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Abstract
This study aims to investigate the feeding ecology of the Tawny Owl (*Strix aluco*) population in Soğuksu National Park, located in Central Anatolia, Türkiye. A total of 423 pellet samples were collected in 2014 and analyzed to identify prey remains to species level. The results revealed a diet dominated by small mammals, particularly M*icrotus subterraneus* (29.1%) and *Myodes glareolus* (19.8%). Parallel small mammal trapping yielded 758 individuals and was used to assess prey availability. A moderate but non-significant correlation was found between the abundance of prey and their representation in the owl's diet (r = 0.2955), suggesting that factors beyond numerical abundance, such as accessibility and habitat structure, influence prey selection. The calculated Levin's index (6.87) indicates a moderate dietary breadth. These findings highlight the owl's flexible foraging strategy in mosaic forest-steppe landscapes and support its use as an ecological indicator species in protected areas such as Soğuksu National Park.

Keywords: Tawny Owl, *Strix aluco*, pellet analysis, feeding ecology, Soğuksu National Park, small mammals, raptor

INTRODUCTION
The feeding ecology of the Tawny Owl (*Strix aluco*) in Soğuksu National Park, located in Kızılcahamam, Ankara, Turkey, exhibits several noteworthy characteristics influenced by environmental, seasonal, and ecological factors. Tawny Owls are predominantly generalist predators, exhibiting a diverse diet that varies according to habitat types and prey availability (Romanowski & Żmihorski, 2009; Capizzi, 2000; Rajković et al., 2024). Across various European habitats, they have been observed to prey on a wide range of taxa, including rodents, insects, and occasionally birds, reflecting their adaptability and opportunistic foraging strategies (Żmihorski & Osojca, 2006; Yatsiuk & Filatova, 2017; Zawadzka & Zawadzki, 2007). In their natural environment, Tawny Owls prefer woodland areas with a well-developed understory that supports their primary hunting method—ambush from elevated perches (Fröhlich & Ciach, 2017; Šotnár et al., 2020). Their diet is often dominated by small mammals such as voles (*Myodes glareolus*) and mice (*Apodemus* spp.), which are frequently the most abundant prey types (Luka & Riegert, 2018; Yatsiuk & Filatova, 2017). Studies have shown that periods of high vole abundance correlate with increased reproductive success and overall fitness in Tawny Owls, highlighting the crucial link between prey density and owl population dynamics (Luka & Riegert, 2018; Zawadzka & Zawadzki, 2007).

In Turkey, and particularly in the Central Anatolian region, studies on *Strix aluco* have begun to emerge more recently, contributing valuable data on regional diet patterns and habitat preferences. In Belgrad Forest near Istanbul, Arslangündoğdu et al. (2013) reported that 93% of prey remains found in pellets consisted of small rodents, especially *Apodemus* and *Microtus* species, while only 7% consisted of birds, amphibians, and insects. Tawny Owls in this region showed strong preferences for mature deciduous forests near water bodies. Playback surveys in the same study revealed 93 individuals, including 34 pairs, providing early population insights for the species in Turkey. In Central Anatolia, Nedyalkov and Boev (2016) documented a broader dietary range for Tawny Owls in semi-arid, rocky habitats. Their analysis revealed that small mammals constituted 76.3% of the diet, including *Mesocricetus brandti*, *Meriones tristrami*, and *Microtus cf. levis*, while birds—such as *Porzana porzana* and *Rallus aquaticus*—comprised 23.7% of prey items. This diversity was quantified by a Levins' Index of 10.65, indicating high dietary plasticity.

Seasonality also plays a vital role in shaping the feeding behavior of *Strix aluco*. Owls adjust their hunting patterns based on fluctuations in prey availability throughout the year, relying more heavily on small mammals during winter months when other prey becomes scarce (Romanowski & Żmihorski, 2009; Żmihorski & Osojca, 2006). In anthropogenically influenced or fragmented habitats, they demonstrate flexibility by incorporating alternative prey species and adapting to new habitat conditions (Rajković et al., 2024; Santoro et al., 2012; Zawadzka & Zawadzki, 2007). Environmental parameters such as elevation, climate, and habitat fragmentation further influence the species' foraging strategy. In Mediterranean and continental Anatolian regions, studies suggest that extreme temperatures and habitat heterogeneity may shape owl diet composition (Comay et al., 2022).

In this study, we investigated the feeding ecology of the Tawny Owl (*Strix aluco*) population in Soğuksu National Park, located in the Central Anatolian montane forest-steppe transition zone. We analyzed diet composition based on pellet contents, assessed prey availability through live trapping, and quantified dietary breadth using standardized indices to determine whether the population exhibits specialist or generalist foraging behavior.

