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Gazella subgutturosa.

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Gazella subgutturosa (Güldenstaedt, 1780)

Goitered Gazelle

Antilope subgutturosa Güldenstaedt, 1780:251. Type locality "Teflifii," Georgian Caucasus; Lydekker and Blaine (1914:43) give the type locality as "Persia; probably the Bussora district"; however, Groves (1969:48) stated "it is clear from the original description (p. 253) the actual type locality is Tiflis (now Tbilisi) in the Caucasus."

Antilope dorcas var. *persica* Gray, 1843:160. (Attributed to Rüppell). *Nomen nudum.*

Gazella subgutturosa, var. *yarkandensis* Blanford, 1875:112. Type locality "Plains of Eastern Turkestan"; Lydekker and Blaine (1914:46) give the type locality as "plains of Yarkand, Chinese Turkestan" (= western Xinjiang, China).

Gazella hillieriana Heude, 1894:245, pl. 36. A type specimen has not been designated and Heude did not mention a locality; Allen (1940:1223) states "the name as well as his *G. mongolica* doubtless applies to the animal of the Gobi, presumably eastern Mongolia."

Gazella mongolica Heude, 1894:245, pl. 37. See remarks for *G. hillieriana.*

Gazella marica Thomas, 1897:162. Type locality "Nejd, Central Arabia"; Ibri, Nejd Desert, Saudi Arabia (Groves, 1969:49).

Gazella subgutturosa typica Lydekker, 1900:180. Type locality not given, but mentions one specimen from Teheran and another from Baluchistan.

Gazella subgutturosa sairensis Lydekker, 1900:184. Type locality "Sair, or Saiar Mountains, situated in the Great Altai on the north-western border of Mongolia, nearly due east of a point midway between the Semipalatinsk and the Semirechinsk Altai, in latitude 86° E., longitude 47° N."

Gazella seistanica Lydekker, 1910:202. Type locality "Seistan districts of eastern Persia" (= Sistan district, eastern Iran).

Gazella subgutturosa reginae Adlerberg, 1931:327. Type locality "Northern Tibet (= Qinghai, China), Tsaidam."

Gazella subgutturosa gracilicornis Stroganov, 1956:17. Type locality Vakhsh valley, surrounding the city of Kaganovichabad (Tadzhikistan).

CONTEXT AND CONTENT. Order Artiodactyla, Suborder Ruminantia, Infraorder Pecora, Superfamily Bovoidea, Family Bovidae, Subfamily Antilopinae, Genus *Gazella*, Subgenus *Trachelocele* (Ellerman and Morrison-Scott, 1951). Four subspecies are recognized (Corbet, 1978; Groves, 1969) as follows:

G. s. hillieriana Heude, 1894:245, pl. 36, see above (*mongolica* Heude, *reginae* Adlerberg, and *sairensis* Lydekker are synonyms).

G. s. marica Thomas, 1897:162, see above.

G. s. subgutturosa (Güldenstaedt, 1780:251), see above (*Antilope dorcas* var. *persica* Gray, *gracilicornis* Stroganov, *seistanica* Lydekker, and *typica* Lydekker are synonyms).

G. s. yarkandensis Blanford, 1875:112, see above.

G. s. marica and *G. s. subgutturosa* intergrade in Kurdistan and the lower Tigris-Euphrates Valley of Iraq (Groves and Harrison, 1967). Ellerman and Morrison-Scott (1951) include *marica* in *G. leptoceros*, but Lange (1972) includes the North African *leptoceros* in *G. subgutturosa.*

DIAGNOSIS. *G. subgutturosa* is generally larger and has a heavier build than other Asian *Gazella.* The mass of an adult male is usually 20–43 kg and an adult female is usually 18–33 kg (Heptner et al., 1988), compared with 15–18.2 kg and 11.4–14.5 kg, respectively, in *G. dorcas*, and 17–29.5 kg and 16.5–25 kg, respectively, in *G. gazella* (Mendelssohn et al., 1995; Yom-Tov et al., 1995). Both sexes have a goiter-like enlargement of the larynx, but it is more prominent in males (Roberts, 1977). Horns of adult males are long (203–340 mm) with 16–29 annular ridges, usually lyrate, and close together at their bases (usually <15 mm apart). Females are usually hornless or with variably developed horns up to 220 mm in length. Pelage color varies, but the face and forehead are frequently whitish and the facial, flank, and pygal stripes are usually indistinct (Groves, 1969; Groves and Harrison, 1967; Harrison and Bates, 1991; Klockenhoff, 1969; Fig. 1).

Compared to *G. dorcas* and *G. gazella*, the skull of *G. subgutturosa* (Fig. 2) is distinguishable by its larger size, broader palate, and greater orbital width, characteristics most evident when comparing adult males (Groves and Harrison, 1967; Harrison and Bates, 1991). Lachrymal pits are relatively large and deep, giving the facial region an angular appearance. Nasals are always in contact with premaxillae (Groves, 1969). Female skulls with horns can be difficult to distinguish from female *G. g. cora*, but the two species can usually be distinguished by the slightly greater orbital and palatal width and larger lachrymal pits of *G. subgutturosa* (Harrison and Bates, 1991). These differences are generally more pronounced when comparing female *G. subgutturosa* to female *G. d. saudiya.* Harrison and Bates (1991) have pointed out the virtual impossibility of a simple key to species identification of *Gazella* due to individual variation in color, horn formation, and cranial characters. However, a firm identification can usually be made by considering all characteristics of an individual. Multivariate analyses, utilizing several different skull measurements, distinguish *G. subgutturosa* from *G. spekei*, *G. gazella* (*G. g. cora*, *gazella*, and *muscatensis*), *G. dorcas* (*G. d. isabella* and *saudiya*), *G. bilkis*, *G. bennetti*, and *G. arabica* (Groves, 1989; Rostron, 1972).

GENERAL CHARACTERS. Goitered gazelles are of medium size and light build (Fig. 1). The hindquarters are at the same level or slightly higher than the shoulder. Dorsal pelage is light brown, varying with shades of gray, red, white, and yellow, and

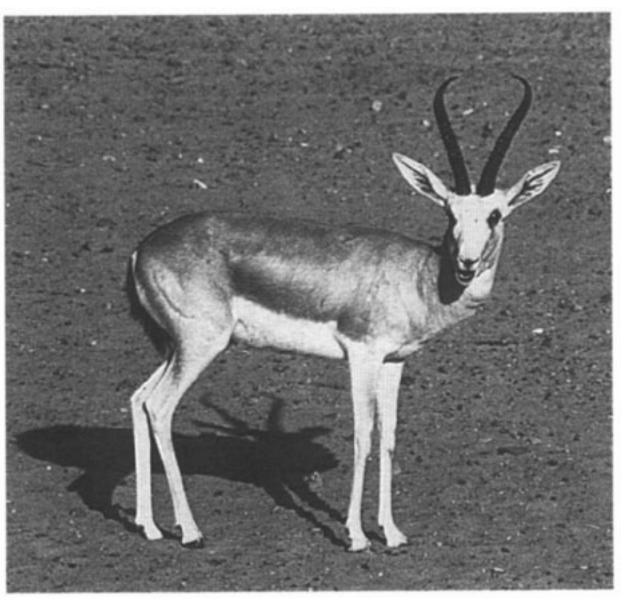
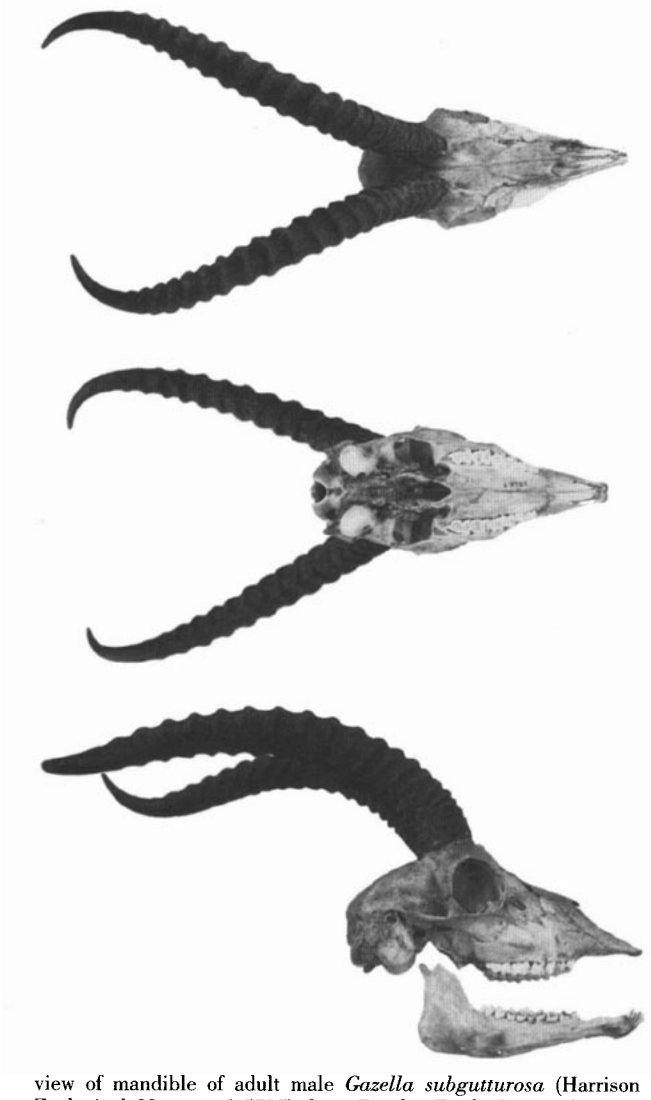


