Ornis Fennica 91:195–200. 2014

Brief report

Sex-specific diet analysis of the Eurasian Eagle Owl in Finland

Heimo Mikkola* & Risto Tornberg

*H. Mikkola, Department of Biology, University of Eastern Finland, P.O.Box 1627, FI-70211 Kuopio, Finland. * Corresponding author's e-mail: heimomikkola@yahoo.co.uk*
R. Tornberg, Department of Biology, P.O.Box 3000, FI-90014 University of Oulu, Finland

Received 28 March 2014, accepted 17 June 2014

1. Introduction

Birds of prey typically show reversed sexual size dimorphism (RSD), with females clearly larger than males, for what purpose has aroused a plethora of hypothesis to explain it (see Krüger 2005). One of the earliest explanations has been avoidance of competition between the mates (Temeles 1985). Though avoidance of competition does not explain the reversed nature of the sizes of the sexes it may be one mechanism to maintain it (Sunde *et al.* 2003, Krüger 2005). The Eurasian Eagle Owl (*Bubo bubo*), hereafter termed Eagle Owl, is the largest owl in the world, a typical top-predator being able to kill smaller birds of prey and owls (Mikkola 1983, 2013, Tornberg & Colpaert 2001). Its breeding season diet is well-known and, based on pellet analysis and nest site prey remains, shows very broad variation (Mikkola 1983, Sulkava *et al.* 2008). The Eagle Owl, mainly dependent on small mammals as its staple food during the breeding season (Korpimäki *et al.* 1990, Sulkava *et al.* 2008), exhibits high RSD (Mikkola 1982).

However, sexual differences in diet are not expressed by pellet and food remains analysis, which might arise from the fact that in Eagle Owls, it is the smaller male that is mainly responsible for prey deliveries during the breeding season. Based on specimens found in good condition at the Zoological museum of University of Oulu, Finland, female owls from Finland had an average weight of 2760 g (N = 50), while male weights averaged 2200 g (N = 35). The RSD index of the Eagle Owls is 9.8 (calculated as in Amadon (1943) and Earhart & Johnson (1970) by using the cube root of body mass to compare the indices of linear measurements). This is the third highest value of all European owls (Mikkola 1982). It seems logical to hypothesize that the heavier females may reduce intraspecific competition for food with males by taking larger prey than their smaller mates. However, this is not easy to verify as it is not possible to differentiate between pellets and food remains from males and females. In addition, a Russian study has shown that male Eagle Owls mainly bring larger prey to the nest than they would normally eat themselves, making it even more difficult to identify sex-related diet differences from pellets and food remains at the nest (Ekimov 2009, see also Sonerud 1992 and Sonerud *et al.* 2013, for theoretical point of view).

In this study we used the stomach contents of Eagle Owls (primarily 1st winter birds) made avail-

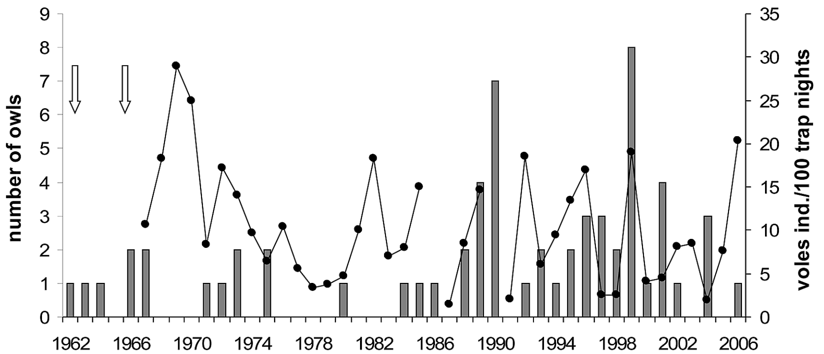

Fig.1. Number of dead Eagle Owls sent to the Zoological museum of University of Oulu (grey bars) and corresponding vole abundance index (solid line) near city of Oulu. First two peak years of voles (before the vole monitoring started at the University of Oulu) are presented by arrows according to Mikkola 1981.

able from museums or taxidermists, which is a reliable method to study between sex differences in diet provided that the owls have been sexed internally (Mikkola 1971*)*. We expect that based on a remarkable size difference between the sexes a corresponding difference in the prey size should exist.

