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DIET COMPOSITION OF THE GOLDEN JACKAL (*CANIS AUREUS*) IN THE NGORONGORO CRATER, TANZANIA

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ABSTRACT

The Ngorongoro crater is known for having the highest density of carnivores in the world. In the past, most of the research focused on large carnivores such as lions and spotted hyenas. Medium sized carnivores such as jackals have received very little attention and the information on these carnivores including their diet composition is limited. Diet composition of golden jackal(Canis aureus) was studied in the Ngorongoro crater from July 2014 to May 2015 covering both dry and wet seasons using focal animal observation (direct method) and collection (and analysis) of faecal/scat samples from known individuals in the field (indirect method). In both seasons, insects (mostly dung beetles, Family Scarabaeidae) were the most common food item consumed. Quantitatively, carrion (carcasses of large herbivores mainly wildebeest and buffalo) and Abdim's storks (Ciconia abdimii) contributed the most to the diet of golden jackal in the dry and wet season respectively. Jackals also consumed plant materials of the family Cucurbitaceae in both dry and wet seasons. Seasonal variation in types of food was noted; in wet season when the jackals consumed birds (Abdim's storks), Thomson's gazelle fawns and wildebeest placenta. The results suggest that the golden jackals are omnivorous and opportunistic foragers.

Key words: diet, season, golden jackal, Ngorongoro

INTRODUCTION

Ngorongoro Crater exhibits the highest density of predators in the world including lion (*Panthera leo)*, spotted hyena (*Crocutacrocuta*), jackal (*Canis* sp.), cheetah (*Acinonyx jubatus*), and leopard (*Panthera pardus*) (Swanson 2007). For many years research in the area has been focused on large carnivores such as lion and spotted hyenas. Very limited information exists on medium-sized carnivores like jackals in the area (Van Lawick and Van Lawick-Goodall 1970) and thus making this study important. The focus of the study was to investigate the diet composition of the golden jackal in dry and wet seasons in order to shade light on the dietary behaviour of the jackals in Ngorongoro.

The three species of jackals; golden (common) jackal (*Canis aureus*), silver-backed (black-backed) jackal (*Canis mesomelas*) and the side-striped jackal (*Canis adustus*) coexist in the Ngorongoro crater, Tanzania. East Africa is the only region where all the three species of jackals coexist. Elsewhere each species exists alone

or in sympatry with one other jackal species (Valkenburgh and Wayne 1994).

The golden jackal is the most widely distributed of the three jackal species. It is the only jackal species that occurs outside the Sub-Saharan Africa. The golden jackal occurs in North and East Africa, South-eastern Europe, Middle East and South Asia up to Burma and Thailand.

Due to tolerance of dry habitats and omnivorous diet, the golden jackal can inhabit a wide variety of habitats, from the Sahara Desert (except the most hyper-arid parts) and Sahel to the evergreen forests of Myanmar and Thailand. In Africa, the golden jackal typically prefers semi-desert, short to medium grasslands, and savannas (Moehlman and Jhala 2013).

Information on dietary requirements is important in determining the animal's range for effective conservation and is of paramount importance to wildlife management authorities like Ngorongoro Conservation Area Authority (NCAA) in planning for and the management of the species and their habitats. Diet assessment is also important in mammalian ecology as food availability influences population size, social organization and interspecific relationships and thus has significant implications in conservation (Balestrieri et al.2011).

Dietary studies on golden jackal in many parts of world indicate that the animal is an omnivorous and opportunistic forager (Lamprecht 1978,Moehlman 1983, Vaughan 1985, Moehlman 1986, Fuller et al. 1989, Moehlman and Hofer 1997, Moehlman and Jhala 2013).

In the Serengeti National Park, although they consume invertebrates and fruit, over 60% of their diet is vertebrates and they will kill rodents, lizards, snakes, birds (from quail to flamingos), hares and gazelles. They also scavenge the carcasses of larger herbivores, such as common wildebeest (*Connochaetes taurinus*), plains zebra (*Equus quagga*) and African buffalo (*Syncerus caffer*) (Moehlman 1983, 1986, 1989, Moehlman and Jhala 2013).