FIG. 1. Adult male *Gazella subgutturosa* at King Khalid Wildlife Research Center, Saudi Arabia. Photograph by Khushal Habibi.



view of mandible of adult male *Gazella subgutturosa* (Harrison Zoological Museum 1.5725) from Ramlat Fasd, Oman. Greatest length of skull is 190 mm. Photographs by Paul Bates.

ventral pelage is white. The tail is relatively short and tufted dorsodistally for two-thirds of its length with dark brown or black hair. Goitered gazelles have a small head and long neck. Males have long, black horns that curve upward and backward, widening in a lyrate curve before the sharp tips close inward and slightly forward. Horns are often lacking or poorly-developed in females. Eyes are black, large, and placed anterolaterally; ears are long. The legs are relatively long and slender. Hooves are black, narrow, and pointed anteriorly.

G. subgutturosa is sexually dimorphic; males are larger and possess longer horns than females. Means (and ranges) of external measurements (in mm) of adult males and females, respectively, are: total length, 1,158 (940–1,260; n = 68) and 1,097 (940–1,200; n = 74); length of tail, 168.2 (120–210, n = 75) and 161.5 (100–230, n = 80); length of hind foot, 333.2 (232–350, n = 10) and 314.0 (270–335, n = 5); length of ear, 135.6 (116–150, n = 82) and 136.3 (120–160, n = 85); length of horn, 300.0 (203–400, n = 142) and 115.6 (33–226, n = 7); height at shoulder, 727.4 (580–790, n = 67) and 691.6 (560–765, n = 77); height at sacrum, 820 (710–840, n = 57) and 763 (680–875, n = 69); chest girth, 756.2 (700–810, n = 60) and 733.0 (670–780, n = 71); and body mass (kg), 27.4 (22.0–33.8, n = 60) and 23.2 (17.5–33.2, n = 72—C. P. Groves, in litt.; Groves and Harrison, 1967; Harrison, 1968; Harrison and Bates, 1991; Klockenhoff, 1969; Mowlavi, 1978; Zhevnerov and Bekenov, 1983). Means (and ranges) of external measurements (in mm) of *G. s. marica* indicate their smaller size (and greater horn development in females) and are: total length, 974 (940–993, n = 3); length of tail, 148 (140–160, n = 3); length of hind foot, 286 (272–300, n = 2); length of ear, 125 (n = 1); length of horn (males), 266.8 (203–312, n = 29); length of horn (females), 148 (71–226, n = 5); and body mass, 20.2 kg (n = 6—C. P. Groves, in litt.; Groves and Harrison, 1967; Harrison and Bates, 1991; Rietkerk and Delima, 1994). Horn development in females apparently increases from Mongolia and China to the Arabian Peninsula. Females of *G. s. hillieriana* and *G. s. yarkandensis* are hornless; females of *G. s. subgutturosa* are hornless or have short horns (usually <70 mm); and females of *G. s. marica* have well-developed horns (Allen, 1940; Groves, 1969, 1985; Groves and Harrison, 1967; Heptner et al., 1988; Lobachev and Smirin, 1970; Zhevnerov, 1984). Pelage coloration also varies geographically. *G. s. marica* varies from nearly white to light sandy-yellow; *G. s. subgutturosa* is light brown dorsally with variable tones of gray, red, or yellow; and *G. s. hillieriana*, *G. s. reginae*, *G. s. seistanica*, and *G. s. yarkandensis* are light sandy-yellow with less gray or red. Facial coloration and markings vary geographically and tend to whiten and fade with age (Groves, 1985; Lydekker and Blaine, 1914; Sokolov, 1959; Zhevnerov and Bekenov, 1983). In *G. s. yarkandensis* and young *G. s. subgutturosa*, facial stripes are fairly distinct; *G. s. marica* has a white face that lacks markings.

Skulls of *G. subgutturosa* have the following characteristics: in males, horn cores are large and circular in cross-section and closer together than horn cores of females; posterior braincase is more inflated and less downwardly deflected than in caprines; occipito-parietal suture is angular; premaxillae are nearly straight; fronto-nasal suture is somewhat V-shaped; nasals are short and wide; palato-maxillary suture is V-shaped; lachrymal fossae are well developed; lachrymal fissures are present; tympanic bullae are large, inflated, and lacking ventral ridges; supraorbital foramina are recessed in deep pits; frontal bones are not pneumatised; and the skull is not excessively flexed (Groves, 1969; Harrison and Bates, 1991; Sokolov, 1959). The facial region of the skull is not elongated or enlarged and the profile of the frontonasal region is relatively straight (Heptner et al., 1988). Means (and ranges) of greatest length of skull (in mm) of males and females, respectively, are: *G. s. hillieriana*, 203.1 (198–210, n = 20) and 201 (193–209, n = 2); *G. s. marica*, 181.2 (169–193, n = 18) and 169.3 (157.3–188, n = 11); *G. s. subgutturosa*, 208.5 (186.2–225, n = 93) and 196.3 (168–217, n = 59); and male *G. s. yarkandensis*, 214 (210–220, n = 5). Means (and ranges) of length of maxillary toothrow (in mm) of males and females, respectively, are: *G. s. hillieriana*, 61 (55–65, n = 28) and 59.3 (56–64, n = 3); *G. s. marica*, 57.4 (52–61.2, n = 34) and 55.5 (52–59, n = 10); *G. s. subgutturosa*, 64.5 (54.5–71, n = 73) and 62.1 (54–66, n = 31); and male *G. s. yarkandensis*, 68.6 (64–73, n = 7—C. P. Groves, in litt.; Harrison, 1968; Zhevnerov and Bekenov, 1983). Harrison and Bates (1991) reported means (and ranges) of skull measurements (in mm) of *G. s. marica* and *G. s. subgutturosa*, respectively, of unspecified sex as follows: greatest length of skull, 171.8 (151.6–191.8, n = 16) and 175.7 (160.2–186.2, n = 5); and length of maxillary toothrow, 57.1 (52.7–61.2, n = 19) and 56.1 (54.0–59.0, n = 7). Means (and ranges) of organ weights (in g) of adult males (n = 15) and females (n = 7), respectively, are: heart, 261 (246–278) and 223 (220–250); lung, 529 (460–612) and 473 (425–515); liver, 715 (592–809) and 672 (485–800); kidney, 205 (180–250) and 197 (172–250); and spleen, 56 (42–68) and 49 (38–63—Zhevnerov, 1984; Zhevnerov and Bekenov, 1983). Means (and ranges) of organ lengths (in cm) for males (n = 15) and females (n = 7), respectively, are: small intestine, 1,395 (1,250–1,475) and 1,354 (1,252–1,430); large intestine, 650 (600–690) and 625 (602–681); and caecum, 30 (25–35) and 29 (27–32–Zhevnerov, 1984; Zhevnerov and Bekenov, 1983).

