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Woody Plant Species in the Diet of the Golden Jackal (*Canis aureus* Linnaeus, 1758) in Trabzon, Türkiye

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ABSTRACT

Woody plant species whose fruits or seeds the golden jackals eats were investigated in Trabzon's agricultural, forest, and suburban areas (Türkiye, ca 426 ha) between January 2023 and June 2024. The fruits or seeds of woody plants in the diet of the golden jackal were identified for the first time using camera trapping, and a total of 21 scat samples were subsequently collected and analyzed. Of the 25 woody plant species producing edible fruits or seeds recorded in the study area, 20 were consumed by golden jackals. These species include *Arbutus unedo*, *Castanea sativa, Cornus mas, Corylus maxima, Crataegus rhipidophylla, Diospyros lotus, Eriobotrya japonica, Ficus carica, Juglans regia, Ligustrum vulgare, Malus sylvestris, Mespilus germanica, Morus alba, Morus rubra, Prunus avium, Prunus domestica, Pyrus communis, Rosa canina, Rubus idaeus* and *Vitis labrusca*. This study reveals that golden jackals feed on nearly all fruit- or seed-bearing plants in the area, highlighting the significant role these plants play in their diet.

Keywords: scats, camera traps, plants, fruits, seeds, diet, seasonality, opportunistic, golden jackal, Türkiye

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INTRODUCTION

The golden jackal is widely distributed across various regions of Africa, Asia, and Europe (Moehlman and Hayssen 2018, Krofel et al. 2022). The species inhabits a wide range of conditions, including forests, steppes, semi-deserts, short and medium grasslands, savannahs, mangroves, agricultural areas, suburban regions, villages, towns, and semi-suburban habitats (Jhala and Moehlman 2004, Šálek et al. 2014, Koepfli et al. 2015). Golden jackals often inhabit agricultural areas and wetlands because they prefer lowland and mixed habitats for nesting, hiding, giving birth, and rearing their young (Šálek et al. 2014).

Golden jackals are omnivorous and opportunistic feeders, and their diet varies seasonally and by habitat (Macdonald 1979, Nowak 1983, Jhala and Moehlman 2004). They adapt to local food availability, which allows them to occupy a wide range of habitats and exploit diverse food sources (Jhala and Moehlman 2004). Golden jackals feed on a wide variety of foods, including plants, arthropods, reptiles, birds, rodents, and poultry. They can also destroy crops such as sugar cane and fruit (Markov and Lanszki 2012). Golden jackals cause damage to melon, peanut, grape, coffee, maize, and sugarcane crops; they sometimes take to killing lambs, weak sheep, goats, and poultry (Jhala and Moehlman 2004). Studies of European golden jackal populations have identified mammals (especially domestic animals), plant material (fruits), insects, and birds as being a part of their diet in southern Greece (Giannatos et al. 2005). In Serbia, small mammals and a high proportion of plant material, especially ripe fruits, were prominent in the diet during summer and autumn (Penezić and Ćirović 2015). In Bulgaria, the diet was dominated by mammals, followed by plant material (mainly fruits, seeds, acorns, and agricultural products), fish, insects, reptiles, and crustaceans (Stoyanov 2012). In Croatia, studies of golden jackals' scat revealed the presence of mammals, fruit and plant residues, insects, birds, artificial materials, branches, leaves, and grasses (Radović and Kovačić 2010).

Frugivory in carnivores has traditionally been overlooked, but recent ecological research has increasingly emphasized its significance. Fruits provide a high-energy, easily digestible food source that can be particularly important during periods when animal prey is scarce or difficult to obtain (Herrera 1982). For generalist predators such as the golden jackal, frugivory not only enhances dietary flexibility but may also provide significant ecological advantages by reducing competition with other carnivores and by enabling individuals to exploit seasonal peaks in fruit availability. The importance of fruits and vegetables as the second most common component highlights the importance of human-derived food resources in the golden jackal's diet. They often visit fields, vineyards, and orchards, sometimes approaching humans even during the daytime in the summer and autumn. The importance of fruits and vegetables becomes more apparent in spring and autumn (Radović and Kovačić 2010).

