



Determination of prey base and prey preference of marsh crocodile (*Crocodylus palustris*) by scat analysis in selected villages of Anand district, Gujarat, India

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Abstract

Crocodylus palustris is distributed throughout Indian subcontinent. Wetlands of Charotar region possess healthy population of marsh crocodiles which are also being utilized by humans. As a result, peaceful coexistence can be seen in the villages of Charotar where villagers are living in the harmony with mugger crocodiles. Understanding the feeding preference and prey base of the threatened species like crocodiles plays a vital role in wildlife conservation for the well-being of wild animals as well as people who share the place with them. This study was initiated to understand prey base as well as prey preference of the Marsh crocodile by non-invasive method which is scat analysis. Fieldwork was carried out from March 2018 to March 2020. Total 556 faecal samples were taken and identified by direct (presence of animal) and indirect (pug mark and body scale mark) signs as well as with the help of local people from four villages of Anand district. Undigested materials from the scat such as mammalian hair, feathers of the birds, insect remains and scales of fish mounted on slides, observed under microscope and characterized with the help of reference keys. The present study provides details of the food habits of adult and sub-adult crocodiles as well as effects of seasonal changes on the food habit of the animal. Moreover, this study also provides a general picture of predator-prey relationship which is one of the important inter species interactions.

Keywords: Marsh crocodile, prey preference, scat analysis, wildlife conservation.

Introduction

Marsh crocodiles live in many of the large fresh water bodies in the Gujarat¹⁻³. This crocodile population is one of oldest mugger populations in the state, which is known to be survived in the state before the Indian Wildlife Preservation Act-1972 was proclaimed³. Crocodile is an ambush hunter which usually waits for its prey to come closer and is also an opportunistic skilled predator which preys on several types of species⁴. In order to understand any particular carnivores' character in the ecosystem it is essential to have knowledge of the carnivores' diet⁵. Estimating numbers of prey individuals killed by carnivores is paramount for studying prey preferences of carnivores, prey overlap of carnivores which are sharing same habitat, and for explaining functional responses of carnivores to swapping prey densities⁶. Predation on livestock by top predators such as carnivores and their revengeful punishment to the animal by the owner of cattle is global threat to the conservation; owing to this, human-wildlife conflict increases⁷. The foraging behavior of an animal concludes both the available potential prey and their adaptation which assists them to ingest different types of prey⁸. Scat analysis is the foremost method to ascertain the prey species of carnivores because scats contain undigested prey material such as hair, quills and feathers that can be used for identification^{9,10,11}. Microscopic scat analysis is a safe and fruitful method which is also non-invasive to the animals and is

a vital tool to understand mysterious animals especially carnivores by looking at remains of preys such as hairs, quills, bones, feathers etc^{5,12}. Scat analysis is a basic method to study feeding ecology of elusive carnivores¹³. The crocodiles are important species of aquatic system that play an important role as indicators of healthy wetlands and rivers that maintain environmental integrity of the area. The crocodiles are considered the top predators in the aquatic system. Crocodiles feed majorly on fish, amphibians, mammals, reptiles and birds¹⁴. However, very little attention has been given on the foraging behavior of the marsh crocodile in the past. The mugger's diet varies depending on age and ecosystem. It has also been documented that scat analysis has been conducted for prey identification of mugger crocodiles which showed the presence of hairs of sambar in scat¹⁵. Lithophagy (ingestion of stones) has also been observed in many crocodylian species, function of this behaviour is unknown though. Vertebrates may ingest pebbles by accident or for the purpose to grind food, as a source of minerals, to throw away parasites. In aquatic animals these pebbles may serve as cargo or to increase gravity¹⁶.

Materials and methods

Study area: The study area includes four villages named Deva, Petli, Vaso, Malataj of Anand and Kheda districts, Gujarat state, India at 22°37'12.86" N and 72°44'6.14". It is located between

two main rivers of Gujarat: Sabarmati River in the west side and Mahisagar river in the east direction in central Gujarat. Tobacco and paddy are one of the most important crops of this region. The climate of the region is semi-arid, tropical monsoon type. monsoon rain starts from the month of June to September. Peak precipitation occurs in July and August. Temperature starts rising from middle of April and reaches its peak in month of May.

