

## Studies on Ethology and Eco-physiology of the Antelopes of the Indian Desert

H C Bohra, S P Goyal\*, P K Ghosh and Ishwar Prakash  
Central Arid Zone Research Institute, Jodhpur-342 003 India

**Abstract** The present paper deals with the findings of a long term study conducted on the ethology and eco-physiology of the antelopes, the chinkara or the Indian gazelle (*Gazella bennetti*), the blackbuck (*Antelope cervicapra*) and the nilgai (*Baselaphus tragocamelus*) inhabiting the arid region of India. The blackbuck is basically a grazer and prefers open scrub lands, saline flats or gravelly to hard pan soil having a waterhole nearby, whereas the chinkara is a browser and prefers sandy undulating or dune slopes or sandy to loamy bush lands and fallows. The presence of waterhole (s) in the chinkara habitat is desirable but is not essential. The chinkara's preference for moisture laden leaves and flowers and its habit of seeking shade during the hottest part of the day curtails its dependence on free water intake. The nilgai's preferred haunts are gravelly wasteland and piedmont areas as well as hard pan areas. Their numbers are considerably high around irrigated double cropped agricultural fields. The blackbuck and chinkara population are generally dwindling and hence they need protection whereas the nilgai has proved to be a menace to the standing crops as well as stored agricultural produce. The blackbuck and the chinkara may be further protected by demarcating some more areas around the Bishnoi dominated villages for preservation of the whole eco- system. These areas should be suitably fenced and should have assured feed and water supply which will keep the animals away from the crop fields. Special attention is required to be given to the problem of the fast multiplying nilgai population in the desert region. Uptil now, no viable method is available to keep the nilgais away from the crop fields.

**Key words** Antelopes, Eco-physiology, Ethology, Desert.

The existence of three ungulate species viz. the blackbuck or the Indian antelope (*Antelope cervicapra* Linnaeus), the chinkara or the Indian gazelle (*Gazella bennetti* Sykes) and the nilgai or the blue bull (*Baselaphus tragocamelus* Pallas) in different parts of the desert in western Rajasthan indicates that these animals are well adapted for survival in arid and semi-arid regions. The wild ungulates of this region not only face scarcity of feed due to the physical conditions of their habitat but they are also being increasingly deprived of their share of the natural resources by the ever increasing hordes of domestic livestock whose number in the 11 arid districts of western Rajasthan has shown 73% increase over a period of 27 years since 1956 (Ghosh *et al.* 1988a).

### Nomenclature and General Characteristics

Of the three wild ungulates of the Indian desert, the blackbuck and chinkara belong to the

sub-family Antelopinae and the nilgai to the Bovinae. Commonly, the blackbuck and the nilgai are called antelopes whereas the chinkara is called a gazelle. In the antelopes horns are generally marked with prominent rings. Antelopes generally have a gland under the eyes. Outwardly this gland takes the form of a vertical slit of black, nearly hairless skin. Large inguinal glands are present; as also large glands between the hooves (Prater 1971). The gazelles are characterised by their sandy colouring and a white streak on each side of the face. Completely ringed horns are present in both sexes, however, they are smaller in the females. A characteristic of the gazelle is the tuft of hair growing from the knees of this animal (Roberts 1977).

**Blackbuck :** According to Mungall (1978) the word "antelope" means only the blackbuck. However, after Pallas published his 1766 list of antelope forms (*Antelope* in the Latin in which Pallas wrote), both the English and the Latin words were increasingly

\* Wildlife Institute of India, Dehradun, 248 006

used to designate any of a heterogenous group of horned ungulates made up of all those species which did not fit into the familiar and comparatively homogenous groups like "cattle", "sheep", and "goats" (Pallas 1767 in Sclater & Thomas 1897-98). Subsequently, the 'antelope' of English writers became the "Indian antelope" and, finally, the "Indian blackbuck antelope" (Sclater & Thomas 1897-98, Lydekker 1907). It is the sole representative in India of the genus *Antelope*.

The sportsman's term "blackbuck" is synonymous with the Hindi name—*Kala hiran* translated as "black deer" or "black buck" (Brander 1882-1923, Krishnan 1972). In Tamil *Kalai* is the word for the male blackbuck and *Pulvaai* designates the female (Krishnan, 1972). In the arid parts of Rajasthan the buck is known as *Kaliyan* (possessing black coat colour) and the doe as *Modiyan* (an animal without horns). Ellerman and Morrison Scott (1951) recognised 4 Sub-species of blackbuck (*Antelope cervicapra* Linnaeus), of which *A. cervicapra centralis* (Zukowsky) occurs in Central India, *A. cervicapra rajputanae* (Zukowsky) in Rajasthan and Punjab, *A. cervicapra rupicapra* (Muller) from Uttar Pradesh eastward, and *A. cervicapra cervicapra* (Linnaeus) in southern India. On the basis of detailed study of the skulls and other physical attributes of a large number of blackbuck specimens, Groves (1980) could distinguish only two distinct sub-species of this animal.

*Chinkara* : The Genus *Gazella* includes about 13 species. In the opinion of Corbet (1978) the classification within the genus *Gazella* is very problematical, the slight differences between species being obscured by considerable geographical variation within species. Recent work of Groves (1969) and Gentry (1971) altered the classification given by Ellerman and Morrison-Scott (1951). Referring to Groves (1969), Agrawal (personal communication 1988) opined that *G. dorcas* (Groves) and *G. gazella* (Pallas) are two distinct species. But *G. bennetti* (Sykes) which was earlier considered to be a sub-species of *G. gazella* (Ellerman and Morrison-Scott 1951) is now considered to be a sub-species of *G. dorcas* (Groves 1969). Recently, Furley *et al.* (1988) revealed that the chromosome number of *G. bennetti* is different

from that for other gazelle species. Therefore, the Indian gazelle must not be classified as a species of either *G. gazella* or *G. dorcas* but should be considered a distinct species: *Gazella bennetti*. Till this discrepancy in nomenclature of this gazelle species is fully resolved, the Indian gazelle or the chinkara should be called as *Gazella bennetti*.

