Food Habits of Golden Jackal (*Canis aureus*) and Striped Hyena (*Hyaena hyaena*) in Sariska Tiger Reserve, Western India

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**Abstract:** Food habits of golden jackal (*Canis aureus*) and striped hyena (*Hyaena hyaena*) were investigated using scat analysis between November 2010 and June 2011 in Sariska Tiger Reserve, Western India. Total 104 scats of golden jackal and 86 scats of striped hyena were collected and analyzed. The frequency of occurrence of each prey species was estimated through bootstrapping using program SIMSTAT. Niche breadth of these two species was quantified using Levin’s measure. The diet overlap in the two species was assessed using Pianka’s index. Twelve food items were identified in golden jackal scats and nine in striped hyena scats. Vegetative matter contributed maximum (17.57%) in jackal’s diet followed by rodents (15.77%), chital (10.81%), sambar (5.41%) and nilgai (4.05%). Nilgai and domestic cattle contributed maximum (24.76% each) in the diet of striped hyena, followed by sambar (17.14%), chital (16.19%) and vegetative matter (10.48%). The estimated dietary overlap between striped hyena and golden jackal was 67%. Niche breadth for golden jackal was estimated as 0.69 and for striped hyena it was 0.57. The considerable overlap was attributed to mutual dependence on ungulates, which indicated high resource competition between the two species.

**Key words:** *Canis aureus* - Dietary Niche Overlap - Food Habits - *Hyaena hyaena* - Prey Size - Scat

**INTRODUCTION**

The extent of niche differentiation and resource partitioning determines the degree to which different species can either coexist or competitively exclude each other [1, 2]. An important mode of resource partitioning is the degree of dietary overlap between sympatric species [3]. This overlap is influenced by each species’ physical ability to obtain food [4, 5] and also by variation in the spatial and temporal availability of food [6]. For distinct carnivore guilds different mechanisms may be involved, such as different body sizes of predators [7] and prey species [8, 9], activity pattern [10] and microhabitat use [11]. However, whereas resources are limited, the strength of competition between sympatric species generally decreases with increased resource partitioning [12].

Study by Dickman [13] showed that the smaller predators in an insectivorous mammal guild consumed smaller prey, but switched over to larger prey when the larger predators were removed. Consequently prey selection could depend more on competition among predator guild members than on any inherent relationship between predator and prey sizes. A confounding factor in predator-prey studies that include a wide size-range of mammalian predators is the high variability in diet of smaller species, which can switch between insectivore, omnivore and carnivore. Canid and felid species above certain threshold weight class predate purely on vertebrates, while those below may be omnivorous or predate on invertebrates and vertebrates. This implies that large carnivores (>21.5 kg) constitute a distinct functional group from which predator-prey size relationships should emerge more clearly than from carnivore assemblages that are distributed across both sides of the body mass threshold [14]. The diet of the golden jackal and the striped hyena was studied through scat analysis in India [15-18] and other countries [19-22]. Merve et al. [23] studied diet overlap between brown hyena (*Parahyaena brunnea*) and black-backed jackal (*Canis mesomelas*) in Atherstone Nature Reserve, Pilanesberg National Park and private farm (Mankwe Wildlife Reserve) in South Africa. They inferred that, despite the marked body size differences, brown hyena and black-backed jackal can be considered as either meso-carnivores or apex predators,
depending on the presence or absence of larger carnivores [24]. As meso-predators, the potential food availability increases as dietary items previously unattainable, are killed by apex predators and interspecific competition could decline concomitantly. The diet of black backed jackal comprises high proportion of small and large mammals, corroborating that both scavenge and hunt competently [25]. Brown hyenas, on the other hand, are predominant scavengers [26]. Thus, jackals may be excluded from carcass sites by brown hyenas, eventually forcing them to hunt more frequently [27].

Both striped hyena (*Hyaena hyaena*) and golden jackal (*Canis aureus*) are found in semi-arid zone and tropical dry and moist deciduous forests of the country and their diet ranges from wild ungulates to domestic livestock and rodents. Although numerous studies have investigated their diet separately, only a few studies [23] have investigated the overlap and resource partitioning, which may vary with the presence or absence of apex predators like tiger (*Panthera tigris*) and leopard (*Panthera pardus*). In the present study, we assessed 1) the relative contribution of different prey species to the diet of golden jackal and striped hyena and 2) the dietary overlap between these two sympatric species. In the present study we estimated the food habits of striped hyena (*Hyaena hyaena*) and golden jackal (*Canis aureus*) and compared the dietary overlap between them in Sariska Tiger Reserve, Western India from November 2010 to June 2011.