MATERIALS AND METHODS
Study Area
The study was conducted in Soğuksu National Park (39°49'N, 32°38'E), located near Kızılcahamam in the Ankara province of Turkey. The park lies in the Central Anatolian biogeographic region and covers approximately 1,188 hectares. Elevation ranges from 1,050 to 1,750 meters above sea level. The dominant vegetation types include mixed coniferous and deciduous forest patches composed primarily of *Pinus nigra*, *Quercus* spp., and *Juniperus* spp., interspersed with open rocky habitats and grasslands. The climate is continental, characterized by hot, dry summers and cold, snowy winters.

Soğuksu National Park is part of the Important Bird Area (IBA) network and holds ecological significance due to its avian diversity and its role as a refuge for various raptor species.

Pellet Collection and Analysis

Pellet samples were collected between May and September 2014 from known roosting and nesting sites of Tawny Owls (*Strix aluco*) within the park boundaries. A total of 423 pellets were gathered non-invasively from beneath perches, tree cavities, and rocky ledges. The pellets were air-dried, measured, and dissected manually using forceps and a binocular stereomicroscope.

Prey remains were identified based on diagnostic features such as skulls, mandibles, and teeth, using reference collections and identification keys (e.g., Kryštufek & Vohralik, 2005; Niethammer, 1989). Prey items were grouped into major taxonomic categories: Rodentia, Insectivora, Aves, Amphibia, and Insecta.

Relative frequency (%) of prey types was calculated based on the number of individuals identified per taxonomic group. Bones found in multiple pellets were only counted once per pellet to avoid pseudoreplication.

Small Mammal Trapping

To assess the availability and diversity of small mammal species in the area, live trapping was conducted using Sherman traps in parallel with the pellet collection. Trapping was performed over 15 nights, covering different microhabitats (forest edge, steppe, and rocky zones). Traps were baited with apple slices and checked each morning. Captured individuals were identified, and released at the point of capture.

To assess the availability and diversity of small mammal species in the area, live trapping was conducted across five different habitat types between May and November in 2014 and 2015. Individuals were classified to species level, sexed, and weighed using standard procedures. Small mammal trapping was conducted monthly from May to November in 2014 and 2015, each sampling month comprising three consecutive nights. The total trapping effort amounted to 5250 trap-nights across five habitat types, with 1250 trap-nights conducted annually. These efforts complied with the ethical approval granted by the Hacettepe University Animal Research Ethics Committee (decision date: March 26, 2014; ref: 52338575-41).

Statistical Analysis

The correlation between prey abundance (from live trapping) and prey representation in pellets was evaluated using Pearson's correlation coefficient (r). Dietary breadth was calculated using Levins' index (B), and niche overlap between trapping and pellet data was measured with Pianka's index. Trophic niche breadth was calculated using Levins' index (1968), defined as $B=1/\sum p_i^2$, where p_i represents the proportion of each prey type in the diet. Standardized Levins' index (Hurlbert, 1978) was also computed to allow comparisons across studies with different prey category numbers. All statistical analyses were conducted in SPSS 20.0, with significance set at $p < 0.05$.

Results

Pellet Composition

A total of 423 regurgitated pellets from Tawny Owls (*Strix aluco*) were collected and analyzed. All pellets contained identifiable prey remains, yielding a total of 1,029 individual prey items assigned to five major taxonomic groups. The overall dietary composition was strongly dominated by small mammals, particularly rodents.

Rodentia constituted the majority of the diet (approximately 78.3%), with *Microtus subterraneus* (29.1%) and *Myodes glareolus* (19.8%) being the most frequent prey species. Murid rodents such as *Apodemus flavicollis* and Mus spp. were also frequently consumed. Insectivores (e.g., *Crocidura* spp.) accounted for 2.6% of prey items, while non-mammalian taxa—comprising birds, amphibians, and insects—collectively represented 19.2% of the diet When all major prey groups (including birds, amphibians, and insects) are included in the dietary analysis, the standardized Levin's index was recalculated as Ba = 0.53, indicating a moderate trophic niche breadth for the Tawny Owl population in Soğuksu National Park.

These results are summarized in Table 1, while the relative proportions of the five major prey groups are illustrated in Figure 1.

Table 1. Prey composition of Tawny Owl (*Strix aluco*) in Soğuksu National Park based on pellet analysis (n = 423). Frequencies are expressed as percentages of total identified prey items.