2. Material and methods

The contents of the stomachs of 66 Finnish Eagle Owls, found dead along roads, having flown into power lines and having been killed and confiscated after illegal hunting, were analysed. A total of 85 prey items were identified from 42 females and 48 from 24 males. The samples were collected by taxidermist Pentti Alaja, and the University of Oulu from 1931 to 2006. Around 47% of the owls were found dead in autumn (September–November), 14% in mid-winter (December–February) and rest 40% during the breeding season (March–August). Of those owls for which cause of death was known (N = 51), 43% died in collision with power lines, 33% in traffic accidents, 10% in collision with unknown obstacles, 4% were shot and for 2% cause of death was unknown. More than half (55%) of our age determined study birds were juveniles (N = 38). Owls were found, most often south of the city of Oulu (25°30' E, 65°00' N) at less than 200 km distance. We classified each sample according to whether it was found in a good or poor vole year based on vole trappings mainly by staff of Zoological museum of University of Oulu and the Forest Research Institute (METLA) (see Fig. 1). According to our classification, 35 owls originated from a poor vole year and 31 from a good vole year (Fig. 1).

Prey items were identified based on bones, hairs and feathers using reference material of the Zoological museum. Small mammals were identified into species level by jaw and tooth morphology according to Siivonen & Sulkava (1994).

For the prey items, we used average weights given by: (a) Siivonen & Sulkava (1994) and Jensen (1994) for mammals; and (b) von Haartman *et al.* (1963–1972) for birds. For birds showing remarkable sexual dimorphism we used special weight for the sex in question. Differences in diet between sexes were tested by χ^2-tests in a 2 × 2 contingency table. We applied Yates continuity correction, which is recommended when data is divided into 2 categories or frequency within some of cells remains low (Ranta *et al.* 1989). Diet width was calculated by using Levins' index (Levins 1968) $B = 1 / \Sigma P_i^2$, in which P_i is the proportion of the i^{th} prey or prey group.

3. Results

The most common prey for both male and female owls was Field vole (*Microtus agrestis*) by numbers (31 and 29% respectively), but this vole represented only 3% of the female and 4% of the male diet biomass. Somewhat surprisingly, the Harvest mouse (*Micromys minutus*) was the second most common prey by numbers, making 22% of the diet of females and 29% of the males. Due to its small size (avg. 7 g), the weight percentages were only 0.4% for the females and 0.7% for the males (Table 1). By pooling small mammals together, the difference between females and males was not statistically significant (χ^2 = 0.939, df = 1, p > 0.1). Both female and male mainly ate Mountain hares (*Lepus timidus*), which formed over 56% of the

Table 1. Sexual differences in the diet of Eurasian Eagle Owls in Finland based on 66 stomach contents (42 females and 24 males). Average weights calculated from Siivonen & Sulkava (1994) and Jensen (1994) for mammals, and from von Haartman *et al.* (1963–1972) for birds.

	Females			Males		Total	
Prey item	Weight g	% mass	% *N*	% mass	% *N*	% mass	% *N*
Micromys minutus	7	0.4	22.4	0.7	29.2	0.5	24.8
Myodes glareolus	24	0.2	3.5	0.5	6.3	0.3	4.5
Small passerines	25	0.1	1.2			0.1	0.8
Cricetidae sp.	25			0.2	2.0	0.1	0.8
Microtus agrestis	40	3.0	30.6	4.1	29.2	3.3	30.1
Arvicola terrestris	150	1.3	3.5			0.9	2.3
Rattus norwegicus	225	5.2	9.4	14.7	18.8	7.8	12.8
Sciurus vulgaris	290	4.2	5.9			3.0	3.8
Erinaceus europaeus	765	11.0	5.9	5.5	2.1	9.5	4.5
Ondatra zibethica	1,100	3.2	1.2			2.3	0.8
Lepus timidus	3,900	56.1	5.9	56.5	4.2	56.2	5.3
Small birds	< 100	2.4	0.3			1.5	0.2
Mid-sized birds	100–1,000	0.4	6.7			0.3	4.8
Large birds	> 1,000	2.4	8.6	4.2	17.1	3.0	11.0
Rana sp.	50			0.7	4.2	0.2	1.5
Number prey			85		48		133
Mean prey/stomach			2.0		2.0		2.0
Mean prey size			828		575	736	
Levins' index			5.996		4.664		

food biomass for both sexes. Females took more Hedgehogs (*Erinaceus europaeus*) and males more Brown rats (*Rattus norwegicus*), both making more than 10% of their diet biomass. The average weight of the 85 prey items taken by female was 828 g, while the average weight of male prey based on 48 items was 575 g. The number of large prey above rat size accounted 27.1% for females and 10.4% for males, the difference being statistically significant ($\chi^2 = 4.160$, df = 1, $p < 0.05$). The difference was much less when taking into account the contribution to the diet biomass: 89.2% and 79.1%, respectively.