Most studies on diet composition of jackals have been based on the analysis of faecal samples and a few studies have been based on stomach content analysis. Both are indirect methods. As frequency of occurrence relies on the presence of undigested hard parts in scats (faeces), any food, which has a large proportion of soft material will be underestimated. Thus, in this study both direct observation and faecal analysis methods were employed to ensure more detailed and realistic data on diet composition of the golden jackal is obtained.

MATERIALS AND METHODS

Study site

This study was conducted in the Ngorongoro Crater (3°15'S, 35°30'E) which is part of the Ngorongoro Conservation Area (NCA). The Ngorongoro Conservation Area (Fig. 1) was established in 1959 and is both a World Heritage Site and a Biosphere Reserve. It is adjacent to the Serengeti National Park and together they form the Serengeti–Maasai Mara–Ngorongoro ecosystem. It encompasses an area of over 8,292 km^2 which includes the world famous Ngorongoro Crater. The Crater itself, including its walls, covers approximately 310km^2, and the floor of the Crater, where most wildlife resides, is about 250km^2 (Marttila 2011). There are two seasons in Ngorongoro; a dry season (from June to September) and a rainy season (from October through May). The yearly precipitation is < 600 mm in the north and >

900 mm in the south and southeast while the daily mean temperatures are between 24ºC and 30ºC in Ngorongoro Crater and sometimes range up to 38ºC at Oltupai. Nights are cool or cold (close to 0ºC) from June to August on the rim of the crater (Marttila 2011). The dominant vegetation is tall, medium and short grasslands (Anderson and Herlocker 1973).

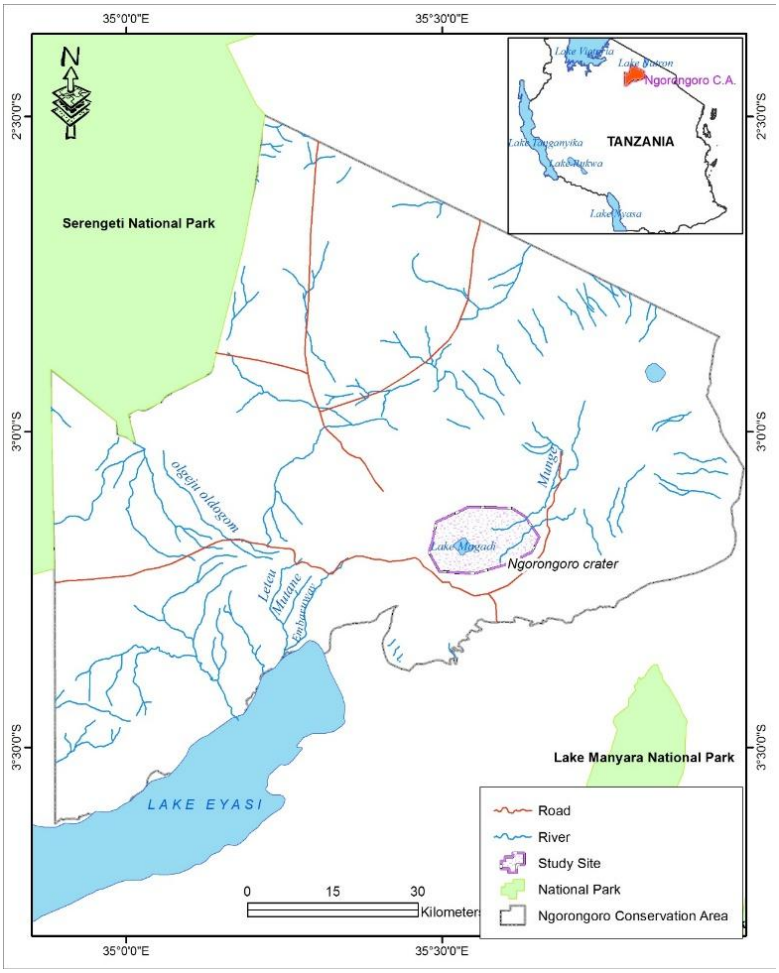

Figure 1: Map of the Ngorongoro Conservation Area**.**

Data collection

Sampling method

Focal animal sampling method (Altmann 1974) in which individual golden jackals were followed as they foraged in the field by four-wheel drive vehicle from morning (0630) to evening (1750) and various aspects of feeding were recorded; these included food items observed being eaten, GPS location, time and habitat. During the daily field observations follows were done systematically on an individual jackal or a

pair (and in cases of lost or spooky individuals, observation was switched to another individual) of habituated jackals. This ensured that different adults of different sexes were followed. During the dry season one pair of golden jackals plus twelve individual golden jackals were followed. During the wet season at least two territorial pairs (adult male and female) were identified and followed. Individuals were identified based on natural markings such as scars and ear notches (Moehlman 1983). Most individuals tolerated the presence of the vehicle as close as 20m and could be followed both on and off road. Data were collected in dry season (July - October, 2014) and wet season (Jan - May, 2015).

