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Short Note

Mahmood Soofi, Ali Turk Qashqaei*, Achyut Aryal and Sean C.P. Coogan

Autumn food habits of the brown bear *Ursus arctos* in the Golestan National Park: a pilot study in Iran

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Abstract: Food consumed by brown bears in the Golestan National Park in Iran was analyzed during autumn 2011. We identified 22 food items in 61 scats, with the most important food items being hawthorn fruit, cherry plum fruit and chestnut-leaved oak hard mast, based on importance value (IV) estimates of 26.4%, 18.1% and 12.9%, respectively. The overall bear diet (percent digestible dry matter) was composed of 77.9% soft mast (i.e. fruit), 21.3% hard mast and small proportions of other vegetation (0.3%) or animal matter (0.4%). One anthropogenic food was identified (vine grape) and was of minor importance (IV = 0.2%).

Keywords: brown bear; conflict; diet; digestible dry matter; scat; *Ursus arctos*.

Diet influences most aspects of an animal's biology (Simpson and Raubenheimer 2012). For brown bears (*Ursus arctos* Linnaeus, 1758), food resources and their nutritional properties are critical factors affecting their hibernation and reproduction (López-Alfaro et al. 2013), habitat selection (Nielsen et al. 2010) and population density (Nielsen et al. 2016), among others. Furthermore, conflict between humans and brown bears often revolves around shared food resources and is an issue of global concern (Can et al. 2014, Coogan and Raubenheimer 2016).

In Iran, brown bears are often killed to protect anthropogenic food resources, often during autumn (Qashqaei et al. 2012, 2014). There are, however, relatively few studies investigating the foraging ecology and diet of brown bear in the country (e.g. Gutleb and Ziaie 1999, Nezami and Farhadinia 2011, Nezami Balouchi 2014). Recent research suggests that the brown bear is largely herbivorous in northern and southwestern Iran (Motaghian et al. 2012, Qashqaei et al. 2012, Nezami Balouchi 2014), leading to human-bear conflicts in some areas, such as the Central Zagros (Qashqaei et al. 2012, 2014).

The aim of this study was to better understand the food habits of the brown bear in Iran, focusing on the Golestan National Park (GNP), a region in which little is known about the brown bear diet. Our data was collected in autumn, a period when bears consume food resources in preparation for hibernation and when human conflict is often high. This study will improve our knowledge of the main natural food resources for brown bears in the GNP, as well as help identify anthropogenic foods consumed by bears; this will improve our understanding of the source of human-bear conflicts in the region.

The GNP (55°43′–56°17′ E, 37°16′–37°31′ N) was Iran's first biosphere reserve established in 1957 (Firouz 2005). The GNP covers 87,402 ha and is home to almost 20% of Iran's flora (Akhani et al. 2010). The elevation ranges from 450 m to 2411 m, with a mean annual precipitation and a mean annual temperature from east to west of 150–700 mm and 11.5°C–17.5°C, respectively (Khorozyan et al. 2015). There are no settlement and farming activities inside the GNP; however, there are 34 villages around the park, and a highway passes through the middle of the park (Khorozyan et al. 2015). The park is home to other large carnivores including the Persian leopard (*Panthera pardus saxicolor* Pocock, 1927) and gray wolf (*Canis lupus* Linnaeus, 1758), and several potential prey species, such as the Caspian red deer (*Cervus elaphus maral* Gray, 1850), roe deer (*Capreolus capreolus* Linnaeus, 1758), wild boar (*Sus scrofa* Linnaeus, 1758), wild sheep (*Ovis vignei* Blyth, 1841) and wild goat (*Capra aegagrus* Erxleben, 1777). The

