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Analisi della dieta invernale e tafonomia delle prede di Gufo comune (*Asio otus*) a Camisano Vicentino, Vicenza, NE Italia

Analysis of the winter diet and prey taphonomy of the Long-eared Owl (*Asio otus*) in Camisano Vicentino, Vicenza, NE Italy

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Riassunto - L'ecologia dell'alimentazione invernale del Gufo comune (*Asio otus*) è stata studiata attraverso l'analisi di 1849 borre raccolte in ambiente residenziale a Camisano Vicentino, Vicenza, Italia nordorientale, negli inverni da novembre a marzo dal 2016 al 2020. La specie più predata è stata *Apodemus sylvaticus*, seguita da *Microtus arvalis* e *Apodemus flavicollis*. Nelle borre sono stati rinvenuti 38 taxa, tutti appartenenti al subphylum Vertebrata. È stata effettuata anche l'analisi tafonomica dei resti, ossia lo studio delle modificazioni post-mortem delle prede, il grado di frammentazione dei loro resti craniali e la perdita di elementi scheletrici, confrontando i risultati con i dati di ricerche precedenti. Nonostante il maggior grado di frammentazione dei crani dovuto alla presenza di numerosi esemplari giovani, la perdita di elementi scheletrici si conferma correlata alla loro dimensione, mentre il tipo di frammentazione dipende dal taxon di riferimento.

Parole chiave: *Asio otus*, gufo comune, ecologica trofica, tafonomia, Italia.

Abstract - The winter feeding ecology of the Long-eared Owl (Asio otus) was studied by analysing 1849 pellets collected in a residential area in Camisano Vicentino, Vicenza, northeastern Italy, during winters from November to March from 2016 to 2020. The most preyed-upon species was *Apodemus sylvaticus*, followed by *Microtus arvalis* and Apodemus flavicollis. 38 taxa were found in the pellets, all belonging to the subphylum Vertebrata. We also carried out the taphonomic analysis, which involves studying post-mortem modifications of prey, the degree of fragmentation of cranial bones and the loss of skeletal elements. The results were compared with previous research data. Despite the higher degree of cranial fragmentation due to the presence of numerous subadult specimens, the loss of skeletal elements is confirmed to be correlated with their size, while the type of fragmentation depends on the reference taxon.

Key Words: *Asio otus*, Long-eared Owl, feeding ecology, taphonomy, Italy.

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INTRODUCTION

The Long-eared Owl (*Asio otus*), belonging to the order Strigiformes, is widely distributed across the Holarctic region (Mikkola, 1983; Cramp, 1985). It exhibits a preference for hunting in areas characterized by low and sparse vegetation (Marti, 1976; Bertolino *et al.*, 2001; Sergio *et al.*, 2008; Birrer, 2009; Benedek & Sîrbu, 2010). Numerous studies have already meticulously investigated its dietary habits (Marti, 1976; Mikkola, 1983; Cramp, 1985; Birrer, 2009), highlighting a distinct inclination towards small rodents (constituting most of vertebrate prey) and birds, which are an important alternative prey (Birrer, 2021). The Long-eared Owl is thus highly stenophagous, as it has a highly specialized and restricted diet. Indeed, it usually targets specific rodent species, particularly voles when available (Marti, 1976; Wijnandts, 1984; Birrer, 2009). The predominance of other taxa is uncommon and typically involves a greater capture of passerine birds (Sándor & Kiss, 2008; Cecere *et al.*, 2013). Nevertheless, studies indicate that seasonal changes in the prey population, fluctuations, density, and availability can influence the composition of the Long-eared Owl's diet.

In summary, the Long-eared Owl is a stenophagous bird with a primarily specialised diet, yet it demonstrates flexibility in adjusting its feeding niche width in response to variations in prey density, accessibility, and environmental conditions (Wijnandts 1984; Cecere & Vicini, 2000; Pirovano *et al.*, 2000; Bertolino *et al.*, 2001; Romanowski & Żmihorski, 2008; Tome, 2009; Cecere *et al.*, 2013; Mori & Bertolino, 2015).

During the winter, Long-eared Owls commonly gather in communal roosts, comprising on average 4-20 owls in Italy (Mastrorilli *et al.*, 2010). They typically prefer coniferous trees situated near regions abundant in food resources (Glutz von Blotzheim & Bauer, 1994; Mebs & Scherzinger, 2000). This behaviour facilitates the examination of their diet through the analysis of numerous pellet collections.

The prey body mass spans from less than 1 gram in insects to over 500 grams in birds and mammals, with a preference for prey weighing less than 50 grams in 66.5% of cases (Birrer, 2009). The Long-eared Owl's ideal prey is the Common Vole *Microtus arvalis*, given its 30-gram body mass, preference for low vegetation areas, similar activity periods to the Long-eared Owl, gregarious nature, and less agility compared to other rodents (Benedek & Sîrbu, 2010).