Prey Taxon	Frequency (%)
Microtus subterraneus	29.1
Myodes glareolus	19.8
Apodemus flavicollis	11.4
Mus spp.	6.1
Microtus spp. (undiff.)	4.8
Apodemus spp. (undiff.)	4.2
Crocidura spp.	2.6
Nannospalax xanthodon	1.3
Dryomys nitedula	0.8
Birds	8.2
Amphibians	6.1
Insects	3.3

Small Mammal Abundance

Live trapping efforts yielded 758 individuals from six small mammal species. The most commonly captured taxa were *Apodemus* spp. (54.9%), *Mus macedonicus* (15.2%), and *Myodes glareolus* (12.8%). *Microtus subterraneus* was captured at lower frequencies (11.6%) despite its high representation in the pellet data (Figure 2).

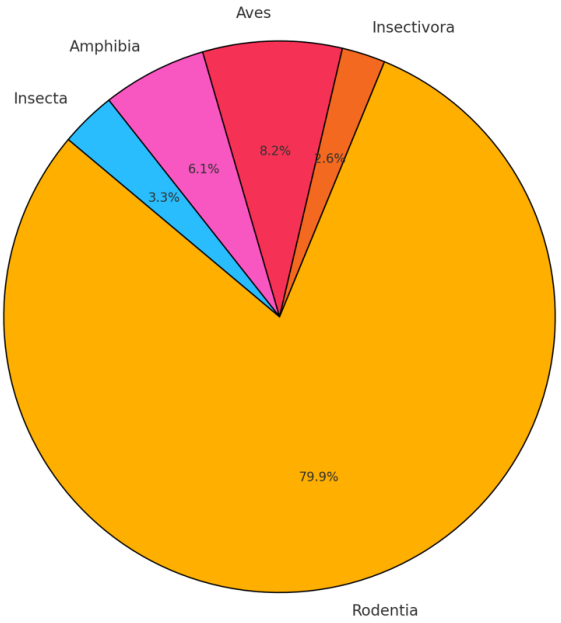

Figure 1. Relative proportions of major prey groups (Rodentia, Insectivora, Aves, Amphibia, Insecta) identified in Tawny Owl (Strix aluco) pellets collected from Soğuksu National Park.

Comparison of Diet and Prey Availability

To assess the relationship between prey availability and dietary composition, small mammal live trapping was conducted concurrently with pellet collection. A total of 758 individuals were captured, with *Apodemus* spp. being the most abundant (54.9%), followed by *Mus macedonicus* (15.2%), *Myodes glareolus* (12.8%), and *Microtus subterraneus* (11.6%). Other captured taxa included *Crocidura suaveolens* and *Dryomys nitedula*, albeit in lower frequencies.

When these trapping results were compared to pellet contents, several discrepancies were observed. Notably, Microtus subterraneus, although less frequently trapped, was disproportionately represented in the diet (29.1%). Conversely, Apodemus spp., the most abundant in the environment, were relatively underrepresented in the owl's diet (15.6%). This suggests that factors beyond abundance—such as detectability, habitat openness, and prey vulnerability—may influence prey selection.

A weak and statistically non-significant correlation was found between prey abundance in the environment and its representation in the owl's diet (Pearson's r = 0.2955, p = 0.11). Although not statistically significant, the trend suggests a weak tendency toward dietary selection aligned with availability.

A visual comparison of small mammal proportions from live trapping and pellet analysis is provided in Figure 2.

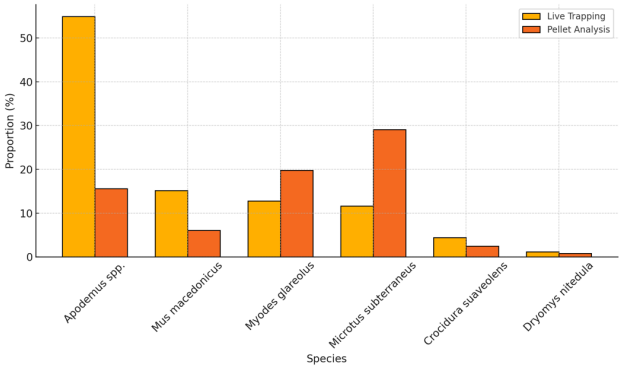

Figure 2. Comparison of small mammal species proportions based on live trapping and pellet analysis. Note the overrepresentation of *Microtus subterraneus* and underrepresentation of Apodemus spp. in the owl's diet relative to field availability.