***Corresponding author: Ali Turk Qashqaei,** Plan for the Land Society, PO 1689733767, Tehran, Iran, e-mail: a.t.qashqaei@gmail.com
Mahmood Soofi: Workgroup on Endangered Species, J.F. Blumenbach Institute of Zoology and Anthropology, Georg-August University of Göttingen, Göttingen, Germany
Achyut Aryal: School of Life and Environmental Sciences and the Charles Perkins Centre, University of Sydney, Sydney, NSW 2006, Australia; Department of Forest and Resource Management, Toi Ohomai Institute of Technology, Rotorua 3046, New Zealand; and Faculty of Science and Technology, Federation University of Australia, Ballarat, Australia
Sean C.P. Coogan: School of Life and Environmental Sciences and the Charles Perkins Centre, University of Sydney, Sydney, NSW 2006, Australia; and Department of Renewable Resources, University of Alberta, Edmonton, AB, T6G 2E9, Canada

population density of bears in the study area has not been evaluated; however, their relative abundance in the region is low (Hamidi et al. 2014).

We collected 61 bear scats opportunistically along wildlife trails from late September to the end of December 2011. Scats were collected throughout three habitat classes in the GNP: steppe (north and east of the GNP); forest (middle to west of the GNP); and transition zone, which occurs between the two (middle GNP). Based on the experience of MS, bear scats were unambiguously identified, and dubious scats were disregarded. Fresh scats containing only one clearly identifiable food were identified in the field without collection (n = 44), while both fresh scats containing more than one food item and all relatively older scats (n = 17) were collected in plastic bags and transported to the laboratory for identification. For reference, we collected fruit seeds and mammal species' hair from the GNP during June 2010–December 2011.

Scats were soaked in water and liquid detergent for 24 h, and then washed through a 1-mm sieve (Paralikidis et al. 2010). Food items were separated using forceps and then air-dried in paper bags. Fruit seeds and prey hairs were identified by MS using our reference collection and a hand lens or microscope (Nikon, 10× and 40× magnifications) when necessary (Aryal et al. 2014, 2015a,b).

We calculated the frequency of occurrence (FO%) of items following Dahle et al. (1998) and Klare et al. (2011):

$$\text{FO\%} = \frac{\text{Number of scats in which food item } (i) \text{ occurred}}{\text{Total number of scats}} \times 100.$$

We estimated the volume of items in each scat, based on the following five categories: <1; 1–25; 25–50; 50–75; and 75–100. For each category, we assigned mean values: 1%, 12.5%, 37.5%, 62.5% and 87.5%, respectively (Hashimoto et al. 2003). To determine the importance value (IV%) of each item, we estimated the average percent volume ($V\%_{item}$) of item per scat following Hashimoto et al. (2003) and Paralikidis et al. (2010):

$$V_{item}\% = \frac{\Sigma \text{Percent of volume of item } (i) \text{ in scat } (j)}{\text{Number of scats in which food item } (i) \text{ occurred}}.$$

We estimated the IV% of food items (an estimate of the importance of consumed foods) following Sumner and Craighead (1973):

$$\text{IV\%} = \frac{\text{FO\% of item } (i) \times \text{V\% of item } (i)}{100}.$$

To determine the overall diet composition of bears, we first calculated the volume of food items as a percentage of total scats ($V\%_{diet}$). To account for differences between volume of foods ingested and volume of residues found in scats, we applied correction factors (CFs) to $V\%_{diet}$ estimates following Hewitt and Robbins (1996) and López-Alfaro et al. (2015) to determine the percent digestible dry matter (DDM) consumed. Because food-specific CFs for items in the diet of brown bears were not available, we grouped food items into four categories: (1) soft mast (i.e. berries); (2) hard mast (e.g. oaks and Greek juniper fruit); (3) other vegetation; and (4) animal matter. A complete list of all food items in each category is given in Table 1. We applied the following CFs to each food category: 1.2 for soft mast; 1.5 for hard mast; and 0.26 for vegetation (Hewitt and Robbins 1996, López-Alfaro et al. 2015). We used the CF for ungulates (3) when estimating the contribution of wild boar to the diet because boar-specific CFs were not available (Hewitt and Robbins 1996, López-Alfaro et al. 2015).