DISTRIBUTION. Goitered gazelles were formerly widespread from the Arabian Peninsula to southern Mongolia (Fig. 3). Their geographic distribution included arid regions of Yemen to eastern Turkey, Transcaucasia, Turkmenistan, Baluchistan, Kazakhstan, and west through northern China (Harrison and Bates, 1991; Heptner et al., 1988). Isolation of the eastern Transcaucasus population is evidently the result of prehistoric range contraction (Heptner et al., 1988). However, Heptner et al. (1988) believed areas occupied by goitered gazelles at the end of the 19th century roughly corresponded to their distribution during prehistoric periods.

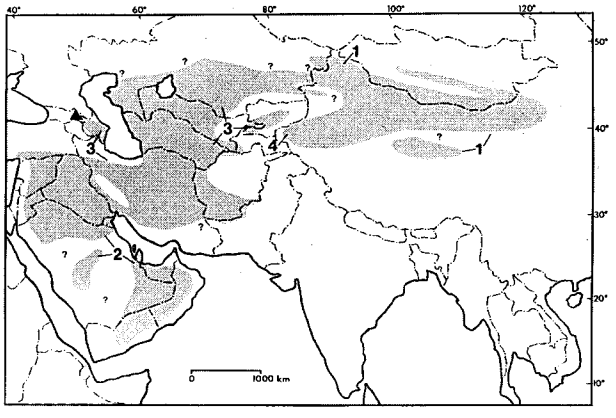


FIG. 3. Former geographic distribution of *Gazella subgutturosa* in Asia and the type locality (triangle). Subspecies are: 1, *G. s. hillieriana*; 2, *G. s. marica*; 3, *G. s. subgutturosa*; 4, *G. s. yarkandensis*. Adapted from Allen (1940), Harrison and Bates (1991), Heptner et al. (1988), Klockenhoff (1969), Mallon (1985), Roberts (1977), and Thouless et al. (1991).

Since the beginning of the 20th century, the range of goitered gazelles has contracted drastically. They are still common in areas of Mongolia, northwestern China, and former Soviet Central Asia, but elsewhere they have declined and occur primarily as isolated remnant populations in remote areas or protected reserves (East, 1992). Goitered gazelles are probably extinct in Georgia (Flint and Prisiazhniuk, 1986), Iraq, Kuwait, Syria, and Yemen, and nearly extinct in Jordan (East, 1992). A few small populations are said to survive in western and southern Afghanistan (Hamadan, Margo, and Registan) and Pakistan (Maslakh Game Reserve and Patao Valley of northern Baluchistan). Larger populations occur in southeastern Turkey, northern Saudi Arabia, and the Rub al Khali and Wahiba Sands of Oman (East, 1992; D. Mallon, in litt.; Ogurlu, 1992; Thouless et al., 1991). In Iran, goitered gazelles are widespread and increasing in protected areas outside the central deserts (East, 1992) and gazelles on Kharg Island in the Persian Gulf are believed to be *G. subgutturosa* (Karami and Groves, 1992). Populations on Barsa-Kel'mes and Ogurchinsky Islands in the Aral and Caspian Seas, respectively, are introduced (Heptner et al., 1988; Kuznetsov, 1986), and populations on islands in Bahrain and other areas in the United Arab Emirates also may have been introduced (East, 1992; Gallagher and Harrison, 1975).

Altitudinally, *G. subgutturosa* is found below 1,000 m in Afghanistan (Habibi, 1977), but it ranges from sea level to about 2,100 m in Iran (Lay, 1967; Sclater and Thomas, 1897–1898) and generally from 1,050 m up to 2,100 m in Pakistan (Roberts, 1977). It occurs at altitudes of 2,700 to 3,000 m in the Qaidam Basin in China (Cai et al., 1990). During warmer months in Kazakhstan, Mongolia, and China, it lives in mountains from 3,000 m to 3,500 m (Heptner et al., 1988).

FOSSIL RECORD. *Gazella* is among the oldest of contemporary bovid genera. It first appeared in the fossil record in the Rusingan (early Miocene) of Libya (Savage and Russell, 1983). During middle Miocene, *Gazella* makes its first appearance in Europe (*G. stehlini* in Astaracian) and in Asia in the Astaracian equivalent (Savage and Russell, 1983). The first female gazelles with horns probably occurred in late Miocene, and this may have been related to their expansion into more open habitats (Gentry, 1990). Radiation of *Gazella* apparently coincided with this expansion, and several species of gazelles were present during late Miocene and early Pliocene in Europe, Asia, and Africa (Savage and Russell, 1983). The widest distribution of *Gazella* probably occurred in Pliocene when it reached England (Heptner et al., 1988).

Species similar to *G. subgutturosa* appeared in Asia during late Pliocene (Gromova and Baranova, 1981; Savage and Russell, 1983; Sokolov, 1959). *G. subgutturosa* has been found in late Pliocene and early Pleistocene fauna of Kazakhstan, Uzbekistan, and Tadjikistan (Kozhamkulova, 1981). Remains of putative goitered gazelle have been reported for Pleistocene strata in Iran, but no fossil specimens have been found in Pleistocene deposits of the Russian plain or eastern Transcaucasia (Vereshchagin, 1967). Goitered gazelles apparently moved into the eastern Caucasus relatively late in the postglacial period and replaced saiga (*Saiga tatarica*) in Azerbaidjan (Vereshchagin, 1967). Quaternary remains of *G. subgutturosa* lie within the limits of its present distribution (Heptner et al., 1988). Pleistocene remains of goitered gazelles in Iran and Mesopotamia tend to be larger in size than remains from the recent geological period and remains from Mesopotamia are smaller than those from highland Iran (Uerpmann, 1986).

FORM AND FUNCTION. Winter pelage of goitered gazelles is long, dense, and pale compared to summer pelage (Allen, 1940; Lydekker, 1900; Roberts, 1977). Hair length on the back during winter is 30–70 mm and density is 2,340–4,000/cm² (Heptner et al., 1988; Zhevnerov, 1975; Zhevnerov and Bekenov, 1983). There are no distinct differences between guard hair and underfur (Heptner et al., 1988). Because the winter coat is not as dense and curly as the winter coat of saiga (Zhevnerov, 1975), goitered gazelles are more sensitive to low temperatures and wind. Summer hair is shorter (10–15 mm) and sparser (density 1,200/cm²). Hair is shorter on the head and longer on the belly; in winter, length is 4–5 mm on the head and 70–90 mm on the groin, and in summer, 3 mm and 25 mm, respectively (Zhevnerov and Bekenov, 1983). Molt occurs during spring and fall, but the timing varies geographically and with age and nutritional state. Spring molt is from late February until late May, and fall molt occurs during August and September (Zhevnerov, 1984). During spring, the first areas to molt are the neck and withers, followed by the head, back, flanks, and hindquarters; the underside is the last area to molt. The neck, back, and flanks are the only areas to molt in the fall. New growth of wool begins during the fall molt and is complete by early December (Zhevnerov, 1984).

Foreleg hooves are about 50–56 mm long and 25–28 mm wide; hindleg hooves are slightly smaller (Sokolov, 1959). Tracks of an adult goitered gazelle are heart-shaped and measure about 55–60 mm long and 35–40 mm wide (Heptner et al., 1988). Body weight loading on hooves is 491 g/cm² for males, 434 g/cm² for females, and 340 g/cm² for young, compared to 140–180 g/cm² for *Rangifer tarandus* (Sludsky, 1977; Sokolov, 1959; Zhevnerov, 1984). This high load bearing on the hooves does not allow goitered gazelles to move over deep snow (Sludsky, 1963). An intensified mass of coxofemoral joint muscle gives strong forward and upward thrust and stabilizes the irregular load on the hindlegs when these animals are running over broken terrain and through vegetation. The articular is rounded, making it possible to move the hindleg laterally and to make a steep turn (Sokolov et al., 1964).