**MATERIALS AND METHODS**

**Study Area:** The study was conducted in Sariska Tiger Reserve (Sariska TR) (27°05'-27°33' N; 76°15'-76°35' E) between November 2010 and June 2011. Sariska TR is situated in the Aravalli Hill Range in the semi-arid part of Western India [28]. The total area of the Tiger Reserve is 881 km², of which 273.8 km² is notified National Park. The vegetation of Sariska corresponds to Northern tropical dry deciduous and Northern tropical thorn forests [29]. Open areas are covered with scrub forests dominated by shrubs such as *Zizyphus nummularia*, *Capparis sepiaria*, *Capparis decidua*, *Adathoda vasica*, *Prosopis juliflora* and *Acacia sp*. The valleys are dominated by *Zizyphus mauritiana* mixed forest, gentle slopes are dominated by *Anogeissus pendula* forest and the steep slopes are occupied by *Boswellia serrata* forest. Other than golden jackal and striped hyena, the Park supports various carnivores and omnivores such as tiger, leopard, jungle cat (*Felis chaus*), common mongoose (*Herpestes edwardsii*), small Indian mongoose (*H. auropunctatus*), ruddy mongoose (*H. smithi*), common palm civet (*Paradoxurus hermaphroditus*), small Indian civet (*Viverricula indica*), ratel (*Mellivora capensis*) and prey species like chital (*Axis axis*), sambar (*Rusa unicolor*), nilgai (*Boselaphus tragocamelus*), common langur (*Semnopithecus entellus*), wild pig (*Sus scrofa*), porcupine (*Hystrix indica*), rufous-tailed Hare (*Lepus nigricollos ruficaudatus*) and Indian peafowl (*Pavo cristatus*)[30]. There are 32 villages within Sariska TR of which six are located in the intensive study area of 160 km². A large number of brahmini cattle (*Bos indicus*), buffaloes (*Bubalus bubalis*), goats (*Capra hircus*) and sheep (*Ovis aries*) are kept by people living in villages.

**Scat Analysis:** Estimation of food habits of golden jackal and striped hyena was done using scat analysis. Scats were collected on transects, trails and roads whenever encountered within the intensive study area. Each collected scat sample was labeled with the name of the species, date and location. The collected scats were sun dried and later broken down and washed under running water through a sieve. The scat contents were teased apart and remain of different food items such as hair, feather, scales of reptiles, invertebrate remains and vegetable matter (grass and fruit seeds) were separated. The frequency of occurrence of each food item was estimated through bootstrapping using program SIMSTAT [31]. This technique measures 95% confidence limits of the proportion of each food item in the diet, the limits of which range measure the random sampling errors [19]. Niche breadth of the two species was quantified using Levin’s measure [26] to measure the uniformity of resources being utilized by each species. The overlap in diet of the two species was assessed using Pianka’s [32] index.

**RESULTS**

Altogether 104 scats of golden jackal and 86 scats of striped hyena were collected and analyzed. Hair samples from scats were identified from their histological structure using microscope. In total 12 food items were identified in golden Jackal scats and nine in striped hyena scats. The frequency of occurrence and percentage frequency of occurrence of each food item found in golden jackal and striped hyena scats are given in table 1.
Table 1: Frequency of occurrence and percentage frequency occurrence of each food item found in golden jackal and striped hyena scats in Sariska Tiger Reserve, Western India between November 2010 and June 2011