In the western part of Rajasthan, the chinkara gazelle is known as *Chikliya*. This name has probably originated from the characteristic vocal emissions (*Cheenk-cheenk-cheenk*) of the chinkara when it is alarmed.

*Nilgai* : Regarding the naming of nilgai, Fuente (1970) describes : "In the latter half of the 18th century the German born Zoologist, Peter Simon Pallas, then Professor of Natural History at the Imperial Academy of Science in St. Petersburg, Russia, made a six-year journey across Asia. To one animal he met on his travels he gave the name *Boselaphus tragocamelus*. *Bos* is Latin for bull and *elaphus* for deer, and the description certainly fits the animal in question". The name blue bull is derived from the coat colour of the male nilgai which is, however, not really blue but has a slateish-grey colour mingled with dark brown. The coat, however, does give off gleaming bluish reflections when the sun shines directly on it. Throughout the desert region, and also in the non-arid parts of Rajasthan, the nilgai is called *Rojh* of *Rojdro*.

### Morphology and Behavioural Aspects

#### *Blackbuck*

A well grown buck (Fig.1) stands about 80 cm at the shoulder and on the average weighs about 40 kg. Its body measures 100-130 cm and the tail is 14-17 cm long (Prater 1971). The male Indian antelope is particularly handsome and elegantly built with a magnificent pair of divergent, spiralling horns which seldom exceed 50 cm in specimens from south India but may reach 65 cm or more in north India (Prater 1971), the maximum recorded being 68.5 cm (Hanak & Mazak 1979). Horns of a fully adult buck, attacked and killed by dogs, in Guda Bishnoiyan area near Jodhpur, measured 55.4 cm (spirals 4, rings 54). Adult buck horns obtained from the Talchhappar sanctuary in Churu



Fig. 1 A sprinting male blackbuck in its typical habitat in the Indian desert

district in Rajasthan measured 46.4 cm (spirals 2, rings 38). Horned females are occasionally, but rarely, met with. In the yearling buck the horns are without spirals. In the second year a large open spiral is developed. It is believed that the full number of spiral twists is attained with the dark coat about the end of the third year.

The coat colour in the male in the dorsal and lateral parts is blackish-brown, with white patches on the muzzle and white rings around the eyes. The dorsal and lateral coat of the females is fawn coloured. The underparts of both males and females are always white or off white. When young, its coat, like that of the does, is a yellowish fawn. When three years old the dorsal coat in the male commences to turn black. The darkening of the coat varies in intensity. In south India the adult buck is rarely black, his coat remains a dark brown. In general, there is a fading in the richness of the tone during the hot weather and an increase in its velvety lustre after the rains. According to Mungall (1978) the dark colouration is a secondary sexual characteristic in the blackbuck and is responsible for major sexual and aggressive displays. Castrated

bucks do not turn dark, grow robust horns, show full development of the preorbital glands or gain the thick neck characteristic of normal adult males. In sub-adult males a relationship between serum testosterone level and dominance rank and coat colouration has been recorded (Mungall 1978).

*General behaviour and activity pattern:* Due to the gregarious habit of the blackbuck, groups of these animals generally occupy small areas of 2.0 to 3.3 ha (Mungall 1978). In the course of a day's grazing they cover very little area and generally follow the same paths while foraging and visiting water holes and even while moving towards their usual resting grounds. This constant movement over the same paths make distinct track marks. The blackbuck's sense of hearing is moderate, of olfaction fair, it has a keen eye sight and a very high speed. When alarmed the herd moves off in a series of light leaps and bounds, and then breaks into a gallop. The leadership of a herd is usually vested in an old and vigilant female. When alarmed the does and the kids move first, followed by the sub-adult males. The adult buck moves last with elegant gaits. The blackbuck is one of the fastest land animals. It

shows its ability of fast running especially when alarmed. It has a remarkable leaping power. It can easily cross fences about 4 feet high by "stotting".

In the Indian desert, blackbucks usually concentrate their feeding activity from the morning hours till noon and resume it after 16.00 h. The mid day is usually spent resting in the open. During the night hours, blackbucks have been found to rest in groups of 150-200 animals spread over a small open area. The resting blackbuck, like the cattle, may snore frequently. Night foraging, especially, raiding of wheat and pearl millet crop fields has been noticed, generally between the late-evening and late night hours in the Rampura and Talchhappar areas, but the animals return to their resting grounds by early morning. Blackbucks have also been seen at waterholes during summer nights. According to Mungall (1978), 60% of the blackbuck's total night activity comprises resting only. This author identified two peaks of foraging activity between mid-night and dawn, but of shorter periods. Before mid-night most of the animals were found to be resting. After mid-night the young fawns were frequently found to rise and suck for a period. The territorial bucks generally remained more alert and active during the dark hours than others.

*Social Organization* : In the southern part of India, blackbucks can be seen in herds of 20 or 30 animals although in Rajasthan a herd can have as many as 80 to 120 animals. The blackbucks can be seen in the following distinct groups : (i) scattered, lonely territorial male, (ii) female group having one or two adult bucks, adolescent females and a few adolescent males and fawns, (iii) all male group (bachelor associations) comprising adolescent males with non-territorial males; the territorial males may sometimes join the females as they pass through their territories (Mungall 1978).

*Territorial marking by the buck* : An undisturbed territorial buck spends most of the time in a small area where it is less prone to disturbances; and where it can be found sitting near or over one of its dung piles.

*Breeding* : Blackbucks breed all the year round, but the main rut takes place between February and

March, when the bucks fight each other for the possession of the does. A buck then struts about with a peculiar mincing gait, uttering short challenging grunts, with its head thrown upwards so that its horns lie along its back and with its face glands widely open. The female remains pregnant for 170 to 180 days, and bears mostly one young. The mother usually conceals the newborn fawns under grass or in crop fields. The fawns gain strength rapidly and soon join the herd. Regarding twins Mungall (1978) opined that the blackbuck does give birth only to singlets. The twins, as sometimes seen following one mother, are most likely to be an example of the "companion effect." Breeding of blackbuck with different gazelle species has been reported. In a Persian gazelle cross, the female blackbuck became pregnant but died before giving birth (Brehm, in Krumbiegel 1954) and twice, a blackbuck doe living with Thomson's gazelles in the Walter Stone Zoo in Massachusetts has given birth to a 'tombuck' (Mungall 1978). In India, Dharmakumarsinhji successfully raised two sterile female hybrids, the 'gazellops' from a blackbuck doe and a chinkara buck (Ranjitsinh 1989).