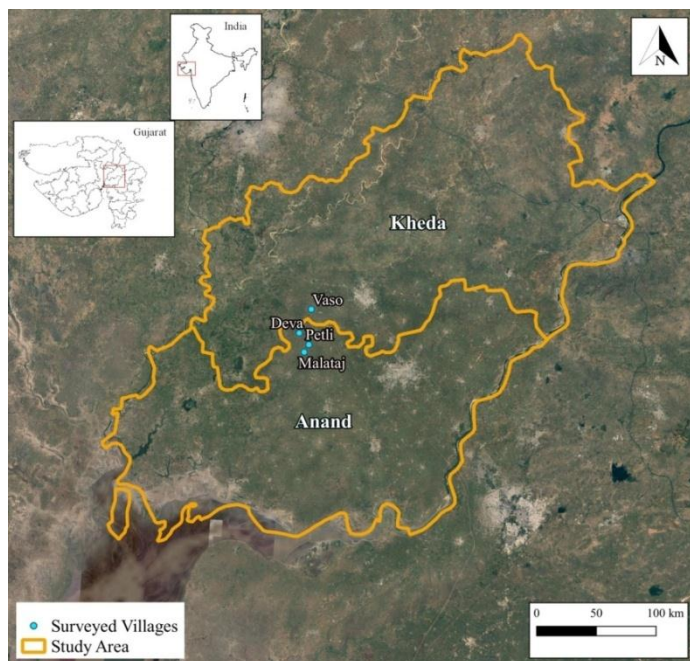


Figure-1: Location map of study area showing four surveyed villages.

Scat collection and identification: Study was conducted from March 2018 to March 2020 which is two-year period. Scat samples were collected in plastic/paper bags from lake shores of

four villages and they were classified into sub-adult and adult categories based on the diameters (1.5-2.5cm sub-adult; 3.5-5.5cm adult)¹. Scat samples were collected season wise: summer (March-June), monsoon (July-October), winter (November-February). Every scat sample's GPS location was taken to mark spots of collection and distribution¹⁷.

Scat analysis: In order to choose one method for scat analysis, both the methods (dry and wet) were applied during study period. i. Wet method: Scat samples were separated by hand separation method and then soaked in water for 24 hours. After that, content was filtered through the sieve. Undigested food materials settled in sieve were collected and identified. ii. Dry method: Dry scat was carefully and gently broken by hands and prey materials were cautiously separated with the help of forceps making sure any of the prey remain does not break. Dry method is more helpful because it does not involve washing of scat hence, it would be beneficial for prospective analysis of chemical composition. From this collected content, prey types were identified, such as scales (Fish and reptiles), feathers (birds), hair (mammals), and insect remains. Scales and hair were permanently mounted on the slide however feathers and insect remains were stored in the plastic bottles after properly cleaned with water and 70% ethanol and dried.

Mounting on the slides: The hair samples were carefully washed in running water then kept in 70% ethanol for 5 minutes in order to remove dirt and dried, then were observed by placing under the microscope at 10X magnification. Hair and scales were whole mounted permanently on the slide by DPX and observed under the compound light microscope first at 10X and then 45X magnification.

Data analysis: Frequency occurrence and its percentage were calculated in Microsoft excel.



(a)



(b)



(c)



(d)

Figure-2: Scats of marsh crocodile (*Crocodylus palustris*) identified in study area (a) Vaso, (b) Malataj, (c) Deva, (d) Petli.



Figure-3: Insect remains found in scat sample of marsh crocodile.