<table>
<thead>
<tr>
<th>Food item</th>
<th>Golden jackal Frequency of occurrence (±SD)</th>
<th>Percentage frequency of occurrence</th>
<th>Striped hyena Frequency of occurrence (±SD)</th>
<th>Percentage frequency of occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scales of reptiles</td>
<td>4±1.9</td>
<td>1.80</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Vegetation</td>
<td>37.5±4.7</td>
<td>17.57</td>
<td>12.8±3.4</td>
<td>10.48</td>
</tr>
<tr>
<td>Fruit</td>
<td>19.1±3.8</td>
<td>9.01</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bird</td>
<td>15.5±3.6</td>
<td>7.21</td>
<td>2.3±1.5</td>
<td>1.90</td>
</tr>
<tr>
<td>Insect</td>
<td>15.3±3.8</td>
<td>7.21</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rodent</td>
<td>34±4.5</td>
<td>15.77</td>
<td>1.2±1.1</td>
<td>0.95</td>
</tr>
<tr>
<td>Hare</td>
<td>8.9±2.9</td>
<td>4.05</td>
<td>1.2±1.1</td>
<td>0.95</td>
</tr>
<tr>
<td>Sambar</td>
<td>11.3±3.1</td>
<td>5.41</td>
<td>20.9±4.4</td>
<td>17.14</td>
</tr>
<tr>
<td>Chital</td>
<td>23.1±3.9</td>
<td>10.81</td>
<td>19.8±4.0</td>
<td>16.19</td>
</tr>
<tr>
<td>Nilgai</td>
<td>8.7±2.8</td>
<td>4.05</td>
<td>30.2±4.8</td>
<td>24.76</td>
</tr>
<tr>
<td>Cattle</td>
<td>32.9±4.5</td>
<td>15.32</td>
<td>30.2±4.8</td>
<td>24.76</td>
</tr>
<tr>
<td>Goat</td>
<td>3.7±1.9</td>
<td>1.80</td>
<td>3.5±2.1</td>
<td>2.86</td>
</tr>
</tbody>
</table>

Vegetative matter contributed maximum (17.57%) in golden jackal’s diet followed by rodents (15.77%), cattle *Bos indicus* (15.32%), chital (10.81%), fruits (9.01%), birds (7.21%), sambar (5.41%), hare (4.05%), nilgai (4.05%), goat (1.80%) and reptile scales (1.80%). No attempt was made to identify the rodent and reptile species in golden jackal’s scat. Out of 104 golden jackal scats, one had six food items, one had five food items, ten had four food items, 23 had three food items, 34 had two food items and 35 had single food item. *Zizyphus mauritiana* seeds were the only fruit species found in golden jackal’s diet. Beetles (Class: Insecta), centipedes (Class: Chilopoda), millipedes (Class: Diplopoda) in golden jackal’s diet were identified on the basis of locomotory organs, i.e. shiny elytra of beetles and round or oval shields of centipedes/ millipedes. Feathers of grey partridge (*Francolinus pondicerianus*) and peafowl (*Pavo cristatus*) were identified in golden jackal’s diet. Narrow ventral scales and translucent round scales were also identified to be of lizards (*Calotes sp.*) and skinks (family: Scincidae) but not at species level.

In some incidences (n=9) golden jackals were found to prey upon chital fawns in the study area and this may be attributed to higher occurrence of chital in their scats. Golden Jackal was never found to prey on sambar or nilgai (adult or fawn) in the study period, but they scavenge on sambar and nilgai kills made by tiger or leopard in the study area, which is reflected in lower occurrence in their scats. Golden Jackal were also found scavenging on cattle carcasses at the dump sites outside villages in the study area, which is attributed to higher occurrence of cattle in their diet. There were records of jackal predating on goats in the study area but cattle predation by them was not recorded. The result of scat analysis supports the typical diet generalist of golden jackal, feeding on a variety of food source available to them in the study area.

Out of 86 striped hyena scats, three scats had three food items; 40 scats had two food items and 43 scats had single food items. Nilgai and cattle (*Bos indicus*) contributed maximum (24.76%) in the diet of striped hyena followed by sambar (17.14%), chital (16.19%), vegetation (10.48%), goat (2.86%), unidentified bird (1.90%), hare (0.95%) and unidentified rodent (0.95%). The remains of larger ungulates such as sambar, nilgai and chital were observed more in scat samples as compared to the remains of goat, bird, rodent and hare. The above mentioned large ungulates are also the major food items of tiger and leopard in the study area [33, 34]. This may lead to the inference that the occurrence of larger ungulates in hyena diet is perhaps the result of scavenging.

The estimated dietary overlap between striped hyena and golden jackal was 67% (Table 2). Niche breadth for golden jackal was estimated as 0.69 and for striped hyena it was 0.57 (Table 3). MacArthur and Levin’s [35] niche overlap was calculated as an overlap measure of species A on species B and vice-versa. The niche overlap of golden jackal on striped hyena was 66% (0.66) i.e. out of total diet range of striped hyena, 66% of food items are common with golden jackal and the niche overlap of striped hyena on golden jackal was 47% (0.47) i.e. out of total diet range of golden Jackal, 47% of food items are common with striped hyena.
Table 2: Dietary overlap between golden jackal and striped hyena as shown by scat analysis in Sariska Tiger Reserve, Western India between November 2010 and June 2011

