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Is Resource Utilization by Desert Fox (*Vulpes vulpes pusilla*) in thar Landscape an Indicative of its Opportunistic Feeding Behavior? – A Preliminary Insight

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ABSTRACT

Opportunistic feeding behavior may absolve species survival entirely upon the resources available within its habitat. Present study assesses this assumption with respect to Desert fox found in Thar landscape in India. Density of selected food items that encompass dietary spectrum of this species was estimated in a given area and the biomass available for its consumption was calculated seasonally. Relative percentage of biomass available and biomass consumed was correlated, wherein preference was calculated using Ivlev's Index. It is concluded that opportunistic feeding behavior is being exhibited by Desert fox especially in winter season, when resources are limited in terms of their availability. Also, it prefers scavenging on dead carcasses and fallen fruits rather than hunting.

Key words : *Generalist, Prey, Density, Preference, Avoidance*

Introduction

Red Fox *Vulpes vulpes* Linnaeus, 1758 are regarded to be placed at any point along the specialist (Vlasseva *et al*., 2017) to generalist continuum (Tsukada *et al*., 2014). Predominant distribution ofgeneralist species is indicative of opportunistic feeding behaviourwherein, sudden decline in the main prey lead these predators to switch into feeding alternative food items (Elmhagen *et al*., 2002). Desert fox *Vulpes vulpes pusilla* is one of the sub-species of Red fox found in arid and semi-arid region of Thar Desert of Western Rajasthan and Kutch region of Gujarat, India. It is a medium sized meso-carnivore whose diet changes seasonally as well as depends upon availability of food resources (Wilson and Dookia, 2019) in Thar landscape. Desert foxes have a generalist dietary spectrum ranging from ungulates, rodents, insects and fruits that contribute significantly in terms of proportions based on their availability (Wilson and Dookia, 2019). However, estimation of food preference requires not only a knowledge of dietary pattern but also significant information on food availability in terms of abundance and density (Mukherjee, 1998). The most appropriate method for estimation of abundance of herbivore such as ungulates in the Indian Subcontinent is the line transect method for density estimationin conjugation with distance sampling (Karanth *et al.*, 2004). Another significant prey base forming a major portion of diet of small to medium sized carnivores are rodents whose density could be effectively estimated by using a trapping web and distance sampling method that was provided by Anderson *et al.* (1983). Such methods have been used by many researchers in India and worldwide (Durant *et al.*, 2011; Ramesh *et al.*, 2012; Elbroch and Wittmer, 2013; Venkatesh *et al.*, 2017; Kshettry *et al.*, 2018). Keeping this in mind, the present study was undertaken to i) estimate availability of selected food items in terms of density and biomass; ii) estimate biomass availability of selected food items and biomass consumed; and iii) determine food preference.

Materials and Methods

Study area and sampling period: The study was conducted in Desert National Park (DNP) which is one of the largest protected area of Thar Desert and falls in arid regions of the Desert in Rajasthan (26°01′00" N and 28°02′12" N latitudes and 69°30′00" E to 72°21′30" E longitudes (Figure 1) from for a period of around two years, covering all seasons of the year between 2015 to 2017.

Estimation of food availability of selected prey/food items: Density of both wild (Chinkara and Pig) and domestic (Camel, Cow, Goat and Sheep) ungulate potential prey species in the study area was estimated using line transect (Buckland *et al.*, 2001) using DISTANCE 7.0 software (Laake *et al.*, 1998) in which 60 transects of length varying from 0.84 km to 2.9 km were laid and walked during 6:00 hrs to 10:00 hrs. The number of groups, cluster size and sighting distance was measured and recorded with the help of a laser range finder (Bushnell) whereas, the geographical coordinates were recorded with a GPS (Garmin etrex10) for every prey species encountered. Density of rodents was estimated by laying trapping web design (Anderson *et al.*, 1983) using 48 Sherman trapseach at 15 different locations/grids were used for 6 consecutive days at the same location (for 2 years with 3 different seasons each) amounting for total effort of 4320 trap night/season for two years with a circular area of each web being 1.13 ha. Beetles and fruits (*Ziziphus* sp.) availability was estimated by direct counts along transect linesand density were estimated manually as number/km^2.