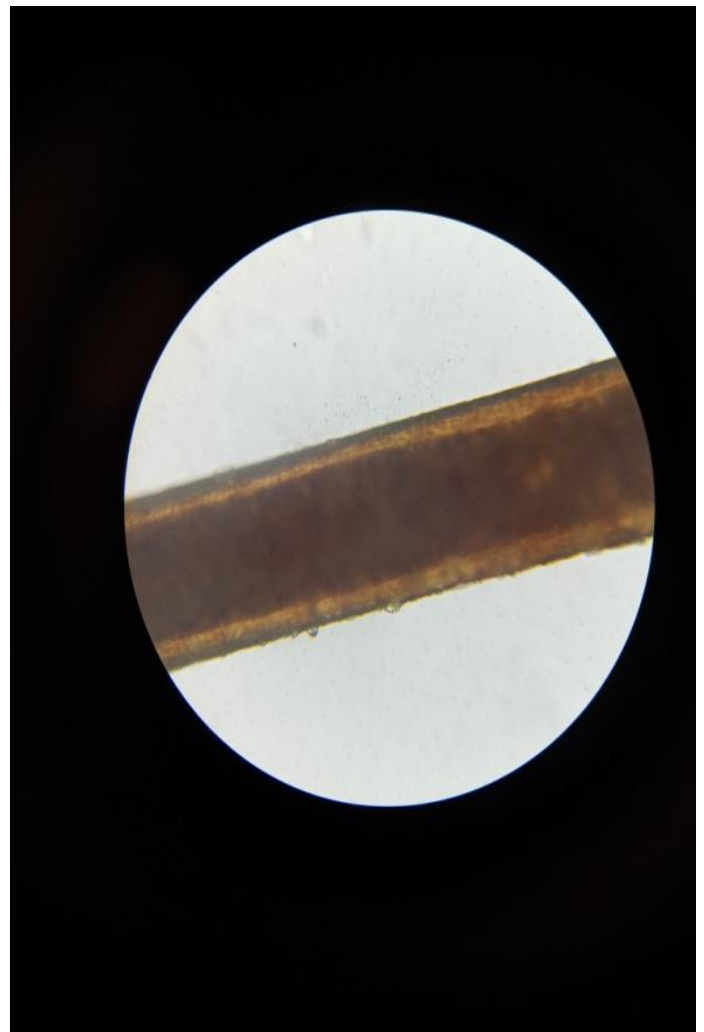


Figure-4: Microscopic image (40X) of mammalian hair found in scat sample of marsh crocodile.



Figure-5: Feathers found in scat sample of marsh crocodile.

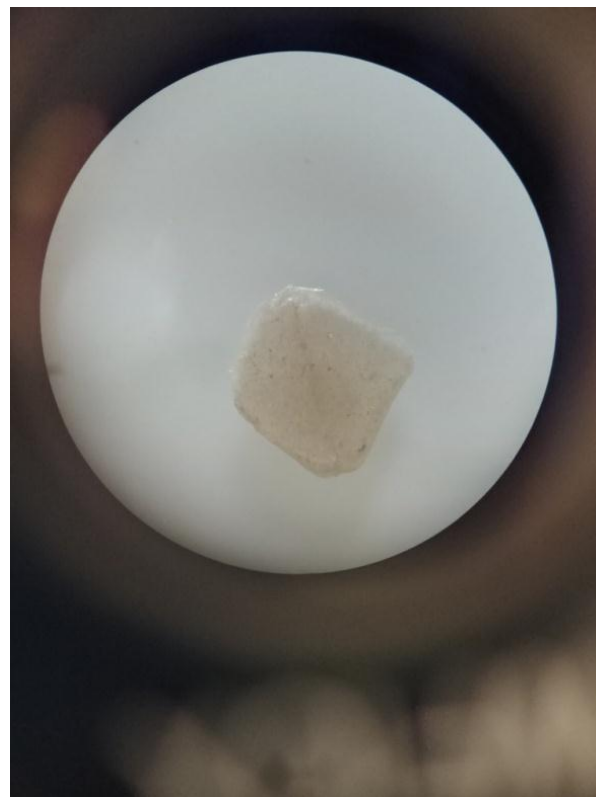


Figure-7: Microscopic image (10X) of fish scale found in scat sample of marsh crocodile.



Figure-6: Microscopic image of snake scale (10X) found in scat sample of marsh crocodile.

Total collection of scat samples was 556 during two years study period from March 2018 to March 2020.

