BioOne COMPLETE

Sympatric mongoose species may opt for spatial adjustments to avoid feeding competition at Margalla Hills National Park Islamabad, Pakistan

Authors: Hira, Fatima, Mahmood, Tariq Janjua, Sakhawat, Ali, Faraz, Akrim, Muhammad, Farooq, et al.

Source: Wildlife Biology, 2020(2)

Published By: Nordic Board for Wildlife Research

URL: https://doi.org/10.2981/wlb.00654

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Downloaded From: https://bioone.org/journals/Wildlife-Biology on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Wildlife Biology 2020: wlb.00654
doi: 10.2981/wlb.00654
© 2020 The Authors. This is an Open Access article
Subject Editor: John Ball. Editor-in-Chief: Ilse Storch. Accepted 16 February 2020

Sympatric mongoose species may opt for spatial adjustments to avoid feeding competition at Margalla Hills National Park Islamabad, Pakistan

Fatima Hira, Tariq Janjua Mahmood, Ali Sakhawat, Akrim Faraz, Farooq Muhammad and Andleeb Shaista

F. Hira, T. J. Mahmood (http://orcid.org/0000-0002-2432-7732) ✉ (tariqjanjua75@uaar.edu.pk), A. Faraz, F. Muhammad and A. Shaista, Dept of Wildlife Management, PMAS Arid Agriculture Univ., Rawalpindi 46300, Pakistan. AF also at: Dept of Zoology, Univ. of Kotli, Kotli, Azad Jammu & Kashmir (AJ&K), Pakistan. – A. Sakhawat, Islamabad Wildlife Management Board, Islamabad, Pakistan.

We investigated the occurrence and diet of two sympatric mongoose species; the small Indian mongoose *Urva auropunctatus* and the grey mongoose *Herpestes edwardsii* inhabiting Margalla Hills National Park, Islamabad, Pakistan. The two species occurred in the park at elevations between 537 m and 1363 m a.s.l., with the grey mongoose occurring at higher elevations than the small Indian mongoose. Out of 23 sites sampled, only three were common to both mongoose species. The diet of mongooses, determined through food remains in scats, comprised of small mammals (rodents, shrews), insects, birds, reptiles and seeds and fruits. Rodents were the most frequently-consumed prey species of both mongooses during summer and winter, whereas insects were consumed more frequently during the summer. The small Indian mongoose showed a wider niche breadth than the grey mongoose, but the overall dietary overlap between the two mongoose species was high with a value of 0.93. Our results support the idea that these sympatric mongoose species may reduce interspecific competition for food with each other through spatial adjustments in their habitat use.

Keywords: diet, distribution, *Herpestes*, Margalla Hills National Park, mongooses, niche, Pakistan, sympatric

The survival of a predator is dependent upon the quality and quantity of its diet (Melville 2004) and determination of food resources is important in order to analyse the interspecific interactions between coexisting wildlife species. Categorization of the food resource among species is also important in order to analyze the kind of interactions between the coexisting species (Taper and Marquet 1996). The feeding niches of species may also overlap in terms of spatial resources (Johnson et al. 1996) and predators often selectively prey upon different taxa, age classes and body sizes of prey species which facilitates coexistence among them (Karanth and Sunquist 1995). The sympatric species that overlap in resource requirements are often considered to have co-evolved in the same environment to minimize inter-specific competition between them. The competition allows predators to evolve different strategies for co-existence with sympatric species to fit in a variety of ecological conditions. The divergences in behavior may separate the feeding niches, minimize inter-specific competition facilitating coexistence of sympatric species (Sunquist and Sunquist 1989). Investigating the diets of predators may thus be crucial to understand life-history strategies and to develop conservation recommendations (Miquelle et al. 1996).

Mongooses (genus *Herpestes*, family Herpestidae, order Carnivora) are classified into two groups; one group in small sized but social species whereas the other group includes large-sized and solitary species (Veron et al. 2004). They occur widely throughout the tropics and sub-tropics (Corbet and Hill 1992) but they do not occur in North America. Pakistan harbors two species of mongooses, the small Indian mongoose *Herpestes javanicus* and the other is the grey mongoose *Herpestes edwardsii* (Corbet and Hill 1992, Wilson and Reeder 1993, Roberts 1997). Both species are distributed widely in the country occupying all four provinces (Roberts 1997) and play important roles in ecology of the community by consuming a variety of prey species including both invertebrates and vertebrates. For example, the small Indian mongoose feeds upon different prey items including invertebrates, amphibians, reptiles, birds and mall mammals, some of the populations of this species are predominantly

This work is licensed under the terms of a Creative Commons Attribution 4.0 International License (CC-BY) <http://creativecommons.org/licenses/by/4.0/>. The license permits use, distribution and reproduction in any medium, provided the original work is properly cited.

Downloaded From: https://bioone.org/journals/Wildlife-Biology on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

insectivorous whereas others may feed on fruits for at least a part of the year (Seaman and Randall 1962). The grey mongoose is an opportunistic hunter, consuming a variety of food items including mice, rats, lizards, snakes, beetles, ground birds as well as their eggs, and fruits, berries and roots (Santiapillai et al. 2000, Postanowicz 2002).

Small Indian mongoose and the grey mongoose are sympatric in many parts of Pakistan, but information on their relative distribution and dietary comparison is lacking. In this study, we compared the two species' distribution and their dietary composition. We also assessed dietary niche breadth for each species and their dietary niche overlap. Our aim was to explore the possible strategies used by these two sympatric species to cope with potential interspecific competition (such as spatial partitioning) following studies by Fedriani et al. (1999), Azevedo et al. (2006) and Drouilly et al. (2018).

