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Food habits of the endemic Cyprus scops owl (*Otus cyprius*) during the breeding season

Potrava endemického druhu výrika cyperského (*Otus cyprius*) v priebehu hniezdnej sezóny

Nicolaos KASSINIS, Haralambos ALIVIZATOS, Antaia CHRISTOU, Markos CHARALAMBIDES & Zoltán TÖLGYESI

Abstract: The diet of the endemic Cyprus scops owl (*Otus cyprius*) was studied for the first time during the breeding season 2021 in 7 nesting sites from 6 sampling locations using the pellet analysis (n = 65 pellets). Insects, mostly Orthoptera and Coleoptera, comprised the bulk of the owl diet (87% abundance, 31% biomass), whereas small mammals and reptiles were important in terms of biomass, with 41% and 24%, respectively. Birds were the lowest prey order, with 0.6% abundance and 3.6% biomass. The most essential insects were grasshoppers (Acrididae) (17%) and scarab beetles (Scarabaeidae) (6%). From vertebrate prey, Mus spp. (23.7%), Mediterranean house gecko (*Hemidactylus turcicus*) (8%), Cyprus spiny mice (*Acomys nesiotes*) (8%), juvenile black rats (*Rattus rattus*) (7%), and Cyprus agamas (*Laudakia cypriaca*) (5%) stand out as % biomass. Predation on a bat species (*Pipistrellus* sp.) by scops owl was documented for the first time in Cyprus. The estimated prey biomass ranged from 0.1 – 25 grams, averaging 2.1 g.

Abstrakt: V priebehu hniezdnej sezóny 2021 bola po prvýkrát študovaná potrava endemického druhu výrika cyperského (*Otus cyprius*). Analýzované boli vývržky (n = 65 vývržkov) so 7 hniezd na 6 lokalitách. Hlavnú časť potravy tvoril hmyz, väčšinou Orthoptera a Coleoptera, (87 % abundancia, 31 % biomasa), zatiaľ čo drobné cicavce a plazy boli dôležité najmä z hľadiska biomasy so 41 % resp. 24 %. Vtáky boli najmenej zastúpenou korisťou s 0,6 % abundanciou a 3,6 % biomasy. Najdôležitejším hmyzom boli kobylky (Acrididae) (17 %) a chrobáky (Scarabaeidae) (6 %). Z koristi stavovcov to boli *Mus* spp. (23,7 %), gekón turecký (*Hemidactylus turcicus*) (8 %), myš cyperská (*Acomys nesiotes*) (8 %), mladé potkany čierne (*Rattus rattus*) (7 %) a agama cyperská (*Laudakia cypriiaca*) (5 % biomasy). Prvý raz zdokumentovaná predácia netopiera (Pipistrellus sp.) výrikom na Cypre. Odhadovaná biomasa koristi sa pohybovala od 0,1 do 25 gramov, v priemere 2,1 g.

Key words: foraging, birds of prey, pellet, diet, Orthoptera, Coleoptera

Nicolaos Kassinis, Game and Fauna service, Ministry on Interior, 1453 Nicosia, Cyprus,
E-mail: lemesos.thira@cytanet.com.cy
Haralambos Alivizatos, Zaliki str. 4, 115 24 Athens, Greece
Antaia Christou, Markos Charalambides, Zoltán Tölgyesi, BirdLife Cyprus, 2340 Nicosia, Cyprus

Introduction

Knowing the foraging ecology of owls is important for the species conservation, given that diet may influence its reproductive performance and, ultimately, survival (LourenÇo 2006). The Cyprus scops owl (*Otus cyprius*, hereafter CSO) is an endemic species to the island of Cyprus (Flint et al. 2015, Flint 2017, Flint et al. 2017, Gill et al. 2016). Even though IUCN classifies it as Least Concern (BirdLife International 2019), its population trend is unknown, and it is generally understudied. It is the smallest owl on the island, the other being the long-eared owl (*Asio otus*), the barn owl (*Tyto alba*) and the little owl (*Athene noctua*). The short-eared owl (*Asio flammeus*) is recorded as a scarce passage migrant (Flint and Stewart 1992). The CSO is a common owl in Cyprus occurring in woodlands, orchards, olive groves, and villages at all altitudes (Flint and Stewart 1992), with a population estimated at 10,000 – 24,000 individuals (BirdLife International 2023). It nests in tree cavities and holes in old buildings and ruins and accepts artificial

nest boxes. Nest boxes for CSO have been placed by the Game and Fauna Service, BirdLife Cyprus and the Forestry Department to increase the species population. In addition, several nesting boxes placed for barn owls have been occupied first by CSO, where they nested before being taken over by barn owls in later years. In some cases, CSOs were found dead under the nesting box after the barn owl occupation. Avian predators of CSO include the long-legged buzzard (*Buteo rufinus rufinus*) (Kassinis et al. 2022), the barn owl (Moysi et al. 2016) and possibly the goshawk (*Accipiter gentilis*) since they are sympatric in forested and woodland areas.