The golden jackal is classified as Least Concern by the International Union for Conservation of Nature (IUCN) (Hoffmann et al. 2018) and is listed in CITES Appendix III (CITES 2024). This is one of the species whose hunting is permitted by the Central Hunting Commission during certain periods in Türkiye (Arpacık 2021). The feeding ecology of the golden jackal in the Caucasus and Anatolia remains largely understudied (Radović and Kovačić 2010). The present study investigates the woody plant species whose fruits and seeds are consumed by the golden jackal in Trabzon (Türkiye) using complementary methods: scat analysis and camera trapping. By combining these approaches, the study aims to (1) identify fruiting woody plants used as food resources, (2) determine seasonal patterns in fruit consumption, and (3) assess the overlap between camera traps and scat-derived evidence.

MATERIAL AND METHODS

Study Area

The study was conducted between January 2023 and June 2024 in the eastern Black Sea region of Türkiye, specifically in Bulak, Ortahisar, Trabzon province, at coordinates

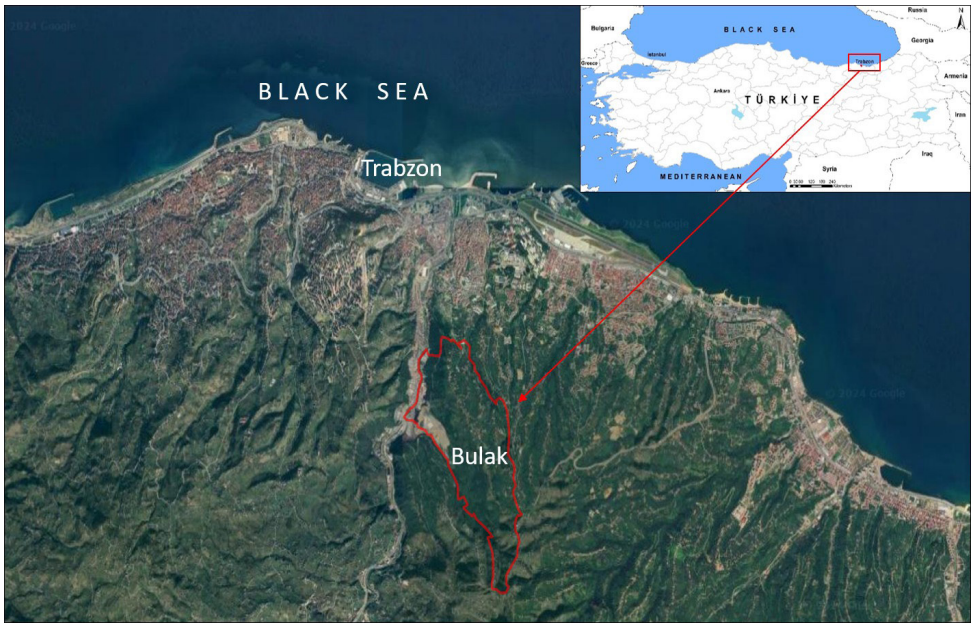

Figure 1 Study area (Google Earth 2026).

40°58′16.9″ N 39°45′43.6″ E. The study area covered 426 ha. It is situated at an average altitude between 20 and 620 meters (Figure 1). The study area lies in the transition zone between polar air masses from the north and tropical air masses from the south. Precipitation tends to fall as rain in the coastal areas and as snow in the middle and higher altitudes. The average summer temperature is around 18.8°C. Spring provides a smooth transition from winter to summer, characterized by abundant rainfall that facilitates intensive planting, particularly in coastal areas, with an average annual rainfall of 800–850 mm. Spring begins in March, with average monthly temperatures rising above 15°C. Autumn lasts approximately three months, with September exhibiting summer-like characteristics and November displaying more winter-like characteristics. A notable feature of the region is the variation in rainfall over short distances (microclimatic areas). The study area is one of the well-watered regions of Türkiye. The driest months are July and August, while the highest snowfall is usually in February. The coldest months are January and February (TPDCT 2024).

Of the total 426 ha of the study area, 126 ha are forested, 233 ha consist of agricultural and suburban areas, 15.8 ha are agrarian land dominated by hazelnut cultivation, 23.7 ha are rocky areas, 23.4 ha are industrial areas and 4.1 ha are river habitats. Forested areas comprise tree species such as Oriental beech (*Fagus orientalis* Lipsky), common hornbeam (*Carpinus betulus* L.), oak (*Quercus* spp.), black alder (*Alnus glutinosa* (L.) Gaertn.), and black locust (*Robinia pseudoacacia* L.), and also include shrub vegetation, small streams, and rocky habitats. Suburban areas are interspersed with agricultural land. Although hazelnut cultivation is the predominant agricultural activity, crops such as maize, beans, potatoes, and collard greens are also cultivated. Both planted and naturally occurring fruit-bearing trees and shrub species are present within suburban and agricultural areas. Rocky areas are mainly characterized by shrub vegetation and the presence of a small stream (Figure 2).

