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Boselaphus tragocamelus (Artiodactyla: Bovidae)

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Abstract: *Boselaphus tragocamelus* (Pallas, 1766) is a bovid commonly called the nilgai or blue bull and is Asia's largest antelope. A sexually dimorphic ungulate of large stature and unique coloration, it is the only species in the genus *Boselaphus*. It is endemic to peninsular India and small parts of Pakistan and Nepal, has been extirpated from Bangladesh, and has been introduced in the United States (Texas), Mexico, South Africa, and Italy. It prefers open grassland and savannas and locally is a significant agricultural pest in India. It is not of special conservation concern and is well represented in zoos and private collections throughout the world. DOI: 10.1644/813.1.

Key words: antelope, Asia, blue bull, exotic species, India, nilgai, ruminant, Texas, ungulate

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Boselaphus de Blainville, 1816

Antilope Pallas, 1766:5. Part.
Cerophorus de Blainville, 1816:74. Part; said to be equivalent to contemporary Bovidae (Ellerman and Morrison-Scott 1966:379); no type species selected.
Boselaphus de Blainville, 1816:75. Type species *Antilope tragocamelus* Pallas, 1766, by subsequent designation (Sclater and Thomas 1900:91); originally used as a subgenus of *Cerophorus* de Blainville, 1816.
Cemas Oken, 1816:729. Part; unavailable name (International Commission on Zoological Nomenclature 1956:Opinion 417).
Damalis Hamilton-Smith, 1827a:343. Part.
Portax Hamilton-Smith, 1827b:366. Type species *Damalis risia* Hamilton-Smith, 1827a, by monotypy; used as a subgenus of *Damalis* Hamilton-Smith, 1827a.
Tragelaphus Ogilby, 1837:138. Type species *Tragelaphus hippelaphus* Ogilby, 1837, by original designation; preoccupied by *Tragelaphus* de Blainville, 1816.
Oreades Schinz, 1845:448. Part; used as a subgenus of *Antilope* Pallas, 1766; contained *Antilope picta*, *A. oreas*, and *A. canna*; no type species selected.
Buselaphus Reichenbach, 1845:142. Incorrect subsequent spelling of, but not *Boselaphus* de Blainville, 1816 (see "Nomenclatural Notes").
Bosephalus Horsfield, 1851:169. Incorrect subsequent spelling of, but not *Boselaphus* de Blainville, 1816 (see "Nomenclatural Notes").
Boselaphas Allen, 1939:586. Incorrect subsequent spelling of, but not *Boselaphus* de Blainville, 1816 (see "Nomenclatural Notes").

CONTEXT AND CONTENT. Order Artiodactyla, suborder Ruminantia, family Bovidae, subfamily Bovinae, tribe Boselaphini, genus *Boselaphus*. *Boselaphus* is monotypic.

Boselaphus tragocamelus (Pallas, 1766)
Nilgai or Blue Bull

Antilope tragocamelus Pallas, 1766:5. Type locality unknown; name based on zoo specimen from "Bengal [= northeastern India] from a very remote Part of the *Mogul's* Dominions" (Parsons 1745:465).

Fig. 1.—Male *Boselaphus tragocamelus* in characteristic defecation posture (foreground), Koleado National Park, western India, December 2004; note beard below the white gular patch and short, pointed horns, both unique to males. Photograph courtesy of David Behrens (http://www.pbase.com/dbehrens).

[*Antilope*] *albipes* Erxleben, 1777:280. Type locality "India;" name based on zoo specimen (Hunter 1771; Pennant 1771).

Antilope leucopus Zimmerman 1777:541. Type locality "India Orientali;" name based on zoo specimen (Pennant 1771).

Ant[*ilope*]. *picta* Pallas, 1777:14. Type locality "Indiae orientalis forte propria;" name based on zoo specimen (Pennant 1771).

C[*emas*]. *tragocamelus*: Oken, 1816:729. Name combination.

C[*emas*]. *picta*: Oken, 1816:729. Name combination.

[*Cerophorus* (*Boselaphus*)] *picta*: de Blainville, 1816:74–75. Name combination.

Boselaphus albipes: Desmarest, 1816:199, plate A.33. Name combination.

D[*amalis*]. *risia* Hamilton-Smith, 1827a:363. Replacement name for *Antilope picta* Pallas, 1777.

D[*amalis* (*Portax*)]. *risia*: Hamilton-Smith, 1827b:366. Name combination.

Damalis picta: Brookes, 1828:64. Name combination.

[*Damalis* (*Portax*)] *picta*: Lesson 1836:304. Name combination.

T[*ragelaphus*]. *hippelaphus* Ogilby, 1837:138. Replacement name for *Antilope picta* Pallas, 1777.

A[*ntilope* (*Oreades*)]. *picta*: Schinz, 1845:448. Name combination.

P[*ortax*]. *tragelaphus* Sundevall, 1846a:198. Incorrect subsequent spelling of *Antilope tragocamelus* Pallas, 1766; see Sundevall (1846b).

P[*ortax*]. *tragocamelus*: Sundevall, 1846b:323. Name combination.

Antilope (*Damalis*) *picta*: Schniz, 1848:44, plate xliv. Name combination.

A[*ntilope* (*Cephalophus*)]. *picta*: Giebel, 1855:323. Name combination.

Ant[*ilope* (*Bubalus*)]. *picta*: Laurillard, 1861:625. Name combination.

Boselaphus tragocamelus: Sclater, 1883:137. First use of the current name combination.

CONTEXT AND CONTENT. Context as for genus. *B. tragocamelus* is monotypic.

NOMENCLATURAL NOTES. The expression "… of, but not *Boselaphus* de Blainville, 1816" for the last 3 entries in the generic synonymy is used to include apparent misspellings of *Boselaphus* that were applied to $\geq$ 1 species that did not include *Antilope picta* or any of its synonyms (A. L. Gardner, United States Geological Survey, Patuxent Wildlife Research Center, pers. comm.) but could result in potential confusion in the nomenclatural history of *Boselaphus*. In previously published generic synonymies of *Boselaphus* de Blainville, 1816 (e.g., Grubb 2005:693; Lydekker and Blaine 1914:224), the incorrect subsequent spellings *Buselaphus* Reichenbach, 1845 and *Bosephalus* Horsfield, 1851 sometimes have been included. I did not find Allen's (1939) *Boselaphas* presented in any previous generic synonymy, but his usage deserves mention.

Reichenbach's (1845:141–142, table XLIII, plates 242–244) use of *Buselaphus* was inserted as a generic synonym after his description of *Antilope caama*, which was accompanied by 3 unambiguous illustrations of "der hartebeest" from Africa. Before 1845, the specific epithets *buselaphus* and *caama* were associated with the nomenclatural history of the red hartebeest (*Alcelaphus caama*) of southern Africa and the common hartebeest (*A. buselaphus*) of northern Africa (Grubb 2005:674). Therefore, this use of *Buselaphus* has little direct bearing on the nomenclatural history of *Boselaphus tragocamelus* (= nilgai) and probably references the species-level, not the generic-level, epithet for the hartebeest, *buselaphus* Pallas, 1766 (although Reichenbach misattributed the epithet to Hamilton-Smith, undated, for which I could find no reference).

Horsfield's (1851:169) use of the epithet *Bosephalus* appeared in a museum catalog of the Honorable East-India Company. It listed specimen 239 as "*Bosephalus caama*" and gave its synonyms as *Antilope caama* and *Acronota caama*, its vernacular name as "La Caama," and its occurrence as southern Africa. Horsfield's use of *Bosephalus* may have been a lapsus for the generic epithet *Alcelaphus* de Blainville, 1816, perhaps from confusion with the specific epithet *buselaphus* Pallas, 1766, or Reichenbach's (1845) use of *Buselaphus*. Critically, specimen 242 in Horsfield (1851:170) was identified as *Portax picta* (= *Boselaphus tragocamelus*) and labeled the "nylghau" (= nilgai) from the "Peninsula of India." Therefore, Horsfield (1851) used the epithet *Bosephalus* only to describe a hartebeest and did not confuse it with the nilgai. As such, the epithet *Bosephalus* seems more appropriately regarded as an incorrect subsequent spelling of *Alcelaphus* de Blainville, 1816.

Allen (1939:470–472, 541–543, 586) presented the misspelling *Boselaphas* in his Index but used the correct spelling relative to the nilgai, *Boselaphus*, as various synonyms of *Alcelaphus* and *Taurotragus* (eland). Grubb (2005) did not list *Boselaphas* as synonyms for either genus. The misspelling stands only as a "header" for various specific epithets in the Index, and it would seem most appropriately included in generic synonymies of *Alcelaphus* and *Taurotragus* as "*Boselaphas* Allen, 1939:586. Incorrect subsequent spelling of *Boselaphus* de Blainville, 1816." Regardless, Allen's use of *Boselaphas* for hartebeest and eland has little direct relevance to the nomenclatural history of the nilgai.

In his review of artiodactylan taxonomy, Grubb (2005:693) designated the lectotype of *Antilope tragocamelus* Pallas, 1766, as "a male nilgai in London" (based on accounts by Cais, Gesner, and Ray [no dates] and the description by Parsons 1745). However, according to Article

Fig. 2.—Three tawny-colored female *Boselaphus tragocamelus* in a game park in Roseburg, Oregon, United States; note the characteristic white cheek spots and the 2 white rings above the fetlocks, which led to the early common name, white-footed antelope. Photograph courtesy of Faye Pekas (http://www.pbase.com/fayepek).

74.7 of the *International Code of Zoological Nomenclature* (International Commission on Zoological Nomenclature 1999:83; K. Helgen, Smithsonian Institution, pers. comm.), such a designation cannot be made after 1999 without meeting 3 criteria, including "an express statement of the taxonomic purpose of the designation" (Article 74.7.3). I found no reference to such a purpose in Grubb (2005:693) and concluded that this designation is not valid under the current *Code*.

DIAGNOSIS

Boselaphus tragocamelus has no congeners; it is easily distinguished from the 4-horned antelope (*Tetracerus quadricornis*), the only other genus in the tribe Boselaphini, also monotypic, by its larger mass (9 times greater) and height (2.3 times greater) and lack of anterior horns. *B. tragocamelus* is distinguished from related tragelaphine antelopes of comparable stature (e.g., kudus [*Tragelaphus*] and eland [*Taurotragus derbianus*]) by short, straight, and sharp horns and pronounced frontal beard on the neck of males (Fig. 1) and distinctive coloration and patterning of both sexes (Fig. 2).

GENERAL CHARACTERS

Boselaphus tragocamelus is sexually dimorphic; coloration, male-only horns, and body mass are the most disparate characteristics (Figs. 1 and 2). Blanford's (1888) early description has been amended through time: somewhat equine (Prater 1980), neck deep and compressed; tufted tail reaching hocks; hind limbs shorter than front legs with high withers (Prater 1980); preborbital gland small with no lachrymal fossa; interdigital and unguicular glands present but no inguinal glands (Gosling 1985; Pocock 1910); adult males dark gray but varying from bluish to brownish gray except mane, terminal one-half of the ear outside and 2 spots inside, and tip of the tail are black; and a patch on the throat (gular patch), 2 spots on each cheek, lips, chin, inside of ears (except for the 2 black spots), lower surface of the tail, abdomen, and 2 rings above and below the fetlock are white. Females, calves, and young males are tawny brown with the same white markings as males (Schaller 1967). Males have a pronounced "pennant" or beard of coarse hair directly beneath the gular patch (Fig. 1); it is rudimentary in females (Fig. 2). Both sexes have a short and bristly mane that extends the length of the neck and terminates in tuft at the base of the neck (hog-mane—Sclater and Thomas 1900); the mane and hog-mane are darker and more prominent in adult males than females and other age classes (Blanford 1888; Schaller 1967; Sclater and Thomas 1900).