Direct observation

The number of prey items consumed was recorded and the amounts of food/prey consumed were estimated through direct observation of focal animals. Estimation of weights of prey items was based on known weights from literature. Dung beetles were the main insects consumed (approximately 5 grams, Kettle, 1990). Rodents weighed between 70 and 130 grams (Senzota 1982, Kingdon 1997). Estimates of carrion consumed were done consistently according to the size of meat that was consumed e.g. 0.5kg, 2kg, 3kg. The observer was trained with known weights of meats for learning how to estimate weight by the size of a piece of meat. Amount of food consumed was then expressed as grams of food per kilometre (from odometer readings) and per hour of foraging.

Indirect method (Scat collection)

Faecal samples were collected from focal individuals after they were deposited. These samples provided additional information on jackal diets. Fresh scats were stored in paper bags and the date, GPS location, species name, sex and habitat were written on the bags. Scats were collected in both the dry and wet season for determination of possible seasonal differences. In the laboratory, scat samples were stored in 70% ethanol, sorted under microscope and the indigestible prey remains were identified to the lowest possible taxon with assistance of a specialist, the use of identification guide books and a reference collection from the field (especially for dung beetles). From the scats, insects were identified by fragments of exoskeletons. Hair and skeletal parts were used to identify the remains of mammals and the presence of seeds indicated the consumption of plant food (fruits) materials. A total of 32 scat samples in the dry season (July -December, 2014) and 38 samples in the wet season (Jan-May, 2015) were collected.

Data analyses

Data are presented in tables and graphs. Data were tested for normality and they did not conform to normal distribution hence a Mann-Whitney U test was used to test for the differences in the amount of prey categories consumed by golden jackal in the dry and wet seasons. The test was also used to compare percentage frequency of occurrence of different broad food categories in the scats in both dry and wet seasons.

The amount of food consumed by jackals and percentage total weights were computed using the expressions:

$$\textbf{Weight consumed per hour of foraging} = \frac{\text{Total weight of food items consumed}}{\text{Total hours foraged}}$$

$$\textbf{Weight consumed per kilometre of foraging} = \frac{\text{Total weight of food items consumed}}{\text{Total kilometres foraged}}$$

Percentage of weight of food item consumed

$$= \frac{\text{Total weight of particular food item consumed}}{\text{Total weight of all food items consumed}} \times 100\ \%$$

Percentage frequency of occurrence of food items in the scats

$$= \frac{\text{Number of scat samples containing particular food item}}{\text{Total number of scat samples}} \times 100\%$$

RESULTS

Direct observation method

In the dry season (July-December, 2014), food/prey items eaten by golden jackal were insects, rodents, scavenged items (carrion) and at least one bat eared-fox. In the wet season (Jan-May, 2015) the food/prey items were insects, rodents, carrion, wildebeest placenta, birds (Abdim's stork), Thomson's gazelle fawns and one adult. In both seasons; insects were the most frequent prey item followed by carrion and rodents (Table 2). Carrion of large herbivores (mainly buffaloes and wildebeests) was consumed in both seasons. The amount of carrion consumed was higher in dry season than in the wet season though the difference was not significant (Mann-Whitney U test, $p > 0.05$, $U = 44.5$) (Table 1 and Table 2). Availability of other food types such as Thomson's gazelle fawns, wildebeest placenta and birds (in particular, Abdim's storks) in wet season could be a reason for less carrion consumed in the dry season. Quantitatively, carrion contributed the highest amount to jackal's diet in the dry season as compared to rodents and insects (Table 1). Although insects had the highest percentage frequency of occurrence (100% in each season), their contribution to jackal's diet in terms of weight consumed was the lowest (Table 1).

