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Food composition and feeding ecology of the Arabian Red Fox *Vulpes vulpes arabica* (Thomas, 1902) in Sakaka, northern Saudi Arabia

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Abstract

The food composition and feeding ecology of the Arabian Red Fox *Vulpes vulpes arabica* inhabiting Sakaka city in the northern part of Saudi Arabia was studied using stomach contents analysis. The analysis of 32 stomach contents during February 2015 to May 2016 showed a great diverse of food like mammals, birds, reptiles, insects, scorpions, cooked rice, plants and carrion. Diet composition showed seasonal variations that associated with changes in the availability of different food items. The results clearly showed that the Arabian Red Fox is an opportunistic omnivore, capable of depending on a great types of dietary compositions. This is the first study for the food composition and feeding ecology for the Arabian Red Fox in Sakaka city and Al Jouf governorate in Saudi Arabia.

Key words: The Arabian Red Fox, *Vulpes vulpes arabica*, Sakaka, Food composition, Feeding ecology.

1 Introduction

The Arabian Red Fox *Vulpes vulpes arabica* is found in all regions of Saudi Arabia with some exceptions of the large sand deserts and the central areas of Saudi Arabia. Walid (2016) recorded the first occurrence of *V. v. arabica* in Sakaka city and described it precisely by introducing new detailed morphological and cranial measurements of this subspecies. It is almost distributed over all habitats and may be strongly attracted to scavenge around camps and human settlements (Kingdon, 1991; Wilson and Reeder, 2005; Feldhamer, *et al*., 2007 and Walid, 2011).

Study of food clarifies the role of this subspecies in the energy flow and food chain of the ecosystem. It also provides a foundation for understanding the foraging behaviour, population dynamics, habitat use and social organization of a species (Mills, 1992). The study of diet in carnivores is very important, because they are often at the end of a food chain and have important effects on the distribution and abundance of other species.

Taking in our consideration the insufficient available information about food and feeding habits (Walid, 2016), it was necessary to mention that the present study examined food composition and feeding ecology of the Arabian Red Fox beside any possible seasonal fluctuations in its diet composition. Taking data of Levins (1968) and Macdonald (1983) in our consideration, the present investigation based upon examining 32 stomach contents of this subspecies, which allowed a relatively thorough assessment of the trophic niche for this animal in Sakaka.

2 Materials and Methods

Food composition of the Arabian Red Fox was investigated by the analysis of the stomach contents of 32 adult specimens supplied by an animal dealer from the dwellers of Sakaka city. Specimens were captured in steel traps, killed directly after capture and stomachs were removed and preserved in 10% formalin for subsequent laboratory analysis. This procedure was carried out in the four seasons of the year winter, spring, summer and autumn respectively from February 2015 to May 2016. According

to seasons, 11 specimens were collected in winter, 9 in spring, 5 in summer and 7 in autumn. Locations of samples from Sakaka city are represented in figure (1).

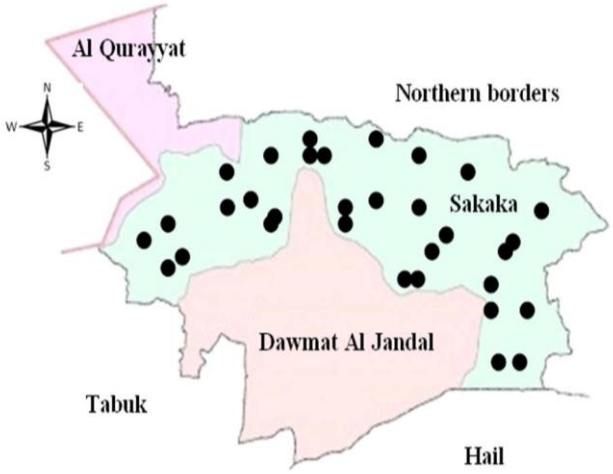

Figure 1: Collection localities of specimens from Sakaka city

Frequency of occurrence of animal and plant food items was calculated according to the method developed by Sparks and Malechek (1968).

Trophic niche breadth was calculated according to the method described by Krebs (2009). Index was applied to the frequency and volume of the various food categories. The Krebs' Index formula is:

$$\mathbf{B = \Sigma\ 1/\ Pj^2}$$

Where (**Pj**) is the proportion of records in each food category (**j**) set at 100 %. The trophic niche breadth value was calculated seasonally**.**

3 Results

The general composition of the diet was illustrated in Table (1), expressed as the number of stomachs containing the food item and its frequency of occurrences (expressed as a percentage of all samples).

Table 1: Occurrence and frequency of occurrence (%) of food items in the stomach contents of the Arabian Red Fox *Vulpes vulpes arabica* collected from Sakaka.