We made an attempt to relate stomach contents to the vole situation apparent in their habitats (Fig. 1). Though majority of the owls were found farther than 100 km from Oulu, our vole data should fairly reliably indicate good and poor vole years, since voles are in synchrony over wide areas up to 200 km in diameter (Huitu *et al.* 2003). Bank vole (*Myodes glareolus)* and Field voles were more common in the stomachs in good than in poor vole years (43% vs. 22%), the difference being statistically highly significant ($\chi^2 = 12.006$, df = 1, $p < 0.001$). Some stomachs that were examined were empty or contained only some unidentified hair, but some individuals had remarkable numbers of prey items in their stomachs. One male had nine Harvest mice in its stomach (total stomach weight = 63 g) and another male had three Harvest mice, one Bank vole and five Field voles in its stomach (total stomach weight = 245 g). One male took two Brown rats, the average weight of which makes 450 g. A stomach from one female contained nine Field voles, while the highest number of prey found in a single stomach came from a female that had 14 items: nine Harvest mice, four Field voles and one European water vole (*Arvicola terrestris*). The total weight of these two stomach contents was ca. 370 g.

Females killed slightly more birds than males (12% vs 4%) though difference by weight was vice verse (16% vs 17%). Largest birds killed by Eagle owls were Capercaillie hen (*Tetrao urogallus*) by a female and Black grouse cock (*Tetrao tetrix*) by a male (Table 1, S1). Levin's index of dietary niche breadth was larger for females (5.996) than for males (4.664). Smaller prey classes are relatively better represented in the male diet and larger prey classes, respectively, in the female diet (Table 1).

4. Discussion

Compared to Eagle Owl's diet during the breeding season, largely non-breeding diet in this study differs strikingly in the high proportion of small mammals, about 60%, and especially in the high proportion of the Harvest mouse (24%). Large amounts of data collected during the breeding season in western Finland indicates that the proportion of small mammals is about 30%, with Harvest mice making up less than 1% of the diet (Mikkola 1970, Korpimäki *et al.* 1990, Sulkava *et al.* 2008). Large prey items, on the other hand, show quite similar percentages, with those of Brown rats and Water voles, however, being much smaller. Our data is emphasized on autumn-winter season (58% of the stomachs) when small mammals reach their highest densities especially in increasing and peak years of voles. Indeed, our data hints that Microtidae were more common in the diet during such years. Mice can show population booms in favorable years, being then easy and profitable prey even for such a big bird of prey like the Eagle Owl. High number of Harvest mice in the diet may also be an indication of food shortage or even starvation when tiny prey specimens may be hunted as a last chance. Two Eagle Owls having 9 Harvest mice in their stomachs were from poor vole years (1990 and 2001) near the sea shore, where Harvest mice live in the reed beds. One of these owls was a lean juvenile male weighing less than 2 kg but the other bird was a well conditioned adult female weighing above 3 kg. The reason for this relatively high percentage of small mammals in the diet of both sexes might also be directly connected to the cause of death, the road kills and collisions with power lines. Small mammals thrive in grassy belts by the roads, where owls come to hunt them and as slow fliers they are easily hit by cars, which seem to be supported by our data as one third of the Eagle Owls were killed in traffic accidents. The other main cause of death, flying into power lines may also relate to the same phenomenon. Wide, permanently open power lines often have a grassy understory which is suitable habitat for Field voles. Electric poles are also good perching sites for the owls (Rubolini *et al.* 2001). For some reason, females seem to be more common than males in museum material, e.g. in the collection of the Zoological museum of Oulu University females account for 61% ($N = 122$) and males 39% ($N = 80$) of sexed Eagle Owls. Furthermore, first winter birds formed the main bulk (55%) among our aged study birds, which is reasonable in that young juveniles generally suffer of higher mortality than older individuals. However, we believe that sex differences found for the diet among young specimens likely exist also among older ones.