Table 1: **A comparison of percentage of direct feeding observations, weight of food consumed per km (g/km), per hour of foraging (g/hour) and percentage of relative total weight of food consumed by golden jackal in the dry and wet seasons in Ngorongoro Crater.**

Food item	% of all direct feeding observations	Weight consumed per Km of foraging (g/km)	Weight consumed per hour of foraging (g/hr)	% of relative total weight consumed

	dry season	**wet season**	**Dry season**	**Wet season**	**dry season**	**wet season**	**dry season**	**wet season**
Rodents	14.60	1.30	4.21	0.63	6.70	1.00	7.81	0.62
Insects	63.40	68.40	2.70	4.42	4.30	7.20	5.01	4.49
Carrion	19.50	7.30	47.18	10.91	74.80	17.80	87.18	11.10
Bat-eared fox	2.40							
Thomson gazelle's fawn		1.30		18.92		31.00		19.34
Abdim's stork		10.10		34.44		56.30		35.12
Wildebeest placenta		10.10		9.78		16.00		9.98
Adult Thomson's gazelle		1.30		18.92		31.00		19.34
Total (%)	**100%**	**100%**					**100%**	**100%**
Total weight (g)			**54.09**	**98.01**	**85.80**	**160.30**		

Indirect method

Insects (mainly dung beetles), small mammals (rodents), carrion (of large herbivores including buffaloes and wildebeests) and plant materials (fruits of Cucurbitaceae family) constituted the jackals' diet in both seasons (Table 2). Bird remains were found in scats collected during the wet season in addition to the mentioned food items. Insects were frequently eaten (found in all scats analysed). The percentage occurrence of dung beetles (family Scarabaeidae, order Coleoptera) in the dry season was significantly greater in the scats (65.6%, n = 32) as compared to other insect families (Kruskal-Wallis test, $p < 0.001$) (Table 3). Likewise, in the wet season, insects (mostly dung beetles, family Scarabaeidae) formed the largest percentage of food items consumed (89.5%, n = 38) (Mann- Whitney U test, $p < 0.001$, $U = 228$), Table 2)

Table 2: Percentage frequency of occurrence of various food items found in scats of golden jackals in dry and wet seasons in Ngorongoro Crater.

Food item category	**Percentage frequency of**	**Percentage frequency of**

	occurrence in dry season	occurrence in wet season
Insects	100	100
Rodents	59.4	29.0
Plant materials	25	39.5
Carrion	9.4	5.3
Birds	0	5.3

Table 3: Percentage frequency of occurrence of insects (families/orders) in the scats of golden jackals in the dry season in Ngorongoro Crater.

Scarabaeidae (Order Coleoptera), dung beetles	Calliphoridae (Order Diptera)	Formicidae (Hymenoptera)	Orthoptera	Unidentified invertebrates
65.6%	25%	9.4%	15.6%	25%

Frequency of occurrence of rodents was significantly greater in the dry season (59.4%, n = 19) as compared to the wet season (28.9%, n = 11), Mann-Whitney U test, p = 0.0001, U = 318.5) (Table 2)
There was no significant difference in amount of plant materials consumed between the two seasons (Mann-Whitney U test, p > 0.05, U = 580) although jackals appeared to feed more plant materials during the wet than dry season.

DISCUSSION

Results obtained in this study show that golden jackals had a varied diet consisting of both animal and plant food items. Opportunistic feeding also observed in this study is one of the reasons for the success of the golden jackals and other members in the family Canidae (Vaughan 1985). Seasonality in terms of quantity and types of food items consumed was reflected in the diet of golden jackals. Lesser amount of rodents and carrion consumed in the wet season as compared to the dry season may be due to availability of more food types during that season. For example, Abdim's storks (a migratory bird, 1.2 kg live weight) were abundant at the beginning of the wet season, and they were scattered all over the short grasslands in the crater, the preferred habitat for golden jackals. These storks were opportunistically hunted by the golden jackals. The hunting was usually performed by a single individual and the kill was usually taken to a den to be shared by pups and the rest of the family group members.