Material and methods

Study area

The current study was conducted in the Margalla Hills National Park (MHNP) Islamabad, Pakistan (33°43′N, 73°55′E) (Fig. 1). The park covers an area of 15 883 ha with some rugged terrain (Rasheed et al. 2005). The elevation ranges from 450 to 1580 m a.s.l. (Jabeen et al. 2009). The climate is humid subtropical, with hot summers followed by monsoon season, and accompanied by mild and wet winter seasons. There are two rainy seasons each year; the summer monsoon (July–September) with heavy rainfall and evening thunderstorms and the winter rainy season (January–March). Average minimum and maximum temperatures are 19.5°C and 33.3°C, respectively (Hussain 1986) and mean annual rainfall is about 940 mm. Average relative humidity during the monsoon period varies between 59% and 67% (Masroor 2011).

Study design

The study area was surveyed between August 2015 and July 2017 to record direct (field sightings and road kills) and indirect (scats) signs of the two mongoose species. Potential sampling sites were selected, mainly focusing on the criteria of presence or absence of direct sightings and the scats of the targeted species and also based on the knowledge of the staff of the department of wildlife and local inhabitants. Data collection was conducted during fortnightly field visits that lasted for three consecutive days. The scats of each mongoose species were identified using criteria including their typical shape, smell and color. More importantly, both these species exhibit the behavior of forming latrines near their burrows which prevents errors in identification, so scat collection was preferred from these sites with confirmed visual species identification. The collected scats were further confirmed in the laboratory by measuring their length, breadth and weight, as mentioned in the previously published studies (Hussain et al. 2017, Akrim et al. 2019) and found that grey mongoose scats are comparatively larger in all respects than small Indian mongoose. Geographical coordinates and elevation of the positive locations were recorded for each collection site using a global positioning system (GPS) handheld

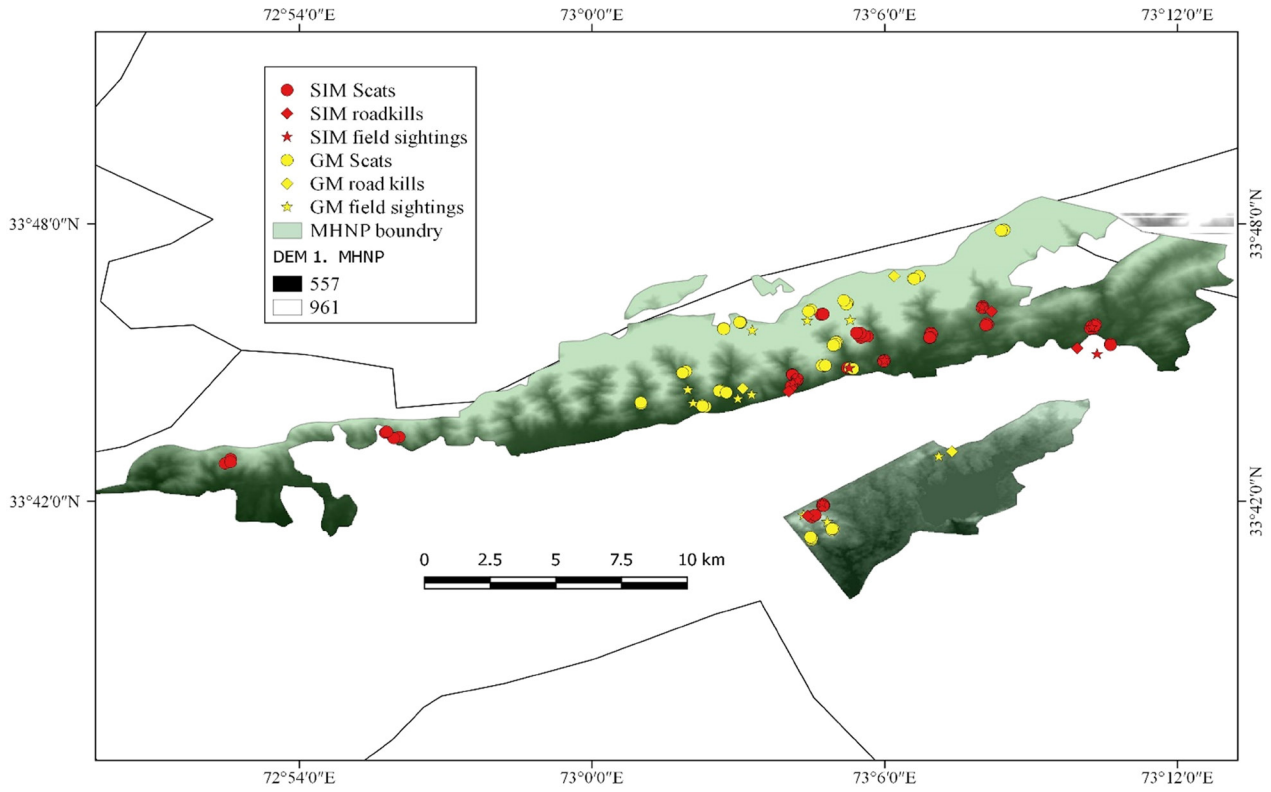


Figure 1. Distribution of two sympatric mongoose species (the small Indian mongoose: *Herpestes auropunctatus* and the grey mongoose; *H. edwardsii*) in the MHNP, Pakistan, between August 2015 and July 2017.

Downloaded From: https://bioone.org/journals/Wildlife-Biology on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

unit. The scats were stored in a deep freezer to avoid any fungal growth until the final analysis.

To identify the remains of prey species in the scat samples of the two mongoose species, reference material of potential food items (both animal and plant prey) were collected from the Park. Likewise, bones of amphibians, reptiles, birds, feathers of birds, invertebrates and fruits of plants were collected as a reference material. We also performed light microscopy (whole mount slides) of the hairs of prey species recovered from the scats of the mongooses, to identify their mammalian prey.