To date, sex-specific owl diet data is sparse and often fails to support the prediction of sexual differences in feeding niches, most likely because the species studied fed chiefly on small voles which provide little variety in size classes (Mikkola 1983, Wiklund & Stigh 1983, Mikkola *et al.* 2013). Especially in years of vole abundance, owls typically concentrate on this super abundant food resource independent of the owl size (e.g. Korpimäki 1981, Mikkola 1981). Actually, Sunde *et al.* (2003) could not show niche separation in Tawny Owls (*Strix aluco*) by year- round radio tracking. On the other hand, in years of low vole abundances, most owl species do not breed, causing poor quantitative diet data from such years. It is, however, known that many owl species can switch to alternative prey types. Most typical in this sense being the smallest owl species, the Pygmy Owl (*Glaucidium passerinum*) being capable of preying upon small passerines (Solheim 1984, Kullberg 1995) and the largest species, the Eagle Owl, being capable of killing adult Capercaillie males and Mountain hare weighing up to 4 kg. Therefore, the broad diet of the Eagle Owls, including larger mammals and birds, may permit more size partitioning in prey utilization than in some other owl species. Moreover, analysis of road kills may give a more general sample of an owls' diet than data obtained from the breeding individuals has shown.

Despite our limited material, it suggests that Eagle Owl females preyed upon relatively larger prey (Hedgehogs *Erinaceus europaeus*, Muskrat *Ondatra zibethicus* and a wider variety of larger birds) than males. Greater differences between sexes may be masked by the nature of the samples. Since we are dealing with partially digested stomach contents, we have to rely on average weights of the prey items for this analysis. For the largest prey items identified there can be a huge difference in minimum and maximum weights, e.g., Mountain hare ranges in weight from 2 to 5.8 kg (Siivonen & Sulkava 1994), so there is still a real possibility that males and females specialize at either end of the range. According to Ekimov (2009) there is some evidence in Russia that smaller size Eagle Owl males hunt most successfully for young hares (*Lepus europaeus*) weighing only up to 1.5 kg, while larger females are supposed to take bigger animals than males.

Surprisingly, females took more birds than males, though general expectation should have been *vice versa*; smaller males should be more capable than larger females in capturing agile prey like birds (Hakkarainen & Korpimäki 1991, Massemin *et al.* 2000). Diet composition during the breeding season is mainly a result of males' hunting based on samples collected in nest cups because owlets leave the nest well before females participate in hunting. This data indisputably shows that males are well capable of hunting birds successfully: noticing, however, that these are mainly juveniles and therefore easy prey (Mikkola 1970, Korpimäki *et al.* 1990, Sulkava *et al*. 2008). In accordance with our results, In Canada, Boxall & Lein (1982) have shown that female Snowy Owls (*Bubo scandiaca*) consumed a greater diversity and larger prey than males which preyed almost exclusively upon voles and mice. On top of voles and mice, females preyed upon 11 Gray Patridges (*Perdix perdix*), 4 weasels (*Mustela* spp.) and 3 White-tailed jackrabbits (*Lepus townsendii*). None of the male pellets included remains of any of these larger prey items. A Snowy Owl female is some 300–400 g heavier than the male (Mikkola 2013). In Russia it has been noted that a close relative to the Eagle Owl, Blakiston's Fish Owl (*Bubo blakistoni*) has a clear size difference in the favourite prey between male and female. The male mainly catches frogs and small fish while the female takes large fish with weight up to 600–900 g (Pukinskiy 1973). As with Eagle Owls, females of the Blakiston's Fish Owl are on average more than 1kg heavier than males (Mikkola 2013).

A more correct way to test whether females and males select different prey, diet for males and females hunting in the same area simultaneously should be studied. This would include intensive radio telemetry studies or the video filming of sexed individuals at nest, together with close monitoring of density and dynamics in relevant prey species. The Eagle Owl specimens used in the current study represent a somewhat serendipitous sample, but salvaged birds such as these may provide the cheapest avenue to address sexual dietary differences in species where internal examination is the only sure way to determine gender.