Owl food habits are usually studied through pellets and prey remains analysis (Šotnár et al. 2008, Latková et al. 2012). Scops owl (*Otus scops*) species, widely occurring in mainland Europe, the Middle East, and Northern Africa, prey primarily on insects, mainly Coleoptera, Orthoptera and Lepidoptera (Šotnár et al. 2008, Latkova et al. 2012, Jusztin 2022). Small vertebrates such as mice (Muridae), shrews (Soricidae), lizards (Lacertidae) and birds (Passeriformes) constitute a small portion of its diet (Herrera and Hiraldo 1976, Mikkola 1992, Marchesi and Sergio 2005).

The food habits of the CSO have never been systematically studied before, even though anecdotal observations have been reported in BirdLife Cyprus annual reports. The chairman of the organization observed, through a camera placed in a nesting box, that the main food items that the parents fed the chicks were arthropods such as centipedes (Chilopoda), crickets, bush crickets and grasshopers (Orthoptera), cockroaches (Blattodea), moths (Lepidoptera), spiders (Araneae), and beetles (Coleoptera). He also observed them feeding their nestlings with mice and a gecko (Gekkonidae) (BirdLife Cyprus 2009, 2017). This study presents the CSO's food habits based on pellet analysis.

Material and Methods

Study area

Cyprus is the third largest Mediterranean island (after Sicily and Sardinia), covering an area of 9,251 square km (Vogiatzakis et al. 2020). The island is dominated by two mountain ranges, the central Troodos Mountains and the smaller Pentadaktylos Range, with the large, flat central plain of Mesaoria in between. Cyprus has a Mediterranean climate with dry, hot summers and rainy, mild winters with relatively short autumn and spring seasons. Cyprus's high forests, mainly of Calabrian pine (*Pinus brutia*), cover 17% of its surface. The endemic golden oak (*Quercus alnifolia*) grows in either pure stands or under conifers in altitudes over 700 m across the Troodos range. Dominant shrubs typical of Mediterranean landscapes are the Olive tree (Olea sp.) / Carob tree (Ceratonia sp.) / Lentiscus, and Turpentine (*Pistacia lentiscus* and *Pistacia terebinthus respectively*) spp. maquis with lower thorny phrygana are typical at lower ground, whereas Juniper (*Juniperus phoenicea*) Sclerophyllous scrub

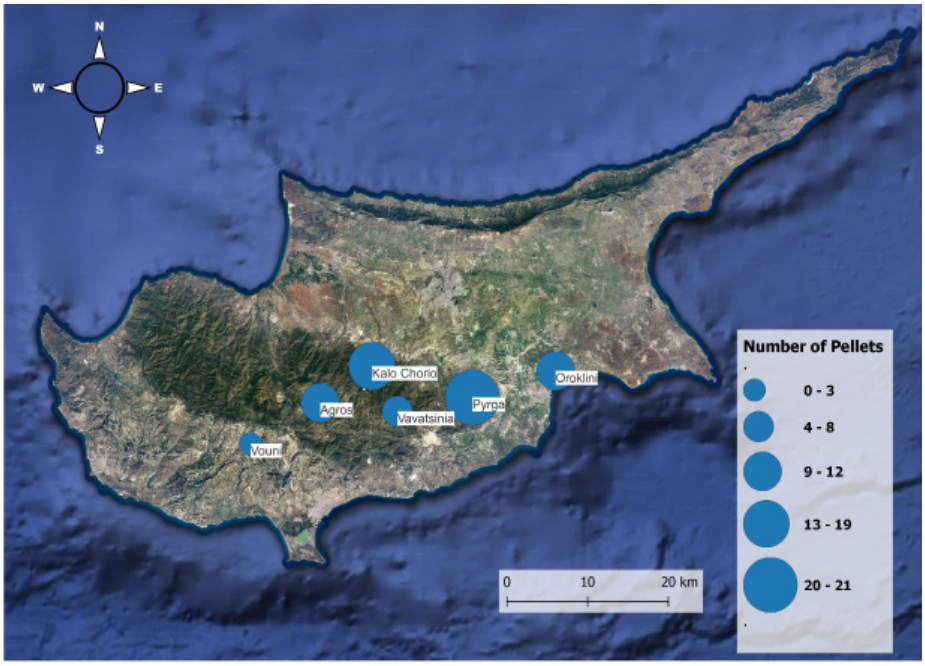

Fig. 1. Sampling locations of Cyprus scops owl pellets within Cyprus during the breeding season 2021.
Obr. 1. Lokality zberu vývržkov výrika cyperského na Cypre v priebehu hniezdnej sezóny 2021.