Frontals and parietals of the skull (Fig. 3) are almost in a single plane, forming a right angle with the occipital (Blanford 1888). Cranial measurements (in mm) of a male *B. tragocamelus* were: length of temporal fossa, 96; breadth of braincase, 86; breadth of skull between orbits, 145; breadth of frontal at horn-cores, 165; breadth of skull at mastoid, 123; height of occipital, 91; distance between horn-cores, 70; distance between primary keels of horn-cores at base, 41; distance between external face of horn-core and inner keel, 43; distance between outer edge of occipital condyles, 69; breadth of foramen magnum, 26 (Pilgrim 1939:163).

DISTRIBUTION

Boselaphus tragocamelus is endemic to the Peninsular Indian and Indus divisions of the Indian Subregion in the Asian Indomalayan Region (Fig. 4A; Corbet and Hill 1992). Native range of *B. tragocamelus* in Asia includes the foothills of the Himalayas in Nepal (Dinerstein 1980), northeastern Pakistan (Mirza and Khan 1975), and almost all of India, except eastern Bengal, Assam, east of the Bay of Bengal, and the Malabar coast (Blanford 1888; Ellerman and Morrison-Scott 1966; Prater 1980).

Introduced *B. tragocamelus* also exist in southern North America (Fig. 4B), where latitude, climate, and habitat characteristics are comparable to those of India (Ables and Ramsey 1972; Sheffield et al. 1983). The species was introduced into fenced areas of about 5,000 ha in southern Texas, United States, between 1924 (1st translocation of 2 females and 1 male according to Sheffield et al. [1971], but 5 individuals according to Presnall [1958]) and 1949 (releases of 3–5 individuals probably from the San Diego Zoological Park, San Diego, California). By 1971, *B. tragocamelus* occurred in 9 counties in Texas and Nuevo Laredo, Mexico (Ables and Ramsey 1972; Schmidly 1994; Sheffield et al.

Fig. 3.—Dorsal, ventral, and lateral views of skull and lateral view of mandible of adult male *Boselaphus tragocamelus* (National Museum of Natural History, specimen 269127). Greatest length of skull is 376 mm. Photograph courtesy of Don Hulbert.

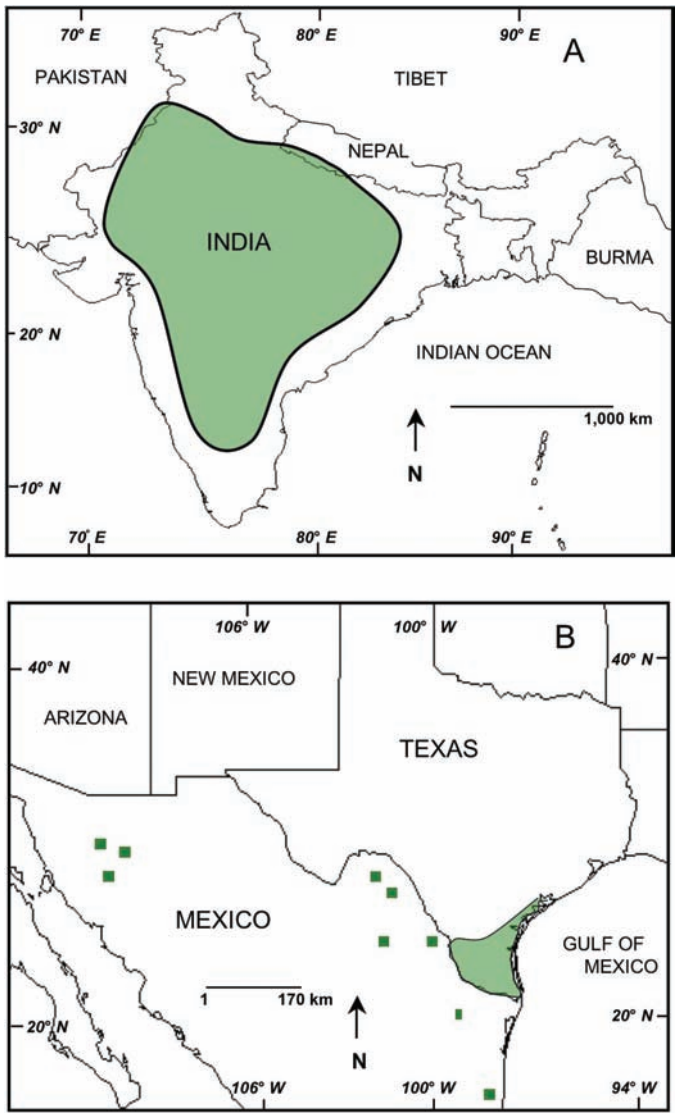

Fig. 4.—Distribution of *Boselaphus tragocamelus* in A) native India, Nepal, and Pakistan and B) southern North America (green squares = distinct areas of occurrence in Mexico), where exotic free-ranging populations occur.

1971, 1983); by 1992, the largest semiconfined population occurred in Kennedy and Willacy counties, Texas, with additional confined populations on 36 ranches in 25 counties (M. Traweek and R. Webb, in litt.). By 2005, 10 populations occurred in 5 Mexican states (Fig. 4B; Coahuila, 3; Nuevo Leon, 2; Sonora, 3; Tamaulipas, 1; Veracruz, 1—Álvarez-Romero and Medellín 2005). Several populations are confined to > 85,000-ha ranches in South Africa (Lever 1985), and introduced *B. tragocamelus* near Rome, Italy, disappeared during World War II (Long 2003). Fences have not provided complete confinement of *B. tragocamelus* in the United States, and in many areas of southern Texas, populations can now be considered free-ranging (B. R. Winton, in litt.).

Some of the most replete published ecological and behavioral insight on *B. tragocamelus* comes from introduced populations in North America. Detailed research was conducted in 2 adjacent fenced areas of 4,857 ha and 5,680 ha on what was considered a free-ranging population in southern Texas from the late 1960s to the early 1980s (e.g., Sheffield et al. 1983). Although the population was somewhat restricted by fences, basic ecological and behavioral characteristics likely were not greatly affected. Syntheses of that information are provided herein to permit comparison to native populations of *B. tragocamelus* and to fill gaps where information is missing.

FOSSIL RECORD

Fossils related to the tribe Boselaphini are well represented in Africa and Eurasia from the Miocene and represent the earliest bovids that arose 16–18 million years ago (e.g., *Eostragus*—Gentry 1978; Ginsburg and Heintz 1968; Solounias 1990). Extant *B. tragocamelus* and *T. quadricornis* are Miocene relicts and most related to early bovids (Pilgrim 1939; Pitra et al. 1997; Prothero and Schoch 2002), with horn morphology representing the primitive condition (straight and circular in cross section—Geist 1966; Janis 1982; Lundrigan 1996). Extant *Boselaphus* and *Tetracerus* and related fossil forms share the same primitive horn-core ontogeny (Solounias 1990).

The artiodactylan fossil fauna of India is rich and includes extinct genera and species closely related to extant *B. tragocamelus* (Colbert 1935; Pilgrim 1937, 1939). India may have been the ''developmental centre,'' or close to it, of Bovinae because from the lower Miocene ''onward the number and variety of Bovine genera found in India is out of all proportion to what is the case in other parts of the world'' (Pilgrim 1939:27). Bovids differentiated considerably during the middle Miocene; extinct *B. namadicus* and 6 boselaphine-like genera (*Duboisia*, *Perimia*, *Proboselaphus*, *Selenoportax*, *Sivaportax*, and *Tetracerus*) with similar ''circular or equilaterally triangular cross-section[s]'' of their horn cores are represented in the fossil record of India (Pilgrim 1939:191). *Sivaportax* may have represented the most primitive stage in the *Boselaphus* lineage (Pilgrim 1939). Today, *B. tragocamelus* can have traces of the anterior horns of extant *T. quadricornis*, suggesting close affinity between the 2 species (Pilgrim 1939).

Unlike extant *B. tragocamelus*, females of many related fossil boselaphines had horns with similar morphology and developmental processes as other bovids (e.g., Janis and Scott 1987; Kostopoulus 2005). Late Miocene boselaphine fossils from the eastern Mediterranean region are common (Kostopoulus 2005; Kostopoulus and Koufos 2006). Boselaphine and boselaphine-like fossils from the Pleistocene have been found eastward from India to Burma (Colbert 1943; Dassarma et al. 1982). Bones of *B. tragocamelus* occur in caves of Pleistocene origin in southern India (Prasad 1996; Prasad and Yadagiri 1986), and use by Mesolithic humans is evident 5,000–8,000 years ago (Murty 1985).

FORM AND FUNCTION

Form.—Koppiker and Sabnis (1981) describe hairs from *B. tragocamelus* that are 23–27 cm in length (collection site on the body not specified), 140 μm in diameter at the proximal end, and fragile and easily broken; scales are imbricate with flattened edges; color is nearly white proximally and gradually changes to brown or black distally (color and length match those from the nape of the neck described by Sclater and Thomas [1900]). Abnormally light-colored (almost white but not albino) individuals were observed twice in Sariska National Park in Rajasthan, India (Ranjitsinh 1987); unusual coloration also was noted on a captive female that had large white spots on the neck and trunk, both sides of her body, and buttocks (Smielowski 1987).

Maximum reported masses of adult males are 270 kg in India (Brander 1923) and 288 kg (Sheffield et al. 1983) and 268.0 kg ± 7.0 *SE* (6-year-old males—Lochmiller and Sheffield 1989) in southern Texas; mean mass of males in southern Texas is 241 kg. Maximum reported mass for adult females is 212 kg in southern Texas; mean mass was 169 kg (Sheffield et al. 1983). Other body measurements (in cm) are head-to-body length: 180–210 for males and 170 for females; girth at highest point of the shoulders: 160 for males and 130 for females; shoulder height: 120–140 for males and females; hip height: 110 for males and females; head length: 46 for males and 43 for females; tail length: 46–53 for males and 45 for females; and ear length, 15–18 for males and 15 for females (Blanford 1888; Sheffield et al. 1983).

Male-only horns characteristically arise close together just behind the orbits directed upward (Fig. 3) and are short, nearly straight with no catching arch, black, generally smooth, sharp, and 15–24 cm long at maturity (Blanford 1888; Schaller 1967; Sheffield et al. 1983). Horns are subconical above and triangular at the base (circumference about 20 cm) with a flat posterior side and a ridge in the front (Blanford 1888); they may develop ≥1 base rings annually after maturity (about 3–4 years old—Sheffield et al. 1983). Horn characteristics of adult male *B. tragocamelus* are: length, 14.0 cm; core surface, 70.8 cm^2; sheath surface, 100.7 cm^2; sheath thickness, 0.38 cm (Picard et al. 1996). Chitampalli (1983a) observed a male *B. tragocamelus* with downward-curved horns in Umarzari, India, and although rare, local Shikaris observed similar individuals frequently enough to call them ''Mendha nilgai,'' meaning ''sheep nilgai.'' Vision and hearing of *B. tragocamelus* are well-developed but sense of smell, less so (Brander 1923; Dharmakumarsinhji 1959; Fall 1972).

Dentition of adult *B. tragocamelus* is typical of bovids: i 0/3, c 0/1, p 3/3, m 3/3, total 32. Molars are very hypsodont with tall crowns and a large accessory column on upper molars (Blanford 1888; Lydekker and Blaine 1914). Age-specific eruption and wear patterns of teeth of male *B. tragocamelus* (n = 15, Natural History Museum of London—Kostopoulos 2005:767–768) are 1–2 year olds: M3 within alveoli, M2 just erupted, and milk dentition weakly to moderately worn; 3 year olds: premolars unworn, last milk tooth worn, and M3 just erupted; 4–5 year olds: full permanent dentition in 1st stages of wear; > 6 years old: full permanent dentition in advanced stages of wear. Exotic *B. tragocamelus* in southern Texas can be aged in annual classes ≤ 9 years old by examination of tooth wear on the mandible and counting annuli of p1, p2, and m1; precise aging ≥ 10 years is not possible (Brown 1976; Sheffield et al. 1983).