The table shows that mammals are the predominant food item in about half of the analyzed stomach contents, 15 stomachs represented by 46.88% frequency of occurrence. Of mammalian remains detected in the stomachs, remains of cooked flesh of dromedary camels *Camelus dromedarius* and flesh of domestic sheep *Ovis* sp. which are often mixed with rice of the feasts. In addition, remains of some mammals are found in the fox's diet represented by lesser Egyptian jerboa *Jaculus jaculus*, long-eared hedgehog *Hemiechinus auritus*, cape hare *Lepus capenesis* and house mouse *Mus musculus*.

Insects represented the second predominant food item in the stomach contents, 13 stomachs represented by 40.63% frequency of occurrence. More than one third of the analyzed stomach contents had insect remains. It is interesting that the household American cockroach *Periplaneta americana* frequently appeared in the stomach contents of the foxes, indicating that they forage close to human habitations where this insect can be usually found. Dung beetle *Scarabaeus sacer*, praying mantis *Mantis religiosa***,** Egyptian locust *Anacridium aegyptium* and desert locust *Schistocerca gregaria* are among the more frequently found insects in stomach contents.

Cooked rice was found in 10 stomachs and represented by 31.25%. Foxes got rice from dumps and from the wastes and refuse of parties of the dwellers.

Reptiles are also occurred in the diet of the fox, 9 stomachs with 28.13% frequency of occurrence. Reptiles were represented by some lizards such as Baluch rock gecko *Bunopus tuberculatus*, bent-toed gecko *Cyrtodactylus scaber* and fringe-fingered lizard *Acanthodactylus schmiditi*. Three snakes were identified, false cobra *Malpolon moilensis*, cat snake *Telescopus dhara* and Braid snake *Platyceps rhodorachis*.

Two scorpions were identified in food of the Arabian Red Fox, they are, Vachon scorpion *Vachoniolus minipectinibus* and the Arabian fat-tailed scorpion *Androctonus crassicauda*.

Plant remains also ingested in the stomach contents of some foxes, 7 stomachs represents 21.88%. These plants are grown in Sakaka city and some of them are planted by the native people there. Some plants seem to be regularly eaten, they are fruits of date palm *Phoenix dactylifera*, tomato *Solanum lycopersicum*, cucumber *Cucumis sativus*, common fig *Ficus carica* and bell pepper *Capsicum annum*. Other parts of wild plants especially leaves were ingested by foxes such as *Plantago amplexicualis*, *Trigonella stellate* and *Alhagi graecorum*.

It was found that foxes ingested dates even it is ripe or not ripe and also they ingest garbage where plastic pieces, torn papers, aluminum foil and robes were detected in stomachs.

Remains of birds were detected in only 4 stomachs and had a frequency of occurrence of 12.50%. Birds represented the least food item in the diet of the Arabian Red Fox. These remains were mostly domestic chicken *Gallus gallus domesticus* and the domestic pigeon *Columba livia*.

Figure 2 shows the relationship between number of stomachs examined and food items in the stomach contents of the Arabian Red Fox collected from Sakaka city during the time of the present work.

Table 1: Occurrence and frequency of occurrence (%) of food items in the stomach contents of the Arabian Red Fox *Vulpes vulpes arabica* collected from Sakaka

Food item	Number of stomachs containing item (N = 32)	Frequency of occurrence (%)
Cooked rice	10	31.25
Mammals	15	46.88
Birds	4	12.50
Reptiles	9	28.13
Insects	13	40.63
Scorpions	8	25.00
Plants	7	21.88
Garbage	5	15.63
Dates	6	18.75