(Matorral) is characteristic of the coastal areas (Tsintides et al. 2007). The island's proximity to the Middle East makes it one of the hottest parts of the Mediterranean. The mean annual temperature has increased by approximately 1°C during the last century, with a more rapid increase of 0.015°C annually since the 1970s (Flint 2019). During the 20th century, the average annual precipitation was 559 mm in its first 30 years and 462 mm in its last 30 years, a decrease of 17% (Flint 2019). In contrast, in the first 19 years of this century (2001–2019), the annual average precipitation was 491 mm (calculated from data provided by the Cyprus Department of Meteorology 2020).

Pellets analyses

To assess diet composition, we collected 65 pellets between May and August 2021 from 7 nesting sites at 6 sampling locations where BirdLife Cyprus and Game and Fauna Service had nesting boxes occupied by the target species (Fig. 1). The pellets were carefully broken up in the dry state. Their contents were identified with the help of suitable guides (Arnold & Burton 1980, Chinery 1993, Macdonald & Barret 1993). Insects were identified at the Family level, so a magnifying glass was used. In each pellet, the minimum number of individuals of each taxon was estimated.

The prey items from all sites were summed after the pellet analysis was finished, and the relative proportion (%) of the number of each taxon was calculated. For calculating the biomass, an average mass for each taxon was taken (Macdonald & Barret 1993, James & Gilbert 2011) and multiplied by the number of individuals of each taxon. All these were summed up, and then each taxon's proportion of biomass was calculated. Only areas under the effective control of the Government of the Republic of Cyprus were surveyed.

Diet comparison

Due to the lack of other data from the CSO pellets analysis, the species diet composition and major prey species were compared with the diet of the closely relatedEuropean scops owl from southern Spain (Herrera & Hiraldo, 1976), central Romania (Latková et al. 2012), Austria (Muraoka 2009), central Europe: Slovakia (Šotnár et al. 2008), Czechia (Grim et al. 2022), Hungary (Streit & Kalotás 1991, Balázs (2022), Italy: Italian Alps (Marchesi & Sergio 2005) and Tuscany (Panzeri et al. 2014).

Results

In total, 357 prey items were recorded in the diet of the CSO (Tab. 1). Of these, by number, insects made up 87%, reptiles 7%, mammals 6% and birds less than 1% of the prey items. In terms of biomass, mammals were the most important prey, making up 41%, followed by insects (31%), reptiles (24%) and birds (4%). The most important mammalian prey taxa, in terms of biomass,

Tab 1. Diet of the Cyprus scops owl during the breeding season 2021.
Tab 1. Potrava výrika cyperského v priebehu hniezdnej sezóny 2021.

Prey	Number	% Abundance	% Biomass
INSECTA	**309**	**86.6**	**31.5**
Orthoptera	**131**	**36.7**	**17.3**
Tettigoniidae	5	1.4	0.7
Acrididae	126	35.3	16.6
MANTODEA	**3**	**0.8**	**0.4**
Mantidae	3	0.8	0.4
Dermaptera	**21**	**5.9**	**0.6**
Forficulidae	21	5.9	0.6
Hemiptera	**4**	**1.1**	**0.7**
Pentatomidae	2	0.6	0.1
Cicadidae	2	0.6	0.5
Lepidoptera	**2**	**0.6**	**0.3**
Lepidoptera indet.	2	0.6	0.3
Coleoptera	**146**	**40.9**	**12.3**
Carabidae	42	11.8	2.8
Staphylinidae	5	1.4	0.1
Scarabaeidae	44	12.3	5.8
Buprestidae	10	2.8	0.7
Elateridae	3	0.8	0.2
Tenebrionidae	2	0.6	0,1
Cerambycidae	1	0.3	0,1
Curculionidae	17	4.8	1.1
Coleoptera indet.	22	6.2	1.4
Hymenoptera	**4**	**1.1**	**0.1**
Formicidae	4	1.1	0.1
REPTILIA	**24**	**6.7**	**24**
Hemidactylus turcicus	12	3.4	7.9
Laudakia cypriaca	2	0.6	5.3
Scincidae indet.	2	0.6	2.6
Lacertidae indet.	2	0.6	2.6
Lacertilia indet.	6	1.7	5.5
AVES	**2**	**0.6**	**3.6**
Phylloscopus sp.	1	0.3	0.9
Passer sp.	1	0.3	2.6
MAMMALIA	**22**	**6.2**	**41**
Pipistrellus sp.	1	0.3	0.8
Acomys nesiotes	3	0.8	7.9
Rattus rattus (juv)	2	0.6	6.6
Mus spp.	15	4.2	23.7
Rodentia indet.	1	0.3	2
Total	**357**	**-**	**-**
No. of taxa	**29**		