***Function.*—**Hemoglobin of *B. tragocamelus* contains 3 polypeptide chains with 1 beta and 2 alpha chains (John and Barnabas 1978). Mean (± *SD*) blood chemistry values are: aspartate aminotransferase, 31.1 ± 10.9 IU/l; alanine aminotransferase, 12.0 ± 3.5 IU/l; creatinine phosphokinase, 94.2 ± 84.6 IU/l; lactate dehydrogenase, 368 ± 213 IU/l; gamma glutamyl transpeptidase, 5.04 ± 1.31 IU/l; alkaline phosphatase, 183 ± 199 IU/l; glucose, 7.91 ± 2.08 mmol/l; urea, 7.76 ± 2.11 mmol/l; uric acid, 43.7 ± 10.7 mmol/l; creatinine, 209 ± 39 mmol/l; cholesterol, 1.89 ± 0.36 mmol/l; triglycerides, 0.21 ± 0.07 mmol/l; total bilirubin, 6.8 ± 2.7 μmol/l; protein, 6.84 ± 1.45 g/dl; albumin, 59.5% ± 10.1%; albumin–globulin ratio, 1.6 ± 0.7 (n = 7 adults—Peinado et al. 1999). Carbohydrate-free pancreatic ribonucleases from *B. tragocamelus* are relatively unique among bovids and compare most closely with the ''swamp-type'' water buffalo (*Bubalus bubalis*—Beintema 1980).

Boselaphus tragocamelus is herbivorous with a ruminal digestive system. Dry weights of ruminal contents of 79 adult males, adult females, and subadults (< 2 years old) of either sex in southern Texas averaged 2.1, 1.8, and 1.0 kg, respectively; wet weight contents averaged 35, 27, and 15 kg, respectively (Sheffield et al. 1983). Assuming 3 feeding periods/day and a 10-h passage rate of digesta through the rumen, 75% of ruminal contents at any point in time is from a single feeding bout, and 4.7, 4.0, and 2.3 kg of dry weight are consumed daily by adult males, adult females, and subadults, respectively (Sheffield et al. 1983).

Percent in vitro dry matter, organic matter, and cell wall digestibilities, respectively, in *B. tragocamelus* (70.9%, 69.4%, and 34.6%) are comparable to those of domestic cattle (69.5%, 68.3%, and 33.6%) and goats (68.3%, 67.4%, and 33.8%) but higher than those of white-tailed deer (*Odocoileus virginianus*; 57.9%, 57.4%, and 20.2%—Priebe et al. 1987). Retention of digesta in the reticulorumen and overall mean retention time for *B. tragocamelus* on formulated diets are 14.9 h and 20.6 h, respectively (Priebe 1985). A positive relationship exists between in vivo digestible organic matter of *B. tragocamelus* and in vitro digestible organic matter using cattle rumen inoculum, but in vivo digestible organic matter of *B. tragocamelus* was about 15% higher than in vitro digestible organic matter estimates (Strey 1987). Based on nitrogen-balance studies on subadult *B. tragocamelus*, levels of dietary crude protein of about 5% (dry-matter basis) maintain nitrogen equilibrium (Priebe 1985; Priebe and Brown 1987).

Unique fungal isolates from feces of *B. tragocamelus* enhance in vitro apparent digestibility, true digestibility, and neutral detergent fiber digestion of high-lignin–cellulose diets (Paul et al. 2004). Methane production from methanogenic bacteria in feces of *B. tragocamelus* averages 107 CH_4 nmol g^{-1} h^{-1} (maximum = 175 CH_4 nmol g^{-1} h^{-1}), a level comparable to that of other ruminal and cecal digesters (Hackstein and van Alen 1996). The ''modulus of fineness'' (Poppi et al. 1980) of fecal particle size from digesta residue suggests that *B. trgaocamelus* (modulus of fineness = 2.72) is an intermediate feeder; percentage of fecal particles passing through various sieve sizes are: 4-mm sieve, 2.72%; 1-mm sieve, 5.40%; 0.25-mm sieve, 12.71%, and < 0.125-mm sieve, 54.57% (Clauss et al. 2002).

ONTOGENY AND REPRODUCTION

Sexual maturity of female *B. tragocamelus* in southern Texas typically occurs at 2 years of age with the 1st parturition after 3 years of age; ovaries of 2-year-old female *B. tragocamelus* can have corpora lutea (Mungall 2000; Mungall and Sheffield 1994; Sheffield et al. 1983), and accessory corpora lutea have been reported (Amoroso 1955). Four inguinal mammae are present. Twinning is common; 50% of births are twins in southern Texas, and triplets are occasionally noted (Sheffield et al. 1983). Gestation is 243–247 days (Brown 1936; Sheffield et al. 1983). Females can breed shortly after parturition. Interparturition intervals for 3 captive females were 319–664 days (n = 8 litters) and averaged 436 days; 1 captive female produced 7 litters in 7 years and 8 months (Acharjyo and Misra 1975). Captive female *B. tragocamelus* can bred at just over 2 years of age (Acharjyo and Misra 1971, 1973), and births in captivity occur in any month of the year when males and females are housed together (Acharjyo and Misra 1972).

Generally, males 4–5 years of age are the most active breeders (Brown 1976; Sheffield et al. 1983). Testes of most male *B. tragocamelus* in southern Texas (n = 26; 10 months–7 years old) are histologically active by 3 years old (Lochmiller and Sheffield 1989). By 4 years old, male *B. tragocamelus* have large seminiferous tubules (202–283 μm) with large numbers of spermatogonia, spermatocytes, spermatids, and spermatozoa (Lochmiller and Sheffield 1989). Changes in percent seminiferous tubules and mean number of spermatozoa per seminiferous tubule are lower in summer (nonbreeding) than during all other months when no clear changes in testicular morphology or spermatogenic

activity are noted (Lochmiller and Sheffield 1989). Serum level of testosterone peaked at 11 ng/ml in a captive 8-year-old male after injection of 2,000 IU of human chorionic gonadotropin—considered normal (Bryant et al. 2004). A captive adult male *B. tragocamelus* displayed persistent penile frenulum from a combined congenital and acquired condition, rendering him incapable of breeding (Bryant et al. 2004); similar cases have not been reported in the wild.

In Keoladeo Ghana Sanctuary, India, an extended breeding season occurs in October–February with offspring born in June–October (Schaller 1967). Extended breeding (August–December) and birthing (April–August) seasons also occur in southern Texas, but neonates can be observed throughout the year (Sheffield et al. 1983). When *B. tragocamelus* was transported from tropical India to the United Kingdom, no change in the traditional time of rut (March–May) or parturition occurred (Duke of Bedford and Marshall 1942; Heape 1900).

ECOLOGY

Population characteristics.—Densities of *B. tragocamelus* in India vary widely depending on habitat conditions, competition with domestic livestock, predation, and degree of protection: 0.23–0.34 individuals/km^2, Indravati National Park (Pandey 1988); 0.39–1.47 individuals/km^2, Gir Lion Sanctuary (Berwick 1974; Berwick and Jordon 1971; Khan 1997; Khan et al. 1996); 0.40 individuals/km^2, Pench Tiger Reserve (Biswas and Sankar 2002); 0.44–7.81 individuals/km^2, Panna National Park (Awasthi et al. 1994; Mathai 1999); 6.60–11.36 individuals/km^2, Ranthambhore National Park (Bagchi et al. 2004); and 7.0 individuals/km^2, Keoladoe National Park (Bagchi et al. 2004). In Royal Karnali-Bardia Wildlife Reserve, Nepal, densities were 3.2 individuals/km^2 during the hot-dry season and 5.0 individuals/km^2 in April (Dinerstein 1980). In southern Texas, densities of a population in about 10,000 ha of fenced private property were 3.05–4.04 individuals/km^2 and 3.74–4.76 individuals/km^2 from helicopter and ground surveys, respectively (Brown 1976:56).

Maximum life span is 12–13 years in the wild (Berwick 1974; Mungall 2000; Mungall and Sheffield 1994) and 20–21 years in captivity (Grzimek 1990; Jones 1982); 1 female born at the National Zoo, Washington, D.C., lived 21 years and 8 months (Weigl 2005). Survival patterns among male and female *B. tragocamelus* are similar to those of other ungulates (Brown 1976) but vary depending on population density and status of particular populations, either on native or introduced range (cf. Berwick 1974; Sheffield et al. 1983). High rates of mortality are common for males in particular, but also females, before age 3 (Berwick 1974; Brown 1976). In Gir Forest, India, 34% of calves die each year, and there is a general linear decline of 52% of 2–10-year-olds of both sexes (Berwick 1974). In southern Texas, mortality of both males and females is high from birth to 3 years of age and relatively low from 6 to 8 years of age (Sheffield et al. 1983). As a tropically adapted species, *B. tragocamelus* cannot endure low temperatures and maintains meager winter fat reserves; where introduced in southern Texas, 1,000 individuals died in a single winter due to exposure and presumed protein malnutrition (Brown 1976; Schmidly 1994; Sheffield et al. 1983).

Fig. 5.—Male *Boselaphus tragocamelus* reaching for leaves of woody vegetation in Ranthambore National Park, Rajasthan, India, December 2004; browse is seasonally important in the diet in India and southern North America; note the characteristic "hog-mane" at base of the neck. Photograph courtesy of David Behrens (http://www.pbase.com/dbehrens).

Space use.—In India, *B. tragocamelus* is a habitat generalist (Mathai 1999) but tends to occur in "thin bush with scattered low trees or alterations of scrub and open grassy plains" with "either level or undulating" topography, rarely in thick forest but often on cultivated areas (Blanford 1888:518; Prater 1980). In agricultural areas, *B. tragocamelus* will feed throughout the night in open fields and retreat to the cover of forests during the day (Bohra et al. 1992; Mathai 1999; Pandey 1988; Prajapati and Singh 1994;

Sharma 1981; Shukla and Khare 1998). In southern Texas where confinement to large tracts of fenced land does not limit habitat availability, *B. tragocamelus* avoids dense woodlands and frequents improved pasture, sparse forests of live oak (*Quercus virginiana*) and scrub, and coastal prairies (Ables and Ramsey 1972; Schmidly 1994; Sheffield et al. 1971, 1983).

Boselaphus tragocamelus is nonmigratory, although individuals and groups are capable of considerable movement if ambient conditions (e.g., drought) dictate (Berwick 1974; Dharmakumarsinhji 1959; Sheffield et al. 1983). Home ranges of *B. tragocamelus* in a 5,680-ha fenced area in southern Texas averaged 4.3 km^2 (0.6–8.1 km^2); males were transient, often traversing their entire home range daily, and were not completely impeded by fences (Sheffield et al. 1983).

***Diet.*—**Premaxillary shape of *B. tragocamelus* suggests a mixed feeder (Solounias and Moelleken 1993). Dietary selection varies seasonally and includes grasses (*Cenchrus*, *Cynodon dactylon*, *Desmostachya bipinnata*, *Scripus tuberosus*, and *Vetiveria zizanoides*), woody vegetation (*Acacia nilotica*, *A. senegal*, *A. leucophloea*, *Clerodendrum phlomidis*, *Crotalaria burhia*, *Indigofera oblogifolia*, *Morus alba*, and *Zizyphus nummularia*), and herbaceous species (*Cocculus hirsutus*, *Euphorbia hirta*, and *Sida rhombifolia*—Khan 1994; Mirza and Khan 1975; Prajapati and Singh 1994; Sankar and Vijayan 1992; Sharma 1981; Shukla and Khare 1998; Solanki and Naik 1998). Woody vegetation dominates diets of *B. tragocamelus* in dry tropical forests of India (Khan 1994; Fig. 5).