#### *Chinkara*

A full grown chinkara buck (Fig. 2) measures about 65 cm at the shoulder and weighs about 23 kg. The horns average 25 to 30 cm. A horn length of over 40 cm has been the longest on record. Horns of does usually range between 10 and 13 cm (Prater 1971).

The chinkara is of a slender graceful build. The dorsal and lateral coat colour is light chestnut, the colour deepening where it joins the white of the under parts on the flank and rump. There is the usual white streak down each side of the face and a dusky patch above the nose. Both the sexes bear horns. The horns of the male appear almost straight when seen from the front, in profile they take a slightly S-shaped curve. Each horn of the male has 15 to 25 rings. Horns of the female animals are ringless and are straight smooth spikes. Hornless females, however, are not uncommon (Prater, 1971).

*General behaviour and activity pattern* : Chinkaras are shy of man, and are not so frequently seen in



Fig. 2 The Chinkara gazelle, a cute denizen of the desert

cultivated areas except around villages where the *Bishnoi* community predominates. When alarmed, a chinkara herd goes off at a wild pace, and then stops some 180 or 275 m away to discover the cause of the alarm. Faculties of sight, smell and hearing are all equally developed in these animals. The chinkara, in the arid region of western Rajasthan, spends more time in foraging in the early hours and in the late afternoon. It grazes throughout the day in winter.

Chinkaras are less gregarious than the blackbuck and live in small herds of 5 to 20 animals. They are found as (i) a family herd comprising of a single buck, one or more does and the kids, (ii) solitary bucks or (iii) small all male herds.

*Exhibition of territoriality by the buck:* Several dung piles of the bucks leading the family herds can be seen in chinkara habitats. As in the blackbuck,

when a chinkara group gets alerted, the chinkara doe with the kids leave the area first. Before leaving the occupied area the buck approaches its nearest dung pile, smells and scrapes with its forelegs; bends its hind legs and urinates on the pile. Then it further bends the hind legs (squatting low) and defecates. While urinating and defecating it watches the intruder, and then runs away flickering its tail all the time. Chinkara dung piles are found only in those areas where these animals feel absolutely secure.

*Breeding:* The chinkara has no particular breeding season. The chinkara buck, like bucks of other gazelles touch the underparts of the doe with a stiff leg, an action termed *laufs Schlag* by Walther (1964). One or two fawns are born at a time. There is a record of a captive hybrid male chinkara x female-blackbuck completely dominating the herd of blackbucks, driving away the males and retaining mastery of the herd (Prater 1971 Ranjitsinh, 1989), although hybridization between the chinkara and the blackbuck has never been noticed in wild population

### *Nilgai*

The nilgai (Fig.3) is the largest Asian antelope. Its body is usually 190-230 cm long, the tail measures 45-55 cm, height at the shoulder is 130-140 cm but may reach 150 cm, and the maximum weight is 190-210 kg. Females are smaller by approximately one-fifth and have no horns. Horns in the males reach 15-20 cm (29.8 cm is the maximum length recorded). The males have a lock of black hair hanging from below the throat.

*General behaviour and activity pattern:* Senses of smell and sight are good in nilgais, while hearing is only moderately developed. An alarmed nilgai produces grunting sounds followed by an ungainly gallop. Their chief means of escape is speedy movement. They can easily cross fences 2 m high. They feed mainly in the very early morning and late in the evening and generally rest under the shade of some trees during the hotter parts of the day. They frequently enter the crop fields at night and cause severe damage to the standing crops as well as stored produce.

*Social organization:* Small groups of females and young males may sometimes be seen grazing or



Fig. 3 The powerful nilgai—an ever increasing menace for the desert agriculture

drinking together, whereas adult males tend to be solitary, but occasionally forming small or large bands which wander to and fro in search of food. The composition of nilgai herds, excluding the breeding herds, change constantly and the following groupings may be seen: (1) small herds consisting of 1 or 2 cows with young calves, (2) small herds composed of 3 to 6 adult and yearling cows with an occasional calf, and (3) bull herds varying in number from 2 to 18 animals. On one occasion about 50 nilgais have been seen to form a loose herd (Schaller 1967).

*Breeding:* The nilgai breeds from November to February when rival bulls can be seen fighting for the possession of a herd of cows. The ritualised fights of the rutting males, as described by Sankhala (1978) are initiated by particular males challenging their rivals with short vocal messages. Rival bulls

start to circle each other, the circle narrows slowly and finally the bulls attack each other but not by the horns. They kneel down on the ground and push each other with their necks and try to prod the soft flanks of the opponent with their strong pointed horns. The stronger bull then charges furiously with its neck held high and with the tail raised like a victory flag. The scared bull leaves the ground with the tail between his legs. But disputes are sometimes settled without a fight, simply by the ritualistic display of the arched body, after which the dominant males join the female herds for mating.

Gestation lasts from 240 to 250 days and a female drops one or two young calves. Twin calves were seen in February, 1988 at Rampura, near Jodhpur. At the time of birth the calves are pale brown in colour like their mother. One year old male calves join an all male band whereas the female calves remain with their mother.

### Distribution

**Blackbuck** : It is on record that in the 1920s, blackbucks were so abundant in the Jodhpur region that if a gun was fired, one could watch a continuous stream of fleeing blackbucks across the road for a fairly long period (Prakash 1977). Jerdon (1874) cited a contemporary (Dr. Scott) who had informed him that herds estimated at between 8000 and 10,000 heads roamed the Government Cattle Farm at Hisar. However, with the destruction of the forest cover, these animals have adapted to life in wastelands around cultivated areas (Saharia 1982). The blackbuck prefers level plains. It avoids hilly and forest regions. Neginhal (1980) reported that blackbucks spent more time in open harvested fields than in an adjoining sanctuary of good vegetation cover. They are now almost typically associated with semi-desert or open grassland country, although some do occur in sub-tropical dry evergreen forests.