were small mice (Mus spp.) (24%), Cyprus spiny mice (*Acomys nesiotes*) (8%) and juvenile black rats (*Rattus rattus*) (7%). The most essential insects were grasshoppers (Acrididae) (17%) and scarab beetles (Scarabaeidae) (6%). All the reptilian prey consisted of lizards, mainly Turkish geckoes (*Hemidactylus turcicus*) (8%), Cyprus agamas (*Laudakia cypriaca*) (5%) and indeterminate species, including Scincidae and Lacertidae. The estimated prey biomass ranged from 0.1 – 25 g, with a mean of 2.1 g + SD 4.9. The detailed diet results are given in the Appendix 1.

Discussion

In terms of prey abundance, the CSO appears to be mainly insectivorous. However, in terms of biomass, it is shown to have a much more varied diet, with mammals as the most crucial prey and reptiles also very prominent. The findings of this study match with the only available diet data we have on the study species; two years of observations through a nestbox camera at a nesting site (Cyprus Bird Reports 2009 and 2017).

As there are no published studies regarding CSO, the findings of this study were compared to the studies of the closely related European scops owl (Tab. 2). Herrera and Hiraldo (1976), found in the southern half of Spain (Mediterranean shrub and woodland), in terms of abundance, 94.3% invertebrates, 3.7% amphibians and reptiles, 1.2% mammals and 0.6% birds in owls' diet. In our study, the vertebrate contribution was more than double the Spanish findings (5.5% and 13.5%, respectively). In contrast, this contribution in other European studies was even lower, with invertebrate prey dominating the diet composition. In central Romania, its main prey was Orthoptera, mainly bush crickets (Tettigoniidae), with much fewer Coleoptera, other insects, rodents and passerine birds (Latková et al. 2012).

In the Italian Alps, the main prey by numbers were insects, particularly bush crickets and many Coleoptera; however, rodents were the most important prey by biomass (Marchesi & Sergio 2005). In an island of the Tuscan Archipelago, central Italy, outside the breeding season, the scops owl was preying mainly on Coleoptera of the family Vesperidae, with fewer other Coleoptera, Orthoptera, rodents, geckos and passerines (Mori et al. 2016). Šotnár et al. (2008) and Grim et al. (2022), at the northern range limit of central Europe (Slovakia and Czechia, respectively), also found that the primary prey source was insects. In addition, studies in Austria and Hungary (Muraoka 2009, Streit & Kalotás 1991, Balázs 2022) show a clear dominance of invertebrate prey (99.1%, 97.2% and 98%, respectively). Finally, a study of the African species Sokoke scops owl (*Otus irenae*) revealed mainly Coleoptera (particularly

Tab 2. Diet composition (relative abundance) of European scops owl populations, compared to the present CSO study.
Tab 2. Porovnanie zloženie potravy (relatívna abundacia) výrika lesného s výsledkami potravy výrika cyperského tejto štúdie.

State	Spain[1]	Austria[2]	Slovakia[3]	Romania[4]	Hungary[5]	Hungary[6]	Italy[7]	Italy[8]	Czechia[9]	CSO Cyprus[10]
Region and year	southern half of Spain 1976	2007	2000 – 2002	2008 – 2009	Szekszárd 1979 – 1990	Gödöllö 2017	Central–eastern Alps 2002 – 2003	Tuscan, Archipelago 2011 – 2013	Olomouc 2022	2021
Number of nesting pairs	N/A	1	5	26	43	1	20	N/A	2	7
Method of data collection	N/A	infrared camera	pellet, analysis of prey remnants, direct observation	pellet, analysis of prey remnants	analysis of prey remnants, direct observation	infrared camera during 20 d of breeding	pellet, analysis of prey remnants, direct observation	pellet, analysis of prey remnants	photographs, droppings and detritus analysis	pellet, analysis of prey remnants
Orthoptera (%)	-	61.8	87.6	86.8	-	81.6	78.7	44.1	79.6	36.7
Other insects (%)	94.3	15.8	10.3	7.8	97.2	13.4	20.8	40.1	18.9	49.9
Other arthropods (%)	-	21.5	0.5	1.6	-	3	0.6	13.6	1.1	-
Vertebrates (%)	5.5	0.9	1.6	3.8	2.8	2	-	1.7	0.4	13.5
Number of prey items	159	2152	884	831	640	546	342	59	1079	357