Methodology

Distribution

Information generated from collected scats, direct field sightings, recovered road kills of the two mongoose species were used to develop distribution maps of the two mongoose species using the Quantum Geographical Information System (QGIS, ver. 2.14.14; Quantum GIS Development Team 2012).

Diet analysis

The diet composition of the two mongoose species was investigated using the method of identification of the undigested remains detected in the scat samples. During analysis, the scats were temporarily placed in a warm, dry and sunny place to avoid damage by fungus and to dry them for further process. After drying, the scats were analyzed in the laboratory following Jackson and Hunter (1996). The hair-mounting technique is widely used to determine the diet composition of a variety of carnivore species (Ackerman et al. 1984, Leopold and Krausman 1986, Reynolds and Aebischer 1991, Jackson and Hunter 1996). For this procedure, microscopic slides of the hairs of prey species obtained from scat analysis were prepared by mounting the hair in DPX (Distyrene Plasticizer Xylene; a colorless synthetic resin). The identification of prey species was done from the medullary pattern of the hair as described by Moore et al. (1974) and also on the basis of cuticle cast pattern. Slides of hairs obtained from scats were matched with those of reference hair slides to identify the prey species. To observe the cuticle pattern of hairs, slides of scales of reference hairs of potential prey species and those recovered from the scats were prepared following Lavoie (1971).

Microphotographs of reference hairs of the representative medulla, scale patterns and plant materials were taken using an electronic eyepiece camera attached to the light microscope.

Plant remains (seeds, stems, leaves etc.) recovered from the scats of the mongoose species during analysis were identified by comparing those with the reference plant materials collected from the same sampling sites of the Park. All recovered seeds and fruit residuals along with reference material gathered from study area for identification were sent to Department of Plant Sciences, Quaid-e-Azam University, Islamabad in Plant Systematic and Biodiversity Lab for correct identification of plant remains as an expert opinion.

Feeding niche

Feeding niche breadth of each mongoose species occurring in the park was calculated by using the standardized Levin's index (*Lst*) (Levins 1968, Colwell and Futuyma 1971) by using following formulae:

$$L = \left(\sum_{i=1}^{n} p_i^2 \right)^{-1} \text{ and } Lst = \frac{L-1}{n-1}$$

where *Lst* is the standardized niche breadth, p_i is the relative percentage of food item *i* and *n* is the number of food items.

Levin's index is a value ranging from 0 to 1. A higher *Lst* indicates a broader dietary niche of the animal.

Pianka's index (Pianka 1973, 1974) based on the frequency of occurrence of each prey category, ranging from zero (signifying no overlap) to one (complete overlap) was used to compute the feeding niche overlap between the two mongoose species using the formula:

$$Qjk = \frac{\sum_i^n P_{ij} P_{ik}}{\sqrt{\sum_i^n p_{ij}^2 \sum_i^n p_{ik}^2}}$$

where p_{ij} (or p_{ik}) is the relative percentage of food item *i* in diet *j* (or *k*).

Prey species indices

Prey species richness (*S*); was estimated by taking into account the total number of animal and plant prey species consumed by each mongoose species in a specific season. Diversity index (*H′*), was measured by using the following formula:

$$H' = -\Sigma \left[pi \times \ln pi \right]$$

where *pi* represents the prey index.

The evenness index (*E*), was calculated by using the formula:

$$E = H' / \ln S$$

Results

Occurrence of mongoose species

The small Indian mongoose and the grey mongoose were found in the MHNP, Islamabad at different sites ranging from 537 m to 1363 m a.s.l. (Table 1). The grey mongoose was recorded at higher elevations than the small Indian mongoose (Table 1). The small Indian mongoose was present at eleven sites whereas the grey mongoose occurred at twelve different sites (Fig. 1). There were only three sampling sites common to both mongoose species for occurrence (Table 1, Fig. 1).

Diet analysis

Scat analysis (n = 58 for small Indian mongoose; n = 53 for the grey mongoose; Fig. 2) of both mongoose species revealed vertebrate and invertebrate prey items along with plant matter (seeds, stem parts and leaves), and some anthropogenic

Downloaded From: https://bioone.org/journals/Wildlife-Biology on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Table 1. Distribution records of the small Indian mongoose and the grey mongoose in the Margalla Hills National Park, Islamabad, Pakistan, between August 2015 and July 2017. +: present, −: absent.

Sample site no.	Site name	Geographic coordinates	Elevation (m)	Small Indian mongoose	Grey mongoose
1	Shahdra	33°76′84.27″N, 73°16′60.50″E	721	+	−
2	Bri-Imam Trail	33°76′74.24″N, 73°12′14.05″E	871	+	−
3	Pir-Sohawa	33°77′82.25″N, 73°09′99.13″E	1246	−	+
4	Trail-6A	33°77′06.43″N, 73°09′00.87″E	1064	+	+
5	Trail-5A	33°75′96.74″N, 73°08′06.80″E	764	+	+
6	Trail-5B	33°76′26.25″N, 73°08′55.04″E	976	+	−
7	Trail-3	33°75′47.45°N, 73°74′76.0″E	1025	−	+
8	Talhaar	33°76′61.95°N, 73°04′88.95″E	947	−	+
9	Saidpur Trail	33°75′08.21°N, 73°06′62.65″E	713	+	−
10	Gokina	33°76′78.52°N, 73°06′80.72″E	967	−	+
11	Nariyas	33°79′93.19°N, 73°14′68.34″E	1363	−	+
12	Ratta Hottar	33°75′61.46°N, 73°09′93.14″E	663	+	−
13	Trail-2	33°73′82.00°N, 73°05′57.94″E	721	−	−
14	Trail-4	33°74′13.28°N, 73°04′15.36″E	796	−	+
15	Trail-6 (Faisal Masjid)	33°75′47.04°N, 73°02′61.39″E	891	−	+
16	Klinjer Trail	33°74′26.38°N, 73°01′68.52″E	736	−	+
17	Sinyaari	33°73′84.26°N, 72°99′98.44″E	693	−	−
18	Chauntra	33°73′25.60°N, 72°98′15.75″E	866	−	−
19	Shah-Allah Ditta	33°72′20.98°N, 72°92′07.46″E	780	+	−
20	Dhoke Jouri	33°71′10.05°N, 72°87′60.97″E	699	+	−
21	Rumli	33°76′09.73°N, 73°13′34.86″E	655	+	−
22	Shakar Pariyan	33°69′08.13°N, 73°08′12.15″E	549	+	+
23	Rawal Lake	33°71′24.21°N, 73°11′65.24″E	537	−	+