In the eastern, non-arid part of Rajasthan, and in some other parts of the country, the blackbuck is mostly found now inside wildlife sanctuaries only or in and around villages inhabited by people of the *Bishnoi* community. In western Rajasthan, the range of these animals extend from Sri Ganganagar district in the north to Barmer (Ramji Ki gal) and Jalore districts in the south western part of the State. Their preferred habitat in this range is flat scrub land or saline flats in the vicinity of one or more water holes.

**Chinkara**: Brander (1882-1923) had dwelt on the earlier distribution of the Indian gazelle in the sub-continent. Ellerman and Morrison-Scott (1951) have described the distribution of the Indian gazelle - *Gazella gazella* (Pallas) *bennetti* (Sykes), from Morocco, Algeria, Western Tunisia, through the Arabian Peninsula and the desert areas of eastern Iran to the Indian sub-continent. The chinkara is presently distributed in the plains and low hills of western and central India, extending southwards to a little south of the Krishna river. It is found in Pakistan, in the Middle Eastern countries and westwards in northern Africa. The chinkara is undoubtedly a very adaptable animal. It is common even in the salt range in Pakistan Punjab and occurs in extensive sand dune areas, down to the sea level

as well as in rocky plateaus and hilly regions of upto 1200 m or 1500 m elevation (Roberts 1977).

### Habitats

**Blackbuck and Chinkara** : The major vegetation composition of two habitats, occupied by the chinkara (Habitat-A) and the blackbuck (Habitat-B) in Guda Bishnoiyan village complex near Jodhpur (Ghosh *et al.* 1987, Goyal *et al.* 1986) indicate qualitative differences in respect of their soil texture and floral coverage. Habitat-A was dominated by *Crotalaria burhia*, *Tephrosia purpurea*, *Zizyphus nummularia* and *Capparis decidua*, the former two species forming about 79% of the total vegetation cover of this habitat. *Prosopis cineraria* trees were widely scattered in the area, with a plant density of 5-12 km<sup>-2</sup>. The ground flora comprised, mainly, *Eleusine compressa*, *Cyperus arenarius*, *Heliotropium strigosum*, *H. subulatum* and *Boerhavia diffusa*. Parts of this habitat were utilized for seasonal agricultural practices.

Habitat-B, a gravelly wasteland preferred by the blackbucks was dominated by *Prosopis cineraria*, *T. purpurea*, *P. juliflora* and *C. decidua*. The density of *P. cineraria* in this habitat ranged from 4 to 10 plants km<sup>-2</sup> (Ghosh *et al.* 1988b). There was a fairly good grass cover here, particularly around the waterholes and also in scattered patches. The dominant grass species were : *Cynodon dactylon*, *Desmostachya bipinnata*, *Dactyloctenium aegyptium* *E. compressa*, *Sporobolus marginatus* and *Mollugo* spp. The scattered grass patches mostly had *C. dactylon*.

**Nilgai** : The nilgai's usual haunts are hills or gravelly plains sparsely dotted with trees. In the arid parts of Rajasthan, their preferred areas are the pied-monts having a few bushes and water points or the areas having loamy soil where intensive (double crop) farming using well water is being done. Sandy and forest areas are not preferred by these animals. Nilgais have been recently sighted in an extremely arid area, near Pokaran, on hard gravelly land having a good vegetation cover comprising *Acacia tortilis*, *Calotropis procera*, *C. decidua*, *Fagonia cretica*, *P. juliflora*, *Salvadora persica*, *T. purpurea*, *Z. nummularia* and a few plants of *Acacia nilotica*. There is a waterhole near this area. In Guda Bish-

noiyan village complex near Jodhpur, these animals are found only in the hard pan, gravelly wasteland (Habitat B, described earlier) and in areas near the bank of Luni river which are also the favoured haunts of the blackbuck. The nilgais, however, are found in considerably large numbers around agricultural fields in Nagaur district where a double cropping system is followed.

### Feed Preferences

*Blackbuck and chinkara:* Our studies would point to the blackbuck as mainly a grazer like the sheep, and to the chinkara as a browser like the goat (Ghosh *et al.* 1984, 1987). During the post monsoon and winter seasons, the chinkara generally preferred the leaves of *C. burhia* and *Z. nummularia* and also fed on the leaves of *A. tortilis*, and on the standing crops of *bajra* (*Pennisetum typhoides*) and *moth* (*Phaseolus aconitifolius*) (Bohra & Goyal 1991). *E. compressa* appeared to be the most preferred grass of the chinkaras. The chinkaras have also been noticed to pick up the highly nutritious green or dried pods shed by the *P. cineraria* trees (crude proteins 11.5%, gross energy value 6.5 kcal g<sup>-1</sup>). The occurrence of *P. cineraria* seeds in chinkara pellets during the lean period, particularly in June (average 2.3 seeds g<sup>-1</sup> dry faecal matter) is further proof of this animal's liking for *P. cineraria* pods (Goyal *et al.* 1988).

The blackbucks, during the post-monsoon and winter seasons, fed upon *C. dactylon*, *D. bipinnata* and *S. marginatus*. However, during summer, when green grasses become scarce, the antelopes feed on the dried grass patches, and pick up the green or dried pods shed by *P. cineraria* and *P. juliflora* trees (Table 1). The maximum utilization of pods of these two plants was observed during June, when each gram of dry faecal pellet contained on average 6 seeds (Goyal *et al.* 1988).

Blackbucks and chinkaras in their respective habitats both avidly consume the moisture-laden nutritious flowers of *Tecomella undulata* shed by this tree from mid March to April. The chinkaras inhabiting the Dawa-Doli sanctuary near Jodhpur and the Desert National Park areas in Jaisalmer and Barmer districts, consume, during summer, the latex bearing leaves of the generally shunned

*Calotropis procera*. Again, during summer, the chinkaras in the Desert National Park dig up the loose sandy soil of the dunes and expose the roots of *Dipterygium glaucum* to eat its moisture-laden root bark to quench their thirst (Ghosh *et al.* 1988b).