Throughout the phases of prey capture, preparation, ingestion, and digestion, bones undergo alterations and fractures. These modifications vary based on the prey type, its age, and the predator's age (Andrews, 1990). Andrews (1990) correlated the type of skeletal fragmentation and loss in rodents with the predator species, aiding in determining the predatory origin of fossil bone accumulations. Starting from Andrews' work, this research delves deeper into the analysis of bone fragmentation and loss, extending it to different taxa found in the pellets.

STUDY AREA

The study area is in the Vicenza plain, southeast of Vicenza city. Specifically, the roosting area is situated on some stone pines (*Pinus pinea*) in a playground in the residential area of Santa Maria di Camisano Vicentino (45.518430, 11.688018). Considering the average home range of the Long-eared Owl, reported to be 4.5 km^2 (3.37 - 5.6) (WIJNANDTS, 1984), the hunting range covers the town of Camisano Vicentino and the surrounding countryside. The main crops in the countryside include cereals, particularly wheat (*Triticum* spp.), corn (*Zea mays*), and soybeans (*Glycine max*), as well as permanent meadows cultivated with mixed grasses. The meadows are often interspersed with hedgerows containing tree species such as willow (*Salix* spp.), field elm (*Ulmus minor*), black alder (*Alnus glutinosa*), black locust (*Robinia pseudoacacia*), and plane tree (*Platanus* sp.). Some canals and streams with the same tree species on the banks are also present within the home range. In the surrounding area there are also rice fields suitable for the presence of the Harvest Mouse *Micromys minutus*.

The climate in Camisano Vicentino is continental, thus humid, and cold in winter and hot and muggy in summer.

MATERIALS AND METHODS

1849 Long-eared Owl pellets were collected in winters from 2016 to 2020, each year from November to March. The study was conducted through biweekly visits to the roost. We counted a minimum of at least 2 individual Long-eared Owls, with peaks reaching at least 8 individuals.

Intact pellets were collected and placed in multicellular trays to keep them separate and avoid mixing the bones from different pellets. The opening was done mechanically, taking care to preserve the skull parts as completely as possible after soaking them in water for 24-48 hours. Hydrogen peroxide was not used, because it can disassemble some parts and we aimed to keep the teeth in their alveoli as much as possible. Subsequent drying was conducted with natural open-air ventilation. The remains were then observed with a 32x stereoscope.

In the taphonomic analysis of bone fragmentation, we considered rodents, insectivores, and birds. Rodents were divided into Cricetidae and Muridae. Birds were analysed according to the model proposed by BOCHEŃSKI *et al.* (1996), while mammals were analysed according to the models of ANDREWS (1990), PERUZZO & VICARIOTTO (2023) and VICARIOTTO (2018). The categories of fragmentation for skulls and mandibles are those described in PERUZZO & VICARIOTTO (2023).

Vertebrate remains were identified from publications and reference collections. For the identification of mammals, the texts of CHALINE (1974), LAPINI *et al.* (1995), NIETHAMMER & KRAPP (1978, 1982, 1990) and VERNIER (1997) were used; for birds, CUISIN (1989) was consulted.

Nomenclature of mammals follows LOY *et al.* (2019), nomenclature of birds follows BACCETTI *et al.* (2021).

The average weight obtained from the literature was used for the calculation of the biomass (Niethammer & Krapp, 1978, 1982, 1990; Gerdol *et al.*, 1982; Wijnandts, 1984; Bon *et al.*, 1993, 1998; Vernier, 1997).

The minimum number of individuals preyed upon (MNI) was calculated by counting the maximum number of cranial remains per pellet (Chaline, 1974).

On the sample, we calculated: total prey; total taxa; prey per pellet; percentage presence of prey (PNI); percentage biomass of each prey species (PBI); percentage presence of each prey species in the pellets (PFI); global index of relative importance IGRi = (PNI+PBI)*PFI (Herrera, 1978); total biomass; average weight of prey; average weight of individual meals (or average weight of meal); bones/pellet; bones/MNI.

We analysed digestion and bone loss of rodents, insectivores, and birds by counting all the bones found in the pellets and calculating the expected bones by multiplying the MNI by the all the bones that should be present in the complete skeleton. We then determined the ratio of observed bones to expected bones and compared the results with those from Andrews (1990), Peruzzo & Vicariotto (2023) and Vicariotto (2018).

We also calculated the fragmentation levels of skull remains of rodents, insectivores and birds and compared them with the same bibliography.