Diet composition varied according to the seasons: summer (March-June), monsoon (July-October), winter (November-February), and as well as size of the animals. Apart from the fish scales and bird feathers, occurrence of mammalian hair, insect remains and snake scales has also been observed.

Table-1: Frequency of occurrence of prey and its percentage from March to June (summer).

Material found	Frequency of occurrence (n=250)	Percentage of occurrence
Mammalian hair	98	25%
Fish scales	162	41%
Feathers	43	11%
Insect remains	40	10%
Snake scales	52	13%

It is evident from the Table-1 that in summer, fish (41%) was the most preferred prey compared to other four prey animals. Whereas, mammals (25%) were the second most preferred prey followed by snakes (13%), birds (11%) and insects (10%).

Table-2: Frequency of occurrence of prey and its percentage from July to October (monsoon).

Material found	Frequency of occurrence (n=96)	Percentage of occurrence
Mammalian hair	67	23%
Fish scales	90	31%
Feathers	56	20%
Insect remains	37	13%
Snake scales	37	13%

In monsoon (Table-2), due to heavy rain, very few scat samples were collected (n=96). Consumption of insect was the highest during monsoon than other two seasons. Occurrence of snake scale remains same as insect. Mammals were taken nearly quarter which is less than other two seasons. Among all, fish intake was the highest in monsoon as well just like winter and summer. Moreover, one fifth of the diet comprises of birds which is third highest after mammals.

In winter (Table-3), apart from fish (30%), mammals and birds comprise major amount of content in diet which are 28% and 27% respectively. Consumption of snake (6%) and insect (9%) is the lowest in winter among all seasons.

Table-3: Frequency of occurrence of prey and its percentage from November to February (winter).

Material found	Frequency of occurrence (n=210)	Percentage of occurrence
Mammalian hair	120	28%
Fish scales	130	30%
Feathers	114	27%
Insect remains	40	9%
Snake scales	21	6%

From Figure-8, it is clear that fish is the mainstay of the diet in all three seasons (summer, monsoon, winter). Few carp fish species were identified by direct observation which were Catla catla (Catla), Labeo rohita (Rohu), Cirrhinus cirrhosus (Mrigal). Consumption of birds is more in winter (27%) as compared to other two seasons due to availability of winter birds. Moreover, frequency of insects increased in monsoon (13%) and decreased during summer months. There is no significant difference in consumption of mammals in all three seasons. During field work, a crocodile was observed scavenging on corpse of domestic buffalo. In addition, intake of snakes (checkered keelback) drastically decreased in winter season (6%) than other two due to low temperature when snakes go into hibernation.