<table>
<thead>
<tr>
<th>Food Item</th>
<th>Percentage frequency of occurrence (striped hyena) ($P_{ia}$)</th>
<th>Percentage frequency of occurrence (golden jackal) ($P_{ib}$)</th>
<th>$P_{ia}P_{ib}$ (C)</th>
<th>$P_{ia}^2$ (D)</th>
<th>$P_{ib}^2$ (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation</td>
<td>10.48</td>
<td>17.57</td>
<td>184.04</td>
<td>109.75</td>
<td>308.62</td>
</tr>
<tr>
<td>Bird</td>
<td>1.90</td>
<td>7.21</td>
<td>13.73</td>
<td>3.63</td>
<td>51.94</td>
</tr>
<tr>
<td>Rodent</td>
<td>0.95</td>
<td>15.77</td>
<td>15.02</td>
<td>0.91</td>
<td>248.56</td>
</tr>
<tr>
<td>Hare</td>
<td>0.95</td>
<td>4.05</td>
<td>3.86</td>
<td>0.91</td>
<td>16.44</td>
</tr>
<tr>
<td>Sambar</td>
<td>17.14</td>
<td>5.41</td>
<td>92.66</td>
<td>293.88</td>
<td>29.22</td>
</tr>
<tr>
<td>Chital</td>
<td>16.19</td>
<td>10.81</td>
<td>175.03</td>
<td>262.13</td>
<td>116.87</td>
</tr>
<tr>
<td>Nilgai</td>
<td>24.76</td>
<td>4.05</td>
<td>100.39</td>
<td>613.15</td>
<td>16.44</td>
</tr>
<tr>
<td>Cattle</td>
<td>24.76</td>
<td>15.32</td>
<td>379.24</td>
<td>613.15</td>
<td>234.56</td>
</tr>
<tr>
<td>Goat</td>
<td>2.86</td>
<td>1.80</td>
<td>5.15</td>
<td>8.16</td>
<td>3.25</td>
</tr>
<tr>
<td>Scales of reptiles</td>
<td>0.00</td>
<td>1.80</td>
<td>0.00</td>
<td>0.00</td>
<td>3.25</td>
</tr>
<tr>
<td>Fruit</td>
<td>0.00</td>
<td>9.01</td>
<td>0.00</td>
<td>0.00</td>
<td>81.16</td>
</tr>
</tbody>
</table>

$P_{ia}$ of food item $i$ in the diet of striped hyena; $P_{ib}$ of food item $i$ in the diet of golden jackal; $C = P_{ia}P_{ib}$; $D = P_{ia}^2$; $E = P_{ib}^2$; $F = \sum C$; $G = \sum D$ and $H = \sum E; I = G^2; J = H^2; O = F(J*I)^0.5$.

Table 3: Dietary niche breadth between Golden Jackal and Striped Hyena as shown by scat analysis in Sariska Tiger Reserve November 2010 to June 2011

<table>
<thead>
<tr>
<th>Variable</th>
<th>Golden jackal</th>
<th>Striped hyena</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>B</td>
<td>8.604</td>
<td>6.157</td>
</tr>
<tr>
<td>$B_\lambda$</td>
<td>0.691</td>
<td>0.573</td>
</tr>
<tr>
<td>$M_{\lambda}$ MacArthur and Levins measure</td>
<td>0.663</td>
<td>0.475</td>
</tr>
</tbody>
</table>

**DISCUSSION**

In Sariska TR, the striped hyena occupies all the major habitat types, compared to golden jackal that is mainly distributed in the open scrub land and valley habitat. There are predictions that body size and behavioral flexibility would influence the response of predators and this response would be evidenced in individual use of habitat elements and in the spatial distribution of predators [36]. Specifically, larger species (i.e. striped hyena) would be more equitably distributed among all spatial habitat elements compared to smaller species (i.e. golden jackal), because large size would confer an increased ability to traverse the habitat matrix with minimal risk of predation. Similarly, species with a broader niche would be more equitably distributed among spatial habitat elements because broader diet breadth would allow a species to use the majority of spatial elements and exploit a wider range of resources. Additionally, presence of larger species and species with broader niches would be more closely linked to characteristics of favorable elements (cover or food) and the landscapes surrounding an element, because the combined effects of large size and a broad niche on the species would impose fewer constraints on its element and landscape use compared to smaller, more specialized species [36]. In Sariska TR, golden jackals are found to be confined in the valley areas where a range of smaller prey species as well as fruiting trees (Zizyphus sp.) are available, while distribution of striped hyena was wider including valley habitats and hilly areas [37]. In the present study, broader dietary niche was observed for golden jackal as compared to striped hyena, because golden jackal assumed to compensate their limited distribution by utilizing broader spectrum of food.