Skulls of *G. subgutturosa* possess lachrymal vacuities similar to those of antilocaprids (O'Gara and Matson, 1975). The dental formula is: i 0/3, c 0/1, p 3/3, m 3/3, total 32. Molariform teeth are hypsodont; each molar is bilobate and has normal selenodont structure. The row of lower cheekteeth is nearly straight, the crowns narrow, and the medial cusps of molars prominent and trenchant (Harrison and Bates, 1991). At birth, three incisors, one incisiform canine, and three deciduous cheekteeth are present on each side of the lower jaw; three premolars are present on each side of the upper jaw (Heptner et al., 1988; Legge and Rowley-Conwy, 1987; Zhevnerov, 1984). Two permanent teeth, m1 and m2, erupt during the first year; at about 14 months, m3 erupts and p1, p2, and p3 have replaced the deciduous molars (Legge and Rowley-Conwy, 1987). Age estimates of animals between 1 month and 10 years of age have been made using patterns of tooth eruption and wear (Binh, 1963). Osteomorphological characteristics of the appendicular skeleton of goitered gazelles are consistent with 10 other species of gazelles (Peters, 1989).

Goitered gazelles typically have two inguinal mammae, but occasionally four develop. When two pairs of mammae are present, the inguinal glands are connected with the posterior pair, indicating that the anterior pair are supernumerary (Pocock, 1910; Sokolov, 1959). Goitered gazelles possess inguinal, carpal, pedal, and preorbital glands (Pocock, 1910; Sokolov, 1959). The two inguinal glands, with pouches extending 3–5 cm into vascular tissue above the mammae, open lateral to the mammae. The carpal glands are composed of thickened skin and sebaceous components and are located beneath knee-tufts of long, coarse, dark hair. Inguinal and carpal glands produce a yellow, waxy substance with a musky, aromatic odor. Dried secretions from carpal glands glue knee-tuft hairs together. Pedal glands are well developed and present on each foot, opening above the hooves by a lengthwise slit (Pocock, 1910;

Sokolov, 1959). Pocock (1910) did not detect secretions from pedal glands. The preorbital glands consist of a black integumental thickening formed around an invaginated pocket of skin; an elongated slit, located below and in front of each eye, exudes a black, tarry substance (Pocock, 1910). Females and males have preorbital glands, which are very large in males but are usually smaller in females (Walther, 1984). Males occasionally open the lachrymal pits and display the black lining, which is very conspicuous on the light face (H. Mendelssohn, in litt.).

The blood of goitered gazelles (n = 11–62) is characterized by 5,600 white blood cells/mm^3 (range, 4,300–6,900), 9.8 million erythrocytes/mm^3 (range, 7.7–11.2 million), hemoglobin of 16.2 g/100 cm^3 (range, 15.3–17.8), hematocrit of 47.7% packed-cell volume (range, 44.5–51.5), mean corpuscular volume of 50.5 μm^3 (range, 46.5–66.5), mean corpuscular hemoglobin content of 17.1 pg (range, 16.7–21.9), mean corpuscular hemoglobin concentration of 34.2% (range, 33.0–34.6), 4,600 segmented neutrophils/mm^3 (range, 1,300–5,900), 2,300 lymphocytes/mm^3 (range, 2,000–2,700), 227 monocytes/mm^3 (range, 40–280), and 143 eosinophils/mm^3 (range, 142–143—International Species Information System, 1992). Chemical immobilization of captive goitered gazelles apparently caused a decrease of hemoglobin from ca. 15.8 to 13.1 g/100 cm^3 and hematocrit from 47.8 to 40.0% packed-cell volume (Furley, 1986). Decreases of hemoglobin and hematocrit were explained by an increase in heart rate caused by handling stress and the drug etorphine. Heart rate of a subadult female fluctuated between ca. 106 and 131 beats/min during a 22 min period (Furley, 1986). Heart rate, respiratory rate, and certain hematological values decreased during anesthesia with xylazine/ketamine (Rietkerk and Delima, 1994). The cardiac index of adult males is 6.56–8.37, adult females 9.31–10.0, and juveniles 9.04–11.59 (Heptner et al., 1988).

A goitered gazelle eats ca. 6.0 kg of forage/day, about 30% of its body weight; stomach contents weigh 2.5–4 kg (Heptner et al., 1988; Zhevnerov, 1984). Forage consumed by a 4-month-old female was 362 g dry weight/day; daily energy expenditure was 1,657.5 kcal (Mowlavi, 1978). Apparent digestibility (in %) of several species of forage plants was: minerals, 53.7; protein, 9.5–15.9; fat, 3.7–9.7; and crude fiber, 29.6 (Mowlavi, 1978; Zhevnerov, 1975). Means (and ranges) of nutritional values of forage plants (n = 8) were: caloric value, 3.5 kcal/g (2.8–4.4); protein, 5.4 mg/g dry weight (0.6–13.7); water content, 64.1% (49.4–72.5); inorganic content, 5.5% (2.1–9.7—Mohamed et al., 1991). Fecal pellets measure ca. 10 mm in length and 7–8 mm in thickness (Heptner et al., 1988).

During periods of extreme heat, goitered gazelles can bridge thermoregulatory and water balance mechanisms. Excessive dehydration can be prevented by moderately increasing the body's heat load. When air temperatures exceeded normal body temperature, goitered gazelles are able to increase their temperature lability during the day, particularly when dehydrated, and lose heat at night (Williamson et al., 1992). Normal body temperature is about 39°C but ranges from 37.3 to 42.5°C in dehydrated animals. Mean daily temperature range is 2.5°C in dehydrated animals and 1.0°C in hydrated animals (Williamson et al., 1992). At ambient temperatures up to 36°C and skin temperatures up to 39.5°C, cutaneous water loss is primarily through evaporative diffusion and at higher temperatures, evaporation through sweat glands greatly increases water loss. With an elevated heat load, young goitered gazelles reduce water loss from sweat glands by panting and increasing cutaneous evaporative diffusion (Soldatova and Grazhdankin, 1989).

The goiter-like swelling of the throat is an enlarged cartilaginous cylinder (Roberts, 1977). During rut, the throat swelling of territorial males increases noticeably in size (Habibi et al., 1993; Sokolov, 1959; Zhevnerov and Bekenov, 1983).

ONTOGENY AND REPRODUCTION. Goitered gazelles usually reach sexual maturity by 1 year of age. A few precocious females conceive at about 5 months of age, but first estrus generally occurs at 6–18 months of age (Blank, 1985; Carter, 1991; Habibi et al., 1993; H. Mendelssohn, in litt.; Zhevnerov, 1984). Males usually show sperm in the epididymis as yearlings and they can sire offspring as early as 10.5 months of age (Carter, 1991; Tsaplyuk, 1972). Sexual maturity in males is directly related to testicular size and is not strictly age dependent (Bland, 1985). A testis diameter of about 20 mm signals the onset of sperm production. Testes diameters (in mm) and age (in parentheses) of three young males were 4 (2 weeks), 10 (18 months), and 18 (12 months); testes diameters of three adults were 24–27 mm (Bland, 1985). Although yearling males might effectively sire offspring in the absence of older males, they usually do not mate with females before 1.5–2.5 years of age (Heptner et al., 1988; Tsaplyuk, 1972). Goitered gazelles can remain reproductively mature past 10 years of age; a calf was sired by a male at about 10 years, 9 months and a female gave birth at 13 years, 10 months (Carter, 1991).

The rutting season of goitered gazelles occurs from September through January, occurring earliest in Saudi Arabia and latest in Mongolia (Allen, 1940; Habibi et al., 1993; Heptner et al., 1988). Copulation is more strongly seasonal; usually occurring in October in Saudi Arabia (Habibi et al., 1993), October and November in Iran, Turkmenistan, and Tadjikistan (Flerov, 1935; Heptner et al., 1988; Jamsheed, 1976), mid-October to mid-December in Kazakhstan with a peak during 1–10 December (Blank, 1985, 1992), and December through January in Mongolia (Bannikov, 1954). Estrus often lasts only about 12 h, during which there is a slight swelling of the vulva; copulation lasts about 1–3 s (Blank, 1992; Roberts, 1977). Goitered gazelle males apparently undergo either aseasonal sperm production (Bland, 1985) or fall and spring peaks of testicular activity (Tsaplyuk, 1972). Sexual activity during spring is less prominent than during fall and, for the most part, is non-reproductive (Blank and Fedosenko, 1983). Nevertheless, spring matings have resulted in pregnancy and fall or winter births (Antipin, 1941; Blank, 1992; Gorelov, 1972; Soldatova, 1983).