RESULTS AND DISCUSSION

We examined 1849 pellets containing 3868 prey items (tab. 1). The number of prey per pellet depends on the prey species (the bigger the ingested prey, the fewer the number of prey per pellet) and the year (some species may experience fluctuations over the years, while others may be influenced by climate and the presence of snow). The number of prey per pellet was calculated on average as 2.09 specimens per pellet, with mean values per collection ranging between 1.84 and 2.29 prey per pellet.

Tab. 1. Numbers of total prey and species found in pellet samples. The number of pellets depends on the amount of food ingested: the Long-eared Owl produces no pellets up to 27 g; from 63 g it produces one pellet per day; from 93 g it produces two or more pellets per day (Andrews, 1990).

	Winter 2016-2017	Winter 2017-2018	Winter 2018-2019	Winter 2019-2020	2016-2020
Total prey	1085	1499	602	682	3868
Total Soricomorpha species	1	4	2	2	4
Total Chiroptera species	0	1	0	1	2
Total Microtidae species	7	6	5	5	7
Total Muridae species	8	8	7	9	9
Total Mammalia species	16	19	14	17	22
Total Aves taxa	11	9	8	11	16
Total taxa	27	30	23	28	38
Total pellets	474	687	317	371	1849
Prey/pellet	2,29	2,18	1,90	1,84	2,09
Vertebrates/pellet	2,29	2,18	1,90	1,84	2,09
Total biomass	53.569,50	73.509,00	32.675,50	46.336,00	206.090,00
Average weight of prey	49,37	49,04	54,28	67,94	53,28
Average weight of meal	113,02	107,00	103,08	124,89	111,46

TROPHIC ANALYSIS

Predation occurred exclusively on vertebrates (tab. 2). Specifically, mammals constitute an average of 97.98% of the sample (ranging from 96.63% to 99.14%), which is in line with the data from other studies, as variations in the proportion of predation on vertebrates are usually minimal. Indeed, the occurrence of mammals ranges from 80.9% in Asia to 98.1% in North America, with a mean of 89% in southern Europe (MARTI, 1976; WIJNANDTS, 1984; BIRRER, 2009).

Habitat type and features of the hunting area are particularly suitable for Cricetidae and small Muridae, but the significant number of preyed species, i.e. 38 taxa, has led to the absence of a prey of excellence. Muridae were preyed in 60.9% of cases (54.01-71.85%), with Wood Mouse *Apodemus sylvaticus* being the main prey at 23.81% of the total (17.42-28.82%). The high percentage of *Micromys minutus* (6.64%) in the 2016-2017 winter is worth of mention. As for Cricetidae, which are considered the typical prey, the average value is 33.38% (23.46-43.78%), with common vole *Microtus arvalis* representing 21.2% (11.29-32.44%). Predation on other mammal groups (Soricomorpha and Chiroptera, accounting for 1.65% and 0.05% of the PNI and 0.31% and 0.01% of the FBI, respectively) is entirely marginal, especially considering biomass (PBI). However, the presence of the long-fingered bat *Myotis capaccinii* is noteworthy, as this species is rarely reported as prey of owls and especially as a prey of Long-eared Owls (BIRRER S., pers. com.). Indeed, Italian bibliography on Long-eared Owl diet provide only one datum of predation on this bat (VICARIOTTO, 2018). Birds also have a marginal role in the diet composition, contributing exclusively to 2.02% of the prey (1.33-3.37%).

TAPHONOMIC ANALYSIS

The mandibles, found in 89.92% of cases, are the most frequently preserved skeletal element, followed by the tibiae (88.83%), femora (82.19%), and skulls (79.21%). The most lost skeletal elements are molars (4.35%), phalanges (9.39%), and metatarsi (12.10%). The order of probability of recovering skeletal elements is as follows: mandible, tibia, femur, skull, humerus, pelvis, ulna, radius, scapula, calcaneus, rib, vertebra, incisor, metatarsus, phalanx, molar.

The analysis of cranial and postcranial bones in rodents highlights on average a greater loss of skeletal elements compared to most of the data reported in the literature (ANDREWS, 1990; VICARIOTTO, 2018; PERUZZO & VICARIOTTO, 2023). Even so, the loss of skeletal elements is still confirmed related to their size, as already claimed in PERUZZO & VICARIOTTO (2023) and VICARIOTTO (2018), that is, the bigger the bone, the lower its loss (tab. 3).

Skull fragments are typically splintered along the cranial sutures; other fractures can be attributed to prey preparation. According to our data, the type of fragmentation of cranial remains depends on the reference taxon. The skulls of Cricetidae are confirmed to have greater resistance to fragmentation if compared to those of Muridae (tab. 4). In Cricetidae, the mode is represented by the palate with rostrum,

Tab. 2. Summary table: number of prey items, percentages number of prey (PNI) and biomass (PBI) for each prey species, percentage frequency of items (PFI) of each taxon.