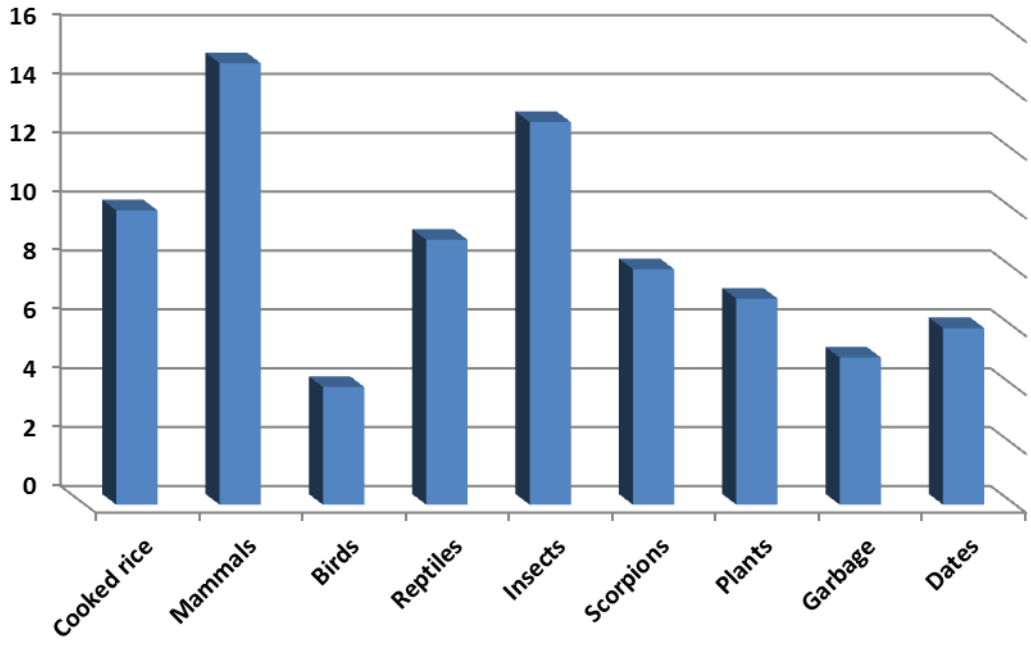

Figure 2.Stomach contents of the Arabian Red Fox *Vulpes vulpes arabica* collected from Sakaka

Table 2 showed a seasonal comparison of stomach contents analysis of the Arabian Red Fox in Sakaka city during February 2015 to May 2016. Plenty of changes in the occurrence of food items took place. Simultaneously, estimation of the niche breadth revealed some seasonal variations. The value of the trophic niche breadth reached its maximum in autumn and its minimum in winter.

These changes reflect the variations in the diversity of available food items in the environment of the Arabian Red Fox in Sakaka city. It is worthy to note that although the calculated value of the niche breadth remains more or less the same, the composition of the food diet shows significant seasonal changes assuming that certain food items are replaced by other items as seasons change. Figure 3 shows the relationship between values of the trophic niche breadth in the four seasons of the Arabian Red Fox in Sakaka city during the present work.

Table 2: Seasonal variation in the diet of the Arabian Red Fox collected from Sakaka, expressed as number of occurrence (N) and frequency of occurrence (F) as (%) of selected food items and the calculated trophic niche breadth (TNB).

Food item	Winter (N = 11)		Spring (N = 9)		Summer (N = 5)		Autumn (N = 7)	
	N	F	N	F	N	F	N	F
Cooked rice	2	18.18	2	22.22	4	80	2	28.57
Mammals	3	27.27	4	44.44	5	100	3	42.86
Birds	1	9.09	1	11.11	2	40	-	0
Reptiles	1	9.09	3	33.33	3	60	2	28.57
Insects	3	27.27	3	33.33	4	80	3	42.86
Scorpions	-	0	3	33.33	3	60	2	28.57
Plants	1	9.09	2	22.22	2	40	2	28.57
Garbage	2	18.18	1	11.11	-	0	2	28.57
Dates	1	9.09	1	11.11	2	40	2	28.57
TNB		6.5		7.4		7.2		7.7

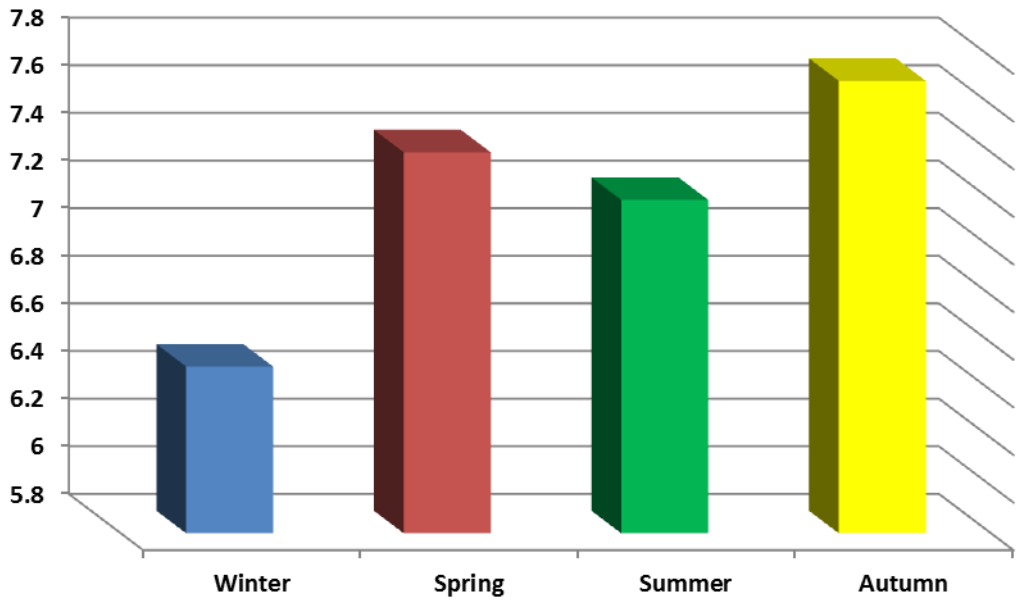

Figure 3: Relationship between values of the trophic niche breadth in the four seasons during period from February 2015 to May 2016

4 Discussion

According to the recent data, the Arabian Red Fox *Vulpes vulpes arabica* is an omnivore (Walid, 2016). Data of the present work confirmed the opportunistic foraging of food habits of the Arabian Red Fox throughout its habitat in Sakaka city in the northern part of the Kingdom of Saudi Arabia.