Frugivory occurs seasonally in India (Sankar and Vijayan 1992). Seeds of 34 plant species germinated in feces of *B. tragocamelus* from Keoladeo National Park, India. Seeds of *Paspalum distichum* occurred in feces year-round, seeds of *A. nilotica* and *Prosopis juliflora* (both with fleshy fruits, but the latter an invasive exotic species in India) occurred in feces during the hot-dry season, and seeds of *Enchinochloa crusgalli* occurred in feces during the monsoon (Middleton and Mason 1992). Easily collected, nutrient-rich, seed-laden feces of *B. tragocamelus* can be used in reforestation efforts in India; seeds of *A. nilotica* from feces germinated at about a 30% higher rate than seeds collected directly (Prajapati and Singh 1994). Albeit atypical, an adult male *B. tragocamelus* stepped on the back of a terrapin near Lake Nawegaon, India, and then pulled out the terrapin's head, neck, and some viscera and ate it; villagers confirmed seeing similar incidents (Chitampalli 1983b).

Boselaphus tragocamelus in southern Texas is more restricted regionally than it is in India, but its diet is equally cosmopolitan. It consumes at least 167 species (66 grasses, 89 herbaceous species, and 12 woody plants); average annual diet is 66% grass, 25% herbaceous species, and 15% browse (Sheffield 1983; Sheffield et al. 1983). Generally, adult males eat more grass throughout the year than adult females, and subadults eat more herbaceous vegetation than adults of either sex; seeds, mainly from mesquite (*Prosopis glandulosa*), are seasonally important (Sheffield et al. 1983). Preferred genera in southern Texas are *Paspalum*, *Setaria*, and *Cenchrus* (grasses); *Lycium*, *Prosopis*, and *Celtis* (woody vegetation); and *Cassia*, *Rhynchosia*, and *Sida* (herbaceous vegetation). Dietary quality in southern Texas is: crude protein, 15.6% in spring to 7.5% in late spring and winter (annual average, 10%); calcium, 1.04% in April and November to 0.36% in October; phosphorus, 0.25% in autumn and as low as 0.10%; calcium–phosphorus ratios, 1.4:1–8.0:1; aside from low levels of phosphorus, those levels are comparable to standards for other wild ruminants and livestock (Sheffield 1983; Sheffield et al. 1983).

In India and Nepal, *B. tragocamelus* is limited by availability of free water (Bagchi et al. 2004; Berwick 1974; Dinerstein 1979, 1980). Wild adult males and calves in India will drink continuously for 2 min and 10 s and 1 min and 10 s, respectively (Bohra et al. 1992). Local distribution of *B. tragocamelus* in southern Texas also is constrained by need for free water, which is generally available within home ranges; all sexes and age classes visit water sources and are not adverse to entering water to drink (Fall 1972; Sheffield et al. 1983). During a drought in 1971, a radiocollared adult male established a new home range 1.6 km away in an area with standing water (Sheffield et al. 1983). Captive *B. tragocamelus* readily drink water (1 adult male consumed 14 l/24 h when ambient temperatures reached 40°C—Sheffield et al. 1983); captive neonates drink water at 3 weeks of age (Goldman and Stevens 1980).

Diseases and parasites.*—Boselaphus tragocamelus* harbors a variety of disease agents, but no particular pathogen or disease singularly affects the species or population levels (Sheffield et al. 1983). Many diseases, or disease-related conditions, are reported in captive individuals, including lesions associated with lymphoproliferative disease and malignant catarrhal fever (Blake et al. 1990), subclinical viral peste des petits ruminants (Furley et al. 1987), intestinal diverticulitis (Rajan et al. 1994), sarcocystotic cysts with associated pathology of a bluetongue-like disease (Acharjyo and Rao 1988), and mesothelioma and reticulum cell sarcoma and hepatoma (Rao and Acharjyo 1984). Domestic livestock likely transmit diseases to free-ranging populations of *B. tragocamelus* in India (Chhangani 2001), including foot-and-mouth disease (type "A" virus—Mukhopadhyay et al. 1975), suspected rinderpest (Mathur et al. 1975), and bovine tubercle bacilli (Datta 1954).

Parasites of free-ranging *B. tragocamelus* in India include nematodes *Ashworthius martinagliai*, *A. perrilli*, *Oesophagostomum venulosum*, *Stephanofilaria*, and *Trichuris globulosus* (Agrawal and Shah 1984; Chauhan et al. 1972; Hiregoudar 1974, 1976; Ortlepp 1935); trematodes *Cotylophoron cotylophoron* and *Gastrothylax crumenifer* (Ortlepp 1935); deer louse fly (*Lipoptena indica*—Hiregoudar 1976); eye worm *Thelazia rhodesii* (Chauhan and Pande 1973); and ticks *Hyalomma brevipunctata* (Hiregoudar 1976)

and *Haemaphysalis bispinosa* (Singh et al. 1978). In Uttaranchal in northwestern India, 41.6% of 161 fecal samples from *B. tragocamelus* were positive for single or mixed infections of *Amphistomes*, *Strongyles*, *Trichuris*, *Fasciola*, and coccidians (Banerjee et al. 2005). In southern Texas, 7 species of trichostrongylid nematodes occur in the gastrointestinal tract, including *Haemonchus*, *Ostertagia ostertagi*, and *Trichostrongylus axei* (Sheffield et al. 1983). External parasites in southern Texas include ticks *Boophilus* (Davey 1993), *B. microplus* (George 1990), and *Amblyomma cajennense* and likely *Dermacentor, Ixodes,* and *Halmaphysalis* (Sheffield et al. 1983). Additional internal parasites of captive *B. tragocamelus* include the spiruroid nematode *Gongylonema pulchrum* (Chakraborty 1994) and the protozoan *Toxoplasma gondii* (Ippen et al. 1981; Sedlák et al. 2004).

Interspecific interactions.—In India, *B. tragocamelus* is sympatric with axis deer or chital (*Axis axis*), blackbuck (*Antilope cervicapra*), chinkara (*Gazella bennettii*), chowsingha or 4-horned antelope (*T. quadricornis*), and sambar deer (*Rusa unicolor*) and less commonly with gaur (*Bos frontalis*) and water buffalo (Berwick 1974). Typically, some degree of habitat (Bagchi et al. 2003a, 2003b; Berwick 1974; Dinerstein 1979; Pandey 1988) and dietary (Berwick 1974; Khan 1994; Shukla and Khare 1998; Sheffield 1983) differentiation occurs. In Ranthambhore National Park, *B. tragocamelus* and chinkara form a ''bovid guild'' and select *Acacia–Butea* habitats during summer and winter, in contrast to sympatric axis and sambar deer that prefer *Anogeissus–Grewia* forests; in contrast to cervids, *B. tragocamelus* was tolerant of livestock grazing and associated degradation of grass cover (Bagchi et al. 2003a, 2003b). In southern Texas, differences in size and feeding preferences appear to minimize competition among native and domestic ungulates; however, when forage supplies are low, *B. tragocamelus* competes with cattle for grasses and white-tailed deer for herbaceous vegetation (Sheffield 1983; Sheffield et al. 1983).

In India, the endangered Indian tiger (*Panthera tigris tigris*) preys on *B. tragocamelus*, although it constitutes only 5–7% of prey items in Ranthambhore National Park (Bagchi et al. 2003c), 2.7% in Sariska Tiger Reserve (Sankar and Johnsingh 2002), and 3.6% in Nagarjunasagar Srisailam Tiger Reserve (Reedy et al. 2004). In Pench National Park, India, tigers do not prey on *B. tragocamelus* (Biswas and Sankar 2002). In Nepal, 1.8% of tiger's prey in the Royal Bardia National Park is *B. tragocamelus* (Støen and Wegge 1996). The rarity of Indian tigers suggests they do not limit any populations of *B. tragocamelus*.

Scats of the endangered Asiatic lion (*Panthera leo persica*) in Gir Forest, India—the only population in the wild—contain $< 3\%$ *B. tragocamelus* (Joslin 1984), paralleling predictions of Hayward and Kerley (2005) that *B. tragocamelus* is not a preferred prey item of lions in general. *B. tragocamelus* comprises 15.4% of the prey biomass of the leopard (*Panthera pardus*) in Sariska Tiger Reserve (Sankar and Johnsingh 2002) but is not preyed on Kalakad-Mundanthurai Tiger Reserve (Ramakrishnan et al. 1999), reflecting leopard preference for smaller prey (Hayward et al. 2006).

Boselaphus tragocamelus comprises a small proportion (frequency of occurrence: winter, 5.2%; summer, 4.9%; monsoon, 7.5%) of the diet of the endangered Indian wolf (*Canis lupus pallipes*) in western India (Jethva and Jhala 2004), but wolves may prey on calves to a greater degree (Sharma 1981). Fourteen percent of 26 scats from striped hyenas (*Hyaena hyaena*) in the Sariska Tiger Reserve contained *B. tragocamelus* (Sankar and Jethwa 2002). Cohen (1978) did not find published evidence that dhole (*Cuon alpinus*) prey on *B. tragocamleus*, but Sharma (1981) stated that they prey on calves.

BEHAVIOR

Grouping behavior.—*Boselaphus tragocamelus* is not as gregarious as other herding ungulates and occurs in relative small groups throughout the year. Adult males segregate from females and subadults during nonbreeding seasons. Annual group sizes in India are 1.9–2.9 individuals (Bagchi et al. 2004; Berwick 1974; Khan et al. 1996); male prevalence in groups during breeding in Nepal is 1 male, 37%; 2 males, 28%; 3 males, 20%; and > 4 males, 15% (Dinerstein 1980). Outside of the breeding season in India, herd composition changes constantly with small groups of 1 or 2 adult females and their offspring; mixed herds of 3–6 adult females, yearling females, and an occasional calf; and male groups of 2–18 individuals (Schaller 1967; Sharma 1981).

Reproductive behavior.—*Boselaphus tragocamelus* is polygynous, and mature adult males breed most often. Early accounts of free-ranging *B. tragocamelus* describe a territorial system with adult males forming breeding groups of 2–10 females (Schaller 1967). In captivity, male territoriality and female social hierarchy, perhaps a condition of confinement, have been suspected (Oguya and Eltringham 1991). However, most researchers find little evidence for territorial breeding or harem formation (Dharmakumarsinhji 1959; Fall 1972; Sheffield et al. 1983). Solitary breeding males are not ''spatially fixed'' but maintain an ''area of dominance'' around themselves as they move among different groups of females; the system results in ''mutual avoidance'' (Fall 1972; Sheffield et al. 1983:43–44) and temporary dominance (Owen-Smith 1977) among breeding males.

As rut approaches, adult male *B. tragocamelus* interact aggressively, and vigorous fights occur to establish dominance. Dominance interactions between males include lateral displays with various head and neck displays that maximize appearance of the chest, white gular patch, and beard (arched-necked display and straight-necked display) and frontal head-erect displays (similar to alert posture)

Fig. 6.—Premounting behavior of *Boselaphus tragocamelus* in Koleado National Park, western India, December 2004. Photograph courtesy of David Behrens (http://www.pbase.com/dbehrens).

often at distances of > 75 m between conspecifics (Fall 1972; Sheffield et al. 1983). Threats are more serious than dominance displays and include a straight-necked threat displayed frontally and usually ≤ 10 m from a conspecific (while stationary, walking, or running toward opponent) and rush threat from a normal stance or after a lateral display with lowered neck, head toward the ground, and horns horizontal (contact and goring of the thighs or flank are common, and chases of ≤ 750 m have been observed—Fall 1972; Sheffield et al. 1983). While displaying, males may circle one another crouched and with a stiff posture (Cowan and Geist 1961; Fall 1972).