	Winter 2016-2017		Winter 2017-2018		Winter 2018-2019		Winter 2019-2020		2016-2020			
	PNI (%)	PBI (%)	PNI (%)	PBI (%)	PNI (%)	PBI (%)	PNI (%)	PBI (%)	PNI (%)	PBI (%)	PFI (%)	IGRi
Crocidura leucodon	0,00	0,00	0,53	0,15	0,33	0,08	0,29	0,06	0,31	0,08	0,65	0,00
Crocidura suaveolens	0,18	0,04	1,93	0,39	1,66	0,31	0,88	0,13	1,22	0,23	2,54	0,04
Sorex araneus	0,00	0,00	0,13	0,03	0,00	0,00	0,00	0,00	0,05	0,01	0,11	0,00
Suncus etruscus	0,00	0,00	0,20	0,01	0,00	0,00	0,00	0,00	0,08	0,00	0,16	0,00
Total Soricomorpha	**0,18**	**0,04**	**2,80**	**0,54**	**1,99**	**0,39**	**1,17**	**0,19**	**1,65**	**0,31**	**3,46**	**0,07**
Myotis capaccinii	0,00	0,00	0,07	0,01	0,00	0,00	0,00	0,00	0,03	0,00	0,05	0,00
Pipistrellus sp.	0,00	0,00	0,00	0,00	0,00	0,00	0,15	0,02	0,03	0,00	0,05	0,00
Total Chiroptera	**0,00**	**0,00**	**0,07**	**0,01**	**0,00**	**0,00**	**0,15**	**0,02**	**0,05**	**0,01**	**0,11**	**0,00**
Microtus agrestis	3,32	2,02	0,93	0,57	1,33	0,73	0,73	0,32	1,63	0,92	3,41	0,09
Microtus arvalis	32,44	19,71	19,68	12,04	15,95	8,81	11,29	4,99	21,20	11,94	44,35	0,00
Microtus liechtensteini	3,41	1,62	8,74	4,19	9,97	4,32	9,09	3,14	7,50	3,31	15,68	0,00
Microtus multiplex	0,83	0,39	0,00	0,00	0,00	0,00	0,00	0,00	0,23	0,10	0,49	0,00
Microtus savii	2,12	1,01	1,93	0,93	1,00	0,43	0,00	0,00	1,50	0,66	3,14	0,07
Microtus subterraneus	0,09	0,04	0,53	0,25	0,00	0,00	0,44	0,15	0,31	0,13	0,65	0,00
Microtus sp.	1,57	0,79	0,27	0,14	0,83	0,38	1,91	0,70	1,01	0,47	2,11	0,03
Total Microtidae	**43,78**	**25,59**	**32,09**	**18,11**	**29,07**	**14,68**	**23,46**	**9,30**	**33,38**	**17,53**	**69,82**	**35,54**
Apodemus flavicollis	14,38	10,19	19,01	13,57	19,10	12,32	21,26	10,95	18,12	11,90	37,91	11,38
Apodemus sylvaticus	17,42	7,76	28,82	12,93	26,41	10,71	20,67	6,69	23,81	9,83	49,81	16,76
Apodemus sp.	0,83	0,48	0,53	0,31	0,66	0,35	1,17	0,49	0,75	0,40	1,57	0,02
Mus domesticus	5,71	2,55	6,00	2,69	6,15	2,49	9,97	3,23	6,64	2,74	13,90	1,30
Micromys minutus	6,64	2,02	1,87	0,57	3,82	1,06	4,55	1,00	3,98	1,12	8,33	0,42
Muridae indet.	2,76	1,40	1,27	0,65	3,16	1,45	2,49	0,92	2,20	1,03	4,60	0,15
Rattus norvegicus	5,81	46,75	6,07	49,21	7,48	54,74	10,70	62,62	7,03	52,46	14,71	8,75
Rattus rattus	0,00	0,00	0,00	0,00	0,00	0,00	0,15	0,33	0,03	0,07	0,05	0,00
Rattus sp.	0,46	1,87	0,13	0,54	0,00	0,00	0,88	2,59	0,34	1,26	0,70	0,01
Total Muridae	**54,01**	**73,01**	**63,71**	**80,47**	**66,78**	**83,12**	**71,85**	**88,83**	**62,90**	**80,83**	**131,58**	**189,13**
Total Rodents	**97,79**	**98,60**	**95,80**	**98,58**	**95,85**	**97,79**	**95,31**	**98,14**	**96,28**	**98,36**	**201,41**	**392,02**
Total Mammals	**97,97**	**98,64**	**98,67**	**99,14**	**97,84**	**98,18**	**96,63**	**98,34**	**97,98**	**98,68**	**204,98**	**403,11**
Streptopelia decaocto	0,00	0,00	0,00	0,00	0,33	0,61	0,29	0,43	0,10	0,19	0,22	0,00
Total Columbiformes	**0,00**	**0,00**	**0,00**	**0,00**	**0,33**	**0,61**	**0,29**	**0,43**	**0,10**	**0,19**	**0,22**	**0,00**
Total non-Passeriformes	**0,00**	**0,00**	**0,00**	**0,00**	**0,33**	**0,61**	**0,29**	**0,43**	**0,10**	**0,19**	**0,22**	**0,00**
Aegitalos caudatus	0,09	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,03	0,00	0,05	0,00
Anthus sp.	0,18	0,04	0,00	0,00	0,00	0,00	0,00	0,00	0,05	0,01	0,11	0,00
Carduelis sp.	0,18	0,06	0,20	0,07	0,00	0,00	0,15	0,04	0,16	0,05	0,32	0,00
Emberiza sp.	0,00	0,00	0,00	0,00	0,00	0,00	0,29	0,07	0,05	0,02	0,11	0,00
Fringilla sp.	0,00	0,00	0,00	0,00	0,00	0,00	0,44	0,18	0,08	0,04	0,16	0,00
Motacilla sp.	0,09	0,05	0,00	0,00	0,00	0,00	0,00	0,00	0,03	0,01	0,05	0,00
Parus major	0,00	0,00	0,00	0,00	0,17	0,06	0,15	0,04	0,05	0,02	0,11	0,00
Passer sp.	0,28	0,16	0,20	0,11	0,33	0,17	1,03	0,42	0,39	0,20	0,81	0,00
Passeriformes indet.	0,28	0,22	0,07	0,05	0,17	0,12	0,15	0,09	0,16	0,12	0,32	0,00
Philloscopus sp.	0,09	0,03	0,07	0,02	0,17	0,05	0,15	0,03	0,10	0,03	0,22	0,00
Ptyonoprogne rupestris	0,00	0,00	0,07	0,02	0,00	0,00	0,00	0,00	0,03	0,01	0,05	0,00
Regulus sp.	0,37	0,04	0,07	0,01	0,17	0,02	0,15	0,01	0,18	0,02	0,38	0,00
Sturnus vulgaris	0,18	0,34	0,07	0,12	0,00	0,00	0,00	0,00	0,08	0,13	0,16	0,00
Sylvia sp.	0,09	0,04	0,47	0,18	0,50	0,17	0,44	0,12	0,36	0,13	0,76	0,00
Turdus merula	0,18	0,37	0,13	0,27	0,33	0,61	0,15	0,22	0,18	0,34	0,38	0,00
Total Passeriformes	**2,03**	**1,36**	**1,33**	**0,86**	**1,83**	**1,21**	**3,08**	**1,23**	**1,91**	**1,13**	**4,00**	**0,12**
Total Aves	**2,03**	**1,36**	**1,33**	**0,86**	**2,16**	**1,82**	**3,37**	**1,66**	**2,02**	**1,32**	**4,22**	**0,14**
Total Vertebrates	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**209,19**	**403,25**