The chinkaras selectively consume leaves of low fibre and high crude proteins content. The soft branches and leaves of *C. burhia* are much relished by these animals; when these plants dry up in summer, the chinkaras readjust their feeding habit and feed on the green leaves of *M. emarginata* and to some extent on the pods of *P. cineraria* trees (Table 1). In the saline desert tract of Israel, the pods of *Acacia* species reportedly form a considerable part of the dietary of *G. dorcas* (Baharav 1981). In the Rajasthan desert, it is the blackbuck, and not the chinkara, which consume pods of the indigenous trees to any noticeable extent (Goyal *et al.* 1988). Roberts (1977) observed that the gazelles in the Cholistan desert region of Pakistan browse on *Lepadenia spartium* and *Acacia jacquemontii* during the early part of summer. And when nothing else is available, the animals browse on *Calligonum polygonoides*. During monsoon, the young and sprouting shoots of the grasses *Aristida mutabilis*, *A. juniculata* and *Cenchrus pennisetiformis* provide sustenance to the chinkaras. A changeover from the mainly browsing to a grazing habit of the chinkara is noticed in this season.

The selection of feeds of low fibre and high protein content by the chinkaras may be a reflection of their poor fibre digestibility. This, again, may be related to the absence of certain essential cellulolytic bacteria and of a suitable delaying mechanism in their reticulo-rumen as reported for several other concentrate feeders (Hofmann 1973). The light-weight stomachs of these animals may be considered as an aid to fast leaping, a very effective means for escaping poachers and predators. Shkolnik and Silanikove (1981) have observed that the relatively smaller rumen volume of the dorcas gazelle of the Middle East may be of significance as an adaptation for leaping. In the blackbuck the inactive portion of the small intestine is relatively larger and the reticulum of the stomach is comparatively inefficient. To overcome these inefficiencies

Table 1 Plant species eaten by blackbuck and gazelle.

Animal	Summer	Winter
Blackbuck	<i>Cynodon dactylon</i> <i>Desmostachya bipinnate</i> <i>Mollugo</i> spp. <i>Prosopis cineraria</i> (pods) <i>P. juliflora</i> (pods)	<i>Cynodon dactylon</i> <i>Desmostachya bipinnata</i> <i>Dactyloctenium aegyptium</i> <i>Eleusine compressa</i> <i>Mollugo</i> spp.
Gazelle	<i>Maytenus emarginata</i> <i>Zizyphus nummularia</i> <i>Eleusine compressa</i> <i>Heliotropium</i> spp. <i>Prosopis cineraria</i> (pods)	<i>Crotalaria burhia</i> <i>Zizyphus nummularia</i> <i>Tecomella undulata</i> (flowers)

Table 2 Water content of some feeding stuffs preferred by the Indian gazelle

Feed	Moisture (%)
<i>Acacia tortilis</i> leaves	61.0
<i>A. tortilis</i> pods (unripe green)	61.0
<i>Balanites aegyptiaca</i> leaves	61.0
<i>Calligonum polygonoides</i> young sprouting shoots	71.0
<i>Calotropis procera</i> leaves	80.0-86.0
<i>Caparis decidua</i> young sprouting shoots	71.0
<i>C. decidua</i> flowers	73.0
<i>C. decidua</i> fruits (ripe red)	74.0-77.0
<i>Crotalaria burhia</i> shoots	46.0
<i>Dipterygium glaucum</i> root (whole)	74.0
<i>D. glaucum</i> root bark	69.0
<i>Maytenus emarginata</i> young leaves	72.0
<i>M. emarginata</i> old leaves	59.0-61.0
<i>Prosopis cineraria</i> young leaves	68.0
<i>P. cineraria</i> old leaves	71.0-64.0
<i>P. cineraria</i> pods (green un ripe)	78.0
<i>Salvadora persica</i> leaves	71.0
<i>S. persica</i> fruits (ripe)	77.0
<i>Tecomella undulata</i> leaves	58.0
<i>Zizyphus nummularia</i> young leaves	86.0
<i>Z. nummularia</i> mature leaves	67.0

a fine grinding of food is required (Gill & Korda 1960). This, like in other grazers, is achieved by prolonged chewing of the cud. The efficiency of this mechanism is further enhanced due to the relatively larger stomach volume of this antelope in comparison to that of the browser like chinkara.

During summer (April–July) when the grass cover of their habitat becomes dry and depleted, the blackbuck thrives upon whatever grass species are available there. Even at the peak of the summer season, some green grass is usually available on the fringes of water holes. The blackbucks use this resource as well as the scattered patches of dry grass that dot their territory (Goyal *et al.* 1986). According to Schaller (1967), blackbucks in Central India rarely, if ever, browsed and almost exclusively grazed on grasses wherever these were available.

The blackbucks on the Pakistan side of the Great Indian Desert principally feed on grass species such as *A. mutabilis*, *C. pennisetiformis* and *Cymbopogon jawarancusa* (Roberts 1977). Blackbucks have also been observed to raid agricultural fields and consume moong (*Phaseolus aureus*), moth (*P. aconitifolius*), chana (*Cicer arietinum*) and young shoots of wheat (Ranjitsinh 1989). These antelopes also consume large quantities of pods of *P. cineraria* and *P. juliflora*, both of which species abound in our principal study areas (Guda Bishnoyan, Talchhapar and Dawa–Doli) (Goyal *et al.* 1988).

In normal years, or even under mild scarcity conditions blackbucks do not leave their usual habitats. However, during severe scarcity conditions, as in the extreme drought conditions prevailing in the Rajasthan desert during 1984–89, these animals scattered in the nearby areas in search of forage. This was especially marked during 1987. In contrast, the chinkaras roam over a large territory covering a particular habitat and usually do not go beyond the limits of that habitat.