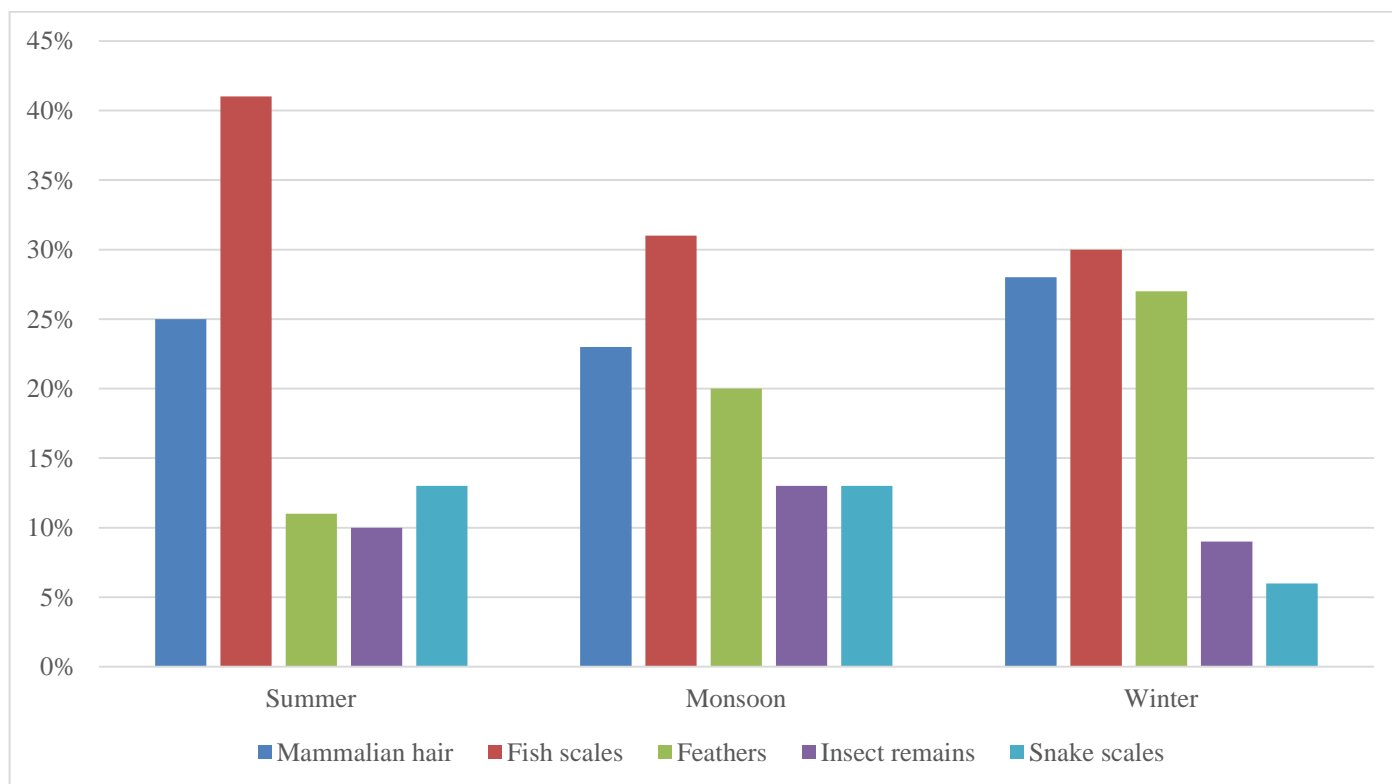


Figure-8: Overall percentage of diet composition found in three different seasons.

Food has been shown to be one of the important factors that determines preference of habitat by the different size-classes of crocodiles¹⁴. This is the first study to examine prey-preference of marsh crocodiles in Charotar region of Anand district.

Among all, fish is the main constituent of the diet throughout the year due to fishing activity in all the water bodies. In summer, fish occurrence is the highest in scat due to low water level which facilitates the animal to capture prey.

In winter, crocodiles utilize land more in order to bask which results in depending more on land animals which are mammals. As a result, consumption of mammals increases in winter than other two seasons. Crocodile predation on domestic buffalo observed during field survey in Vaso as well as mammalian hair was also found from the scat sample of that village.

Feathers of birds were found more frequently in winter followed by summer and monsoon owing to presence of wintering birds which visit wetlands in earlier months of winter.

Insect remains such as appendages were detected from the scat samples. Few studies have suggested that insect remains which are found in the stomach of crocodiles could be obtained secondarily from anurans consumed as prey¹⁸⁻²⁰. However, no anuran remains were found in scat samples during study period.

Apart from fish scales, some other types of scales were also present in several scat samples which were identified as snake scales due to presence of elongated belly scales as well as keel like structure on the scale which make it different from scales of fish. Snake species was identified as Checkered keelback which is inhabitant of freshwater. Frequency of snake scales was highest during summer and monsoon months and lowest in colder months.

Evidences of cannibalism as well as predation on human were not reported during study period.

Conclusion

The findings of the study provide detailed information on prey-preference of free living marsh crocodiles in Anand district region. It has been concluded that fish is the major component of the diet. Microscopic scat analysis results give extensive prey-base including fish, birds, mammals, insects and snakes. Due to fish abundance in the lakes of all villages it could be elucidated that human-crocodile conflicts have not been reported because crocodiles obtain enough food in water only. Moreover, this diagnosis would be helpful in near future to initiate similar investigation using large number of scat samples and regions.

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