Two types of fights occur between males: head butting with horns and neck fighting, either in standing or kneeling positions (Lundrigan 1996; Walther 1958). Neck fighting of male *B. tragocamelus* is relatively unique among ungulates (Sheffield et al. 1983). Neck fighting occurs most often in bachelor herds among subadults and yearlings (also noted in captive calves—Oguya and Eltringham 1991); although intense, these interactions appear to be mock fights (Fall 1972). The thick dermal shield on the neck and chest of male *B. tragocamelus* is protective, but fighting of either type can result in serious goring and mortality. Puncture wounds and even protruding viscera have been observed; 40 mature males collected for dietary studies in southern Texas had noticeable scars on their neck and shoulders (Sheffield et al. 1983). Female *B. tragocamelus* also neck fight and display intrasexual agonistic behavior by rushing; head butting other females on their shoulders, flanks, or sides; and threatening with flattened ears and stretched neck (Fall 1972; Sheffield et al. 1983).

During breeding, generally only 1 mature male accompanies a female group at a time, sometimes for only a few hours (Fall 1972). Even during the breeding season, female groups usually do not have a breeding male present; males display no attempt at harem formation or defense of a spatially defined breeding territory (Fall 1972; Sheffield et al. 1983). Courtship is simple and may last 45 min: breeding male approaches a female stiffly, body stretched lengthwise, and tail erect with the tuft at a right-angle kink; female typically holds her head close to ground and meanders forward (Fig. 6); male licks and nuzzles the female's perineum; if receptive, female raises her tail and elicits a flehmen (lip curl) response from the male, who then rests his chin on her rump, pushes his chest forward to touch her, and mounts; copulation is terminated by the female; no postcopulation display is noted (Fall 1972; Sheffield et al. 1983).

Free-ranging female *B. tragocamelus* become solitary as parturition approaches and keep neonates hidden from other conspecifics for about 1 month (Fall 1972; Sheffield et al. 1983). Even in captivity, neonates are hidden if possible (Lacey 1969); parturition of 1 twin took place in a standing position and the other, 25 min later, in a lying position; neonates stood after 20–40 min (Goldman and Stevens 1980). Neonates nurse from a reverse parallel position, and females often terminate nursing by stepping over their calf (Fall 1972; Sheffield et al. 1983). Average nursing bouts can last 7 min in captivity, and calves show interest in forage during their 4th week (Goldman and Stevens 1980). Play behavior is apparent but not frequent among calves; activities include bounding with a spring start and landing stiff-legged, chasing (Goldman and Stevens 1980), and play-fighting (rudimentary neck fighting) with erect tails as early as 3 months old (Fall 1972; Sheffield et al. 1983).

Communication.—*Boselaphus tragocamelus* is normally quiet, but early accounts describe vocalizations like "a creaking … of a Child's Rattle, or Croaking of some Birds" (Parsons 1745:467). All age classes < 5 months of both sexes use a forceful "guttural, coughing roar ('bwooah') when alerted" that lasts only 0.5 s, can be heard from 500 m, and occasionally is responded to in-kind by other herds ≤ 500 m away; pitch of this vocalization is lowest for males and highest for calves (Fall 1972; Sheffield et al. 1983:35). Aggressive bulls occasionally display a "low-pitched belching moan" while chasing one another (Fall 1972; Sheffield et al. 1983:35). In captivity, females display a "low guttural clicking" while neonates nurse (Goldman and Stevens 1980) and call while in estrus (Lacey 1969).

Boselaphus tragocamelus of both sexes and all age classes defecate repeatedly in conspicuous fecal piles, often > 3 m and up to 6 m in diameter, within their home range; this type of scent-marking likely has social or communicative implications (Blanford 1888; Brander 1923; Dharmakumarsinhji 1959; Fall 1972; Prater 1980; Schaller 1967; Sheffield et al. 1983). In southern Texas, fecal piles are most frequent "on bare or open ground along roads, game trails, and at trail intersections" (Sheffield et al. 1983:33), suggesting a form of advertising. Fresh feces are added to a pile, on

average, every 3.7 days (Sheffield et al. 1983). By manipulating fecal piles, Fall (1972) demonstrated that odor and presence of feces are more important than characteristics of the site of defecation. Fecal piles are sometimes established on carcasses of dead animals (Sheffield et al. 1983).

Defecation postures of *B. tragocamelus* are characteristic and exaggerated (Fig. 1); males stand with their rear legs spread 0.6–1.0 m, rump lowered, tail erect at least above horizontal and often near vertical, and head and neck erect and forward; the position is maintained for $\geq$ 10 s after defecation; forward spraying of urine by males often accompanies defecation (Fall 1972). Females defecate in a similar but less exaggerated posture than males and, unlike males, will defecate while walking (Fall 1972:101). As is common in ungulates, contagious defecations usually occur when individuals arise from a bedded position (Fall 1972). *B. tragocamelus* beds in the typical bovine position but often in sparsely vegetated areas without shade even during the heat of the day, typically separated by 5–10 m (Fall 1972; Sheffield et al. 1983). Position of unguicular glands on the legs may serve to scent-mark bedding sites (Gosling 1985; Pocock 1910).

Miscellaneous behavior.—*Boselaphus tragocamelus* can be very wary (Fall 1972; Schaller 1967; Sheffield et al. 1983), likely related to harassment. In contrast, early accounts from Hindu-dominated areas in India where the species was not hunted or harassed described them as very tame (Blanford 1888; Lydekker 1894; Sclater and Thomas 1900); tame individuals have been used in feeding and nutritional evaluations (Berwick 1974; Sheffield et al. 1983). In southern Texas, males and females are equally likely to flee approaching research vehicles; mean flight distance was about 300 m, but a galloping flight response (up to 48 km/h—Fall 1972:97) was apparent even up to 700 m; individuals did not seek cover but ran opposite of the disturbance (Sheffield et al. 1983).

GENETICS

Boselaphus tragocamelus has a diploid chromosome number (2n) of 46: female fundamental number (FN) = 60, male FN = 59, autosomal arm number = 56 with 16 acrocentric and 6 biarmed autosomal pairs (Gallagher et al. 1998; Wurstor and Benirschke 1968). Compared with a standard cattle karotype, 6 biarmed elements of *B. tragocamelus* are derived from centric fusion between acrocentric chromosomes (1;5, 2;3, 6;13, 8;12, 19;27, 24;25—Gallagher et al. 1998). G-, Q-, and C-band karyotypes are present, chromosome 25 is centrically fused to 24, and chromosome 16 is acrocentric (Gallagher et al. 1998). The X chromosome is compound metacentric, and the Y chromosome is compound acrocentric (Gallagher et al. 1999). Internal telomeric sequences are evident on the Y and X chromosome indicating past translocation events with autosomes (Petit et al. 1999).

DNA sequence conservation occurs in *B. tragocamelus* (Pépin et al. 1995). Gallagher et al. (1998) concluded that *B. tragocamelus* was karyotypically derived with conditions unique to species of Bovinae; some derived chromosomal conditions common to *B. tragocamelus*, the African buffalo (*Syncerus caffer*), and some Tragelaphini could be convergent. Gene sequences for interleukin 2 (Das et al. 2006), Toll-like receptor 3 (Dhara et al. 2007), and prion protein gene (Seabury et al. 2004) suggest that *B. tragocamelus* shares a common lineage with water buffalo (*B. bubalis*) and kudu (*Tragelaphus*) more than with domestic cattle. A unique T→C transition exists at position 345 of the mitochondrial 16S rRNA gene in *B. tragocamelus* that can be used forensically to differentiate it from 23 species in 7 subfamilies of Bovidae and various species in families Equidae, Rhinocerotidae, Felidae, and Hominidae (Guha and Kashyap 2003).

CONSERVATION

Boselaphus tragocamelus is a species of least conservation concern in its native range (International Union for Conservation of Nature and Natural Resources 2006). Numbers in India total about 100,000 but have always been low in lowland Nepal (Adams 1858; Dinerstein 1979); this species is rare in Pakistan (Mirza and Khan 1975) and extinct in Bangladesh (Mallon 2003; Rahmani 2001). About 37,000 exotic *B. tragocamelus* occur in southern Texas (International Union for Conservation of Nature and Natural Resources 2006; M. Traweek and R. Welch, in litt.); the species can be harvested throughout the year with no limit on numbers if the hunter has a valid hunting license from the state of Texas. Recent concern has been expressed over the negative impact of heavily used trails of *B. tragocamelus* that may open up dense shrubby habitats that are critical for the endangered ocelot (*Leopardus pardalis*) and jaguarondi (*Puma yagouaroundi*) in extreme southern Texas (B. R. Winton, in litt.). Numbers of exotic *B. tragocamelus* in Mexico are unknown, but they currently range over 44,500 ha in 5 states (J. Álvarez-Romero, in litt.).

Boselaphus tragocamelus can jump fences 2.1–2.5 m high (Sharma 1981; Sheffield et al. 1983), so exotic populations in the United States, Mexico, and South Africa thought to be contained within fenced private properties likely have, or will, disperse. The species is often a serious agricultural pest in India (Bohra et al. 1992; Chauhan and Sawarkar 1989; Goyal and Rajpurohit 1999; International Union for Conservation of Nature and Natural Resources 2006; Mathai 1999; Prajapati and Singh 1994; Sekhar 1998; Sharma 1981) and is responsible for depredation of wheat (*Triticum*), sorghum (*Sorghum*), mung (*Phaseolus*), and mustard (*Brassica*—Sharma 1981). Legal protection in India is often waved to minimize depredation complaints (International Union for Conservation of Nature and Natural Resources 2006).

REMARKS

Perhaps as a reflection of the primitive lineage and mixed appearance of *B. tragocamelus*, its scientific name translates, in Latin and Greek, to the ox (*bos*, Latin)–deer (*elaphos*, Greek) and goat (*tragos*, Greek)–camel (*kamelos*, Greek). The various common names of *B. tragocamelus* are equally mixed in meaning and origin: nilgai (roots are Hindustani nil meaning blue and gai meaning bovine, and Sanskit gabhih meaning female bovine, or Persian gaw meaning cow), nylghai (Pilgrim 1939), nylghiae, neel-ghae (Ogilby 1837), nylghau (Gray 1850), nilgo, nilgau (International Union for Conservation of Nature and Natural Resources 2006), white-footed antelope (Pennant 1771), and blue bull or bluebuck with clear relevance to the coloration of mature males. The various references to cow and bull have led to local Hindu beliefs that *B. tragocamelus* is sacred (International Union for Conservation of Nature and Natural Resources 2006; Prater 1980) and should be protected from hunting in India.

Early accounts about the palatability of the flesh of *B. tragocamelus* were less than flattering (Sclater and Thomas 1900). However, flesh of adult females is of comparable texture and tenderness to beef but is less flavorful and lower in fat (by 2 times) and cholesterol (Tegarden 1988). In various formulations of hot dogs for human consumption (presumably the American market), taste panels preferred the flavor of hot dogs with 33% *B. tragocamelus* (Eggen et al. 1973).

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LITERATURE CITED

Ables, E. D., and C. W. Ramsey. 1972. Indian mammals on Texas rangelands. Journal of the Bombay Natural History Society 71:18–25.