Diet composition: Estimation of diet composition has been described elsewhere (Wilson and Dookia, 2019). Identified components were classified into various categories and expressed as percent frequency of occurrence of an item/total items (%F_o/

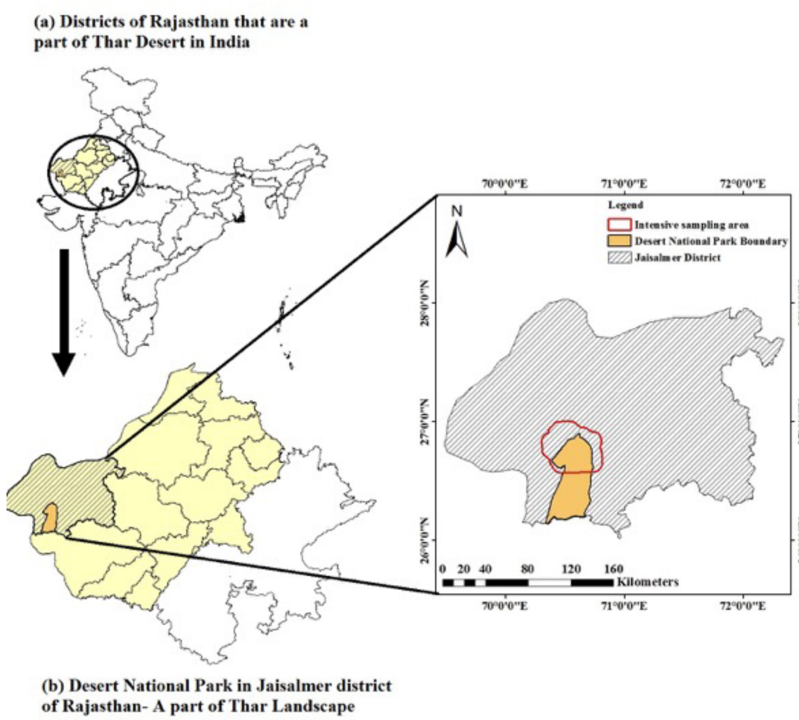

Fig. 1. Map showing the study area with intensive sampling area

Item)described elsewhere (Wilson and Dookia, 2019).

Estimation of prey/fruit biomass available and consumed: The biomass available of mammals (Ungulates and Rodents), insects (Beetles) and fruit (*Ziziphus* sp.) was calculated using the values of density estimated in the previous section. Seasonal contribution of each species towards the diet was calculated using frequency of occurrence of an item/total items (%F_o/Item). However, %F_o/Item was first converted to biomass consumed following the correction factor equation B= 0.0182X + 0.217 (Jethva and Jhala, 2004), where B = Biomass consumed/scat and X is the average prey weight. Correction factor/scat so obtained was used in the equation of Ackerman *et al.* (1984) to determine relative biomass consumed of each species.

Estimation of food preference: The comparison between percent of relative biomass available (expected frequency) as well as relative biomass consumed (observed frequency) was done using Ivlev's Index (Ivlev, 1961). The equation for Ivlev's Index is as follows:

$$I = \left(\frac{r-p}{r+p}\right)$$

where, r = percent relative proportion of biomass consumed

p = percent relative proportion of biomass available

Results

The density of ungulates, rodents, beetles and *Ziziphus* that was estimated is provided in Table 1. For the purpose of the paper, the dietary analyses in terms of %F_o/Item of the selected species is provided in Table 2. However, the details of dietary components are discussed elsewhere (Wilson and Dookia, 2019). Relative biomass available in % (Table 3) was calculated for mammals (ungulates and rodents), insects (Beetles) and fruit (*Ziziphus* sp.) as they contributed highest in terms relative frequency of occurrence and also in terms of number of food items present as dietary components of Desert Fox (Wilson and Dookia, 2019). Beetles were identified as important species as they contributed 93.17%