*Nilgai*: Nilgais prefer to feed on a mixed diet consisting of leaves, tender shoots, fruits and large quantities of grass. They feed twice daily, at dawn and at dusk, spending the rest of the day in the shade, sheltering themselves from the intense heat.

Waterholes are visited regularly for drinking purposes, but during periods of drought the nilgai can apparently manage by utilising the preformed water of their feed for maintenance of body water (Fuente 1970). In the arid part of Rajasthan, the nilgai is generally found in areas having irrigated crops and it thrives well upon almost all types of horticultural and agricultural crops. It prefers to browse on growing *P. typhoides* (bajra) over mature bajra plants. It has also a liking for *P. aureus* (moong), *P. aconitifolius* (moth) and *Cyamopsis tetragonoloba* (guar) crops.

Amongst the winter crops, it has a strong preference for *Medicago sativa* (lucerne) followed by *Triticum sativum* (wheat) and *Hordium vulgare* (barley). It damages much more than it eats the standing *Brassica niger* (black mustard) crops. A great liking of the nilgai for *Ricinus communis* (castor) crops has caused an aversion among farmers to grow this plant in the arid region of Rajasthan. Apart from consuming considerable quantities of standing crops, the nilgai also damages plants by virtue of its habit of vigorously swinging its head left and right and thereby defoliating the adjacent plants with its horns. Outside agricultural fields, the nilgai eats *Tephrosia purpurea*, especially at the flowering stage, *Aerva persica* upto the pre-flowering stages, leaves of *Z. nummularia*, both green and dry, and pods of *A. nilotica*, *P. cineraria* and *P. juliflora*. Like the chinkara and goats, it may also consume considerable quantities of *Calotropis procera* leaves.

*Soil ingestion*: Free ranging ungulates usually ingest substantial amounts of soil in the course of foraging. The ingested soil apparently meets the mineral requirements of these animals. The blackbuck and the chinkara of Rajasthan also ingest considerable quantities of soil while feeding on the ground flora (Goyal & Bohra 1983).

*Water use characteristics*: The blackbuck's and the chinkara's occupation of the desert terrain would point to the possibility of existence of well developed physiological and behavioural adaptive mechanisms in these animals. Both species, and especially the chinkara, are adapt in selecting feeds which are not only rich in nutrients but also in water. This ensures a reasonably large contribution of the

performed water of the feeds to their overall water balance. It is generally held by the desert people, and the view has been supported by earlier naturalists like Sterndale (1884), that the chinkara may not need any free water for drinking purposes, its food habit and physiological efficiency of water use being good enough to keep it in water balance.

*Drinking behaviour of antelopes* : Our studies indicate that in the Indian desert, blackbucks usually drink water between 09.30 and 12.30 hrs, and sometimes after 17.00 hrs during summer. The drinking behaviour of a herd at the water holes follows a pattern. At first an adult male would come near the water hole and make a survey of the scene around the water hole. Presumably, after this male scout gives the clearance, other members of the herd approach the water hole. The adults are the first to drink and the rest of the herd follows. On reaching the edge of the water hole, the animals touch the water with their noses and drink for approximately a minute at a stretch (range: 45-85 seconds), without raising their heads. In Texas, however, blackbucks have been observed to spend an average of 30 seconds per drink (Mungall 1978).

In the arid parts of Rajasthan, some nilgai groups may visit waterholes during summer between 09.00 and 11.00 h and other groups in the afternoon between 16.00 and 18.00 h. On an average, a bull drinks continuously for 2 m and 10s, while the calves take in water for 1 m and 10s.

The chinkaras spent an average of 71s (range: 46-92s) at each bout of drinking. These animals usually quench their thirst with a single draught and rarely go for a second one. In the Desert National Park in Jaisalmer and Barmer districts, as well as in the Dawa-Doli sanctuary, a number of artificial watering points have been provided for wildlife but chinkara is rarely seen taking advantage of these facilities. This points to the extreme desert-worthiness of the chinkara. Apparently, the water balance of these animals is dependent on (i) the preformed water in their feeds, and (ii) the metabolic water that they produce.

*Preformed water in antelope feeds* : Most of the plant species preferred by the chinkara contain more than 60% water on fresh weight basis (Table 2). The

chinkara should, therefore, get considerable quantities of water through their feed, thus, explaining their independence of free drinking water. We have observed the chinkara in the Desert National Park to consume considerable quantities of *Calotropis procera* (80%-86% water) leaves during summer. These animals have also been seen to dig up the soil and expose the roots of the herb *Dipterygium glaucum* (74% water) which grows on the sand dunes and in the interdunal spaces. They nibble at the root bark of this plant which is rich in moisture (Ghosh *et al.* 1988b). A similar report of gazelles in the Pakistan desert digging up and eating the succulent stems of the moisture-rich parasitic plant, *Cistanche tubulosa* has been made by Roberts (1977). The observed ability of the Indian gazelle to go without drinking water indefinitely may also be linked to their preference for the fruits of the wild plant, *Citrullus colocynthis* (Roberts 1977) which contain about 90% water and grows abundantly on sand dunes. Taylor (1969) reported that elands in the African arid zone can survive without water during severe droughts by foraging on *Acacia* leaves (59% water).

In our estimate blackbucks of the Indian desert prefer grass species which contain about 30 to 40% moisture. In common with the blackbucks reared in the United States (Mungall 1978), blackbucks of the Indian desert also instinctively start grazing at the break of dawn. This grazing behaviour is likely to have some eco-physiological significance. In Taylor's (1968) view, dry grasses can trap about 30% of their weight of moisture at night. This moisture is mainly derived from the dew. Although the climatic conditions of the Indian desert do not favour dew formation to any significantly high extent, desert herbivores here are likely to derive some benefit from their early grazing behaviour. One aspect of behavioural adaptation in the blackbuck, as observed by us in the Indian desert, is its habit of night grazing—a phenomenon reported for the Oryx and the gazelle by Taylor (1972). The hygroscopic nature of certain African desert grasses eaten by the Oryx and Grant's gazelle, as reported by Taylor (1969), and the diurnal and seasonal shifts in the moisture content of these grasses, depending on atmospheric humidity, may also be true to some extent for the Indian desert.