Acharjyo, L. N., and R. Misra. 1971. Age at sexual maturity of three species of wild animals in captivity. Journal of the Bombay Natural History Society 68:446.

Acharjyo, L. N., and R. Misra. 1972. Some observations on distribution of zoo births among common wild animals. Journal of the Bombay Natural History Society 69:175–178.

Acharjyo, L. N., and R. Misra. 1973. A note on age of sexual maturity of two species of antelopes in captivity. Journal of the Bombay Natural History Society 70:378.

Acharjyo, L. N., and R. Misra. 1975. A note on inter-parturition interval of some captive wild mammals. Journal of the Bombay Natural History Society 73:841–845.

Acharjyo, L. N., and A. T. Rao. 1988. Sarcocystosis in some Indian wild ruminants. Indian Veterinary Journal 65:169–170.

Adams, A. L. 1858. Remarks on the habits and haunts of some of the Mammalia found in various parts of India and the western Himalayan Mountains. Proceedings of the Zoological Society of London 26:512–531.

Agrawal, M. C., and H. L. Shah. 1984. Stephanofilarial dermatitis in India. Veterinary Research Communications 8:93–102.

Allen, G. M. 1939. A checklist of African mammals. Bulletin of the Museum of Comparative Zoology 83:1–763.

Álvarez-Romero, J., and R. A. Medellín. 2005. *Boselaphus tragocamelus*. Vertebrados superiores exóticos en México: diversidad, distribución y efectos potenciales. Bases de Datos SNIB-CONABIO, Proyecto U020, Instituto de Ecologia, Universidad Nacional Autónoma de México, México City.

Amoroso, E. C. 1955. Endocrinology of pregnancy. British Medical Bulletin 11:117–125.

Awasthi, A. K., S. Sharma, and M. K. Das. 1994. Evaluation and status assessment of Panna National Park (MP). Environment & Ecology 12:685–689.

Bagchi, S., S. P. Goyal, and K. Sankar. 2003a. Niche relationships of an ungulate assemablage in a dry tropical forest. Journal of Mammalogy 84:981–988.

Bagchi, S., S. P. Goyal, and K. Sankar. 2003b. Habitat separation among ungulates in dry tropical forests of Gir National Park, Rajasthan. Tropical Ecology 44:175–181.

Bagchi, S., S. P. Goyal, and K. Sankar. 2003c. Prey abundance and prey selection by tigers (*Panthera tigris*) in a semi-arid, dry deciduous forest in western India. Journal of Zoology (London) 260:285–290.

Bagchi, S., S. P. Goyal, and K. Sankar. 2004. Herbivore density and biomass in a semi-arid tropical dry deciduous forest of western India. Journal of Tropical Ecology 20:475–478.

Banerjee, P. S., R. Garg, C. L. Yadav, and H. Ram. 2005. Parasitic infections in some wild animals of Uttaranchal. Indian Journal of Animal Sciences 75:206–208.

Beintema, J. J. 1980. Primary structures of pancreatic ribonucleases from Bovidae: impala, Thomson's gazelle, nilgai and water buffalo. Biochimica et Biophysica Acta 621:89–103.

Berwick, S. H. 1974. The community of wild ruminants in the Gir Forest ecosystem, India. Ph.D. dissertation, Yale University, New Haven, Connecticut.

Berwick, S. H., and P. A. Jordan. 1971. First report of the Yale–Bombay Natural History Society studies of wild ungulates at the Gir Forest, Gujarat, India. Journal of the Bombay Natural History Society 68:412–423.

Biswas, S., and K. Sankar. 2002. Prey abundance and food habit of tigers (*Panthera tigris tigris*) in Pench National Park, Madhya Pradesh, India. Journal of Zoology (London) 256:411–420.

Blake, J. E., N. O. Nielson, and W. P. Heuschele. 1990. Lymphoproliferation in captive wild ruminants affected with malignant catarrhal fever: 25 cases (1977–1985). Journal of the American Veterinary Medical Association 196:1141–1143.

Blanford, W. T. 1888. The fauna of British India, including Ceylon and Burma: Mammalia. Taylor and Francis, London, United Kingdom.

Bohra, H. C., S. P. Goyal, P. K. Ghosh, and I. Prakash. 1992. Studies on the ethology and eco-physiology of the antelopes of the Indian Desert. Annals of Arid Zone 31:83–96.

Brander, A. A. D. 1923. Wild animals in central India. Edward Arnold and Company, London, United Kingdom.

Brookes, J. 1828. A catalogue of the anatomical and zoological museum of Joshua Brookes, esq. F.R.S., F.L.S. &c. George Robins, London, United Kingdom.

Brown, B. A. 1976. The population dynamics of nilgai (*Boselaphus tragocamelus* Pallas) in southern Texas, with some management considerations. Ph.D. dissertation, Texas A&M University, College Station.

Brown, C. E. 1936. Rearing wild animals in captivity, and gestation periods. Journal of Mammalogy 17:10–13.

Bryant, B., L. Turner, C. MacCallum, and S. D. Johnston. 2004. Persistent penile frenulum in a nilgai (*Boselaphus tragocamelus*). Australian Veterinary Journal 82:419–420.

Chakrborty, A. 1994. Occurrence and pathology of *Gongylonema* in captive wild herbivores. Verterinary Parasitology 52:163–167.

Chauhan, N. P. S., and V. B. Sawarkar. 1989. Problems of over-abundant populations of 'nilgai' and 'blackbuck' in Haryana and Madhya Pradesh and their management. Indian Forester 115: 488–493.

Chauhan, P. P. S., and B. P. Pande. 1973. Observations on the incidence of *Thelazia* infection in cattle and buffalos in Uttar Pradesh with remarks on its significance. Indian Journal of Animal Sciences 43:300–305.

Chauhan, P. P. S., B. P. Pande, and M. Singh. 1972. A new species of *Ashworthius* Le Roux, 1930 (Haemonchinae: Trichostrongylidae) from two wild ruminants with a note on associated lesions. Journal of Helminthology 46:149–155.

Chhangani, A. K. 2001. Threats to Kumbhalgarh Wildlife Sanctuary in relation to flora and fauna. Journal of Nature Conservation 13: 177–185.

Chitampalli, M. B. 1983a. Abnormal horns in the nilgai. Journal of the Bombay Natural History Society 80:209.

Chitampalli, M. B. 1983b. Unusual feeding behavior of nilgai. Journal of the Bombay Natural History Society 80:412.

Clauss, M., M. Lechner-Doll, and W. J. Streich. 2002. Faecal particle size distribution in captive wild ruminants: an approach to the browser/grazer dichotomy from the other end. Oecologia 131: 343–349.

Cohen, J. A. 1978. *Cuon alpinus*. Mammalian Species 100:1–3.

Colbert, E. H. 1935. Siwalik mammals in the American Museum of Natural History. Transactions of the American Philosophical Society, New Series 26:1–401.

Colbert, E. H. 1943. Pleistocene vertebrates collected in Burma by the American Southeast Asiatic Expedition for Early Man. Pp. 395–428 in Research on early man in Burma (H. de Terra and H. L. Movius, Jr., eds.). Transactions of the American Philosophical Society, New Series 32:267–464.

Corbet, G. B., and J. E. Hill. 1992. The mammals of the Indomalayan region: a systematic review. Oxford University Press, Oxford, United Kingdom.

Cowan, I. McT., and V. Geist. 1961. Aggressive behavior in deer of the genus *Odocoileus*. Journal of Mammalogy 42:522–526.

Das, D. K., M. Saini, D. Swarup, and P. K. Gupta. 2006. Molecular cloning and evolution of the gene encoding the precursor of nilgai (*Boselaphus tragocamelus*) interleukin 2. DNA Sequence 17: 465–470.

Dassarma, D. C., S. Biswas, and N. Nandi. 1982. Fossil vertebrates from the late Quaternary deposits of Bankura, Burdwan and Purulia districts, West Bengal. Memoirs of the Geological Survey of India 44:1–65.

Datta, S. 1954. Preliminary report on incidence and prevalence of tuberculosis in cattle and domestic animals with special reference to localization and type of bacilli. Indian Journal of Tuberculosis 1:89–92.

Davey, R. B. 1993. Stagewise mortality, ovipositional biology, and egg viability of *Boophilus annulatue* (Acari, Ixodidae) on *Boselaphus tragocamelus* (Artiodactyla, Bovidae). Journal of Medical Entomology 30:997–1002.

de Blainville, H. 1816. Sur plusieurs espèces d'animaux mammifères, de l'ordre des ruminans. Bulletin des Sciences par la Société Philomatique de Paris 1816:73–82.

Desmarest, A.-G. 1816. Antilope, *Antilope*. Pp. 178–208 in Nouveau dictionnaire d'histoire naturelle, appliquée aux arts, à l'agiculture, à l'économie rurale et domestique, à la medicine, etc. Vol. 2. Par une Societé de Naturalistes et d'Agriculteurs, Chez Déterville, Paris, France.

Dhara, A., et al. 2007. Molecular characterization of coding sequences and analysis of Toll-like receptor 3 mRNA expression in water buffalo (*Bubalus bubalis*) and nilgai (*Boselaphus tragocamelus*). Immunogenetics 59:69–76.

Dharmakumarsinhji, K. S. 1959. A field guide to big game census in India. Indian Board for Wild Life, New Delhi, India.

Dinerstein, E. 1979. An ecological survey of the Royal Karnali-Bardia Wildlife Reserve, Nepal. Part II. Habitat/animal interactions. Biological Conservation 18:265–300.

Dinerstein, E. 1980. An ecological survey of the Royal Karnali-Bardia Wildlife Reserve, Nepal. Part III. Ungulate populations. Biological Conservation 18:5–38.

Duncan, F. M. 1937. On the dates of publications of the Society's 'Proceedings,' 1859–1926. Proceedings of the Zoological Society of London, A. General and Experimental 107:71–84.

Duke of Bedford, and F. H. A. Marshall. 1942. On the influence of the breeding season in mammals after transference to a new latitude. Proceedings of the Royal Society of London, B. Biological Sciences 130:396–399.

Eggen, N., E. Quarrier, Z. L. Carpenter, G. C. Smith, and E. D. Ables. 1973. Utilization of nilgai antelope meat. Journal of Animal Science 37:260.

Ellerman, J. R., and T. C. S. Morrison-Scott. 1966. Checklist of Palaearctic and Indian mammals 1758 to 1956. 2nd ed. Trustees of the British Museum (Natural History), London, United Kingdom.

Erxleben, J. C. P. 1777. Systema regni animalis per classes, ordines, genera, species, varietates cum synonymia et historia animalium. Classis I. Mammalia. Impensis Weygandianis, Lipsiae, Germany.

Fall, B. A. 1972. On social organization and behavior of nilgai antelope, *Boselaphus tragocamelus* (Pallas), in south Texas. M.S. thesis, Texas A&M University, College Station.

Furley, C. W., W. P. Taylor, and T. U. Obi. 1987. An outbreak of peste des petits ruminants in a zoological collection. Veterinary Record 121:443–447.

Gallagher, D. S., Jr., et al. 1998. A karotypic analysis of nilgai, *Boselaphus tragocamelus* (Artiodactyla: Bovidae). Chromosome Research 6:505–513.

Gallagher, D. S., Jr., et al. 1999. A molecular cytogenetic analysis of the tribe Bovini (Artiodactyla: Bovidae: Bovinae) with an emphasis on sex chromosome morphology and NOR distribution. Chromosome Research 7:481–492.

Geist, V. 1966. The evolution of horn-like organs. Behaviour 27: 175–214.

Gentry, A. W. 1978. Bovidae. Pp. 540–572 in Evolution of African mammals (V. J. Maglio and H. B. S. Cooke, eds.). Harvard University Press, Cambridge, Massachusetts.