material (Table 2). The most frequently-recovered prey remains from scats were hairs, followed by bones, feathers, scales (reptiles) and egg shells. Invertebrate prey remains were found in both mongoose species, whereas snail remains only in grey mongoose scats, and egg shell remains only in small Indian mongoose scats (Table 2).

Prey species

In the diet of both mongooses, six species of mammals, birds, reptiles, insects (three orders), domestic poultry, plant species and some anthropogenic matter were identified. The small Indian mongoose consumed nine plant species whereas the grey mongoose consumed seven (Fig. 2).

Among mammals, house mouse *Mus musculus* were most frequently consumed by both mongoose species, followed by house rat *Rattus rattus*, Indian gerbil *Tatera indica*, Asian shrew *Suncus murinus* and Indian mole rat *Bandicota bengalensis* whereas Asian palm squirrel *Funambulus pennantii* was least frequently consumed by both mongoose species. Among insects, Hymenoptera (ants, wasps, bees) were most frequently consumed, followed by Coleoptera (beetles) and Orthoptera (grasshopper). Both mongoose species also

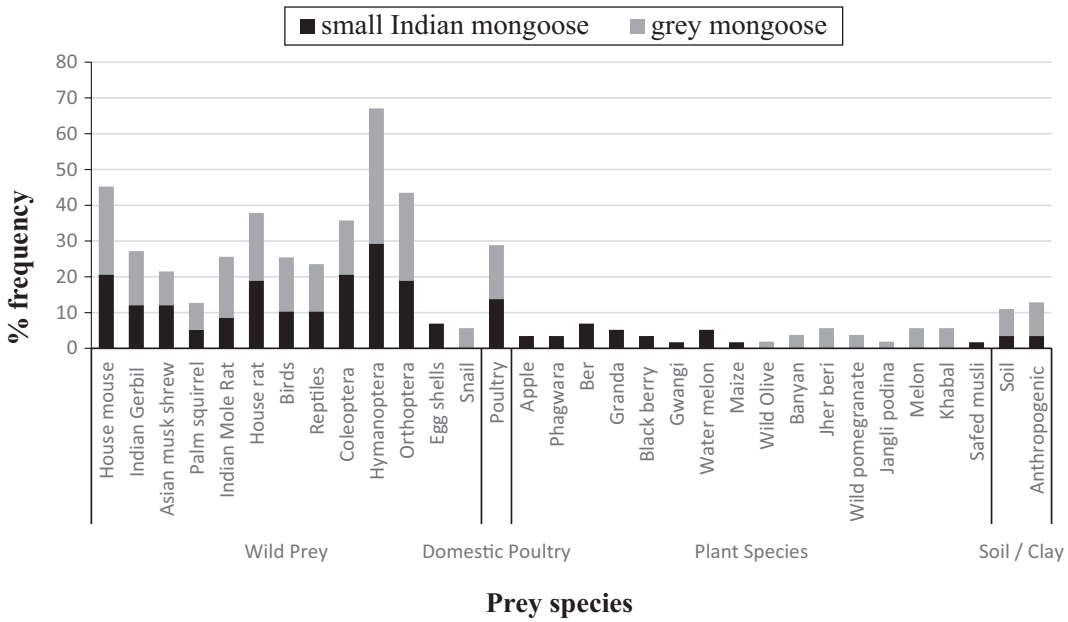


Figure 2. Frequency of occurrence of prey species in the scats of small Indian mongoose and grey mongoose inhabiting Margalla Hills National Park, Islamabad, Pakistan between August 2015 and July 2017.

Downloaded From: https://bioone.org/journals/Wildlife-Biology on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Table 2. Details of undigested prey remains recovered from the scat analysis of two mongoose species (SIM: small Indian mongoose, GM: grey mongoose) from Margalla Hills National Park, Islamabad.

		SIM		GM	
Sr. No.	Prey items	% F	% V	% F	% V
Vertebrate prey remains					
1	Hairs	70.68	25.76	69.81	24.54
2	Recovered bones	58.62	24.51	54.71	22.31
3	Recovered feathers	24.14	9.73	28.31	10.4
4	Scales (reptiles)	10.34	3.37	15.09	4.77
5	Egg shells	3.44	0.62	–	–
	Sub-total		63.99		62.02
Invertebrate prey remains					
6	Insects parts	67.24	21.83	79.24	24.07
7	Snail	–	–	5.66	1.45
	Sub-total		21.83		25.52
Plant food					
8	Plant remains	36.21	11.49	28.3	10.19
Soil/clay					
9	Soil/sand/clay	6.89	1.64	5.66	0.97
Anthropogenic matter					
10	Anthropogenic matter	3.44	1.24	11.32	2.1
	Grand total		100		99.70

consumed domestic poultry regularly, although less often. Among the nine plant species consumed by the small Indian mongoose, *Zizyphus mauritiana* was most frequently consumed, followed by water melon *Citrullus lanatus*, whereas grey mongoose most frequently fed upon Jher beri *Zizyphus nummularia* and melon *Cucumus melo* among seven species (Fig. 2). Both mongoose species also fed on some anthropogenic matter in human vicinity. The two mongoose species also consumed some wild fruits present in the study area including phagwara *Ficus virgata*, black berry *Rubus fruticosus*, Jher beri *Zizyphus nummularia*, wild pomegranate *Punica granatum* and banyan *Ficus benghalensi*) (Fig. 2).