Gestation periods of 148–159 days have been recorded (Frazier and Hunt, 1994; Roberts, 1977; Zhevnerov, 1984). Judging from periods of mass rut and parturition, gestation lasts 5–6 months (Heptner et al., 1988; Zhevnerov, 1984). Goitered gazelle young are most commonly born during March and April in Saudi Arabia with a peak during 3 weeks in March (Habibi et al., 1993), April and May in Iraq, Turkmenistan, and Tadjikistan (Flerov, 1935; Heptner et al., 1988; Pitman, 1922), mid-April to early June in Kazakhstan with a peak during 15–25 May (Blank, 1985; Kostin, 1955; Sludsky, 1956), and during June and July in China and Mongolia (Allen, 1940; Bannikov, 1954). The seasonality of births in Saudi Arabia and Central Asia coincides with the maximum food availability that follows winter and spring rains (Habibi et al., 1993; Heptner et al., 1988). Captive births in North America have also been seasonal; 70% (n = 299) of *G. s. marica* births were during March and April and 84% (n = 729) of *G. s. subgutturosa* births were during April and May (Carter, 1991). Births in London Zoo peaked during May (Roberts, 1977). Snowfall or sudden drops in temperature can delay parturition several days (Blank, 1992).

Goitered gazelles usually have one or two calves, but rarely litters of three or four occur (Carter, 1991; Grzimek, 1972; Heptner et al., 1988). Between 3–7 years of age, females generally give birth to twins, but younger and older females usually produce single calves (H. Mendelssohn, in litt.). The overall proportion of females giving birth to twins varies from 2.6% to 75% (Bannikov, 1954; Carter, 1991; Habibi et al., 1993; Heptner et al., 1988; Pitman, 1922; Rietkerk et al., 1992; Roberts, 1977; Zhevnerov, 1984). Rietkerk et al. (1992) postulated that high reproductive capacity of goitered gazelles in Saudi Arabia may be an adaptive response to unpredictability of favorable conditions (e.g., rainfall and food availability) in a hyper-arid environment. Under such circumstances, it would be advantageous to maximize reproductive output at every opportunity because of uncertainty about the next opportunity. About 5–12% of females remain barren each year (Heptner et al., 1988; Reed, 1977). Of 1,023 captive births of known sex, 506 were males and 517 were females (Carter, 1991). About 27–34% of twin births were both females, 22–33% were both males, and 33–50% were male and female (Carter, 1991; Zhevnerov, 1984). At birth, calves of *G. s. marica* have an average body mass of 1.86 kg (n = 27—Frazier and Hunt, 1994; Lindsay and Wood, 1992); male calves of *G. s. subgutturosa* average 2.4 kg (n = 38) and female calves average 2.2 kg (n = 51—Frazier and Hunt, 1994; Zhevnerov, 1984). Mean body lengths (in mm) at birth for males and females, respectively, are 535 and 530 (Zhevnerov, 1984).

Goitered gazelle calves grow most intensively during their first month; 50% of this growth occurs during the first 10 days (Zhevnerov, 1984). Body masses (in kg) and age (in parentheses) of goitered gazelle calves are: 5–8 (4–5 weeks), 7–13.5 (10–13 weeks), 16.5–20 (6–8 months), and 23 (12 months—Heptner et al., 1988;

Lindsay and Wood, 1992; Mowlavi, 1978; Zhevnerov, 1984). Young reach approximate adult weight at 18–19 months (Zhevnerov, 1984). External measurements (in mm) of females (n = 3) at 3, 6, and 12 months of age, respectively, are: total length, 1,000, 1,010, and 1,040; length of tail, 170, 170, and 190; length of hind foot, 270, 320, and 320; length of ear, 120, 130, and 130; height at shoulder, 520, 650, and 650; and chest girth, 470, 600, and 610 (Mowlavi, 1978). Calves begin to shed hair at about 6 days, and a molt at 15–20 days lightens their pelage from grayish brown to sandy brown. A second molt begins immediately after the first and continues until autumn (Zhevnerov, 1984). Newborn calves have funnel-shaped curls of hair at the site of future horn development. In males, horns are about 10–15 mm long at 1 month of age and 90 mm at 6 months (Heptner et al., 1988; Mowlavi, 1978; Zhevnerov, 1984). Most horn development occurs at 3–6 months and 1–1.5 years of age (Zhevnerov, 1984).

Neonates are precocious, standing and nursing at 10–15 min (Blank, 1985). Calves generally remain lying down for the first 4–6 days and move with their mothers and other adults with young at 2 months of age (Blank, 1985; Habibi et al., 1993). At 2–3 days, young begin to mimic their mother by sniffing at plants and at 5–10 days, they begin nibbling grass and leaves (Blank, 1985; Zhevnerov, 1984). Calves are able to graze like adults and drink water at 4–6 weeks. Females nurse their calves for at least 3–6 months (Blank, 1985; Heptner et al., 1988; Lindsay and Wood, 1992; Roberts, 1977). From the age of 0–10 weeks, hand-reared goitered gazelles consumed milk at the rate of 300–420 ml/day, but were able to survive on solid food at 3 weeks (Lindsay and Wood, 1992).

Although the size difference between the sexes is not great, the age of physical maturity apparently differs (Zhevnerov, 1984). Males reach near-maximum mass (ca. 30 kg) by 3–4 years of age and continue to grow until their fifth year; females reach full growth (ca. 25 kg) by 2–3 years (Jamsheed, 1976; Zhevnerov and Bekenov, 1983). Horns have a true lyrate shape by 2–2.5 years (Zhevnerov, 1984). Horn growth after 5 years of age is negligible, although slight thickening of horns continues (Jamsheed, 1976). Horn annulations have been used to determine the age of goitered gazelles through their fifth year (Zhu et al., 1992). Longevity averages 6 years in the wild; most males live less than average but females can live 8–12 years (Zhevnerov and Bekenov, 1983). Longevity in captivity is at least 15 years, 8 months (Jones, 1993). There is an unsubstantiated report of a male that lived to the age of 20 years (Mendelssohn, 1974).

ECOLOGY. Goitered gazelles live in nearly all types of desert and semiarid terrain within their range (Heptner et al., 1988). They occur in flat or rolling areas, along foothills with broken ground, and mountain valleys and plateaus. They avoid rocky cliffs, country devoid of gullies and ravines, thick, woody vegetation, and land used for cultivation or livestock grazing (Neronov and Bobrov, 1991; Roberts, 1977). However, goitered gazelles graze at the edge of cultivated land throughout much of their range (Blank, 1990; Lay, 1967; Misonne, 1957; Vereshchagin, 1939). The northern distribution of goitered gazelles is limited by the difficulty of foraging where snow depths reach 10–15 cm, and by pelage that does not provide effective insulation from wind and bitter cold (Sludsky, 1963; Zhevnerov, 1975, 1984). In winter, they inhabit windy, snow-free areas, finding shelter from wind in deep wadis, gorges of low mountains, or thickets (Blank, 1990). Habitats range from areas having clayey and sandy soils that support grasses, forbs, and shrubs, to areas nearly devoid of vegetation, such as basalt deserts, salt flats, and shale slopes (Lay, 1967; L'vov, 1979; Sokolov, 1959; Thouless et al., 1991; Zhevnerov and Bekenov, 1983). In the southern Arabian Peninsula and parts of Central Asia, goitered gazelles live primarily in sand dunes (Blank, 1990; Morrison-Scott, 1939). Dominant vegetation of goitered gazelle habitats includes *Anabasis, Artemisia, Artrophyton, Astragalus, Calomagrostis, Haloxylon, Kraschennekocina, Nanophyton, Peganum, Phragmites, Poacea, Salsola, Stipa, Stipagrostis, Suaeda,* and *Zizyphus* (Kurochkina, 1990; Lay, 1967; L'vov, 1979; Mowlavi, 1978; Thouless et al., 1991; Zhevnerov, 1975). Biomass of putative forage species of a plant community in Iran was 340 kg/ha (Mowlavi, 1978).