Tab. 3. Percentage of skeletal remains of Rodentia and comparison with the samples analysed in Caldogno (Peruzzo & Vicariotto, 2023), Sandrigo (Vicariotto, 2018) and Prestwick Carr and Hindshill (Andrews, 1990).

	Skull	Mandible	Incisor	Molar	Humerus	Ulna	Radius	Scapula	Pelvis	Femur	Tibia	Metatarsus	Phalanx	Rib	Vertebra	Calcaneus
Camisano Vicentino	79,21	89,92	18,96	4,35	78,29	67,30	56,07	32,99	69,24	82,19	88,83	12,10	9,39	20,42	20,32	21,59
Caldogno (Peruzzo & Vicariotto 2023)	90,15	99,89	16,19	4,87	91,68	79,87	69,37	54,49	84,25	94,09	97,70	16,37	11,32	23,95	28,36	36,43
Sandrigo (Vicariotto 2018)	72,37	68,21	17,52	8,27	65,68	63,68	58,88	52,71	64,85	66,76	72,28	17,28	10,40	26,44	35,55	36,62
Hindshill (Andrews 1990)	99,00	87,00	10,10	9,90	80,50	63,80	48,10	56,10	87,90	95,50	88,80	-	1,00	10,60	7,70	-
Prestwick-Carr (Andrews 1990)	92,90	82,50	5,10	7,00	92,00	88,00	90,40	65,80	87,30	85,20	99,20	15,80	19,80	59,60	47,40	38,00

constituting 40.34% of the sample, while 2.94% of skulls were intact. In contrast, no intact skulls were found in Muridae. Hemipalates represent 82.31% of the sample, with the remaining 17.69% represented by palates with rostrum. According to our observations, it is very likely that these differences in skull fragmentation are due to the greater strength of the cranial sutures of Cricetidae compared to those of Muridae.