Seasonal variation in diet composition

For small Indian mongoose, rodents and shrew were consumed in both summer and winter seasons with little variation (Table 3). Asian palm squirrel was only preyed upon during the winter season. Reptiles and insects were more frequently consumed during summer than winter season. The consumption of poultry was also found in both seasons. However, among plant species, apple *Pyrus malus*, black berry *Rubus fruticosus*, Gwangi *Grewia tenax* and water melon *Citrullus lanatus*, were fed upon in summer while in winter the small Indian mongoose consumed seeds and fruits of apple *Pyrus malus*, fig *Ficus virgata*, beri *Zizyphus mauritiana*, granda *Carissa opaca*, maize *Zea mays* and safed musli *Asparagus adscendens*. A multiple χ^2 test showed a non-significant difference in consumption of all prey species in the study area ($\chi^2 = 6.661$; df = 3; p = 0.083).

For the grey mongoose species, rodents and shrew were consumed in both seasons, except Asian palm squirrel which was utilized only during the winter season. It also consumed insects more in summer than in winter. Among plant species, it fed upon fruits and seeds of only two plants in summer but on five different plant species in winter season (Table 3). Analysis using a multiple χ^2 test showed non-significant difference in consumption of all prey species in the study area ($\chi^2 = 6.788$; df = 3; p = 0.078).

Niche breadth and niche overlap

Feeding niche of small Indian mongoose was broad (15.02) in summer (meaning that it consumed more prey species in summer) but narrow (11.83) in the winter season (which means that it consumed less prey species in winter). The average niche breadth of the small Indian mongoose was 13.94 (Table 4). Similarly, for the grey mongoose, the feeding niche was also broad in summer (14.49) but narrow (11.33) in the winter season with an average niche breadth of 14.22. Overall, the small Indian mongoose showed wider niche breadth in the study area compared to the other species, the grey mongoose. The overall niche overlap between the two mongoose species was computed to be 0.93 (Table 4).

Prey species indices

For both mongoose species in the study area, prey species richness was greater in summer whereas prey species diversity and the evenness indices were higher in the winter season (Fig. 3).

Discussion

Two species of mongooses (the small Indian mongoose and the grey mongoose) are native and widely distribution across Pakistan, and are sympatric in many parts of the country. Thus, these two species may compete with each other and their dietary niches may overlap. If they do compete, the two species may show some behavioral responses and morphological adaptations to lessen food competition and to be able to co-exist. The main finding of the current study is that the grey mongoose occurs in the study area at higher elevations than the sympatric small Indian mongoose, with only three sites common to both mongoose species. These findings are consistent with the hypothesis that these sympatric mongoose species may reduce interspecific competition with each other through these spatial adjustments in their habitat.

Downloaded From: https://bioone.org/journals/Wildlife-Biology on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Table 3. Prey items (%F) of the small Indian mongoose and grey mongoose inhabiting Margalla Hills National Park, Islamabad, Pakistan between August 2015 and July 2017.

Prey species	Small Indian mongoose (%F)		Grey mongoose (%F)	
	Summer (n = 31)	Winter (n = 27)	Summer (n = 27)	Winter (n = 26)
Wild prey				
House mouse *Mus musculu*	12.07	8.62	15.09	9.43
Indian gerbil *Tatera indica*	8.62	3.45	7.55	7.55
Asian musk shrew *Suncus murinus*	6.9	5.17	5.66	3.77
Palm squirrel *Funambulus pennantii*	0	5.17	0	7.55
Indian mole rat *Bandicota bengalensis*	3.45	5.17	11.32	5.66
Roof or house rat *Rattus rattus*	13.79	5.17	13.21	5.66
Birds	6.9	3.45	9.43	5.66
Reptiles	8.62	1.72	9.43	3.77
Coleoptera (beetles)	18.97	1.72	15.09	0
Hymanoptera (ants, wasps, bees)	18.97	10.34	24.53	13.21
Orthoptera (grasshopper)	6.9	12.07	7.55	16.98
Egg shells	6.9	0	–	–
Snail	–	–	–	5.66
Domestic prey				
Poultry *Gallus gallus domesticus*	5.17	8.62	5.66	9.43
Plant species				
Apple *Pyrus malus*	1.72	1.72	–	–
Wild fig *Ficus virgata*	0	3.45	–	–
Berry *Zizyphus mauritiana*	0	6.9	–	–
Granda *Carissa opaca*	0	5.17	–	–
Black berry *Rubus fruticosus*	3.45	0	–	–
Gwangi *Grewia tenax*	1.72	0	–	–
Water melon *Citrullus lanatus*	5.17	0	–	–
Maize *Zea mays*	0	1.72	–	–
Wild olive *Olea ferruginea*	–	–	–	1.89
Banyan *Ficus benghalensis*	–	–	–	3.77
Jher beri *Zizyphus nummularia*	–	–	–	5.66
Wild pomegranate *Punica granatum*	–	–	–	3.77
Mentha royleana	–	–	1.89	0
Melon *Cucumus melo*	–	–	5.66	0
Khabal *Cynodon dactylon*	–	–	0	5.66
Safed musli *Asparagus adscendens*	–	1.72	–	–
Soil/clay	3.45	0	5.66	1.89
Anthropogenic matter	0	3.45	5.66	3.77

The elevational range of occurrence of grey mongoose was higher than the small Indian mongoose. In addition, the small Indian mongoose is reported to be more adapted to live near human habitations, while the grey mongoose avoids human habitations (Hussain et al. 2017). Corbet and Hill (1992) reported that that small Indian mongoose in its native range lives in sympatric relation to the grey mongoose.