Goitered gazelles most commonly eat grasses (Poaceae: *Aeluropus, Agropyron, Aristida, Bromus, Cutandia, Panicum, Pennisetum, Poa, Sporobolus*), halophytes (Chenopodiaceae: *Anabasis, Camphorosma, Eurotia, Halocnemum, Halogeton, Halostachys, Haloxylon, Kochia, Kraschennekocina, Nanophyton, Noaea, Salsola*), composites (Asteraceae: *Artemisia, Centaurea, Helianthemum, Jurinea, Rhanterium*), legumes (Leguminosae: *Alhagi, Astragalus, Caragana, Halimodendron, Hulthemia*), buckwheats (Polygonaceae: *Atraphaxis, Calligonum*), caltrops (Zygophyllaceae: *Nitraria, Peganum*), ephedras (Ephedraceae: *Ephedra*), borages (Boraginaceae: *Heliotropium*), gourds (Cucurbitaceae: *Citrullus*), leadworts (Plumbaginaceae: *Limonium*), and tamarisks (Tamaricaceae: *Tamarix*—Blank, 1990; Harrison and Bates, 1991; Heptner et al., 1988; Mohamed et al., 1991; Mowlavi, 1978; Sludsky, 1977; Thouless et al., 1991; Zhevnerov, 1975; Zhevnerov and Bekenov, 1983). In agricultural areas, goitered gazelles eat fruits or shoots of barley (*Hordeum*), chick peas (*Cicer arietinum*), cotton (*Gossypium*), dates (*Phoenix dactylifera*), maize (*Zea mays*), melons (*Cucumis melo*), onions (*Allium cepa*), sugar cane (*Saccharum officinarum*), and wheat (*Agropyron*—Afanasyev et al., 1953; Blank, 1990; Dementyev, 1935; Heptner et al., 1988; Pitman, 1922; Vereshchagin, 1939). Plants containing a high percentage of water or protein are preferentially eaten and plants that are preferred in some areas may be neglected in others (Gorelov, 1972; Heptner et al., 1988; Mohamed et al., 1991). Goitered gazelles along the Caspian and Aral Seas eat seaweeds (*Zostera*) and naiads (*Najas*) cast ashore by waves and they are the only animals to eat the lichen *Thelaschistis lacunosus* (Minervin, 1944). The summer diet in Iran was 85.8% shrubs, 11.0% grasses, and 3.2% forbs; available vegetation consisted of 14.2% preferred foods, 41.3% neglected plants, and 44.5% avoided species (Mowlavi, 1978). Goitered gazelles in captivity are fed alfalfa (*Medicago sativa*), oats (*Avena*), pelleted grain enriched with selenium and vitamin E, and provided with a sulfur-free salt block (Reed, 1977). For much of the year, goitered gazelles obtain water from green plants or snow, but they drink occasionally if surface water is available (Heptner et al., 1988). During spring and summer, surface water is sought, particularly by lactating females; daily water intake is about 2–4 l (Heptner et al., 1988; Mowlavi, 1978; Zhevnerov, 1984).

Goitered gazelle populations are 36–50% female, 3–36% male, and 15–51% young (Blank, 1990; Mowlavi, 1978; Schaller, 1990; Zhevnerov and Bekenov, 1983). Annual mortality rates are 9–18% for females, 27–58% for males, and 3–50% for neonates; mortality is generally lowest during summer and highest during winter (Heptner et al., 1988; Zhevnerov and Bekenov, 1983). Given favorable conditions during breeding and calving seasons, fertility of goitered gazelles is such that the population can increase 70–80% by autumn (Heptner et al., 1988). Densities are 0.02–4.21 gazelles/km^2 (Blank, 1990; L'vov, 1979; Mowlavi, 1978; Schaller, 1990; Thouless et al., 1991). As food availability decreases from summer to winter pastures, goitered gazelles concentrate on the best pastures (L'vov, 1979). In Central Asia, goitered gazelles historically migrated during autumn and spring between northern steppes having deep snow cover and deserts in the south; during summer dry periods they were nomadic in search of water (Antipin, 1941; Heptner et al., 1988; Zhevnerov, 1984). Previously, *G. s. marica* migrated in autumn from Syria through Transjordan to northern Saudi Arabia and migrated back to Syria in spring to give birth in moister areas near the Euphrates Valley (Legge and Rowley-Conwy, 1987; Mendelssohn, 1974). Goitered gazelle movements now are more localized, generally 50–60 km, as habitat changes have forced populations out of parts of their former range (Sludsky, 1963).

Goitered gazelles share summer pastures with sheep (*Ovis ammon*), and during fall and winter, they occasionally form mixed groups with zeren (*Procapra gutturosa*—L'vov, 1979). In snow-covered areas, goitered gazelles graze at excavations of wild asses (*Equus hemionus*) and saiga (Zhevnerov, 1975). They seek shade in depressions scraped in sand by Arabian oryx (*Oryx leucoryx*—Stewart, 1963). The range of *G. subgutturosa* overlaps with *G. dorcas* and *G. gazella*, but usually they do not occur in the same habitats (Harrington, 1977; Harrison and Bates, 1991). Domestic livestock are competitors; at high densities, free-ranging camels (*Camelus dromedarius*) slow regeneration of forage plants (Thouless et al., 1991). Wolves (*Canis lupus*) are the main predators of goitered gazelles (Heptner et al., 1988; Sludsky, 1977; Zhevnerov, 1984), especially when abundant snow cover increases the numbers of emaciated animals or when soft ground increases their vulnerability to pursuit (Jamsheed, 1976). Historically, tigers (*Panthera tigris*) hunted gazelles at water holes (Heptner et al., 1988). In Turkmenistan, they were likely preyed upon by cheetahs (*Acinonyx jubatus*—Heptner et al., 1988), but Mowlavi (1978) did not find evidence that cheetahs affected goitered gazelles in the Khosh Yei-

lagh Wildlife Refuge, Iran. Young, particularly neonates, fall prey to foxes (*Vulpes vulpes*), feral dogs (*Canis familiaris*), caracals (*Felis caracal*), imperial eagles (*Aquila heliaca*), and brown-necked ravens (*Corvus ruficollis*—Heptner et al., 1988; Rietkerk et al., 1992; Sludsky, 1977; Zhevnerov, 1984).

Viral diseases infecting goitered gazelles include bluetongue, epizootic hemorrhagic disease, foot and mouth disease, malignant catarrhal fever, parainfluenza-3, and sheep pox (Doyle and Heuschele, 1983; Heuschele et al., 1982, 1983; Zhevnerov and Bekenov, 1983). Doyle and Heuschele (1983) did not find antibodies to bovine virus diarrhea and infectious bovine rhinotracheitis in spite of their presence in several other species of ruminants. Goitered gazelles are susceptible to bacterial infections (*Arizona* sp. and *Salmonella* sp.), omphalophlebitis, polioencephalomalacia, and ulcerative enteritis (Griner, 1983; Rietkerk et al., 1992).

Ectoparasites reported from *G. subgutturosa* include ticks (*Rhipicephalus turanicus, R. rossicus, R. pumilio, R. schulzei, Hyalomma asiaticum, H. plumbeum, H. scupense*), lice (*Linognathus tibialis, Damalinia appendiculata*), warble gadfly larvae (*Pavlovskiata subgutturosae, Przhevalskiana corrinae*), and louse fly larvae (*Melophagus antilopae*—Zhevnerov and Bekenov, 1983). At least 41 species of endoparasites have been found (Boev et al., 1962; Eslami et al., 1980, 1981; Hussein and Mohammed, 1992; Zhevnerov and Bekenov, 1983). Of 34 species of gastrointestinal nematodes found in goitered gazelles, 29 have also been found in domestic animals, indicating some association between goitered gazelles and livestock (Boev et al., 1962; Eslami et al., 1980). At least five species of cestodes have been reported in goitered gazelles (Eslami et al., 1981; Griner, 1983). Eslami et al. (1981) postulated that wild canids were reservoir hosts of the larval cestodes. The absence of trematode parasites may have been due to the absence of their intermediate hosts in desert areas inhabited by gazelles. Parasitic infections probably do not cause significant mortality in goitered gazelles (Zhevnerov and Bekenov, 1983). All 65 individuals examined by Eslami et al. (1981) were infested with at least one helminth species but only one of the hosts was in poor physical condition. *Eimeria rheemi*, a coccidian protozoan believed endemic to *G. subgutturosa*, was found to be pathogenic to captive young (2–4 months of age), causing mild to severe mucoid diarrhea, but treatable with sulfonamide (Hussein and Mohammed, 1992).