Considering solely the studies conducted in Vicenza province (Vicariotto 2018; Peruzzo & Vicariotto, 2023), where we employed the same method of pellets opening and the same classification of the fragmentation levels, the distinct fragmentation of cranial elements in Muridae and Cricetidae can be confirmed, albeit with some variations. Indeed, in the examined sample, many subadult Cricetidae were found, whose cranial bones were not fully fused yet. Therefore, the data from this sample show a higher degree of cranial fragmentation (low bones/pellet and bones/MNI indices, tab. 5) if compared to other studies conducted in Vicenza province.

Andrews's data (1990), in which the two families are not kept separate, are not fully comparable because these two rodent families are grouped together (tab. 5).

Tab. 4. Percentage data of the fragmentation of rodent skulls and comparison with the samples analysed by Peruzzo & Vicariotto (2023) in Caldogno (VI), Italy, Vicariotto (2018) in Sandrigo (VI), Italy, and by Andrews (1990) in Prestwick Carr and Hindshill, UK.

		Complete skull	**Skull without tympanic bullae**	**Skull without occipital bone**	**Palate with rostrum**	**Complete palate**	**Half-palate**
Camisano Vicentino	Cricetidae	2,94	0,42	21,43	40,34	26,05	8,82
Caldogno (Peruzzo & Vicariotto 2023)		7,47	1,72	41,38	36,21	10,34	2,87
Sandrigo (Vicariotto 2018)		2,73	0,55	10,79	47,40	26,23	12,30
Camisano Vicentino	Muridae	0,00	0,00	0,00	17,69	0,00	82,31
Caldogno (Peruzzo & Vicariotto 2023)		0,00	0,00	8,48	27,19	3,51	60,82
Sandrigo (Vicariotto 2018)		0,00	0,00	1,65	22,48	1,62	74,26
Camisano Vicentino	Rodentia	1,47	0,21	10,71	29,01	13,03	45,57
Caldogno (Peruzzo & Vicariotto 2023)		3,74	0,86	24,93	31,70	6,93	31,85
Sandrigo (Vicariotto 2018)		1,37	0,27	6,22	34,90	13,92	43,28
Camisano Vicentino	Rodentia (tot)	41,41				58,59	
Caldogno (Peruzzo & Vicariotto 2023)		61,23				38,77	
Sandrigo (Vicariotto 2018)		42,80				56,20	
Andrews 1990		32,20				61,80	

Tab. 5. Percentage of total bones in the sample, percentage of bones/pellet and percentage of bones/MNI in Camisano Vicentino and comparison with samples analysed by Peruzzo & Vicariotto (2023) in Caldogno (VI), Italy, Vicariotto (2018) in Sandrigo (VI), Italy, and by Andrews (1990) in Prestwick Carr and Hindshill, UK.

	Total pellets	Total bones	NMI	Bones/pellet	Bones/NMI
Camisano Vicentino	1849	82178	3868	44,44	21,25
Caldogno (Peruzzo & Vicariotto 2023)	285	18787	678	65,92	27,71
Sandrigo (Vicariotto 2018)	2240	122935	3521	54,88	34,91
Prestwick Carr (Andrews 1990)	50	3876	63	77,52	61,52
Hindshill (Andrews 1990)	N.R.	1101	54	N.R.	20,39

Tab. 6. Percentage of the fragmentation of rodent mandibles and comparison with the samples analysed in Caldogno, Italy (Peruzzo & Vicariotto, 2023), Sandrigo, Italy (Vicariotto, 2018) and Prestwick Carr and Hindshill, UK (Andrews, 1990).

		Complete mandible	Mandible with broken processes	Mandible without processes	Mandible with broken rim
Camisano Vicentino	Cricetidae	80,86	7,54	8,96	2,65
Caldogno (Peruzzo & Vicariotto 2023)		76,92	8,93	8,68	5,46
Sandrigo (Vicariotto 2018)		72,78	13,94	6,68	6,60
Camisano Vicentino	Muridae	77,57	13,42	5,51	3,49
Caldogno (Peruzzo & Vicariotto 2023)		80,78	10,98	7,25	0,98
Sandrigo (Vicariotto 2018)		71,45	18,96	6,38	3,21
Camisano Vicentino	Rodentia	79,21	10,48	7,24	3,07
Caldogno (Peruzzo & Vicariotto 2023)		78,85	9,96	7,97	3,22
Sandrigo (Vicariotto 2018)		72,12	16,45	6,53	4,90
Andrews 1990		18,52	50,00	17,59	13,89

Tab. 7. Percentage presence of molars in alveolus and percentage of the dispersion of rodent teeth.