The diet of both mongoose species was comprised of small mammals (rodents, shrews), insects, birds, reptiles and seeds and fruits of some plant species, with rodents being the most frequently consumed prey species of both mongooses throughout the year, whereas insects were consumed more frequently during the summer. Niche breadth of the small Indian mongoose was much broader compared to the grey mongoose, while the overall niche overlap between the two species was 0.93.

Table 4. Niche breadth of small Indian mongoose and grey mongoose inhabiting Margalla Hills National Park, Islamabad, Pakistan between August 2015 and July 2017.

	Niche breadth			
	Summer	Winter	Average niche breadth	Niche overlap
Small Indian mongoose	15.02	11.83	13.94	0.93
Grey mongoose	14.49	11.33	14.22	

Results of the scat analysis show that both mongoose species utilize wild prey (both vertebrate and invertebrates), domestic poultry and seeds and fruits of some plant species in the study area. Rodents and shrews are frequently consumed year round, whereas the consumption of birds and reptiles seemed to be opportunistic feeding. The consumption of three different orders of insects was also consistent across the year, yet more frequently consumed in summer than in winter season. These results complement other previously published studies, which report that insects and birds are consumed by mongooses throughout the year, while they feed more frequently on amphibians in summer and reptiles in winter (Watari et al. 2008). Similarly, Hays and Conant (2007) reported that small Indian mongoose is an opportunistic hunter and its diet is variable depending upon the prey availability in the habitat occupied. Earlier published studies also report that both the small Indian mongoose and the grey mongoose consume insects (Gittleman 1989), but they also consume vertebrate prey in diverse habitats, with a variety of animal prey species, and plant matter (Corbet and

Downloaded From: https://bioone.org/journals/Wildlife-Biology on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

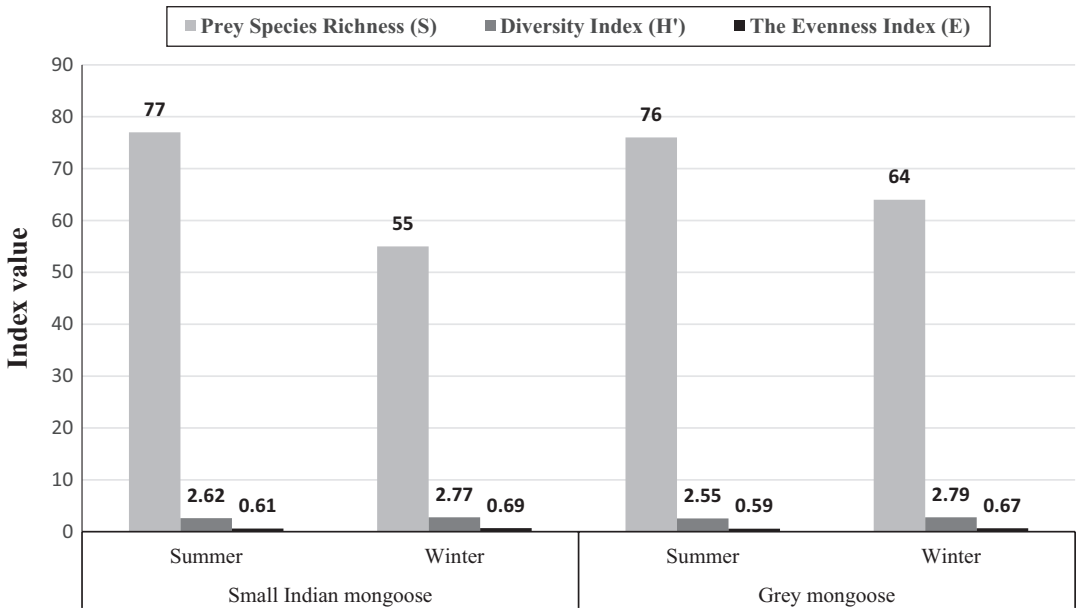


Figure 3. Prey species richness, prey species diversity index and prey evenness index for two mongoose species inhabiting Margalla Hills National Park, Islamabad during August 2015 and July 2017.

Hill 1992, Creel and Macdonald 1995). The small Indian mongoose in the Potohar Plateau consumes many invertebrates including insects, some reptiles and small mammals (Mahmood et al. 2011). The small Indian mongoose plays vital role in controlling and limiting the populations of rodents and thus it acts as a biological control of rat populations (Hoagland et al. 1989), beneficial to humans minimizing economic losses due to rodents (Cavallini and Serafini 1995).

The published literature also suggests that grey mongoose feeds opportunistically on invertebrates (beetles), reptiles (lizards and snakes), rodents (rats and mice), ground birds as well as their eggs, plant parts including fruits, berries and roots while in India, it also feeds upon the eggs and chicks of red jungle fowl, peafowl and partridges (Postanowicz 2002). In the current study, recovery of reptilian scales from its scats indicates its predation on snakes, while recovery of undigested seeds and other plant parts indicate feeding on plant fruits. Parts of snail shells have also been recovered from its scats. Earlier studies have shown that grey mongoose consumes snakes and small mammals in grasslands (Santiapillai et al. 2000, Postanowicz 2002). Opportunistically it also feeds upon invertebrates (grasshoppers, scorpions, crabs and centipedes), amphibians (frogs), and fish as well and it possesses specialized feeding apparatus for crushing such variety of invertebrates and vertebrates (Whitfield 1978).