Deep snow and ice-covered ground are the greatest natural causes of mortality among goitered gazelles (Heptner et al., 1988; Sludsky, 1963). Deaths have also been attributed to entrapment in asphaltic pools, drowning in the ocean, and road kills (Gallagher and Harrison, 1975; Vereshchagin, 1967). Causes of mortality in captive animals (number in parentheses) include stress or trauma from predation (54), capture operations (49), fence injuries (7), fighting (6), unspecified factors (74), or unknown causes (118—Griner, 1983; Rietkerk et al., 1992). Digestive disorders (20), malnutrition (18), respiratory aliments (3), and urinary stasis induced by genital suckling (10) also cause death, particularly in neonates (Griner, 1983; Rietkerk et al., 1992). In a sample of 785 births, 13 were stillbirths (Griner, 1983; Rietkerk et al., 1992). Mortality-causing pathogens include *Corynebacterium pyogenes* (≤ 45), *Mycobacterium* sp. (5), and *Cryptosporidium* sp. in combination with *Escherichia coli* (1—Fenwick, 1983; Rietkerk et al., 1992).

About 1900, an estimated one million goitered gazelles inhabited Soviet Central Asia (Sludsky, 1977). Subsequently, they have declined or have been extirpated in many parts of their range as a result of overhunting, overgrazing by domestic livestock, and agriculture. Currently, populations are estimated to number about 100,000 in Mongolia (Zhirnov and Lushchekina, 1992); 35,000 in Kazakhstan (Blank, 1990); 8,000 in Turkmenistan; 5,000 in Azerbaidjan; 5,000 in Uzbekistan; 1,200 in Saudi Arabia; several hundred in Tadjikistan; 300 in Turkey; and 100 in Kyrgyzstan (Flint and Prisiazhniuk, 1986; K. Habibi, in litt.; Ogurlu, 1992). Elsewhere, goitered gazelles occur primarily as smaller populations, which are vulnerable to further reductions because of their isolation (Blank, 1991; East, 1992). There are more than 1,000 on various islands in Bahrain and other areas in the United Arab Emirates, but some of these introduced populations probably originated from mixed releases of *G. s. marica* and *G. s. subgutturosa* (East, 1992). The captive population numbers at least 529 (International Species Information System, 1994). In Afghanistan, China, former Soviet Central Asia, and Turkey, *G. subgutturosa* is vulnerable to extinction (Cai et al., 1990; Habibi, 1977; Neronov and Bobrov, 1991; Ogurlu, 1992) and *G. s. marica* is considered endangered (Groombridge, 1993). Protected areas with populations of goitered gazelles exist in Mongolia, China, Uzbekistan, Turkmenistan, Iran, Turkey, Jordan, Saudi Arabia, United Arab Emirates, and Oman (Green and Drucker, 1991; Neronov and Bobrov, 1991; Ogurlu, 1992). Reintroductions are being conducted in Saudi Arabia to develop additional reserve populations (Launay and Launay, 1992).

Goitered gazelles were hunted by humans in Syria as early as 11,000 B. P. and in Mongolia from about 4,000 B. P. Subsequently, breeding of domestic livestock, and possibly overhunting, reduced the utilization of gazelles as a food source (Dinesman et al., 1986; Legge and Rowley-Conwy, 1987). From the Neolithic period until the early 1900's, hundreds of goitered gazelles were caught at a time in desert kites ("aran"), which were long, stone walls that funneled animals into an enclosed area (Heptner et al., 1988; Mendelssohn, 1974). Goitered gazelles have also been hunted on camel- and horseback and with dogs and falcons (Gallagher and Harrison, 1975; Misonne, 1957; Roberts, 1977). The advent of modern rifles and motor vehicles during World War I increased the vulnerability of goitered gazelles to hunting, and populations in the Middle East and the former Soviet Union declined significantly during the following years (Heptner et al., 1988; Thouless et al., 1991). From the 1880s through 1940s in Central Asia, about 400–10,000 goitered gazelles were commercially harvested each year for meat and hide (Heptner et al., 1988; Sludsky, 1963; Smimov, 1965); commercial harvest still occurs in Mongolia (Sokolov, 1990). Morrison-Scott (1939) remarked that Bedouin prefer meat of goitered gazelles over that of other gazelles. Gazelle hide is used to make bags to hold water and koumiss (fermented mare's milk) and is sometimes used to make footwear (Heptner et al., 1988). Calves have also been captured and domesticated for use as gifts and pets (Mendelssohn, 1974; Pitman, 1922; Vereshchagin, 1967); they become domesticated quickly in captivity and reproduce well (Heptner et al., 1988). Captive goitered gazelles can be hand-raised to reduce neonatal mortality; apparently, hand-raised individuals are as equally suitable as mother-raised gazelles for reintroduction projects (Lindsay and Wood, 1992). Etorphine, fentanyl/azaperone, tiletamine-zolazepam, and xylazine/ketamine are used to chemically immobilize goitered gazelles (Furley, 1986; Greth et al., 1993; Rietkerk and Delima, 1994).

BEHAVIOR. Goitered gazelles are gregarious and usually occur in small groups, but herds may number in the hundreds or thousands (Allen, 1940; Mendelssohn, 1974). During spring and summer, animals may be solitary or in groups that generally number two to nine animals (Blank, 1990; Heptner et al., 1988; L'vov, 1979). Group structure changes dramatically during fall at the beginning of rut. Females and young gather in herds of up to 10–30 individuals. Single adult males may join herds but they usually remain solitary during rut; sub-adult males often form bachelor groups. Adult males may continue to remain solitary after rut, but they often join bachelor groups or herds of females and young; herds may number >50 individuals (Blank, 1990; Habibi et al., 1993). During spring, large herds divide into small male groups and pregnant females become solitary prior to parturition (Blank, 1992).

Goitered gazelles are polygamous. Males court females throughout the year, but most vigorously during rut (Blank, 1985). During courtship, males have swollen necks and their preorbital glands are dilated and exude a tarry secretion (Allen, 1940; Habibi et al., 1993). Courtship displays of males include: neck stretch, nose-up posture, flehmen, foreleg kick, and erect posture (Habibi, 1992; Walther et al., 1983). Males court only when females are in their territory; they may herd and chase females to keep them in their territory (Blank, 1985; Habibi, 1992). Mating takes place during the peak period (ca. 7–10 days) of rut and courtship when females remain in a male's territory overnight. Males generally mate with 2–12 females; harems may contain up to 30 females, but some territorial males do not mate at all (Blank, 1985; Jamsheed, 1976). When mounting, a male stands on his hindlegs, forelegs spread apart, and moves close to a female, touching her only with his pelvis. Of 185 mounts during 25 min, eight resulted in intromission (Blank, 1992). Males have been observed to orally masturbate (Blank, 1992).

Prior to calving, females move from low-lying or open areas of deserts and plains to foothills or to areas with high ground or vegetative cover (Blank, 1992; Pitman, 1922). After parturition, females graze 50–500 m from their calves, grazing closer as the

calves become older. When females go to watering holes, they may be separated from their calves by 4–5 km. Dams lead their infants to new hiding places after each nursing; twins are bedded 50–1,000 m apart during the first 4–6 days (Blank, 1992). Females cautiously approach hiding places of their young to avoid detection by predators. Twins are nursed and moved in turn, but dams may sometimes nurse both young together (Blank, 1992). Until they are about 6 weeks old, calves are nursed two to four times/day at intervals of 2–6 h. Attempts to nurse from other females are not successful. Young start following their mothers regularly at the age of 2–2.5 months (Blank, 1992). In captivity, hand-reared females have proven to be capable mothers (Lindsay and Wood, 1992).