George, J. E. 1990. Wildlife as a constraint to the eradication of *Boophilus* spp. (Acari: Ixodidae). Journal of Agricultural Entomology 7:119–126.

Giebel, C. G. 1855. Die Säugethiere in Zoologischer, Anatomischer und Palaeontologischer Beziehung Umfassend Dargestellt. Verlag von Ambrosius Abel, Leipzig, Germany.

Ginsburg, L., and E. Heintz. 1968. La plus ancienne antilope d'Europe, *Eotragus artenensis* du Burdigalien d'Artenay. Bulletin du Museum d'Histoire Naturelle 40:837–842.

Goldman, J. E., and V. J. Stevens. 1980. The birth and development of twin nilgai *Boselaphus tragocamelus* at Washington Park Zoo, Portland. International Zoo Yearbook 20:234–240.

Gosling, L. M. 1985. The even-toed ungulates: order Artiodactyla: sources, behavioural context, and function of chemical signals. Pp. 550–618 in Social odours in mammals (R. E. Brown and D. W. Macdonald, eds.). Vol. 2. Clarendon Press, Oxford, United Kingdom.

Goyal, S. K., and L. S. Rajpurohit. 1999. Mass killing of mammalian crop pest—nilgai (blue bull), *Boselaphus tagocamelus*, in Village Parasala, Osian of Jodhpur, India. Advances in Ethology 34:224.

Gray, J. E. 1850. Synopsis of the species of antelopes and strepsiceres, with descriptions of new species. Proceedings of the Zoological Society of London 18:111–146.

Grubb, P. 2005. Order Artiodactyla. Pp. 637–722 in Mammal species of the world: a taxonomic and geographic reference (D. E. Wilson and D. M. Reeder, eds.). 3rd ed. Johns Hopkins University Press, Baltimore, Maryland,

Grzimek, B. 1990. Grzimek's encyclopedia of mammals. Vol. 5. McGraw-Hill Publishing Company, New York.

Guha, S., and V. K. Kashyap. 2003. Sequencing the mitochondrial 16S rRNA gene: a robust approach for identification of *Boselaphus tragocamelus*. Forensic Science International 136, supplement 1: 381.

Hackstein, J. H. P., and T. A. van Alen. 1996. Fecal methanogens and vertebrate evolution. Evolution 50:559–572.

Hamilton-Smith, C. 1827a. The class Mammalia. Supplement to the order Ruminantia. Pp. 343–366 in The animal kingdom, arranged in conformity with its organization, by the Baron Cuvier, with additional descriptions of all the species hitherto named, and of many not before noticed (E. Griffith, C. Hamilton-Smith, and E. Pidgeon, eds.). Vol. IV. G. B. Whittaker, London, United Kingdom.

Hamilton-Smith, C. 1827b. Synopsis of the species of the class Mammalia, as arranged with reference to their organization. Order VII.—Ruminantia. Pecora, Lin. Pp. 366–367 in The animal kingdom, arranged in conformity with its organization, by the Baron Cuvier, with additional descriptions of all the species hitherto named, and of many not before noticed (E. Griffith, C. Hamilton-Smith, and E. Pidgeon, eds.). Vol. V. G. B. Whittaker, London, United Kingdom.

Hayward, M. W., P. Henschel, J. O'Brien, M. Hofmeyr, G. Blame, and G. I. H. Kerley. 2006. Prey preferences of the leopard (*Panthera pardus*). Journal of Zoology (London) 270:298–313.

Hayward, M. W., and G. I. H. Kerley. 2005. Prey preferences of the lion (*Panthera leo*). Journal of Zoology (London) 267:309–322.

Heape, W. 1900. The "sexual season" of mammals and the relation to the "pro-oestrum" to menstruation. Quarterly Journal of Microbiological Science 44:1–70.

Hiregoudar, L. S. 1974. A note on "ear sore" due to *Stephanofilaria* among nilgai (*Boselaphus tragocamelus*) in Gir Forest of Gujarat State. Indian Veterinary Journal 51:72.

Hiregoudar, L. S. 1976. Some parasites of wild ruminants in Gir Forest of India. Indian Veterinary Journal 53:237.

Horsfield, T. 1851. A catalogue of the Mammalia in the Museum of the Hon. East-India Company. J. & H. Cox, London, United Kingdom.

Hunter, W. 1771. An account of the nyl-ghau, an Indian animal, not hitherto described. Philosophical Transactions 61:170–181.

International Commission on Zoological Nomenclature. 1956. Opinion 417. Rejection for nomenclatural purposes of volume 3 (zoologie) of the work of Lorenz Oken entitled Okens Lehrbuch de Naturgeschichte published 1815–1816. Opinions and declarations rendered by the International Commission on Zoological Nomenclature, London, United Kingdom 14(1):1–42.

International Commission on Zoological Nomenclature. 1999. International code of zoological nomenclature. 4th ed. International Trust for Zoological Nomenclature, London, United Kingdom.

International Union for Conservation of Nature and Natural Resources. 2006. The IUCN Red list of threatened species. www.iucnredlist.org. (4 June 2007).

Ippen, R., V. Kozojed, and J. Jíra. 1981. Toxoplasmosis in zoo animals. Folia Parasitologica 28:109–115.

Janis, C. M. 1982. Evolution of horns in ungulates: ecology and paleoecology. Biological Reviews 57:261–317.

Janis, C. M., and K. M. Scott. 1987. The interrelationships of higher ruminant families with special emphasis on the members of Cervidae. American Museum Novitates 2893:1–85.

Jethva, B. D., and Y. V. Jhala. 2004. Foraging ecology, economics and conservation of Indian wolves in the *Bhal* region of Gujarat, western India. Biological Conservation 116:351–357.

John, M. E., and J. Barnabas. 1978. Gene diversity of bovid hemoglobins. Biochemical Genetics 16:787–798.

Jones, M. L. 1982. Longevity of captive mammals. Der Zoologische Garten, Zeitschrift für die Gesmate Tiergärtnerei (Neue Folge) 52: 113–128.

Joslin, J. 1984. The environmental limitations and future of the Asiatic lion. Journal of the Bombay Natural History Society 81:648–664.

Khan, J. A. 1994. Food habits of ungulates in dry tropical forests of Gir Lion Sanctuary, Gujarat, India. Acta Theriologica 39: 185–193.

Khan, J. A. 1997. Estimation of ungulate densities by line transect method in Gir Forest, India. Tropical Ecology 38:65–72.

Khan, J. A., R. Chellam, W. A. Rodgers, and A. J. T. Johnsingh. 1996. Ungulate densities and biomass in the tropical dry deciduous forests of Gir, Gujarat, India. Journal of Tropical Ecology 12: 149–162.

Koppiker, B. R., and J. H. Sabnis. 1981. Aids to the identification of artiodactylan hairs with general comments on hair structure. Journal of the Bombay Natural History Society 78:299–302.

Kostopoulus, D. S. 2005. The Bovidae (Mammalia, Artiodactyla) from the late Miocene of Akkaşdağı, Turkey. Geodiversitas 27:747–791.

Kostopoulus, D. S., and G. D. Koufos. 2006. *Pheraios chryssomallos*, gen. et sp. nov. (Mammalia, Bovidae, Tragelaphini), from the late Miocene of Thessally (Greece): implications tragelaphin biogeography. Journal of Vertebrate Paleontology 26:436–445.

Lacey, M. W. 1969. A note on breeding the nilgai *Boselaphus tragocamelus* at Stanley Zoo. International Zoo Yearbook 9:115.

Laurillard, C. L. 1861. Le nylgau. Pp. 625–626 in Dictionnaire universel d'historie naturelle, resumant et complétant tous les faits preséntés par les encyclopédies (C. d'Orbigny, ed.). L. Houssiaux et Cie, Paris, France.

Lesson, R.-P. 1836. Histoire naturelle générale et particulière des mammifères et des oiseaux découvets depuis la mort de Buffon. Vol. X. Pourrat Frères, Éditeurs, Paris, France.

Lever, C. 1985. Naturalized mammals of the world. Longman Group Limited, London, United Kingdom.

Lochmiller, R. L., and W. J. Sheffield. 1989. Reproductive traits of male nilgai antelope in Texas. Southwestern Naturalist 34: 276–278.

Long, J. L. 2003. Introduced mammals of the world: their history, distribution, and influence. CABI Publishing, Oxon, United Kingdom.

Lundrigan, B. 1996. Morphology of horns and fighting behavior in the family Bovidae. Journal of Mammalogy 77:462–475.

Lydekker, R. 1894. The royal natural history. Vol. II. Frederick Warne and Company, London, United Kingdom.

Lydekker, R., and G. Blaine. 1914. Catalogue of the ungulate mammals in the British Museum (Natural History). Vol. III. Trustees of the British Museum, London, United Kingdom.

Mallon, D. P. 2003. *Boselaphus tragocamelus*. IUCN 2006 Red list of threatened species. www.iucnredlist.org. (4 June 2007).

Mathai, M. V. 1999. Habitat occupancy by tiger prey species across anthropogenic disturbance regimes in Panna National Park, Madhya Pradesh, India. M.S. thesis, Saurashtra University, Rajkot, India.

Mathur, S. C., S. S. Majumdar, and V. K. Jain. 1975. Suspect rinderpest in a blue bull (*Boselaphus tragocamelus*). Indian Veterinary Journal 52:412–413.

Middleton, B. A., and D. H. Mason. 1992. Herbivory by nilgai, feral cattle, and wild boar in the Keoladeo National Park, India. Biotropica 24:538–543.

Mirza, Z. B., and M. A. Khan. 1975. Study of distribution, habitat and food of nilgai *Boselaphus tragocamelus* in Punjab. Pakistan Journal of Zoology 7:209–214.

Mukhopadhyay, A. K., S. K. Das, and S. Kumar. 1975. A note on the pathogenicity of foot and mouth disease virus type A isolated from nilgai. Indian Journal of Animal Science 45:711–712.

Mungall, E. C. 2000. Exotics. Pp. 736–764 in Ecology and management of large mammals in North America (S. Demarais and P. R. Krausman, eds.). Prentice Hall, Upper Saddle River, New Jersey.

Mungall, E. C., and W. J. Sheffield. 1994. Exotics on the range: the Texas example. Texas A&M University Press, College Station.

Murty, M. L. K. 1985. Ethnoarchaeology of the Kurnool Cave Areas, south India. World Archaeology 17:192–205.

Ogilby, W. 1837. Untitled address [On generic characters of ruminants]. Proceedings of the Zoological Society of London 4: 131–139. [Dated 1836, but published 27 June 1837; see Duncan (1937) for dates of publication for the Proceedings.]

Oguya, B. R. O., and S. K. Eltringham. 1991. Behaviour of nilgai (*Boselaphus tragocamelus*) in captivity. Journal of Zoology (London) 223:91–102.

Oken, L. 1816. Okens Lehrbuch der Naturgeschichte. Vol. 3. Zoologie. August Schmid und Comp., Jena, Germany.

Ortlepp, R. J. 1935. On some helminths from the "nylghiae"—*Boselaphus tragocamelus* (Pall) with observations on the parasitic larval stages of the stomach worm *Ashworthius martinagliai* sp. n. Onderstepoort Journal of Veterinary Science and Animal Industry 5:43–50

Owen-Smith, N. 1977. On territoriality in ungulates and an evolutionary model. Quarterly Review of Biology 52:1–38.

Pallas, P. S. 1766. Miscellanea zoological quibus novae imprimis atque obscurae animalium species describuntur et observationibus iconibusque illustrantur. Hague comitun. Petrum van Cleef, The Hague, Netherlands.