	Molars in alveolus	Isolated molars	Lost molars	Isolated incisors
Cricetidae	91,68	6,10	2,22	8,42
Muridae	73,56	3,97	22,47	20,01
Rodentia	82,62	5,03	12,35	14,22

Tab. 8. Percentage presence of skeletal elements of Soricomorpha and comparison with the samples analysed in Caldogno (Peruzzo & Vicariotto, 2023) and Sandrigo (Vicariotto, 2018).

	Skull	Mandible	Humerus	Ulna	Radius	Scapula	Pelvis	Femus	Tibia	Metatarsus	Phalanx	Rib	Vertebra	Calcaneus
Camisano Vicentino	84,21	100,00	57,89	50,53	41,05	34,74	50,53	58,95	54,74	11,47	6,07	13,68	18,68	12,63
Caldogno (Peruzzo & Vicariotto 2023)	91,67	95,83	50,00	50,00	41,67	25,00	50,00	62,50	87,50	12,08	7,08	15,97	20,14	33,33
Sandrigo (Vicariotto 2018)	73,61	70,49	65,63	55,90	39,24	34,03	62,15	65,97	60,07	13,30	7,42	20,02	26,42	30,56

Tab. 9. Percentage fragmentation of Soricomorpha skulls and comparison with the samples analysed in Caldogno (Peruzzo & Vicariotto, 2023) and Sandrigo (Vicariotto, 2018).

	Complete skull	Skull without tympanic bullae	Skull without occipital bone	Palate with rostrum	Complete palate	Half-palate
Camisano Vicentino	0,00	12,50	42,50	40,00	0,00	5,00
Caldogno (Peruzzo & Vicariotto 2023)	0,00	0,00	27,27	72,73	0,00	0,00
Sandrigo (Vicariotto 2018)	0,00	7,55	33,02	50,94	1,89	6,60

Tab. 10. Percentage fragmentation of Soricomorpha mandibles and comparison with the samples analysed in Caldogno (Peruzzo & Vicariotto, 2023) and Sandrigo (Vicariotto, 2018).

	Complete mandible	Mandible with broken processes	Mandible without processes	Mandible with broken rim
Camisano Vicentino	96,84	1,05	2,11	0,00
Caldogno (Peruzzo & Vicariotto 2023)	86,96	0,00	13,04	0,00
Sandrigo (Vicariotto 2018)	92,61	4,43	1,48	1,48

As for mandibles, both in Cricetidae (80.86%) and Muridae (77.57%) the mode is represented by the complete mandible (tab. 6).

As for the dispersion of rodent teeth, Cricetidae's molars tend to remain in the alveoli more than Muridae's (tab. 7).

Also, when considering the postcranial remains of Soricomorpha, digestion is contingent upon the size of the bone: the bigger the bone, the lesser the loss. In contrast to Peruzzo & Vicariotto (2023)'s lot in Caldogno, where tibiae were present in 87.5% of cases, the femur, with a 58.95% presence, emerges as the most frequently found postcranial element (tab. 8). Overall, the data are nevertheless consistent with the literature in Vicenza province (Vicariotto, 2018; Peruzzo & Vicariotto, 2023).

Regarding cranial fragmentation, in 42.5% of cases, skulls lack occipital bones, and in 12.5% of cases, complete skulls without tympanic bullae were found (tab. 9). The skulls of Soricomorpha in Camisano Vicentino show a higher degree of fragmentation if compared to those in lots previously examined (Vicariotto, 2018; Peruzzo & Vicariotto, 2023). Mandibles remain complete in 96.84% of cases (tab. 10).

As with other taxa, in the postcranial elements of birds, the smaller skeletal elements are the most lost: for instance, ribs are found in only 16.94% of the sample (tab. 11). Indeed, during prey preparation, some elements, such as the head, may be removed and sometimes discarded (Andrews, 1990). For this reason, when using only cranial elements to determine the minimum number of individuals, humeri represent 120% of the sample, skulls are present in 46.67% of cases, while mandibles are present in 93.33% of cases: this indicates a significant loss of the NMI.

As for the analysis of skulls, the mode is represented by complete beaks, comprising 71.43% of the sample (tab. 12). On the other hand, in mandible data (tab. 13), hemi-mandibles prevail, constituting 42.86% of the sample.