Present data clearly showed that the Arabian Red Fox consumed practically every food type available in its habitat. Accordingly, the type and the quantity of the available food source will markedly depend on the season. For such a highly opportunistic mammal like Arabian Red Fox, different proportions of plants, invertebrates and vertebrates found in diets should be correlated with the availability of these resources (Blondel, 1969). So, we can predict that the fox will start eating insects such as American cockroach *Periplaneta Americana*, dung beetle *Scarabaeus sacer*, praying mantis *Mantis religiosa***,** Egyptian locust *Anacridium aegyptium* and desert locust *Schistocerca gregaria* and scorpions such as Vachon scorpion *Vachoniolus minipectinibus* and the Arabian fat-tailed scorpion *Androctonus crassicauda*.

Ciampaloni and Lovari (1985) reported that females of the red fox *Vulpes vulpes* consumed resources rich in proteins such as mammals and birds during pregnancy, these findings are consistent with the recent work because the Arabian Red foxes reproduce once a year in spring season and the gestation and lactation periods extend to summer season. So, foxes hunt mammals such as lesser Egyptian jerboa *Jaculus jaculus*, long-eared hedgehog *Hemiechinus auritus*, cape hare *Lepus capenesis* and house mouse *Mus musculus* and also eat flesh of dromedary camels *Camelus dromedarius* and flesh of domestic sheep *Ovis* sp. which are often mixed with rice of the feasts which are more held in spring and summer in Saudi Arabia at all.

Reptiles were the next choice after mammals and insects. Foxes usually hunt lizards such as Baluch rock gecko *Bunopus tuberculatus*, bent-toed gecko *Cyrtodactylus scaber* and fringe-fingered lizard *Acanthodactylus schmiditi* or snakes such as false cobra *Malpolon moilensis*, cat snake *Telescopus dhara* and Braid snake *Platyceps rhodorachis* according to the existence and the availability of each one.

Also Arabian Red Fox tend to eat some food rich in sugar such as dates *Phoenix dactylifera* and common fig *Ficus carica* to gain high energy for locomotion everywhere. On the other hand, other parts of plants such as leaves of *Plantago amplexicualis*, *Trigonella stellate* and *Alhagi graecorum*are are usually found in the diet but they do not provide energy to the fox. These plants may be accidentally taken with other food or are taken only when nothing else is available. Other plants such as tomato *Solanum lycopersicum*, cucumber *Cucumis sativus* and bell pepper *Capsicum annum* form important items in the food of the Arabian Red Fox in Sakaka because they represent the common cultivated plants scattered in the city.

The Arabian Red fox live in the vicinity of human settlements, so foxes usually eat from the dumps of the humans. A great amount of cooked rice is thrown away especially after continuous wedding parties and feasts of the dwellings which attract foxes to consume it easily. This may give an explanation to the high frequency of the presence of cooked rice in foxes' diet. Walid (2011) reported that the red fox *Vulpes vulpes* may feed on some garbage accidently to fill their stomachs and not feel hungry, these findings are agreed with the Arabian Red Fox *Vulpes vulpes arabica* in the present work which may ingest garbage such as plastic pieces, torn papers, aluminum foil and robes and remains of birds such as feathers of the domestic chicken *Gallus gallus domesticus* and the domestic pigeon *Columba livia* which are found in dumps to feel not hungry.

Optimal foraging theory states that a predator should choose prey types based on tradeoff between costs and benefits that will give the maximum net benefit to the individual (Krebs *et al*., 2012). The dietary choices for the carnivores such as the Arabian Red Fox will depend on the temporal variation of foraging costs which are mainly affected by the availability of the food item (Zielinski, 1988).

Seasonal variation in the diet composition of the Arabian Red Fox is related to the seasonal variation in the available food. The observed high degree of variability diet composition also reflects the ability of this fox to adapt to highly variable dietary conditions.

Comparison of the trophic niche breadth in the four seasons during time course of the present work showed that the Arabian Red Fox has the great ability to exploit all food resource in its area.

Conclusion

The Arabian Red Fox *Vulpes vulpes arabica* living in Sakaka city in the northern part of the Kingdom of Saudi Arabia is typical opportunistic forager which consumes easiest accessible plant and animal food in its habitat depending upon seasonal variations. Improper discarding of animal wastes and feasts from households provides sufficient food sources to the Arabian Red Fox and supports their existence in Sakaka city.

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