Pallas, P. S. 1777. Spicilegia zoologica quibus novae imprimis et obscurae animalium species iconibus, descriptionibus atque commentariis illustrantur cura P.S. Pallas. Berloni, Prostant Apud Christianum Fridericum Voss, Langed, Sweden.

Pandey, R. K. 1988. Habitat utilization and diurnal activity pattern in Indian wild buffalo (*Bubalus bubalis* Linn.) in Indravati Wildlife National Park, India: a study of habitat/animal interactions. Journal of Tropical Ecology 4:269–280.

Parsons, J. 1745. An account of a quadruped brought from Bengal and now to be seen in London. Philosophical Transactions of the Royal Society 43:465–467.

Paul, S. S., D. N. Kamra, V. R. B. Sastry, N. P. Sahu, and N. Agarwal. 2004. Effect of anaerobic fungi on in vitro feed digestions by mixed rumen microflora of buffalo. Reproduction, Nutrition, and Development 44:313–319.

Peinado, V. I., J. F. Celdrán, and J. Palomeque. 1999. Blood chemistry values in some wild ruminants in captivity. Comparative Haematology International 9:175–181.

Pennant, T. 1771. Synopsis of quadrupeds. Chester J. Monk, London, United Kingdom.

Pépin, L., Y. Amigues, A. Lépingle, J.-L. Berthier, A. Bensaid, and D. Vaiman. 1995. Sequence conservation of microsatellites between *Bos taurus* (cattle), *Capra hircus* (goat) and related species. Examples of use in parentage testing and phylogeny analysis. Heredity 74:53–61.

Petit, P., et al. 1999. Distribution of internal telomeric sequences within the chromosome of nilgai. Cytogenetics and Cell Genetics 85:766.

Picard, K., M. Festa-Bianchet, and D. Thomas. 1996. The cost of horniness: heat loss may counter sexual selection for large horns in temperate bovids. Ecoscience 3:280–284.

Pilgrim, G. E. 1937. Siwalik antelopes and oxen in the American Museum of Natural History. Bulletin of the American Museum of Natural History 72:729–874.

Pilgrim, G. E. 1939. The fossil Bovidae of India. Memoirs of the Geological Survey of India, New Series 26:1–356 + plates I–VIII.

Pitra, C., R. Fübass, and H.-M. Seyfert. 1997. Molecular phylogeny of the tribe Bovini (Mammalia: Artiodactyla): alternative placement of the anoa. Journal of Evolutionary Biology 10:589–600.

Pocock, R. I. 1910. On the specialised cutaneous glands of ruminants. Proceedings of the Zoological Society of London 78:840–986.

Poppi, D. P., B. W. Norton, D. J. Minson, and R. E. Hendricksen. 1980. The validity of the critical size theory for particles leaving the rumen. Journal of Agricultural Science 94:275–280.

Prajapati, M. C., and S. Singh. 1994. A beneficial aspect of nilgai (*Boselaphus tragocamelus*) in scientifically utilised ravines—an observation. Indian Forester 120:890–897.

Prasad, K. N. 1996. Pleistocene cave fauna from peninsular India. Journal of Caves and Karst Studies 58:30–34.

Prasad, K. N., and P. Yadagiri. 1986. Pleistocene cave fauna, Kurnool District, Andhra Pradesh. Records, Geological Survey of India 115:71–77.

Prater, S. H. 1980. The book of Indian animals. Bombay Natural History Society, Bombay, India.

Presnall, C. C. 1958. The present status of exotic mammals in the United States. Journal of Wildlife Management 22:45–50.

Priebe, J. C. 1985. The digestive efficiency and protein requirements of nilgai antelope. M.S. thesis, Texas A&I University, Kingsville.

Priebe, J. C., and R. D. Brown. 1987. Protein requirements of subadult nilgai antelope. Comparative Biochemistry and Physiology, A. Molecular and Integrative Physiology 88:495–501.

Priebe, J. C., R. D. Brown, and D. Swakon. 1987. Comparative in vitro digestive efficiencies of cattle, goats, nilgai antelope, and white-tailed deer. Texas Journal of Science 39:341–348.

Prothero, D. R., and R. M. Schoch. 2002. Horns, tusks, and flippers: the evolution of hoofed mammals. Johns Hopkins University Press, Baltimore, Maryland.

Rahmani, A. R. 2001. India. Pp. 178–187 in Antelopes. Part 4: North Africa, the Middle East, and Asia (D. P. Mallon and S. C. Kingswood, comps., eds.). International Union for Conservation of Nature and Natural Resources, Gland, Switzerland.

Rajan, A., B. Gangadharan, and P. O. George. 1994. Intestinal diverticulitis in a nilgai (*Boselaphus tragocamelus*). Veterinary Record 135:626.

Ramakrishnan, U., R. G. Coss, and N. W. Pelkey. 1999. Tiger decline caused by the reduction of large ungulate prey: evidence from a study of leopard diets in southern India. Biological Conservation 89:113–120.

Ranjitsinh, M. K. 1987. Unusual coloration of nilgai (*Boselaphus tragocamelus*). Journal of the Bombay Natural History Society 84: 203.

Rao, A. T., and L. N. Acharjyo. 1984. Diagnosis and classification of common diseases of captive animals at Nandan in Orissa (India). Indian Journal of Animal Health 33:147–152.

Reedy, H. S., C. Sprinivasulu, and K. T. Rao. 2004. Prey selection by the Indian tiger (*Panthera tigris tigris*) in Nagarjunasagar Srisailam Tiger Reserve, India. Mammalian Biology 69:384–391.

Reichenbach, H. G. L. 1845. Die Vollständigste Naturgeschichte des In- und Auslandes. Expedition der Vollständigsten Naturgeschichte, Dreseden, Germany.

Sankar, K., and B. Jethwa. 2002. Notes on the food habits of striped hyena *Hyaena hyaena* Linn. 1758 in Sariska Tiger Reserve, Rajasthan. Journal of the Bombay Natural History Society 99:104–105.

Sankar, K., and A. J. Johnsingh. 2002. Food habits of tiger (*Panthera tigris*) and leopard (*Panthera pardus*) in Sariska Tiger Reserve, Rajasthan, India, as shown by scat analysis. Mammalia 66:285–289.

Sankar, K., and V. S. Vijayan. 1992. Notes on the food habits of nilgai *Boselaphus tragocamelus*. Journal of the Bombay Natural History Society 89:115–116.

Schaller, G. B. 1967. The deer and the tiger: a study of wildlife in India. University of Chicago Press, Chicago, Illinois.

Schinz, H. 1845. Systematisches Verzeichniss aller bis Jetzt Bekannten Säugethiere oder Synopsis Mammalium nach dem Cuvier'schen System. Vol. 2. Jent and Gassmann, Solothurn, Germany.

Schinz, H. 1848. Monographien der Säugethiere. Monographien der Cuvierischen Gattung, Antilope. Mit Abbildungern nach der Natur und den Vorzüglichsten Naturwissenschaftlichen Werken Gezeichnet, Zürich, Switzerland.

Schmidly, D. J. 1994. The mammals of Texas. University of Texas, Austin.

Sclater, W. L. 1883. List of the vertebrated animals now or lately living in the gardens of the Zoological Society of London. 8th ed. Taylor and Francis, London, United Kingdom.

Sclater, W. L., and O. Thomas. 1900. The book of antelopes. Vol. IV. R. H. Porter, London, United Kingdom.

Seabury, C. M., R. L. Honeycutt, A. P. Rooney, N. D. Halbert, and J. N. Derr. 2004. Prion protein gene (PRNP) variants and evidence for strong purifying selection in functionally important regions of bovine exon 3. Proceedings of the National Academy of Science 101:15142–15147.

Sedlák, K., E. Bártová, I. Literák, R. Vodička, and J. P. Dubey. 2004. Toxoplasmosis in nilgais (*Boselaphus tragocamelus*) and a saiga antelope (*Saiga tatarica*). Journal of Zoo and Wildlife Medicine 35:530–533.

Sekhar, N. U. 1998. Crop and livestock depredation caused by wild animals in protected areas: the case of Sariska Tiger Reserve, Rajasthan, India. Environmental Conservation 25:160–171.

Sharma, I. K. 1981. Ecological aspects of habitat preferences, feeding, daily activities and niche of the nilgai (*Boselaphus tragocamelus*). Tigerpaper 8:21–22.

Sheffield, W. J. 1983. Food habits of nilgai antelope in Texas. Journal of Range Management 36:316–322.

Sheffield, W. J., E. D. Ables, and B. A. Fall. 1971. Geographic and ecologic distribution of nilgai antelope in Texas. Journal of Wildlife Management 25:250–257.

Sheffield, W. J., B. A. Fall, and B. A. Brown. 1983. The nilgai antelope in Texas. Kleberg Studies in Natural Resources, Texas A&M University, College Station.

Shukla, R., and P. K. Khare. 1998. Food habits of wild ungulates and their competition with livestock in Pench Wildlife Reserve, central India. Journal of the Bombay Natural History Society 95:418–421.

Singh, J., M. R. Borkakoty, G. S. Miranpuri, and B. C. Lahkar. 1978. Ixodid ticks infesting domestic and wild animals of Assam, India. Indian Journal of Parasitology 2:49–50.

Smielowski, J. 1987. Albinism in the blue bull or nilgai, *Boselaphus tragocamelus* (Pallas, 1766). Journal of the Bombay Natural History Society 84:427–429.

Solanki, G. S., and R. M. Naik. 1998. Grazing interactions between wild and domestic herbivores. Small Ruminant Research 27:231–235.

Solounias, N. 1990. A new hypothesis uniting *Boselaphus* and *Tetracerus* with the Miocene Boselaphini (Mammalia, Bovidae) based on horn morphology. Annales Musei Goulandris 8:425–439.

Solounias, N., and S. M. C. Moelleken. 1993. Dietary adaptation of some extinct ruminants determine by premaxillary shape. Journal of Mammalogy 74:1059–1071.

Støen, O. G., and P. Wegge. 1996. Prey selection and prey removal by tiger (*Panthera tigris*) during the dry season in lowland Nepal. Mammalia 60:363–373.

Strey, O. F., III. 1987. In vivo and in vitro digestibilities for white-tailed deer, collared peccary, and nilgai antelope. M.S. thesis, Texas A&I University, Kingsville.

Sundevall, C. J. 1846a. Methodisk öfversigt af Idislande djuren, Linnés Pecora. Kongliga Vetenskapsakademiens Handlinger, för år 1844, New Series 32:121–210. [Dated 1844 but published in 1846 according to Corbet and Hill (1992).]

Sundevall, C. J. 1846b. Methodisk öfversigt af Idislande djuren, Linnés Pecora. Kongliga Vetenskapsakademiens Handlinger, för år 1845, New Series 33:265–330 [Dated 1845, but title page contains the phrase "Till Akademien inlemnad den 1 Febr. 1846."]

Tegarden, C. H. 1988. Quality and acceptability of nilgai antelope (*Boselaphus tragocamelus* Pallas) meat. M.S. thesis, Texas A&I University, Kingsville.

Walther, F. 1958. Zum kampf- and paarungsverhalten einiger antilopen. Zeitschrift für Tierpsychologie 15:340–380.

Weigl, R. 2005. Longevity of mammals in captivity; from the living collections of the world. Kleine Senckenberg-Reihe 48:1–214.

Wurstor, D. H., and K. Benirschke. 1968. Chromosome studies of the superfamily Bovidae. Chromosoma 25:152–171.

Zimmerman, E. A. W. von. 1777. Specimen zoologicae geographicae, quadrupedum domicilia et migrationes sistens. Dedit tabulamque mundi zoographican Adjunxit Eberh. Aug. Guilielm Zimmerman. T. Haak, Leyden, Netherlands.

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