Table 1. Density (number/km^2) of different prey species in intensive study areas

Species	Winter 2015-16	Summer 2016	Monsoon 2016	Winter 2016-17	Summer 2017	Monsoon 2017
Cow	9.54	5.87	8.35	9.83	3.05	15.58
Chinkara	2.75	6.36	4.98	5.76	6.08	5.91
Camel	11.78	7.62	9.10	6.33	4.67	5.49
Pig	1.94	3.51	3.01	2.61	2.95	2.93
Goat	13.69	7.79	6.00	8.47	12.01	13.66
Sheep	20.12	23.17	14.03	26.05	20.62	35.54
Rodents	203	264	307	254	297	364
Beetles	3.16	9.94	13.91	3.43	5.15	16.67
Ziziphus	51.15	-	-	36.31	-	-

Table 2. Dietary components in terms of % Frequency of Occurrence/Item (F_o/Item) identified in Desert Fox scats for the selected species

Food Items	Winter 2015-16	Summer 2016	Monsoon 2016	Winter 2016-17	Summer 2017	Monsoon 2017
			% F_o/Item			
Cow	0.00	2.68	4.46	0.28	2.44	2.99
Chinkara	0.55	1.34	0.00	0.00	0.81	0.50
Camel	0.82	0.00	1.91	0.00	2.03	1.00
Pig	0.27	3.13	1.91	0.56	1.22	0.00
Goat	1.10	4.02	8.92	4.23	5.28	5.97
Sheep	1.92	6.25	5.10	3.66	3.66	4.48
Rodents	0.55	5.36	4.46	0.28	2.44	7.96
Beetles	17.03	23.21	52.17	10.99	17.07	20.90
Ziziphus	36.26	1.79	4.46	44.51	0.81	1.49

of the total insect component whereas *Ziziphus* sp. were identified as important as they contributed 70.50% of the total fruit component during the entire study period.Estimated biomass contribution of different prey species along-with *Ziziphus* sp. fruit (in winter season) to the diet of Desert Fox using equation developed by Ackerman *et al.* (1984) gave better evaluation of the prey/fruit contribution in the diet (Table 4). Lastly, the food preference was estimated using *Ivlev's Index.* The observed frequency of few selected food items (mainly ungulates, rodents, beetles and *Ziziphus* sp.) that formed significant component of Desert Fox diet was compared to the expected values derived from their density estimates to test the hypothesis of nonselective preference of food items using Ivlev's Index (Figure 2). The index value ranges from +1 (indicating complete preference) to -1 (indicating complete avoidance) in proportion to the availability of the respective food/prey item.