Scat Analysis

Scat samples were collected throughout all seasons between January 2023 and June 2024 during a total of 56 days of fieldwork. A total of 21 fresh golden jackal scat samples were collected along four standardized transects, ranging in length from 1 to 5 km. These were identified based on distinct characteristics such as shape, size, diameter, contents, and surrounding tracks, often found in clusters within a 1–1.5 m diameter area (Macdonald 1979, Vanak and Mukherjee 2008). Scat samples were collected across different habitat types within the study area, including forested areas (n = 10), agricultural–suburban areas (n = 6), agricultural areas (n = 4), and rocky areas (n = 1). Some scat samples were collected from golden jackals observed defecating in front of the camera traps that were installed. Samples were placed in paper bags, labeled with the date and habitat type (forests, agricultural, suburban, rocky), and processed in the laboratory. Scats were washed to remove detritus, then dried and separated into identifiable components. Plant material was categorized into plant remains, fruits, and seeds. The identification of plant remains, seeds, and fruit remains recovered from scat samples was performed through comparative analysis with reference specimens of plant species collected from the study area (Figure 3).

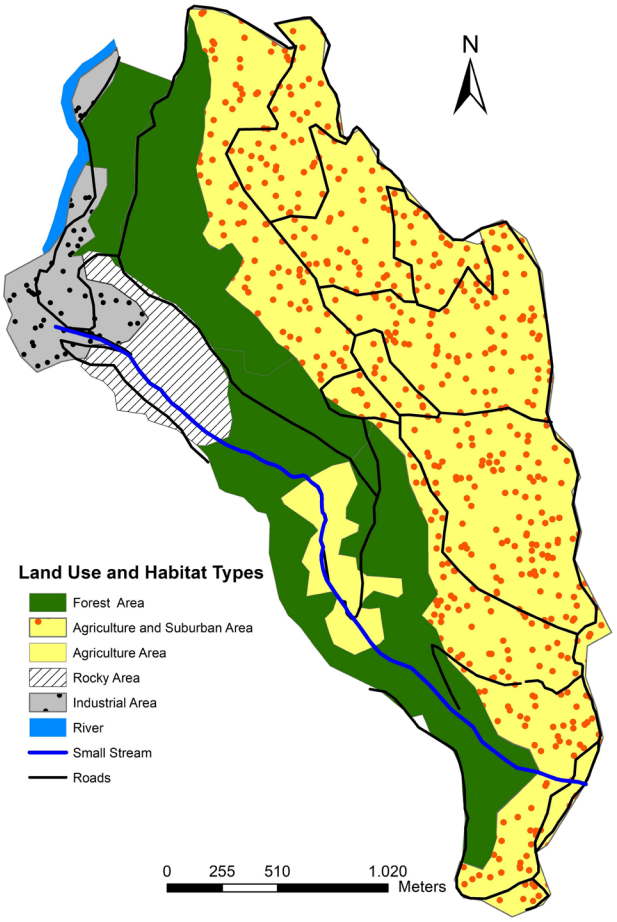

Figure 2 Land use and habitat types within the study area.

The relatively low sample size can be attributed to several factors, including (1) the high intensity of human activities in the study area; (2) the seasonal movement of shepherds to highland pastures for cattle and small livestock grazing during summer, accompanied by their herds, which results in an increased presence of shepherd dogs during the winter months; (3) the presence of free-ranging dogs within the study area; and (4) intensive hazelnut farming activities, particularly during July, August, and September.