A total of 61 scats were collected from three habitats (steppe = 20 scats, forest = 26, transition zone = 15) across 23 sampling sites (steppe = 8 sites, forest = 12, transition zone = 3). Fifty-three scats (86.9%) included only one food item, 7 (11.5%) had two items and one scat (1.6%) contained six items. The average number of items per scat was 1.2 ± 0.7 standard deviation (SD). We identified 22 food items across the four groups: vegetation (FO = 1.6%, IV = 1.6%); soft mast (83.6%, 82.8%), hard mast (18.1%, 17.5%) and animal matter (1.6%, 0.2%) (Table 1). The most important food items were hawthorn (*Crataegus ambigua*; IV = 26.4%), cherry plum (*Prunus divaricata*; IV = 18.1%) and chestnut-leaved oak (*Quercus castaneifoli*; IV = 12.9%) (Table 1). In total, four species were found in scats collected from both the steppe and forest habitats, while *C. ambigua* was the only species found in scats collected from all habitat types (see Table 1). The most important plant families identified were Rosaceae (IV = 73.9%) and Fagaceae (IV = 14.5%) (Table 2). After applying CFs, soft mast (DDM = 77.9%) and hard mast (DDM = 21.3%) represented the highest proportion of the bear diet, with relatively minor amounts of vegetation (DDM = 0.3%) or animal (DDM = 0.4%) matter consumed (Table 3). The only anthropogenic food item found in scats was vine grape (*Vitis vinifera*), which had among the lowest FO% and IV% scores (Table 1).

Brown bears may consume very little terrestrial prey during the late summer and autumn when fruit and hard mast are available (Welch et al. 1997, Dahle et al. 1998, Rode and Robbins 2000, López-Alfaro et al. 2015). Our results also follow this pattern, with a high prevalence of soft and hard mast in the autumn diet composition, while there was a very low occurrence of animals, with only the wild boar being detected. The brown bear is a carnivorous omnivore which can forage on a wide variety

Table 1: Food items in brown bear scats (n = 61) collected from the Golestan National Park, with frequency of occurrence (FO%), volume per item (V_{item}%), importance value (IV%) for each item and availability of mast.

Food items	FO%	$V\%_{item}$	IV%	Availability of mast	Habitat
Vegetation (total)	1.64	100	1.64		
False brome grass, *Brachypodium* sp.	1.64	12	0.2		S
Rye grass, *Lolium* sp.	1.64	87	1.42		S
Soft mast (total)	83.6	99.05	82.81		
Cotoneaster, *Cotoneaster* sp.	1.64	100	1.64	Aug–Oct	S
Hawthorn, *Crataegus microphylla*	3.27	6.5	0.21	Oct–Jan	S, F
Hawthorn, *Crataegus ambigua*	27.86	94.82	26.41	Oct–early Jan	F, T, S
Black hawthorn, *Crataegus pentagyna*	4.92	95.66	4.7	Oct–early Jan	S, F
Wild apple, *Malus orientalis*	4.92	67	3.38	Oct–Dec	S
Medlar, *Mespilus germanica*	6.55	100	6.55	Oct–late Dec	F
Cherry plum, *Prunus divaricata*	18.03	100	18.03	Sep–Oct	S, F
Wild pear, *Pyrus boissieriana*	9.83	83.5	8.2	Sep–Oct	S
Blackberry, *Rubus dolichocarpus*	1.64	100	1.64	Aug–Nov	S
Dog rose, *Rosa canina*	6.55	75.25	4.92	Oct–Dec	S, F
Angelica tree, *Fraxinus excelsior*	1.64	100	1.64	Sep–Dec	T
Date plum, *Diospyros lotus*	3.27	50.5	1.65	Oct–Dec	F
Alexanderian laurel, *Danae racemosa*	1.64	100	1.64	Oct–Dec	F
Vine grape, *Vitis vinifera*	1.64	12	0.2	Sep–Oct	S
Wild grape, *Vitis sylvestris*	1.64	12	0.2	Sep–Oct	S
Honeysuckle, *Lonicera nummularifolia*	1.64	100	1.64	Sep–Nov	S
Hard mast (total)	18.03	97.27	17.53		
Chestnut-leaved oak, *Quercus castaneifoli*	13.11	98.37	12.9	Sep–Feb	F
Persian oak, *Quercus macranthera*	1.64	100	1.64	Sep–Feb	S
Greek juniper, *Juniperus excelsa*	3.27	100	3.27	Sep–early Jan	S
Animals (total)	1.64	12	0.2		
Wild boar, *Sus scrofa*	1.64	12	0.2		S

The habitat of collection is indicated: steppe (S), forest (F) or transition zone (T).