Discussion

Desert National Park of Thar Desert is relatively

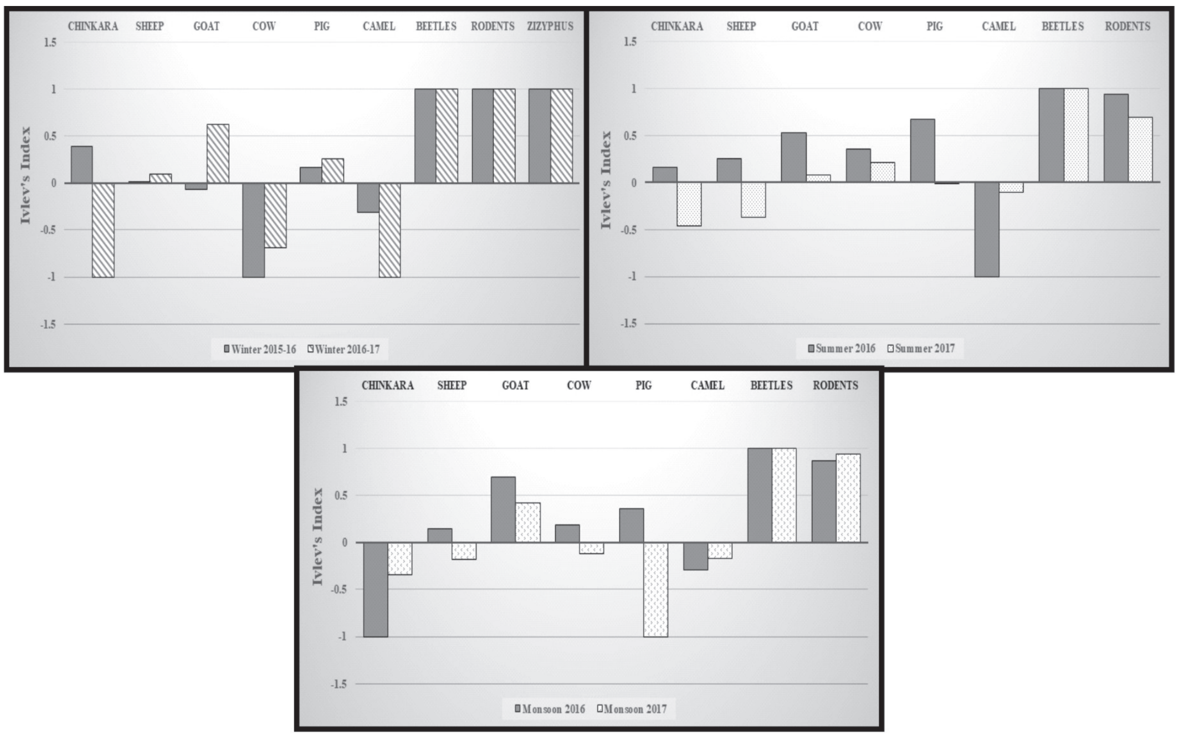

Fig. 2. Ivlev's Index for each of the selected food item in various seasons

Table 3. Percentage of relative biomass available during sampling period

Fruit/Prey Species	Winter 2015-16	Winter 2016-17	Summer 2016	Summer 2017	Monsoon 2016	Monsoon 2017
	Relative Biomass Available %					
Chinkara	0.66	2.02	2.23	3.2	1.53	1.8
Sheep	5.70	10.71	9.54	12.75	5.04	12.73
Goat	3.73	3.36	3.09	7.15	2.08	4.71
Cow	18.02	26.92	16.11	12.57	20.01	37.21
Pig	0.77	1.51	2.03	2.57	1.52	1.48
Camel	71.04	55.36	66.85	61.54	69.68	41.90
Beetles	0.00002	0.00003	0.00009	0.00007	0.00012	0.00014
Ziziphus	0.00026	0.00027	-	-	-	
Rodents	0.07	0.13	0.13	0.22	0.13	0.16

Table 4. Biomass consumed during sampling period

Fruit/Prey Species	Winter 2015-16	Winter 2016-17	Summer 2016	Summer 2017	Monsoon 2016	Monsoon 2017
	Relative Biomass Consumed %					
Chinkara	1.49	0.00	3.10	1.18	0.00	0.88
Sheep	5.81	12.94	16.13	5.90	6.69	8.87
Goat	3.24	14.54	10.10	8.31	11.40	11.52
Cow	0.00	4.91	34.09	19.40	28.86	29.15
Pig	1.07	2.55	10.35	2.52	3.22	0.00
Camel	37.56	0.00	0.00	49.44	37.82	29.72
Beetles	15.77	11.89	18.35	8.43	9.22	12.68
Rodents	0.51	0.31	4.25	1.21	1.80	4.84
Ziziphus	33.57	48.16	-	-	-	-