Setting Camera Traps

Ten camera traps (Bushnell, Cuddeback, and Juo) were strategically placed on rocks and trees to capture images of woody plant species within the field, with a particular focus on those bearing fruit (Arpacık and Sarı 2022). The camera traps were checked monthly, and the images transferred to the computer were analyzed to determine whether golden jackals consumed fruits or seeds. Due to the limited number of camera traps, after images of golden jackals feeding on certain plants were taken every month, the camera traps were relocated to capture different plant species. To ascertain the fate of fruits that were not accessible to golden jackals while still on the tree, the camera traps were positioned to monitor the fruits once they had fallen to the ground. Some camera trap images were recorded as videos, while others were taken as photographs. In total, 25 plant species were monitored with camera traps. These species include *Arbutus andrachne* L., *Arbutus unedo* L., *Castanea sativa* Mill., *Cornus mas* L., *Cornus sanguinea* L., *Corylus maxima*

Figure 3 Comparison of seeds extracted from scat samples (left) with fruit and seed (middle and right) specimens collected from the field, belonging to *Eriobotrya japonica* (Thunb.) Lindl. (a), *Prunus avium* (L.) L. (b), *Cornus mas* L. (c), and *Prunus domestica* L. (d).

Mill., *Crataegus rhipidophylla* Gand., *Cydonia oblonga* Mill., *Diospyros lotus* L., *Eriobotrya japonica* (Thunb.) Lindl., *Ficus carica* L., *Juglans regia* L., *Ligustrum vulgare* L., *Malus sylvestris* (L.) Mill., *Mespilus germanica* L., *Morus alba* L., *Morus rubra* L., *Pistacia terebinthus* (L.), *Prunus avium* (L.) L., *Prunus domestica* L., *Prunus laurocerasus* L., *Pyrus communis* L., *Rosa canina* L., *Rubus idaeus* L. and *Vitis labrusca* L.

In total, we recorded 52 images of golden jackals through a camera trap survey and direct observations in our study area. In the research area, golden jackals utilized the entire region. The jackals in the study area were observed in groups of 1 to 4. It was even observed that they venture down to the coastal areas in the Trabzon province (Figure 4).

Figure 4 Images of golden jackals from the study area.

Identification of Plants

To identify the plant species, 44 woody plant samples were collected from our study area. It was ensured that the collected plant specimens were clean and intact, including generative and vegetative organs such as fruits, flowers, leaves, and buds. Damaged or diseased specimens were not collected, and efforts were made to represent the variation within the population. The location, habitat type, altitude, and sample collection dates were recorded, and the collected plant species were photographed during the study. The primary references for species identification were Davis (1965–1985, 1988), Güner et al. (2000), and plant specimens from the KATO herbarium. The scientific names of the plants were confirmed using the World Flora Online Plant List (December 2023 version) (WFO 2024). *Morus alba* and *Mespilus germanica* were found near small streams; *Prunus avium*, *Ligustrum vulgare*, *Arbutus unedo*, *Diospyros lotus*, *Malus sylvestris*, and *Crataegus rhipidophylla* were located in rocky areas; *Rubus idaeus, Rosa canina*, *Castanea sativa*, *Juglans regia*, and *Prunus domestica* were identified in forests. Additionally, *Corylus maxima*, *Cornus mas*, *Ficus carica*, *Eriobotrya japonica*, *Cerasus avium*, *Diospyros lotus*, *Cydonia oblonga*, *Pyrus communis*, *Malus sylvestris*, and *Vitis labrusca* were found in agricultural, forest, and suburban areas.

RESULTS

Fruit or seed consumption by golden jackals was documented for 20 distinct woody plant species within the study area (Table 1). Each positive scat sample contained the remains of between one and three different plant taxa, indicating a diverse fruit-based diet. Of these, 12 samples (57.1%) contained identifiable seeds or endocarp fragments attributable to various angiosperm taxa, indicating a considerable degree of frugivory in the diet of the focal species. More than one fruit or seed was also detected in a single scat. The number of plant taxa per scat sample ranged from one to three, suggesting individual variation in feeding events and potential overlap in fruit availability. Remains of *Diospyros lotus* were the most frequently encountered ones, occurring in 4 out of the 12 positive samples (33.3%) (Figure 4). *Ficus carica*, *Corylus maxima*, and *Prunus domestica* were each recorded in 3 samples (25%). Additional taxa detected in single samples (8.3%) included *Cornus mas*, *Arbutus unedo*, *Castanea sativa*, *Juglans regia*, *Cerasus avium*, *Malus sylvestris*, *Eriobotrya japonica*, *Pyrus communis*, *Mespilus germanica,* and *Vitis labrusca*.