Acknowledgements. We thank Alan Sieradzki for constructive comments when improving the language. Mrs. Burul Nazarmatova and Mr. S. Yamamoto kindly provided us with English translations of the Russian publications. Comments from Vincenzo Penteriani, and one anonymous reviewer significantly improved the manuscript.

Analyysi huuhkajan sukupuolikohtaisesta ravinnosta Suomessa

Tutkimme huuhkajan (*Bubo bubo*) sukupuolten välisiä ravinnonkäyttöeroja hyödyntämällä museoiden ja eläintäyttäjien preparoinnin yhteydessä tallentamia mahanäytteitä. Oletimme, että n. 25 % kookkaammat naarashuuhkajat saalistavat isompia saaliita kuin pienemmät koiraat. Tavanomaisista pesimäaikana kerätyistä pesänäytteistä ei sukupuolten ravinnonkäyttöeroa voi havaita, koska on mahdotonta sanoa kumpi sukupuoli minkäkin saaliin on pesälle tuonut.

Aineisto käsitti 42 naarashuuhkajan ja 24 koirashuuhkajan mahat. Näistä määritettiin yhteensä 133 saaliseläintä. Pikkunisäkkäiden osuus oli n. 60 %, joista pelkästään vaivaishiiriä (*Micromys minutus*) 25 %. Niiden painonmukainen osuus oli kuitenkin vain n. 0.5 % kun taas metsäjäniksen (*Lepus timidus*) osuus oli molemmilla sukupuolilla n. 56 %. Naarashuuhkajat saalistivat merkitsevästi enemmän rottia (*Rattus norwegicus*) kookkaampia saaliita kuin koiraat (27 % vs 10 %) joskin painonmukainen ero oli selvästi pienempi (89 % vs 79 %). Saaliin keskipaino oli naarailla suurempi kuin koirailla (828 g vs 575 g). Naaraiden ravintovalikoima oli monipuolisempi ja lintujen osuus suurempi kuin koirailla (10 % vs 4 %).

Huuhkajien laaja ravinnonvalinta ja ajoittaiset pikkunisäkkäiden huippuvuodet vaikeuttavat sukupuolten välisten ravinnonvalintaerojen havaitsemista. Niillä on kuitenkin todennäköisesti merkitystä ravintotilanteen heiketessä pikkunisäkkäiden katovuosina, jolloin lajinsisäinen kilpailu ravinnosta kiristyy.

References

Amadon, D. 1943: Bird weights as an aid in taxonomy. — Wilson Bulletin 55: 164–177.

Boxall, P.C. & Lein, M.R. 1982: Feeding ecology of Snowy Owls (*Nyctea scandiaca*) wintering in Southern Alberta. — Arctic 36: 282–290.

Earhart, C.M. & Johnson, N.K. 1970: Size dimorphism and food habits in North American owls. — Condor 72: 251–264.

Ekimov, E.V. 2009: Differences in the proportion and the prey size of male and female of Eagle Owl during the nestling period: the possible and real reasons. — In Owls of the Northern Eurasia: Ecology, Spatial and Habitat Distribution (ed. Volkov, S.V., Sharikov, A.V. & Morozov, V.V.): 152–157. Moscow. (In Russian)

Haartman, L. von, Hilden, O., Linkola, P., Suomalainen, P. & Tenovuo, R. 1963–72: Pohjolan Linnut Värikuvin. — Otava, Helsinki.

Hakkarainen, H. & Korpimäki, E. 1991: Reversed sexual size dimorphism in Tengmalm's Owl: is small male size adative. — Oikos 61: 337–346.

Huitu, O., Norrdahl, K. & Korpimäki, E. 2003: Landscape effects on temporal and spatial properties of vole population fluctuations. — Oecologia 135:209–220.

Jensen, B. 1994: Suomen ja Pohjolan Nisäkkäät. — WSOY, Porvoo.

Korpimäki, E. 1981: On the ecology and biology of Tengmalm's Owl (*Aegolius funereus*) in Southern Ostrobothnia and Suomenselkä, Western Finland. — Acta Universitas Ouluensis (A) 118: 1–84.

Korpimäki, E., Sulkava, S. & Huhtala, K. 1990: Does the Year-to-Year Variation in the Diet of Eagle and Ural Owls Support the Alternative Prey Hypothesis? — Oikos 58: 47–54.