The wet season was the whelping (breeding) season for the golden jackals. The whelping season of jackal species is known to reflect the temporal availability and abundance of food within their ranges (Van Lawick and Van Lawick-Goodall 1970, Moehlman 1983). Jackal pairs with pups usually go back to their dens and regurgitate the food to their pups on regular basis. The wet season is also a breeding season for wildebeest and Thompson's gazelle (Swanson 2007). Golden jackals were observed to follow the wildebeest and feed on their placenta as they gave birth to calves (Table 1). During this season, golden jackals also opportunistically hunted Thomson's gazelle fawns. Hunting was usually performed by a pair of golden jackals and the hunted fawn was usually equally shared between the male and female. Similar observations were reported by Moehlman (1983). Hunting in pairs increases the hunting success of jackals (Lamprecht 1978, Moehlman and Hofer 1997). The golden jackals were also observed in one incidence to cooperatively

hunt and feed on adult Thomson's gazelle (20kg) (Table 1) (Temu et al. 2017). Depending on food availability, golden jackals may be solitary hunters, hunt in pairs or groups (Mondal et al. 2012). This behaviour was also observed during this study.

Several studies conducted on diets and feeding habits of golden jackals in different parts of the world have shown that golden jackals are omnivorous and opportunistic foragers (Van Lawick and Van Lawick-Goodall 1970, Lamprecht 1978, Moehlman 1983, Fuller et al.1989, Radovic and Kovacic 2010, Mondal et al. 2012, Moehlman and Jhala 2013). These studies agree with the findings of this study. Opportunistic foraging allows golden jackals to feed on available food items that are less costly energetically. Moreover, the study results agree with observations obtained by Lamprecht (1978) on diet of golden jackals in the Serengeti National Park, which basically form one ecosystem with Ngorongoro. He found that golden jackals consumed carcasses of large herbivores, hunted gazelle fawns, rodents, and birds and ate insects and vegetable matter.

Prey availability, size and vulnerability are known to influence food choice by golden jackals. For example, insects belonging to family Scarabaeidae, order Coleoptera (dung beetles) were frequently eaten in both seasons as indicated in the results (Tables 2 and 3). The jackals were observed to regularly inspect/check dungs of large herbivores such as elephants, buffaloes and zebras for dung beetles when foraging. The fact that dung beetles were eaten more often may be due to their availability and vulnerability (cannot easily escape) as compared to other flying insects like grasshoppers which were opportunistically caught and consumed. The golden jackals were sometimes seen jumping to catch flying insects but in most cases the attempts were in vain. These results agree with other findings including that of Radovic and Kovacic (2010) where Coleoptera were one of the important orders of insects in the diet of golden jackals in Croatia.

When a carcass especially of big herbivore such as a buffalo, wildebeest or zebra is located, jackals normally spent most of the time feeding on it and caching the surplus. Golden jackals also fed on wildebeest placenta in the wet season when they are plentiful and available. Golden jackals were observed to follow the wildebeest and feed on their placenta as they give birth to calves. Plant items were not observed being fed by jackals in the field, however, some seeds of family Cucurbitaceae were found in their scats in both seasons suggesting the importance of plant food materials to jackals and further confirming the omnivory feeding habits of jackals. A study by Mondal et al. (2012) in Sariska Tiger Reserve, Western India suggested that vegetable matters had maximum contribution to the golden jackal's diet followed by rodents. Furthermore, rodents were observed to represent a primary food for jackals in Bulgaria (Markov and Lanszki 2012) and thus underscoring the similarity of the findings of this study with those conducted elsewhere.

CONCLUSION AND RECOMMENDATION

The study provides further confirmation that golden jackals are omnivorous and opportunistic foragers whose diet is reflected by the availability of food items in their habitats. Insects, rodents, carrion and plant materials are the main food items for the golden jackals in the dry season in Ngorongoro crater. Additionally, Abdim's storks, Thomson's gazelle's fawns and wildebeest placenta are also essential food

source for the golden jackals in the wet season which is also a breeding season for the golden jackals.

It is recommended that further study on diets of golden jackals be conducted in areas outside the crater (within Ngorongoro Conservation Area) where the jackals are also known to occur to ascertain the feeding ecology of jackals in those areas and if it differs from that in the crater. Furthermore, in this study observations were made during the day time only and hence it is recommended that a future study be conducted both in the day and at night to have better information on the diet composition and feeding behaviour of the golden jackals at night since these animals are known to be active at night too. Night data collection will also enable the study of the side-striped jackal, another jackal species which is typically nocturnal (and rarely seen during the day). This will provide an opportunity to make comparisons of the diets of all the three species of jackals coexisting in the area.

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