Camera traps were strategically deployed at 25 fruit-bearing plant species to investigate frugivory behavior in golden jackals. A total of 16 frugivory-related photo/video records were obtained, corresponding to 10 plant species (Table 1). The highest number of detections was associated with *Diospyros lotus* (Figure 5) and *Eriobotrya japonica*, each with 3 independent records, representing 18.75% of all frugivory events. *Prunus domestica* and *Crataegus rhipidophylla* followed with 2 detections each (12.5%). The remaining six species, *Morus alba*, *Morus rubra*, *Ligustrum vulgare*, *Rosa canina*, *Rubus idaeus*, and *Mespilus germanica*, were each recorded in one instance, comprising 6.25% of the total detections per species.

Consumption of four species, *Diospyros lotus* (n=7), *Prunus domestica* (n=5), *Eriobotrya japonica* (n=4), and *Mespilus germanica* (n=2), was dually confirmed by both camera trap and analysis of scat matter. The findings from our observations confirmed the consumption of fruits and seeds from diverse plant species by the golden jackal across all seasons. In spring, *Prunus domestica, Eriobotrya japonica*; in summer, *Corylus maxima, Cornus mas, Arbutus unedo*, *Morus alba, Morus rubra, Ficus carica, Prunus domestica, Prunus avium, Malus sylvestris, Eriobotrya japonica, Rubus idaeus, Pyrus communis, Mespilus germanica*; in autumn, *Arbutus unedo*,

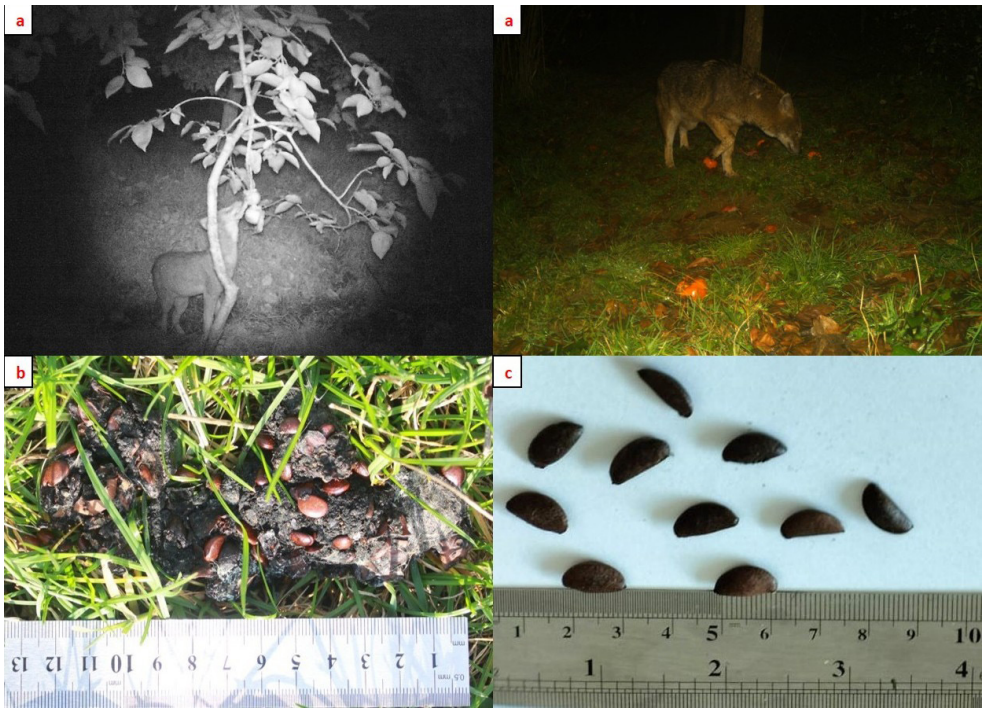

Figure 5 a) Camera trap images documenting *Diospyros lotus* consumption by golden jackals, b) scat samples, c) *Diospyros lotus* seed recovered from a scat sample.

Table 1 Woody plant species in the diet of the golden jackal: seasons of fruit and seed consumption and NPS/NPPV records (Sp = spring, Sm = summer, A = autumn, W = winter, F = fruit, S = seed, NPS = number of positive scats, NPPV = number of positive photos/video).