In the current study, the small Indian mongoose consumed fruits of some wild plants in the park including wild fig *Ficus virgata*, wild berry *Zizyphus mauritiana*, granda *Carissa opaca*, black berry *Rubus fruticosus*. The grey mongoose, on the other hand, consumed fruits of wild plant species including wild olive *Olea ferruginea*, banyan *Ficus benghalensis*, Jher beri *Zizyphus nummularia* and wild pomegranate *Punica granatum*. In this context, both the mongoose species occurring in the MHNP study area may play an important role in ecosystem services by providing seed dispersal. It is established that mongooses, although considered carnivores, do consume plant fruits and seeds. Cavallini and Serafini (1995) had reported that the small Indian mongoose primarily consumes fruits but also feeds upon all kinds of available small mammal species. For grey mongoose, Postanowicz (2002) reported grey mongoose to be an opportunistic hunter that consumes invertebrates like beetles, reptiles (lizards and snakes) rodents (mice and rats), ground-living birds and their eggs and fruits, berries and roots of plants.

The two mongoose species consumed domestic poultry in the study area, but this does not necessarily indicate a high degree of conflict with humans in the park. Both mongoose species are known to prey upon the poultry around the poultry farms in the country (Hussain et al. 2017), but in the MHNP, there are no poultry farms as such. However, the local people living inside the park do keep domestic chickens which roam freely outside during daytime, so it is likely that some of these domestic chickens were preyed upon by mongooses. Nevertheless, there are no reports of mongooses being killed by the local people in retaliation for preying upon domestic poultry or for any other reason.

The results of the current study also show that feeding niches of the two mongoose species under study were broad in summer, but narrow in the winter. Overall, the small Indian mongoose showed wider niche breadth than the grey mongoose. However, the dietary niche of both mongoose species overlapped up to 93%. Given this large overlap in diet, and also being sympatric, it is perhaps very likely that the two mongooses show competition for the same prey species in the study area. Hussain et al. (2017) reported that the feeding niche of small Indian mongoose and the grey mongoose overlaps up to 95% in the Potohar Plateau, while the two species were found distributed at elevations ranging from 200 to 850 m, and in that study elevation did not seem to affect the distribution of the two mongoose species. However, in our current study, the two mongoose species occurred at different elevations, indicating there may be spatial partitioning which would reduce any competition for

Downloaded From: https://bioone.org/journals/Wildlife-Biology on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

food between the two species. This idea is also consistent with the observation that only 3 of our 23 sites had both species. The grey mongoose occurred at relatively higher elevations in the park than the small Indian mongoose. The maximum elevation of occurrence for the grey mongoose was found to be 1363 m a.s.l. compared to 1064 m a.s.l. for small Indian mongoose. In the current study, it seems that the two mongoose species may have adapted to live in different areas of the park at different elevations.

In conclusion, the diet of the two mongoose species, the small Indian mongoose and the grey mongoose, in Margalla Hills National Park Islamabad, overlapped up to 93% but were found at different elevations which is consistent with the idea that these sympatric species may reduce interspecific competition with each other through spatial adjustments in their habitat use. We suggest that further research on the ecology of mongooses (like measuring habitat of the two mongooses at a smaller scale or more sampling sites of mongooses) may give further insights into the spatial partitioning patterns.

Acknowledgements – We are thankful to the staff of Islamabad Wildlife Management Board, Islamabad, for their facilitation and help during the data collection in the current study. We are also grateful to Dr. Muhammad Mushtaq and Dr. Muhammad Zafar, Department of Plant Sciences, Quiad-I-Azam University Islamabad, for identification of plant species of our study samples.

References

Ackerman, B. B. et al. 1984. Cougar food habits in southern Utah. – J. Wildl. Manage. 48: 147–155.

Akrim, F. et al. 2019. Distribution, dietary breadth and niche overlap between two sympatric mongoose species inhabiting Pir Lasura National Park, Azad Jammu and Kashmir, Pakistan. – Pak. J. Zool. 51: 1497–1507.

Azevedo, F. C. C. et al. 2006. Dietary breadth and overlap among five sympatric prairie carnivores. – J. Zool. 269: 127–135.

Cavallini, P. and Serafini, P. 1995. Winter diet of the small Indian mongoose, *Herpestes auropunctatus*, on an Adriatic Island. – J. Mammal. 76: 569–574.

Colwell, R. K. and Futuyma, D. J. 1971. On the measurement of niche breadth and overlap. – Ecology 52: 567–576.

Corbet, G. B. and Hill, J. E. 1992. The mammals of the Indo-Malayan Region. – Natural History Museum Publications, Oxford Univ. Press.

Creel, S. and Macdonald, D. 1995. Sociality, group size and reproductive suppression among carnivores. – Adv. Study Behav. 24: 203–257.

Drouilly, M. et al. 2018. Dietary niche relationships among predators on farmland and a protected area. – J. Wildl. Manage. 82: 507–518.

Fedriani, J. M. et al. 1999. Niche relations among three sympatric Mediterranean carnivores. – Oecologia 121: 138–148.

Gittleman, J. L. 1989. Carnivore group living: comparative trends. – In: Gittleman, J. L. (ed.), Carnivore behaviour, ecology and evolution. Cornell Univ. Press, pp. 183–207.

Hays, W. S. T. and Conant, S. 2007. Biology and impacts of Pacific Island invasive species. A worldwide review of effects of the small Indian mongoose, *Herpestes javanicus* (Carnivora: Herpestidae). – Pacif. Sci. 61: 3–16.