*Body water conservation-behavioural aspects :* Our yearlong study on the blackbucks at Guda-Bishnoiyan and TalChhappar have indicated that most of these animals, especially the full grown adult males, prefer to sit in the open sun all through the day. Solitary males, past the reproductive age, invariably sit in the open fields even during peak summer. In our opinion these animals might have developed a high level of physiological thermolytic efficiency. The mechanism may be somewhat akin to that developed by the Oryx (*Oryx beisa*), a true desert dwelling antelope of Africa which usually prefers open places and conserves body water through a flexible body temperature (Taylor 1969).

Our studies indicate that, in summer months, the chinkara of the Rajasthan desert seeks shade during the period between 10.00 and 17.00 hrs under thickets of bushes and trees. In the Desert National Park in Jaisalmer where large trees are extremely scanty, chinkaras take shelter at midday under the bushes of *Capparis decidua* and *Calotropis procera*, and in dugouts besides tussocks of *Panicum turgidum* grass growing on the sandy slopes. The eco-physiological significance of this behaviour of the chinkara will be appreciated from our finding—that the net radiation and air temperature in the shady part of a desert tree like *Acacia tortilis* is 16 to 24% of the total net radiation in the surrounding open fields, and at least 4°C lower than the air temperature in the open. In other words, the chinkara, by virtue of its habit of avoiding excessive radiant energy cuts down on the necessity to evaporate surface water for homoeostatic purposes. In the Sudanese desert, Ghobrial and Cloudsley-Thompson (1976) found the dorcas gazelle resting in shady places in summer from 09.00 to 16.00 h. In the Kalabagh Reserve of Pakistan, Schaller (1976) observed gazelles usually seeking shade under dense bushes during the hotter parts of the day. The chinkara's shade seeking behaviour is consistent with the theoretical imperatives of medium sized mammals.

It is possible that the chinkara's thermolytic efficiency is, to a considerable extent, due to its having a smooth, highly glossy, reddish buff coat. Roberts (1977) postulated that the gazelle's coat is a valuable part of its overall adaptive strategy to

minimize heat absorption in the course of a hot summer day.

Like the chinkara, the nilgai generally rests under the shade of large trees like *A. nilotica*, *Salvadora persica*, *P. cineraria* and even *P. juliflora* during the hotter part of the day from 10.00 to around 16.00-17.00 h. In areas where such shady trees are scarce or absent, the nilgai utilises the relatively cooler micro-environment provided by *C. decidua* bushes.

### Concluding Remarks

Over the years, there has been gradual encroachment by man and his domestic animals on the natural habitats of these antelopes in the Rajasthan desert. Agricultural activities have increased manifold here, often covering hitherto uncultivated lands of the region, roads have penetrated deep into the desert and human habitations have spread far and wide. Although large quantities of stover and grains are obtained as by-products of crop farming, which can be utilised by both domestic and wild animals, yet the deterioration of the habitat due to human interference especially the attitude of unconcern of most agriculturists for wildlife preservation are causing migration of the wild ungulates from their erstwhile habitats. The overall effect is a continuous shrinkage of wildlife habitats in the desert. Domestic livestock not only compete with the antelopes for feed and water resources but they are also, while using the common grazing grounds, communicating diseases like rinderpest to the wild ungulates. This periodically causes severe losses in wild ungulate number in the region. Large scale shooting of these animals had continued in this region till 1972 when the Government of India enforced the Indian Wildlife (Protection) Act under which killing of all these animals was strictly prohibited. Under this Act, the blackbuck and the chinkara have been kept under Schedule I and the nilgai under Schedule III. Fawns and weak animals easily fall prey to stray dogs, wolves and foxes. Frequent droughts often leave these animals hungry and emaciated, when either death comes on its own or they become easy victims of the predatory carnivores. Occasional devastating flash floods (as the one experienced during July

1979), although a rarity, causes great losses in antelope population of the region. In certain instances these animals are known to have met with severe injuries while crossing barbed wire fences erected for protecting forest and wildlife resources. Above all, the people of the *Bishnoi* community, who have been traditionally holding the blackbucks and the chinkaras in great reverence and have been protecting them from natural calamities, predators and poachers, are slowly, though perceptibly, turning hostile to the presence of these creatures in their crop fields. One way of reversing this process would be to keep certain areas around *Bishnoi* dominated villages preserved for the antelopes, suitably fence those areas and ensure feed and water supplies to the animals. This measure will, while conserving the animals, keep them away from the crop fields.

With the present trend of human population growth it is no longer possible to allocate reasonably large areas like the Desert National Park situated in Jaisalmer and Barmer districts exclusively for preservation of these animals. Establishment of wildlife reserves, such as the Gajner and Talchhappar sanctuaries and the Dawa-Doli and Guda-Bishnoiyan wildlife reserves have proved their worth as successful breeding grounds of the blackbucks and the chinkara. Preservation of whole eco-systems in these areas has not only resulted in higher antelope numbers but also in a simultaneous increase in the number of predators, e.g. the population of wolves in the Guda Bishnoiyan area has shown drastic increase during the last few years, thereby restoring the system of nature's checks and balances.

### Acknowledgment

We thank the Director, CAZRI, Jodhpur, for his support.