Family	Scientific name	Detected altitude (m)	Fruit/seed season	Eaten parts	NPS	NPPV
Betulaceae	*Corylus maxima* Mill.	80–400	Sm, A	S	3	-
Cornaceae	*Cornus mas* L.	20–580	Sm	F	1	-
Ebenaceae	*Diospyros lotus* L.	250–350	A	F	4	3
Ericaceae	*Arbutus unedo* L.	20–500	Sm, A	F	1	-
Fagaceae	*Castanea sativa* Mill.	20–500	A	S	1	-
Juglandaceae	*Juglans regia* L.	280–420	A	S	1	-
Moraceae	*Morus alba* L.	250–500	Sm	F, S	-	1
	Morus rubra L.	250–500	Sm	F, S	-	1
	Ficus carica L.	100–420	Sm, A	F, S	3	-
Oleaceae	*Ligustrum vulgare* L.	50–300	A, W	F, S	-	1
Rosaceae	*Prunus domestica* L.	240–480	Sp, Sm	F	3	2
	Prunus avium (L.) L.	225–495	Sm	F	1	-
	Malus sylvestris (L.) Mill.	180–505	Sm, A	F	1	-
	Eriobotrya japonica (Thunb.) Lindl.	30–450	Sp, Sm	F	1	3
	Rosa canina L.	40–460	A	F	-	1
	Rubus idaeus L.	210–520	Sm	F	-	1
	Pyrus communis L.	190–510	Sm, A	F, S	1	-
	Mespilus germanica L.	270–450	Sm, A	F	1	1
	Crataegus rhipidophylla Gand.	50–300	A, W	F	-	2
Vitaceae	*Vitis labrusca* L.	200–500	A	F	1	-

Ligustrum vulgare, Diospyros lotus, Corylus maxima, Castanea sativa, Juglans regia, Ficus carica, Malus sylvestris, Rosa canina, Pyrus communis, Mespilus germanica, Crataegus rhipidophylla, Vitis labrusca; and in winter, *Ligustrum vulgare, Crataegus rhipidophylla* (Table 1).

Forested areas accounted for the highest proportion of samples (47.6%), followed by agricultural–suburban areas (28.6%), agricultural areas (19%), and rocky areas (4.8%).

In the study area, golden jackals approached and sniffed the fruits or seeds of certain species but did not consume them. These species include *Pistacia terebinthus*, *Cornus sanguinea*, *Arbutus andrachne, Prunus laurocerasus* and *Cydonia oblonga*. Additionally, no camera trap images were obtained, indicating that the golden jackal did not eat the fruits or seeds of these species.

DISCUSSION

This study demonstrates that the golden jackal in the Trabzon region consumes a broad spectrum of fruits and seeds from at least 20 woody plant species, confirming its role as an opportunistic omnivore with a notable frugivorous component. This behavior suggests a significant degree of dietary plasticity and adaptability to local fruit availability (Markov and Lanszki 2012). The detection of multiple plant taxa in single scat samples and the seasonal variation in fruit consumption align with previous findings that jackals adjust their diet according to resource availability (Lanszki et al. 2006, Ćirović et al. 2016). The predominance of *Diospyros lotus* in both scat records and camera trap detections highlights the importance of this species as a seasonal food source, which is consistent with studies from other regions showing that jackals exploit highly abundant and energy-rich fruits when available. The detection of frugivory events throughout all seasons underscores the year-round importance of plant-derived food sources in the diet of jackals. The concordance between scat analysis and camera trap data for species such as *Diospyros lotus*, *Prunus domestica*, *Eriobotrya japonica*, and *Mespilus germanica* strengthens the reliability of the findings. Using both methods allowed a more comprehensive assessment of frugivory than relying on either alone. These species likely represent high-preference or high-availability fruits within the landscape.

