only eaten five species, each.

The average and maximum percentages of bats that have been eaten by the most studied Eurasian owls are shown in **Table 2**. Bats comprise only a very small part of an owls' diet; their percentage share amongst all prey is usually much less than 0.2% (**Table 2**). The very low percentage of bats in the food of owls suggests that bats are normally not a profitable prey item for owls, quite possibly because of the time and energy needed to capture them.

Owl	Average % of bats	Sample size	Author(s) and area	Maximum % of bats	Sample size	Author(s) and area
Barn owl (*Tyto alba*)	0.12	4,023,465	Roulin and Christe [29] Europe	26.6	2931	Sommer et al. [178] Germany
Tawny owl (*Strix aluco*)	0.07	19,902	Mikkola [7] Europe	30.5	13,791	Obuch [59] Slovakia
Ural owl (*Strix uralensis*)	0.06	1739	Jäderholm [91] Finland	0.3	1983	Rosina and Shokhrin [92] Far East, Russia
Eagle owl (*Bubo bubo*)	0.08	29,277	Jánossy and Schmidt [134] Eurasia	5.9	763	Rosina and Shokhrin [92] Far East, Russia
Long-eared owl (*Asio otus*)	0.04	793,309	Birrer [179] Eurasia	29.3	3561	Tian et al. [97] Beijing, China
Short-eared owl (*Asio flammeus*)	0.04	5449	Mikkola [7] Europe	39.3	516	Djilali et al. [128] El Golea, Algeria
Tengmalm's owl (*Aegolius funereus*)	0.04	9698	Mikkola [7] Finland	0.2	581	Uttendörfer [60] Germany
Little owl (*Athene noctua*)	0.01	23,899	Schönn et al. [180] Europe	2.8	360	Barbu and Sorescu [162] Romania
Scops owl (*Otus scops*)	0.03	6871	Malle and Probst [181] Europe	0.1	2152	Muraoka [182] Austria

Table 2.
Average and maximum numerical percentages of bats that have been eaten by European owls.

Owl species	Average weight of the owl	Number of bats in the diet	Number of bat species in the diet	Total weight of bats in the diet	Minimum weight of eaten bat species	Maximum weight of eaten bat species	Average weight of all bats eaten
Aegolius funereus	139.5	19	5	169.7	6.1	11.6	8.9
Athene noctua	166.0	65	15	897.3	5.5	32.8	13.8
Asio otus	310.3	1396	18	17,696.3	5.5	38.0	12.7
Tyto alba	332.5	9165	40	164,934.2	5.1	135.0	18.0
Asio flammeus	355.5	209	5	2525.7	5.5	28.0	12.1
Strix aluco	514.3	8191	33	125,874.7	5.5	50.0	15.4

Owl species	Average weight of the owl	Number of bats in the diet	Number of bat species in the diet	Total weight of bats in the diet	Minimum weight of eaten bat species	Maximum weight of eaten bat species	Average weight of all bats eaten
Strix uralensis	839,5	11	5	134.7	6.1	32.8	12.3
Bubo bubo	2542.5	292	27	6267.5	5.5	135.0	21.5
Total/ average		19,348	18.5	318,500.1	5.1	135.0	16.5

Table 3.
Numbers and weights of bats eaten by European owls in increasing order of weight. The correlation between owl weight and average bat prey weight is 0.736 which is significant at the level of $p < 0.05$. Weights shown are in g.

Figure 1.
An eagle owl has brought to its nest a female Egyptian fruit bat with a baby still sucking when figure was taken in 2008. Courtesy of Ezra Hadad, Israel.

Leading the level of bat consumption is the barn owl, although the absolute value, compared to other prey, is a very modest 0.12% (**Table 2**). No other owl species has taken bats over 0.1% in any large study samples. But the percentage rises markedly depending on the availability of bats as owls respond to increasing overall bat abundance in the environment [183]. Small maximum value samples show that near bat caves or in otherwise bat-rich biotopes, the prey share of bats can be significantly higher, up to 25–39% (**Table 2**).

4. Discussion

Contrary to other mammalian orders, bats face a very low risk of predation. Nocturnality and the capacity to reach remote shelters by active flight offer little opportunities for diurnal avian and terrestrial mammalian predators [21]. It has been shown that non-predator and non-accidental mortality of bats (probably caused by a disease, parasites or starvation) measured inside the fortifications

is higher during transitory periods preceding and following the period of deep hibernation, in which mortality is the lowest [184].

In the Far East, it has been noted that the eagle owl eats more bats during the autumn and close to the seashore where, most probably, it hunts these bats during their seasonal spring and autumn migrations along the coast [92].

Bats flying along line landscape elements (forest edges, shore and tree lines) or in open spaces are more exposed to predation [185].

Although the diet studies are equally numerous, in Europe the short-eared owl catches many fewer bats than the long-eared owl, likely due in part to its diurnal activity in open habitat (with fewer bats). However, in Algeria (North Africa), three short-eared owl pairs had more bats (39% by number and 9.3% by biomass) in their diet when long-eared owls in the same area preferred rodents and birds [128].

In the case of the long-eared owl, Garcia et al. [98] concluded that on a geographical scale, bat abundance does not seem to reflect bat availability for owls, maybe because hunting strategies for preferred prey such as small rodents are not well suited for the capture of flying bats. Bats occurred in many long-eared owl diets across the Mediterranean region, but their contribution remained largely irrelevant, although some bat aggregations were a locally important food source for some individual owls during certain periods.

Large barn owl diet samples show well how bats are eaten more in the south than in the north: In Britain, the frequency of bats was only 0.03% of 66,276 prey [185] and was 0.03% out of 102,588 prey in Belgium [30] but was 0.06% of 18,768 prey in the Pyrenees and 0.11% of 10,716 prey in Corsica [30].

Some cave samples for the tawny owl (30.5% bats out of 13,791 prey items) date back to the second half of the eighteenth century [61]. It is not known if the climate was more favourable to bats at that time, but they must have been more abundant. Roulin and Christe [29] have also shown that bat predation by barn owls has decreased during the last 150 years, due to historical declines in bat populations during the last century [186]. This decline could be caused by the human impacts which have affected many bat species. Lesiński [187] showed that in Poland, tawny owls ate fewer bats in the 1980s, possibly due to the intensive use of toxic pesticides during those years.

5. Conclusions

Owls prey on bats rarely and opportunistically, although bat aggregations could be a locally important food source for some species and individual owls during certain periods. Also, the decrease in the main prey (rodent) abundance can lead owls to expand their diet and include bats. It has been said that pellet studies could underestimate or even miss small bats taken by owls [185]. This study shows, however, that all sizes of bats are widely represented in the diet of the studied owls. That larger owls tend to take larger bat prey could be useful in archaeological cave studies when trying to identify the original predator of recovered bone/fossil remains [188].

We found two main obstacles in the food studies of European owls: first, several studies did not present complete lists of prey numbers or frequencies (often bats are combined with shrews, as insectivorous mammals), and second, identification skills to name the bat species showed a large variation (in this material we had 515 unidentified bats). We urge future owl diet studies to include complete prey lists to provide future reviewers with more accurate bat occurrence data.

Although the number of bats found in owl pellets can be small, such data collected may represent important faunistic and biodiversity contributions, particularly for rare species. Many bat species still have a 'data deficient' conservation label, and even in the most recent atlas of Bats in many European countries, the data on distribution of some bat species remains very scarce and incomplete [31].

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