Goitered gazelles actively feed during early morning and late afternoon, but where they are heavily hunted they become partly nocturnal (Launay and Launay, 1992; Roberts, 1977). They move from nighttime pastures and watering areas to rest areas during the morning and return in evening, a distance of 10–15 km (Blank, 1990). They move leisurely, grazing constantly, and rest once or twice for 20–60 min periods. During inclement weather, they may stay at rest areas throughout the day. Goitered gazelles change pastures even when water is abundant; such movement increases foraging effectiveness (Blank, 1990). During summer, they have morning and evening peaks of feeding activity, and during winter, they graze all day and rest briefly about midday (Heptner et al., 1988; Sludsky, 1977; Zhevnerov, 1984). Grazing time of territorial males is about 50% of its level outside the rut because of increased time spent defending their territory (Blank, 1990). Age, sex, and social status of captive animals may affect time spent foraging and resting (Launay and Launay, 1992).

The vocalizations of goitered gazelles have been variously described as: guttural grunts made by both adults and young (Pitman, 1922); a nasal hiss made as an alarm before taking flight (Roberts, 1977); hoarse, low-pitched calls made by females as vocal signals for their young; and low-pitched "moos" made by young (Blank, 1992). During rut and courtship, males constantly grunt a low, gurgling wheeze that can be heard at a distance of 100–150 m (Blank, 1992; Habibi, 1992).

When excited or disturbed, goitered gazelles have a characteristic gait (stotting) which consists of a series of stiff-legged jumps (Roberts, 1977); however, stotting was not observed among animals in Saudi Arabia (Habibi et al., 1993). When running at high speeds, they do not leap or bound like other Asian gazelles, but gallop with their necks outstretched and tails upright (Harrison and Bates, 1991). Galloping may allow easier locomotion over broken terrain and through vegetation (Sokolov et al., 1964). Speeds of nearly 100 and 50 km/h, respectively, can be maintained for 0.8 and 16 km (Allen, 1940; Jamsheed, 1976). Flight distance of goitered gazelles varies from 2 km to <200 m (Allen, 1940; Habibi et al., 1993; Jamsheed, 1976; Thouless et al., 1991), but motor vehicles may approach as close as 60–70 m (L'vov, 1979). When pursued, goitered gazelles pack closely together like a herd of goats, running a straight course or crossing back and forth in front of the pursuer (Blank, 1992; Harrington, 1977; Harrison and Bates, 1991).

Among captive *G. dorcas*, *G. gazella*, and *G. subgutturosa*, dominance hierarchies are established with five aggressive behaviors: horn-threat, rush-charge, horn-clash, horn-butt, and chasing. *G. subgutturosa* is dominated by *G. dorcas* and *G. gazella*, and adult males of all three species are dominant over females and young (Habibi, 1989). Dams drive other females and yearlings away from their calves and defend them from predators (Blank, 1992).

During rut, adult males occupy and aggressively defend individual breeding territories. Territories are open areas with scant vegetation, situated along daily movement routes of female herds, and usually 50–120 ha (Blank, 1985, 1992; Walther et al., 1983). Males patrol and mark the borders of their territories; marking is done with dung piles, urine, or preorbital gland secretions, or by scraping the ground or vegetation with their horns or forelegs (Blank, 1992; Habibi, 1992; Walther et al., 1983). Marking behavior is observed in males all year, but it is most intense during rut (Blank, 1992). Aggression between territorial males may involve horn displays, chasing, or fighting (Habibi, 1992; Habibi et al., 1993; Walther et al., 1983). Initially, territories are maintained only during the day but after 4 weeks, males remain in their territories day and night. Bachelors do not have territories, and they move each day between grazing and resting areas (Blank, 1985).

Goitered gazelles seek shade under rock ledges and bushes on dune slopes (Gallagher and Harrison, 1975; Stewart, 1963). However, captive individuals often make no attempt to seek shade while resting during the hottest part of the day (Habibi, 1992; Roberts, 1977). Resting areas are usually situated in foothills, dunes, or thickets but in open areas, goitered gazelles avoid detection by resting in depressions (Blank, 1990; Jamsheed, 1976). Grouping is more pronounced during rest periods (Launay and Launay, 1992).

FIG. 4. G-banded karyotype of male *Gazella subgutturosa marica* (2n = 32), heterozygous for a Robertsonian translocation involving chromosomal pairs 14 and 15 and possessing an autosome-to-X translocation involving chromosome 16. Karyotype prepared by Arlene Kumamoto.

GENETICS. Goitered gazelles have 2n = 30–33 chromosomes; 26–28 metacentric and 0–5 acrocentric, with a submetacentric X and an acrocentric Y (Effron et al., 1976; Hsu and Benirschke, 1977; Kingswood and Kumamoto, 1988; Vassart et al., 1993; Fig. 4). Variation in diploid number is the result of two chromosomal rearrangements, a putative centric fusion and an autosome-to-X translocation. The autosome-to-X translocation results in males having an unpaired autosome; the autosome involved in this rearrangement is the same one involved in the autosome-to-X translocations in *G. dama* and *G. soemmerringii* (Vassart et al., 1993). The centric fusion occurs in homozygous (females, 2n = 30; males, 2n = 31) and heterozygous (females, 2n = 31; males, 2n = 32) forms; individuals lacking the fusion are 2n = 32 (females) or 33 (males). Specimens of putative *G. s. subgutturosa* are fusion homozygotes (2n = 30, 31); in *G. s. marica*, the fusion may be absent, or in homozygous or heterozygous forms (Kingswood and Kumamoto, 1988; Vassart et al., 1993).

G-banding patterns of *G. s. subgutturosa* (2n = 30, 31) and *G. s. marica* (2n = 30, 31) are homologous (Kingswood and Kumamoto, 1988). Most of the autosomes exhibit pericentromeric heterochromatin and a few have terminal C-bands; the Y and the short arm of the X are largely heterochromatic (Kingswood, 1992). Neither centric fusion nor autosome-to-X translocation appear to reduce the meiotic fitness of male goitered gazelles (Kingswood et al., 1994). Individuals heterozygous for centric fusion are fertile and produce offspring when crossed with any of the cytotypes (Kingswood and Kumamoto, 1988). Distribution of frequencies for different chromosome numbers conforms with Hardy-Weinberg equilibrium (Vassart et al., 1993). *G. subgutturosa* has hybridized with *G. gazella* [*bennetti*], *G. g. gazella*, and *G. leptoceros* [*subgutturosa*] *marica* (Gray, 1972; H. Mendelssohn, in litt.; Roberts, 1977). Hybridization between *G. s. subgutturosa* females and *G. g. gazella* males resulted in sterile male offspring; the fertility of female offspring was not tested (H. Mendelssohn, in litt.). In a captive population of *G. s. marica*, the percentage of polymorphic

loci (n = 20) and mean heterozygosity were 15% and 0.017, respectively (Granjon et al., 1991).

REMARKS. The name gazelle comes from the Arabic *ghazal*, or *gazaal*. Other names for gazelles include: *dhabi* and *idmi* (Arabic), *djeylan* and *gazal* (Turkic), *ğzal* (Dari, Afghanistan), and *oūsey* (Pashto, Afghanistan—Habibi, 1977; Hatt, 1959). The Kurdish *ask*, *kalla-ask*, and *mombiz* refer to a male gazelle, and *mamiz* refers to a female (Hatt, 1959). Common names for the goitered gazelle are *āhū* (Farsi), *akhcha-keik* (Turkmenistan), *dzheiran* (Soviet Asia), *kara-keuruk* (= black-tail, Kyrgyzstan) and Kropfgazelle (German—Heptner et al., 1988; Klockenhoff, 1969; Sclater and Thomas, 1897–1898). The etymology of *subgutturosa* is *sub* (Latin: below), *guttur* (Latin: throat), and *-osus* (Latin suffix: full of). Common names for the various subspecies of *G. subgutturosa* are: *G. s. hillieriana*, Hillier's goitered gazelle, Mongolian gazelle, *hwang-yang* (= yellow sheep, Chinese); *G. s. marica*, Arabian sand gazelle, Saudi goitered gazelle, *rheem* or *rhim* (Arabic); *G. s. subgutturosa*, Persian gazelle, Gazelle persane (French); *G. s. yarkandensis*, Yarkand (or Xinjiang) goitered gazelle, *saikik* or *kik*, *tairan* (Turkic, Uighur—Allen, 1940; Carter, 1991; Groves, 1969; Misonne, 1957; Sclater and Thomas, 1897–1898).

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