Sources: The original table was taken from Balázs (2022). The table was adjusted to include Marchesi & Sergio (2005), Panzeri and Mori (2014), Grim et al. (2022) and the current study results. N/A = not available; [1]Herrera & Hiraldo (1976), [2]Muraoka (2009), [3]Šotnár et al. (2008), [4]Latková et al. (2012), [5]Streit & Kalotás (1991), [6]Balázs (2022), [7]Marchesi & Sergio (2005), [8]Panzeriet al. (2014), [9]Grim et al. (2022), [10]this study

Scarabaeidae), with much fewer other insects and small birds in their diet (Virani 2008).

The CSO is primarily insectivorous, with Orthoptera and Coleoptera comprising the bulk of its diet. Still, at the same time, small vertebrate prey such as small mammals and lizards were important in terms of biomass. This importance of vertebrate prey in the CSO diet stands out compared to other studies. Predation on a bat species (*Pipistrellus* sp.) by scops owl is documented for the first time in Cyprus, even though Mikkola (2018) reported bat predation as rare. This record came from a site near a wetland (Appendix 1). Predation of lizards is also remarkable since, although the most frequently taken species, the Turkish gecko is nocturnal, the other lizards are typically diurnal. Scops owls have been reported foraging by day occasionally (Mikkola 1992). It is possible that these were taken at dusk while still active, just as the owl started its foraging activity to feed its young. The small percentage of birds as prey is the same as that reported by Herrera and Hiraldo (1976).

The CSO and the European scops owl are the most insectivorous owls in Europe. However, the CSO diet shows the importance of vertebrate prey in a much higher proportion than its European counterpart.

In the future, studies of the CSO diet will expand in the western, more forested part of the island, as well as in urban areas. They will also monitor roosts outside nesting season to have a complete picture of this endemic species foraging ecology.

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Appendix 1. Diet of the Cyprus scops owl during the breeding season 2021 including the number of prey items found per nesting site.
Príloha 1. Potrava výrika cyperského v priebehu hniezdnej sezóny 2021, detailný prehľad potravy na jednotlivých hniezdnich lokalitách

Prey Items / sites	**Pyrga, Larnaca**	**Kalo Chorio Nicosia**	**Vavla, Larnaca**	**Oroklini, Larnaca**	**Vouni, Limassol**	**Agros (nest 1), Limassol**	**Agros (nest 2) Limassol**
No. of pellets	21	13	8	10	3	7	3
INSECTA	104	66	42	65	9	16	9
Orthoptera	34	18	35	39		5	
Tettigoniidae		5					
Acrididae	34	13	35	39		5	
MANTODEA		2	1				
Mantidae		2	1				
Dermaptera	15	5	1				
Forficulidae	15	5	1				
Hemiptera		2			2		
Pentatomidae					2		
Cicadidae		2					
Lepidoptera	2						
Lepidoptera indet.	2						
Coleoptera	53	39	5	24	6	11	8
Carabidae	16	13	2	2	5	4	
Staphylinidae		4		1			
Scarabaeidae	15	12	2			7	8
Buprestidae		10					
Elateridae				2	1		
Tenebrionidae	2						
Cerambycidae	1						
Curculionidae	7			10			
Coleoptera indet.	12		1	9			
Hymenoptera				2	1		1
Formicidae				2	1		1
REPTILIA	8	4		4	3	5	
Hemidactylus turcicus	3	2		1	3	3	
Laudakia cypriaca						2	
Scincidae indet.	2						
Lacertidae indet.	2						
Lacertilia indet.	1	2		3			
AVES			1			1	
Phylloscopus sp.			1				
Passer sp.						1	
MAMMALIA	9		2	3	1	5	2
Pipistrellus sp.				1			
Acomys nesiotes	1					2	
Rattus rattus (juv)	2						
Mus spp.	5		2	2	1	3	2
Rodentia indet.	1						
Total	121	70	45	72	13	27	11