Discussion

The feeding ecology of the Tawny Owl (*Strix aluco*) population in Soğuksu National Park reflects a combination of opportunistic foraging and context-dependent selectivity shaped by prey accessibility and habitat structure. Similar to findings across temperate European habitats, small mammals—particularly voles (*Microtus subterraneus*) and bank voles (*Myodes glareolus*)—comprised nearly half of the prey identified in owl pellets, confirming their role as staple prey in forested ecosystems (Romanowski & Żmihorski, 2009; Luka & Riegert, 2018; Zawadzka & Zawadzki, 2007).

Despite the high trapping frequency of *Apodemus* species (54.9%), their relative contribution to the diet was considerably lower (15.6%). This disparity suggests selective foraging, possibly due to microhabitat differences, prey detectability, or energetic profitability. Microtus species are typically more exposed in open or semi-open habitats, increasing their vulnerability during nocturnal ambush hunting from elevated perches (Šotnár et al., 2020). Similar mismatches between prey availability and consumption have been observed in Central and Eastern Europe, where foraging efficiency and prey accessibility, rather than sheer abundance, better explained dietary patterns (Fröhlich & Ciach, 2017).

Compared to other Turkish populations, the diet composition in Soğuksu is relatively consistent with findings from the Belgrad Forest in northwestern Turkey. There, Arslangündoğdu et al. (2013) found that 93% of prey items were rodents, predominantly *Apodemus* and *Microtus*, while only 7% were birds, amphibians, and insects. In contrast, our study revealed a more taxonomically diverse diet, with non-mammalian prey (birds, amphibians, insects) making up approximately 17.6% of total prey items. This difference may reflect ecological variation between deciduous lowland forests and the mixed montane habitats of Central Anatolia.

A broader prey spectrum was reported by Nedyalkov and Boev (2016) in the semi-arid regions of Central Anatolia, where the owl's diet included 12 mammal and 8 bird species, including wetland-associated taxa. Their calculated Levins'

Index of 10.65 suggested a high level of dietary plasticity. In comparison, the Levin's index calculated in our study (B = 6.87) and its standardized version (Ba = 0.53) indicate moderate trophic niche breadth, consistent with a generalist foraging strategy. The use of a standardized index allows meaningful comparisons across studies with differing prey category richness (Hurlbert, 1978), and in this case, supports the interpretation that S. aluco adjusts its diet based on local ecological constraints.

The weak but positive correlation between small mammal availability and diet composition ($r = 0.2955$, $p = 0.11$) further underscores the role of non-abundance factors in shaping foraging behavior. While not statistically significant, this trend suggests that habitat structure, prey detectability, and seasonal exposure may mediate prey selection. For instance, *Microtus subterraneus* may be more accessible during autumn due to decreased vegetation cover or reduced activity of diurnal predators (Petty, 1999; Sunde & Bolstad, 2004). The presence of generalist traits in the Tawny Owl should therefore be interpreted in light of such context-dependent ecological filters.

In summary, our findings confirm that the Tawny Owl in Soğuksu National Park exhibits a moderately broad trophic niche and displays flexible foraging behavior shaped by a combination of prey availability, habitat complexity, and seasonal patterns. The integration of pellet analysis with live-trapping data has provided a more nuanced understanding of diet composition and foraging selectivity, reinforcing the need for multi-method approaches in raptor feeding ecology studies.

Conclusion

This study provides the first comprehensive assessment of the feeding ecology of the Tawny Owl (*Strix aluco*) in Soğuksu National Park, Central Anatolia. Through pellet analysis and parallel small mammal trapping, we confirmed that the species displays a generalist but prey-selective feeding strategy, with a diet primarily composed of small rodents—particularly *Microtus subterraneus* and *Myodes glareolus*.

Despite Apodemus spp. being the most abundant in the environment, their relatively low representation in pellets suggests that prey behavior, habitat structure, and predator-prey interaction dynamics significantly influence prey choice. These results align with earlier findings from other Turkish regions (e.g., Istanbul and Karaman), yet they also emphasize the site-specific nature of owl foraging patterns.

The moderate dietary breadth observed (Levin's index = 6.87) indicates that Tawny Owls in this montane forest ecosystem rely on a stable core of prey species but may diversify when necessary. The species' capacity to adapt to different ecological contexts reinforces its role as a key indicator of ecosystem health and biodiversity.

From a conservation standpoint, maintaining heterogeneous landscapes that support diverse small mammal populations—particularly in forest–steppe mosaics—is crucial. Long-term monitoring of apex predators like *Strix aluco* can serve as an effective tool for evaluating habitat quality and guiding forest and wildlife management strategies in protected areas such as Soğuksu National Park.

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