Many studies have explained dietary differences within the context of alternative feeding strategies (i.e. generalist vs. specialist foraging) or intrinsic niche differentiation (i.e. disparity in habitat requirements or body size) [38-41]. However, not all species fall into such discrete categories [42]. Indeed, within a given community, the relative breadth of a carnivore’s diet (and by extension levels of interspecific dietary overlap) is best defined in relation to the feeding habits manifested by its tropical counterparts [43]. However, when prey abundance fluctuates dramatically over a period of time, even alleged specialist species may exhibit more generalist feeding patterns [44]. Moreover, a review of dietary breadth among herbivorous insects revealed that while...
generalization characterized the diet of many insect species, the dietary choices of individuals within particular populations were often specialized (according to the traditional framework described above), suggesting that in many cases dietary breadth may be a local (i.e. system-specific) phenomenon rather than an immutable species characteristic [42]. The considerable overlap (67%) characterizing the diets of striped hyena and golden jackal, may be attributed to mutual dependence on ungulates, which intern indicates that resource competition between these two species may be high. However, striped hyena relied more on large ungulates, whereas golden jackal preyed largely on small ungulates and rodents; these dietary specializations may have alleviated overall levels of competition between two species. This pattern of exclusive use of a particular prey items, despite the overall dietary similarity, characterizes the relationships between sympatric coyotes *Canis latrans* and gray foxes *Vulpes velox* [45] and coyotes and red foxes *Vulpes vulpes* [46].

Depending on food availability, golden jackals may be solitary hunters, co-operating in pairs or hunting as groups (mainly when the parents teach the offspring to hunt). The differences in large mammal and small mammal proportions between the diets resulted in a significant difference between golden jackal and striped hyena diets. However, at 67%, the niche overlap between the species was still high. Result of the present study is comparable with the studies by Nowell and Jackson [46] and Walton and Joly [25] on black-backed jackal (*Canis mesomelas*) in Africa. Studies by Owens and Owens [26, 27] on brown hyenas showed that they are predominantly scavengers and black-backed jackals are generally excluded from carcass sites by the much larger brown hyenas, forcing them to hunt more frequently. The similar case may likely happen in Sariska TR where striped hyenas occur in high density i.e. 24.5 individual/ 100 sq. km [47]. Study by Merwe *et al.* [23] on assessment of diet overlap between brown hyena and black-backed jackal suggested that in black backed jackal’s diet, more large mammals were consumed outside protected areas whereas more small mammals were consumed inside protected areas in South Africa’s North West Province. This observation supports the fact that golden jackal are being excluded from scavenging sites and forced to actively hunt when competing with striped hyena in the present study. The low frequency of smaller prey species in the diet of the striped hyena may reflect sufficient carrion resources, as most samples originated in the study area where the hyenas are relegated to meso-carnivore status by the presence of apex predators like tiger and leopard. This suggests that niche partitioning in protected areas in the presence of an apex predator results in a form of competitive exclusion of jackal at carcasses by hyena, resulting in a greater level of hunting by the jackals, connatural to the study in Africa [23].

Review of the studies showed marked interspecific difference in plant-matter consumption by golden jackal. Whereas, plants did not play an important role in the feeding of golden jackals in Hungary [20], compared with the feeding of jackals in southern areas of Asia [48]. In the present study vegetative matter i.e. grass and *Zizyphus* fruits comprised a higher proportion 26.58% in golden jackal’s diet.

Seasonal dominance of small mammals was reported in golden jackal’s diet [49-51]. In the present study no attempt was made to quantify the seasonal diet of golden jackal. Study by Lanszki *et al.* [20] on feeding habits and tropical niche overlap between golden jackal (*Canis aureus*) and red fox (*Vulpes vulpes*) in the Pannonia eco-region, Hungary revealed that functional response of the golden jackal to a limited but favored food item was more rapid than that of the red fox. The golden jackal shifted from small prey to other food items earlier when the availability of small mammals declined and also returned to rodent hunting earlier than did the red fox. Long term ecological studies including seasonal food habits on golden jackal and striped hyena are much desired across different landscapes in the country.

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