Table 2: Family, number of species, FO%, $V\%_{item}$ and IV% of plants identified in brown bear scats (n = 61) in the Golestan National Park during autumn 2011.

Plant family	Identified species	Number and (FO%)	$V\%_{item}$	IV%
Poaceae	2	1 (1.64)	100	1.64
Rosaceae	10	48 (78.68)	93.87	73.85
Oleaceae	1	1 (1.64)	100	1.64
Ebenaceae	1	2 (3.27)	50.5	1.65
Asparagaceae	1	1 (1.64)	100	1.64
Vitaceae	2	2 (3.27)	12	0.4
Caprifoliaceae	1	1 (1.64)	100	1.64
Fagaceae	2	9 (14.75)	98.55	14.53
Cupressaceae	1	2 (3.27)	100	3.27

Table 3: Percent digestible dry matter content (DDM) of the four food groups found in brown bear scats.

	Vegetation	Soft mast	Hard mast	Animal
$VO\%_{diet}$	1.64	80.56	17.64	0.16
CF	0.26	1.2	1.5	3
DDM	0.3	77.9	21.3	0.4

DDM was calculated by applying correction factors (CFs) to percent volume estimates of each food category to the overall diet ($VO\%_{diet}$) following Hewitt and Robbins (1996) and López-Alfaro et al. (2015).

of food (Aryal et al. 2012, Coogan et al. 2014), and has been shown to prefer a relatively high ratio of carbohydrates and lipids in its diet relative to protein (Erlenbach et al. 2014). The high consumption of typically high-carbohydrate soft mast and high-lipid hard mast found in our study may, therefore, reflect brown bear foraging preferences; however, more work is needed to determine the relationships between bear diet and food availability in this ecosystem.

Khaleghizadeh and Khormali (2005) reported bears damaging common sunflower (*Helianthus annuus*) crops in the village of Bidak outside the southern park boundary during summer and autumn 2002–2003; yet, in our study we found only limited consumption of vine grape. Brown bears may increase consumption of anthropogenic foods when natural resources are scarce (Coogan and Raubenheimer 2016). For example, bears may seek out food high in carbohydrates and lipids from anthropogenic sources when such foods are less available in nature (Coogan and Raubenheimer 2016). The low proportion of anthropogenic foods and the absence of reported conflicts during our study suggest that mast was relatively abundant; however, we did not survey outside of the park during this study.

In the GNP, local people illegally pick wild fruits and other edible plants (e.g. *Crataegus pentagyna*, *Prunus divaricata* and *Mespilus germanica*) and this could possibly create human-bear conflicts and also affect food availability for the bears. In such cases, bears may seek out alternatives from anthropogenic sources (e.g. crops and orchards), thereby exacerbating human-bear conflicts. We suggest that human harvesting of wild bear foods be monitored in the region; preventing excessive competition for soft mast between bears and humans may avert conflicts during this period.

We acknowledge the shortcomings of our pilot study, with a low sample size and data collection during a single season; however, the information we provide is a valuable step in understanding brown bear ecology in the region. Further studies are needed, such as the assessment of patterns of bear-human conflicts and larger scale diet studies across the brown bear active season. Given the relationships between nutrition and foraging behavior, incorporating nutritional analyses into diet studies would be crucial.

Furthermore, scat CFs for bears have been developed in a few ecosystems (e.g. Hewitt and Robbins 1996, Bjorska and Selva 2013), and further development of food-specific CFs for Iran and other ecosystems is needed to improve the estimation of diet composition of the brown bear worldwide.

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