Hoagland, D. B. et al. 1989. Biogeography and population biology of the mongoose in the West Indies. – In: Woods, C. A. (ed.), Biogeography of the West Indies, past, present and future. Sandhill Crane Press, FL, pp. 628–645.

Hussain, R. et al. 2017. Human activity mediates reciprocal distribution and niche separation of two sympatric mongoose species on the Pothwar Plateau, Pakistan. – Turkish. J. Zool. 41: 1045–1058.

Hussain, M. 1986. Re-introduction of cheer pheasant in the Margalla Hills National Park: a report by WorldWide Fund for Nature. – Pakistan and Capital Development Authority, Islamabad.

Jabeen, A. et al. 2009. Indigenous uses of economically important flora of Margallah Hills National Park, Islamabad, Pakistan. – Afric. J. Biotechnol. 8: 763–784.

Jackson, R. and Hunter, D. O. 1996. Snow leopard survey and conservation handbook, 3rd edn. – Int. Snow Leopard Trust and U.S. National Biological Service, Seattle, 120 pp.

Johnson, W. E. et al. 1996. Sympatry in canids: a review and assessment. – In: Gittleman, J. L. (ed.), Carnivore behaviour, ecology and evolution, Vol. 2. Cornell Univ. Press, pp. 189–218.

Karanth, K. U. and Sunquist, M. E. 1995. Prey selection by tiger, leopard and dhole in tropical forests. – J. Anim. Ecol. 64: 439–450.

Lavoie, G. K. 1971. Food habits: a technique for slide preparation. – Range Science Department, US International Biological Program. Technical Report, No. 69, pp. 1–5.

Leopold, B. D. and Krausman, P. R. 1986. Diets of 3 predators in Big Bend National Park, Texas. – J. Wildl. Manage. 50: 290–295.

Levins, R. 1968. Evolution in changing environments. – Princeton Univ. Press.

Mahmood, T. et al. 2011. Population estimates, habitat preference and the diet of small Indian mongoose (Herpestes javanicus) in Potohar Plateau, Pakistan. – Pakistan J. Zool. 43: 103–111.

Masroor, R. 2011. An annotated checklist of amphibians and reptiles of Margalla Hills National Park, Pakistan. – Pak. J. Zool. 43: 1041–1048.

Melville, H. I. A. S. 2004. Behavioural ecology of the caracal in the Kgalagadi Transfrontier Park, and its impact on adjacent small stock production units. – MSc thesis, Univ. of Pretoria, Pretoria.

Miquelle, D. G. et al. 1996. Food habits of Amur tigers in Sikhote-Alin Zapovednik and the Russian Far East, and implications for conservation. – J. Wildl. Res. 1: 138–147.

Moore, T. D. et al. 1974. Identification of the dorsal guard hairs of some mammals of Wyoming. – Game and Fish Dept, Wyoming, p.177.

Pianka, E. R. 1973. The structure of lizard communities. – Annu. Rev. Ecol. Syst. 4: 53–74.

Pianka, E. R. 1974. Niche overlap and diffuse competition. – Proc. Natl Acad. Sci. USA 71: 2141–2145.

Postanowicz, R. 2002. Indian grey moongoose. – Lioncrusher's Domain. <www.lioncrusher.com/animal>, accessed 5 December 2013.

Quantum GIS Development Team 2012. Quantum GIS geographic information system. – Open Source Geospatial Foundation Project. <http://qgis.osgeo.org>

Rasheed, F. et al. 2005. Phyto-sociological study and determination of carrying capacity of the reserve forest compartment – 17 of Margalla Hills National Park, Pakistan. – J. Agric. Sci. 42: 70–74.

Reynolds, J. C. and Aebischer, N. J. 1991. Comparison and quantification of carnivore diet by faecal analysis: a critic, with recommendations based on a study of the fox *Vulpes vulpes*. – Mammal. Rev. 21: 97–122

Roberts, T. J. 1997. The mammals of Pakistan. – Oxford Univ. Press.

Santiapillai, C. et al. 2000. The status of mongooses (family: Herpestidae) in Ruhuna National Park, Sri Lanka. – J. Bombay Nat. Hist. Soc. 97: 208–214.

Downloaded From: https://bioone.org/journals/Wildlife-Biology on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Seaman, G. and Randall, J. 1962. The mongoose as a predator in the Virgin Islands. – J. Mammal. 43: 544–546.
Sunquist, M. E. and Sunquist, F. C. 1989. Ecological constraints on predation by large felids. – In: Gittleman, J. L. (ed.), Carnivore behavior, ecology and evolution. Chapman and Hall.
Taper, M. L. and Marquet, P. A. 1996. How do species really divide resources? – Am. Nat. 147: 1072–1082.
Veron, G. et al. 2004. Molecular systematics and origin of sociality in mongooses (Herpestidae, Carnivora). – Mol. Phylogenet. Evol. 30: 582–598.
Watari, Y. et al. 2008. Effects of exotic mongoose (*Herpestes javanicus*) on the native fauna of Amami-Oshima Island, southern Japan, estimated by distribution patterns along the historical gradient of mongoose invasion. – Biol. Invas. 10: 7.
Whitfield, P. 1978. The hunters. – Simon and Schuster, United States Department of Agriculture Circular, New York, 118: 1–4.
Wilson, D. E. and Reeder, D. M. (eds). 1993. Mammal species of the world: a taxonomic and geographic reference, 2nd edn. – Smithsonian Inst. Press.

Downloaded From: https://bioone.org/journals/Wildlife-Biology on 28 Mar 2024
Terms of Use: https://bioone.org/terms-of-use