Conclusions

The environment used by the Long-eared Owls in this roost allows them to prey on species associated with both urban environments and the surrounding meadows, crops, and tree-lined watercourses. Despite *Microtus arvalis* being considered the ideal prey for the Long-eared Owl in the literature (Benedek & Sîrbu, 2010), the combined predation of all cricetids accounts for only 33.38% (23.46-43.78%) of the sample. However, despite being more challenging to prey upon due to their speed and ecology, medium-small-sized murids contribute 55.51% (47.74-60.12%) to the sample.

The Long-eared Owl is a stenophagous bird with a highly specialised diet, but it can modify its food-niche breadth to adapt to prey densities, environmental conditions, and their accessibility (Wijnandts, 1984; Cecere & Vicini, 2000; Pirovano *et al.*, 2000; Bertolino *et al.*, 2001; Romanowski & Żmihorski, 2008; Tome, 2009; Cecere *et al.*, 2013; Mori & Bertolino, 2015). In any case, with over 97% of prey

Tab. 11. Percentage of avian skeletal remains and comparison with the samples analysed in Caldogno (Peruzzo & Vicariotto, 2023) and Sandrigo (Vicariotto, 2018).

	Skull	Mandible	Humerus	Ulna	Radius	Meta-carpus	Wing phalanx	Scapula	Clavicle	Coracoid	Sternum	Pelvis	Femur	Tibia	Meta-tarsus	Falanx	Ribs	Vertebra
Camisano Vicentino	46,67	93,33	120,00	63,33	66,67	50,00	20,00	63,33	53,33	70,00	80,00	80,00	80,00	106,67	83,33	19,72	16,94	17,50
Caldogno (Peruzzo & Vicariotto 2023)	73,68	100,00	94,74	97,37	63,16	57,89	17,11	60,53	42,11	50,00	52,63	57,89	63,16	110,53	78,95	17,76	16,45	19,30
Sandrigo (Vicariotto 2018)	75,68	88,29	73,76	70,72	65,26	66,39	22,66	61,60	43,92	67,23	70,83	73,20	63,06	80,24	70,33	20,93	19,46	24,70

Tab. 12. Percentage fragmentation of bird skulls and comparison with the samples analysed in Caldogno (Peruzzo & Vicariotto, 2023) and Sandrigo (Vicariotto, 2018).

	Complete skull with beak	Skull with beak and cranial lid w/o posterior	Cranial lid without posterior	Complete skull with beak	Complete beak	End of beak	Other fragments
Camisano Vicentino	0,00%	14,29%	0,00%	0,00%	71,43%	0,00%	14,29%
Caldogno (Peruzzo & Vicariotto 2023)	0,00%	5,26%	0,00%	0,00%	42,11%	15,79%	36,84%
Sandrigo (Vicariotto 2018)	3,29%	15,45%	2,86%	0,43%	42,20%	23,61%	12,16%

Tab. 13. Percentage fragmentation of avian mandibles and comparison with the samples analysed in Caldogno (Peruzzo & Vicariotto, 2023) and Sandrigo (Vicariotto, 2018).

	Complete mandible	Hemi-mandible	Articular process	Mandibular symphysis	Fragments of mandible
Camisano Vicentino	21,43%	42,86%	14,29%	21,43%	0,00%
Caldogno (Peruzzo & Vicariotto 2023)	23,08%	34,62%	23,08%	15,38%	3,85%
Sandrigo (Vicariotto 2018)	30,53%	25,79%	22,00%	13,58%	8,11%
Prestwick Carr (Andrews 1990)	50	3876	63	77,52	61,52
Hindshill (Andrews 1990)	N.R.	1101	54	N.R.	20,39

represented by mammals, the complete absence of invertebrates, and only a minimal 16 species of birds preyed upon, the Long-eared Owl confirms its being a stenophagous species.

Taphonomic analysis corroborates the tendency for the loss of smaller bone fragments and greater fragmentation of cranial elements in young or subadult individuals. In rodent analysis, it is confirmed that Cricetidae skulls tend to remain more complete than Muridae's, due to probably weaker sutures of the former. To improve taphonomic analysis precision, it is thus crucial to maintain clear distinctions between rodent families and fragmentation classes.

Unable to control variables such as the individual prey preparation by predators (which can influence cranial fragmentation), the individual characteristics of prey, or the conservation environment of pellets until collection (e.g., it is not excluded that some pellets collected in public areas may have been stepped on), we emphasise the utmost importance of applying a rigorous and consistent method in sample preparation. This is crucial in both the delicate phase of pellet opening (where skulls can break, or teeth can dislodge from alveoli) and in the attribution to the fragmentation category and storage of the data.

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