constrained landscape in terms of availability of food resources when compared to other regions of India (Conservation Area Series, 2004). During the transects that were conducted, mammals was the most abundant group observed in terms of the individual sightings. Among the mammals, it was the ungulates that were observed namely domestic (Sheep, Cow, Goat, Camel) and wild (Chinkara and Pig). When the densities were estimated, Sheep and Goat were found to be the most abundant whereas Pig was found to be the least. Similar findings in Desert National Park, Jaisalmer have been reported by Dutta *et al.* (2014); Ranjitsinh and Jhala (2010). In general, density of domestic ungulates was found to be higher than that of wild ungulates due to the increased number of pastoral and agrarian communities that reside in this landscape that prefers rearing livestock for livelihood practices (NDDB, 2016). Overall, high rodent density was observed during the entire study period that may be attributed to large number of agricultural fields in the study area. Moreover, rodents in desert can adjust their dietary preferences and feed also on stems, leaves, flowers, rhizomes, bulbs and insects, enabling survival during scarcity of water and other food items irrespective of the seasons. Also, highest density of rodents was observed in monsoon season that is in corroboration with the finding of Idris (2009) and may be due to the fact that during monsoon the availability of natural food resources is highest and it also coincides with the maximum breeding activity of the rodents.

Availability of *Ziziphus* sp. fruit was significantly high in both the winter seasons as the *Ziziphus* sp. fruit ripens from November to January, thereby, providing its high density. However, due to the absence of fruiting shrubs during summer and monsoon seasons, no significant observations could be made. Similar observations on the high availability of *Ziziphus* sp. fruit in winter season in Thar Desert landscape has been reported by Home (2005) and Chourasia *et al.* (2012).

Mostly the small carnivores like red fox tends to scavenge on dead carcasses of ungulates which tend to provide the majority of acquired biomass (Metz *et al.*, 2012) or they may occasionally hunt small mammals such as rodents. Resource utilization patterns can be established as an interplay of biomass available and consumed that may help to define the food preference of any species. It is expected that resources would be used in relation to their availability, but this not always be true. Since, in the study area there was a marked difference in seasons in terms of temperature and rainfall, food availability is affected, thereby changing resource usage pattern. Biomass of small mammals like rodents depends mainly on rainfall (Lanszki and Heltai, 2010). Availability of seasonal food resources are of great importance to small bodied animals like foxes since they substitute for prey which are less abundant during the lean seasons and reduce the searching as well as the hunting time, thereby, preferring foraging (Home, 2005).

The biomass consumed calculation model for this study was selected on the assumption that a model was suitable when it was derived from feeding trials using the same or a closely-related species, and when the feeding trials involved the dietary spectrum of the studied species (Klare *et al.*, 2011). In the absence of any better model available for small sized canids like foxes, the correction factor equation used by Jethva and Jhala (2004) for wolf scats and further used by Home (2005) for Indian Fox scats, was used to estimate biomass consumption based on percentage frequency of occurrence of prey/fruit species in scats. Large mammals such as ungulates tends to provide larger biomass at any given time owing to their large body size and weight, whereas small mammals like rodents tend to provide less biomass due to smaller body size. The results suggest that irrespective of the biomass availability of ungulates, it preferred them opportunistically, depending upon chance encounter as well as availability of carcass (Schaller and Ginsberg, 2004). However, biomass was consumed much higher than its availability for *Ziziphus* sp., Beetles and rodents and the same was achieved by consuming a large number of individuals of the same as indicated in the results, signifying the preference of Desert Fox towards these resources (Lanszki and Heltai, 2010). In the absence of *Ziziphus* sp. in summer and monsoon seasons, it is the beetles and rodents that are still preferred more, until a prey is available to scavenge. The relationship between the available biomass of small mammals, insects and fruits, as the primarily important food resource for Desert Fox and proportion of consumed biomass was not close.

Conclusion

This is essentially the first intensive study on the resource utilization of the Desert Fox in an arid landscape, especially in terms of food preference and avoidance. Desert Foxes may have adapted to the land-tenure system and behaviour to suit local circumstances, using alternative sources of prey. Seasonal variations in prey or food availability affect their food choice in Thar landscape. As availability of prey items becomes limited in winter season, fruits are more preferred along-with exclusive selection of rodents and beetles. However, opportunistic scavenging of dead carcasses seemed always a choice. Since prey availability is more or less there, a lot of energy is obtained by Desert Fox from scavenging and switching to *Ziziphus* sp. fruits as an alternative food resource, it cannot be concluded if food availability is a limiting factor for survival of this species.

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