Some research results indicate that golden jackals are opportunistic foragers rather than specialized hunters. The diet of golden jackals primarily consists of animals, but a significant portion of their diet is supplemented by plants, which has led to their classification as omnivores (Markov and Lanszki 2012, Bošković et al. 2013, Penezić and Ćirović 2015). The diet consists of 54% animal food and 46% plant food (Ivory 1999). In Croatia, wild fruits such as *Morus nigra*, *Prunus domestica*, *Prunus spinosa*, *Vitis vinifera*, *Ficus carica*, *Crataegus* spp., and *Rubus fruticosus* are found in their diet, especially during dry summers when they consume *Morus nigra* and greens more frequently (Radović and Kovačić 2010, Bošković et al. 2013). During the autumn and winter seasons, they have been observed eating *Pyrus pyraster* and *Malus communis* (Bošković et al. 2013). In Hungary, research has shown their consumption of *Prunus domestica* and

Prunus spinosa (Lanski et al. 2016), and in Bulgaria, the consumption of *Vitis vinifera*, *Malus sylvestris*, *Pyrus communis*, *Prunus domestica*, *Crataegus monogyna*, *Cornus mas*, and *Juglans regia* (Stoyanov 2012). In Serbia, the consumption of *Prunus cerasifera* Ehrh. and *Morus nigra* has been observed (Penezić and Ćirović 2015). The findings of this study provide compelling evidence of frugivory in golden jackals in the study region, highlighting their opportunistic and omnivorous feeding behavior (Ćirović et al. 2016, Lanszki et al. 2016). Seasonal patterns observed in the study also reflect the phenological dynamics of local vegetation in the eastern Black Sea region. The diversity of fruit species consumed in summer and autumn corresponds to the period of peak fruit availability, whereas winter consumption was limited to only a few species, such as *Ligustrum vulgare* and *Crataegus rhipidophylla*, whose persistent fruits remain accessible during colder months. Golden jackals rely on persistent winter fruits during periods when alternative food resources are scarce.

Scat analysis supported the camera trap findings and revealed additional plant taxa not recorded in direct observations, possibly due to the consumption of fruits in less accessible microhabitats or during unmonitored hours. The presence of identifiable seeds and endocarp fragments in over half of the analyzed scat samples (57.1%) strongly confirms the incorporation of fruits in the jackals' diet. The variation in the number of plant taxa per scat (1–3 taxa) further indicates flexible foraging behavior and potentially reflects temporal variation in fruit availability.

The identification of fruit consumption across multiple plant families, notably Rosaceae (nine species), Moraceae (three species), and others, suggests that golden jackals do not specialize on a particular taxonomic group but rather exploit a wide range of available fruiting plants. This diverse frugivorous behavior may contribute to seed dispersal and ecosystem functioning, as has been documented in other medium-sized carnivores (Herrera 1989).

Interestingly, camera trap data also revealed that jackals approached but did not consume the fruits of several species, such as *Pistacia terebinthus*, *Cornus sanguinea*, *Arbutus andrachne*, *Prunus laurocerasus*, and *Cydonia oblonga*. This avoidance could be attributed to factors such as unpalatability, low nutritional value, or the presence of chemical deterrents. The lack of camera trap images associated with these species strengthens the inference of selective frugivory.

Overall, our results reinforce the role of golden jackals as facultative frugivores capable of exploiting seasonally and spatially variable fruit resources. Their ability to shift between animal-based and plant-based food sources underscores their ecological versatility, particularly in heterogeneous or human-modified landscapes. The plant assemblage represented in the scats comprises both wild and cultivated fruit species, indicating opportunistic foraging behavior. The detection of multiple taxa within individual scat samples supports the hypothesis of a generalist frugivorous feeding strategy and highlights the species' potential ecological role as a vector for endozoochorous seed dispersal in the study area.

CONCLUSIONS

This study demonstrates that frugivory is a consistent and ecologically significant component of the diet of the golden jackal in the eastern Black Sea region of Türkiye. Using complementary evidence from scat analysis and camera trapping, we documented the consumption of fruits and seeds from 20 woody plant species, indicating broad dietary flexibility and opportunistic foraging behavior. Fruit and seed use showed clear seasonal patterns aligned with local phenology, with peak diversity in summer and autumn and the reliance on persistent fruits during winter. The repeated detection of key species, particularly *Diospyros lotus*, *Prunus domestica*, and *Eriobotrya japonica*, highlights the importance of woody plants as reliable food resources. The integration of indirect and direct methods strengthened dietary inference and revealed plant taxa that would likely be underestimated using a single approach. Overall, the results confirm that golden jackals in the Trabzon landscape function as facultative frugivores with high dietary plasticity, capable of exploiting both wild and cultivated fruit resources across heterogeneous and human-modified habitats. The baseline data presented here contribute to a better understanding of golden jackal feeding ecology in Anatolia and can inform future studies on human–wildlife coexistence, as well as ecosystem functioning in the region.

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