### References

- Baharav D 1981 Food habits of the mountain gazelle in semi-arid habitats of eastern lower Galilee Israel. *Journal of Arid Environments* 4: 63-69.
- Bohra HC & Goyal SP 1991 Crop damage by the chinkara gazelle (*Gazella bennetti*, Sykes) in the arid region of western Rajasthan. *Proceedings of the Symposium "Unconventional Pests: Control vs. Conservation"*, UAS Bangalore.
- Brander AAD 1882-1923. *Wild Animals in Central India* Edward Arnold and Company, London.
- Corbet GB 1978 *The Mammals of the Palearctic region—A taxonomic review* (Agarwal VP Zoological Survey of India, Calcutta—personal communication).
- Ellerman JR & Morrison-Scott TCS 1951 *Checklist of Palearctic and Indian Mammals 1758 to 1946*, 2nd ed. British Museum (Natural History), London.
- Fuente FR de la 1970 (German) *World of Wildlife. The East: Animals of the Jungle* (English version Gilbert J. 1978) Orbis Publishing Limited, London.
- Furley Ch W, Tichy II & Verpmanu HP 1988 Systematics and chromosomes of the Indian gazelle, *Gazella bennetti*, Sykes 1831). *Z. Säugetierkunde* 53: 48-54.
- Gentry AW 1971 Genus *Gazella* *Meester & Setzer Part 15* (Agarwal VP Zoological Survey of India, Calcutta personal communication).
- Ghobrial LI & Cloudsley-Thompson JL 1976 Daily cycle of activity of the dorcas gazelle in the Sudan. *Journal of Interdisciplinary Cycle Research* 7: 47-50.
- Ghosh PK Goyal SP & Bohra HC 1984 Habitat Utilization by Wild and Domestic Ungulates: a Case Study in a desert biome. *Proceedings of the 2nd International Rangeland Congress* Adelaide.
- Ghosh PK Goyal SP & Bohra HC 1987 Resource partitioning by wild and domestic ungulates in a desert habitat (in Russian) *Problems of Desert Development* (USSR) 42-48.
- Ghosh PK Bohra HC & Goyal, SP 1988a Livestock population and ecological implications of overgrazing In: *Desert Ecology* (ed. Ishwar Prakash) Scientific Publishers, Jodhpur. 179-187.
- Ghosh PK Goyal SP & Bohra HC 1988b Eco-physiological characteristics of two wild ungulate species of the Indian desert. In: *Ecophysiology of Desert Vertebrates*. (eds. P K Ghosh & Ishwar Prakash) Scientific Publishers, Jodhpur.
- Gill J & Korda P 1960 Untersuchungen über den Magendarmkanal der hirschziegentilope, *Antilope cervicapra* (Linnaeus 1758). *Acta Theriologica* 4: 45-52.
- Goyal SP & Bohra HC 1983 Soil ingestion by two wild ungulates *Antilope cervicapra* and *Gazella gazella* in their natural habitats. *Annals of Arid Zone* 22: 99-102.
- Goyal SP, Bohra HC & Ghosh PK 1986 Food preferences of the Indian antelope (*Antilope cervicapra*) and Gazelle (*Gazella dorcas*) in a desert environment *My Forest* 22: 153-158.
- Goyal SP, Bohra HC, Ghosh PK & Prakash I 1988 Role of *Prosopis cineraria* pods in the diet of two Indian desert antelopes. *Journal of Arid Environments* 14: 285-290.

- Groves CP 1969 On the smaller gazelles of the genus *Gazella*. *Z. Säugetierk* **34** 38-60
- Groves CP 1980 A note on geographic variation in the Indian blackbuck (unpublished). In Rajnitsinh, MK, *The Indian Blackbuck*. Natraj Publishers, Dehradun, 1-156
- Hanak V and Mazak V 1979 *The Illustrated Encyclopedia of Mammals* (ed. Lowry S) Octopus Books Limited London
- Hofmann RR 1973 *The Ruminant Stomach East African Monograph in Biology*. Vol. II. East African Literature Bureau, Nairobi.
- Jerdon TC 1874 *Mammals of India A natural history of the animals known to inhabit continental India*. John Wheldon, London.
- Krishnan M 1972 An ecological survey of the larger mammals of peninsular India : *Journal of Bombay Natural History Society* **69** 469-501
- Krumbiegel I 1954 *Biologie der Säugetier I* Agisverlag, Krefeld, Germany.
- Lydekker, R. 1907 *The Game Animals of India, Burma, Malaya and Tibet*. Rowland Ward Limited, London.
- Mungall EC 1978 *The Indian Blackbuck Antelope: A Texas veiw*. The Texas A & M University System, College Station, Texas.
- Neginhal SG 1980 Ecological impact of afforestation of the Ranebennur blackbuck sanctuary. *Journal of Bombay Natural History Society* (Special issue) 1254-1258
- Prakash I 1977 *The Amazing Life in the Indian Desert*. CAZRI Monograph No. 6 Central Arid Zone Research Institute, Jodhpur, India.
- Prater SH 1971 *The Book of Indian Animals* Bombay Natural History Society, Bombay.
- Ranjitsinh MK 1989 *The Indian Blackbuck* Natraj Publishers, Dehra Dun, p. 155.
- Roberts TJ 1977 *The Mammals of Pakistan* Ernest Benn Limited, London.
- Saharia VB 1982 *Wildlife in India* Natraj Publishers, Dehra Dun.
- Sankhala K 1978 *Tiger : The Story of the Indian Tiger* Collins, London.
- Schaller GB 1967 *The Deer and the Tiger-A study of Wildlife in India* University of Chicago Press, Chicago and London.
- Slater PL & Thomas O 1897-98 *The Book of Antelopes. I II* RH Porter, London.
- Shkolnik A and Silanikove N 1981 Water Economy and Energy Metabolism and Productivity in Desert Ruminants (eds. Morand-Fehr P, Bourfouzi A & Simiane M) Tours France May 12-15, 1981.
- Sterndale RA 1884 *Natural History of the Mammalia of India and Ceylon*. Thacker Spink and Co, Calcutta
- Taylor CR 1968 Hygroscopic food : a source of water for desert antelopes *Nature*, London **219** 181-182
- Taylor CR 1969 The Eland and the Oryx *Scientific American* **220** 88-95
- Taylor CR 1972 The desert gazelle : a paradox resolved *Comparative Physiology of desert animals* (ed.) GMO Maloiy Symposium, Zoological Society of London Academic Press, London.
- Walther F 1964 Einige Verhaltenspeobachtungen an Thomson gazellen (*Gazella thomsoni* Cicinther, 1884) in Ngorongora- Krater *Zf Tierpsych* **21** 870-890

(Received August 1991 Accepted April 1992)