Kullberg, C. 1995: Strategy of the Pygmy Owl while hunting avian and mammalian prey. — Ornis Fennica 72: 72–78.

Krüger, O. 2005: The evolution of reversed sexual dimorphism in hawks, falcons and owls: a comparative study. — Evolutionary Ecology 19: 467–486.

Levins, R. 1968: Evolution in changing environments. — Princeton University Press. Princeton, New Jersey.

Massemin, S., Korpimäki, E. & Wiehn, J. 2000: Reversed sexual size dimorphism in raptors: evaluation of the hypotheses in kestrels breeding in a temporally changing environment. — Oecologia 124: 26–32.

Mikkola, H. 1970: On the food of great grey owl (*Strix nebulosa*), the Ural owl (*Strix uralensis*) and the eagle owl (*Bubo bubo*) in Finland during summer. — Suomen Riista 22: 97–104. (In Finnish with English summary)

Mikkola, H. 1971: Petolintujen ravintotutkimusten tekniikasta II. — Lintumies 3–4: 73–75.

Mikkola, H. 1981: Der Bartkauz *Strix nebulosa.* — Die Neue Brehm-Bücherei 538. A. Ziemsen Verlag, Wittenberg-Lutherstadt.

Mikkola, H. 1982: Ecological Relationships in European Owls. Publications of the University of Kuopio. – Natural Sciences. — Series Original Reports 6: 1–157.

Mikkola, H. 1983: Owls of Europe. — A. & T. Poyser. Calton.

Mikkola, H. 2013: Owls of the World. A Photographic Guide, 2nd Edition. — Christopher Helm, London.

Mikkola, H., Tornberg, R. & Willard, D.E. 2013: Sex-related dietary differences in Great Gray Owls in Finland and the USA. — Ontario Birds 31: 160–171.

Pukinskiy, Y.B. 1973: Ecology of Blakiston's Fish Owl in the Bikin river basin. — Biulleten 'Moskovskogo Obshchestva Ispytatelei Prirody. Otdel Biologicheskii 78: 40–47. (In Russian).

Ranta, E., Rita, H. & Kouki, J. 1989. Biometria. Tilastotiedettä ekologeille — Yliopistopaino. Helsinki. (In Finnish).

Rubolini, D., Bassi, E., Bogliani, G., Galeotti, P. & Caravaglia, R. 2001: Short communication Eagle Owl *Bubo bubo* and power line interactions in the Italian Alps. — Bird Conservation International 11: 319–324.

Siivonen, L. & Sulkava, S. 1994: Pohjolan nisäkkäät. — Otava, Keuruu.

Solheim, R. 1984: Caching behaviour, prey choice and surplus killing by Pygmy Owls Glaucidium passerinum during winter, a functional response of a generalist predator. — Annales Zoologici Fennici 21: 301–308.

Sonerud, G.A. 1992: Functional Responses of Birds of Prey: Biases Due to the Load-Size Effect in Central Place Foragers. — Oikos 63: 223–232.

Sonerud, G.A., Steen, R., Løw, L.M., Røed L.T., Skar, K., Selås, V. & Slagsvold, T. 2013: Size-biased allocation of prey from male to offspring via female: family conflicts, prey selection, and evolution of sexual size dimorphism in raptors. — Oecologia 172: 93–107.

Sulkava, S., Lokki, H. & Koivu, J. 2008: The diet of the Eagle Owl (*Bubo bubo*) during the nesting season in Häme (Southern Finland). — Suomen Riista 54: 83–94. (In Finnish with English summary)

Sunde, P., Bølstad, M.S. & Møller J.D. 2003: Reversed sexual dimorphism in Tawny Owls, Strix aluco, correlates with duty division in breeding effort. — Oikos 101: 265–278.

Temeles, E.J. 1985: Sexual size dimorphism of bird-eating hawks: the effect of prey vulnerability. — American Naturalist 125: 485–499.

Tornberg, R. & Colpaert, A. 2001: Survival, ranging, habitat choice and diet of the Northern Goshawk Accipiter gentilis during winter in Northern Finland. — Ibis 143: 41–50.

Wiklund, G.G. & Stigh, J. 1983: Nest defence and evolution of reversed sexual size dimorphism in Snowy Owls (*Nyctea scandiaca*). — Ornis Scandinavica 14: 58–62.