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# Camelus dromedarius.

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## *Camelus* Linnaeus, 1758

*Camelus* Linnaeus, 1758:65. Type species by Linnaean tautonomy and elimination (International Commission on Zoological Nomenclature, 1910) *Camelus bactrianus.*

*Dromedarius* Gloger, 1841:xxxiii. Type species *Dromedarius africanus* Gloger, 1841, by monotypy.

**CONTEXT AND CONTENT.** Order Artiodactyla, Suborder Tylopoda, Family Camelidae, Subfamily Camelinae, Genus *Camelus.* A key to the species of *Camelus* follows:

One dorsal hump, pelage short ..... *C. dromedarius*
Two dorsal humps, pelage long and shaggy in winter ..... *C. bactrianus*

## *Camelus dromedarius* Linnaeus, 1758

Dromedary

*Camelus dromedarius* Linnaeus, 1758:65. Type locality "Africae."

*Camelus dromas* Pallas, 1811:19. Type locality "Persiae parte australiore."

*Camelus arabicus* Desmoulins, 1825:452. Type locality "Caucase, Afrique."

*Dromedarius africanus* Gloger, 1841:134. Type locality "Nordafrika, Süden Asiens bis nach Indien hin."

**CONTEXT AND CONTENT.** Context noted in generic summary above. The species is monotypic.

**DIAGNOSIS.** *Camelus* differs from *Lama* in being humped and having a shoulder height >1.7 m (Fig. 1). It has smaller, rounded ears, almost square feet, a longer and tufted tail, four teats (two in *Lama*) and three upper premolars (two in *Lama*; Simpson, 1984). Dromedary and *C. bactrianus* digress in their adaptations to temperature extremes: The dromedary is extant in hot deserts and has a lighter frame, longer limbs, and shorter hair than *C. bactrianus*, which is better adapted to withstand low temperatures.

The cranium of the dromedary has a more pronounced sagittal crest, an indented nasal bone, a longer facial part and hard palate, and a smaller or absent ethmoidal fissure compared to the Bactrian camel (Leche, 1904; Lesbre, 1903). Because both camels have been subject to selective breeding control, much genetic variability exists and traits may overlap (Fig. 2).

The length of gestation is usually <400 days in the dromedary, whereas it exceeds this period in the Bactrian camel. The inflation of the soft palate during rut appears to be a trait unique to the dromedary (Pilters, 1956).

**GENERAL CHARACTERS.** Male dromedaries have a shoulder height of 1.8–2.0 m (height of hump is 20 cm more) and mass is 400–600 kg. Females are about 10 cm less in height and about 10% less in mass than males. Body shape is characterized by the long-curved neck, deep-narrow chest, one hump on the back,

FIG. 1. Adult male *Camelus dromedarius* from Petra area of southern Jordan.

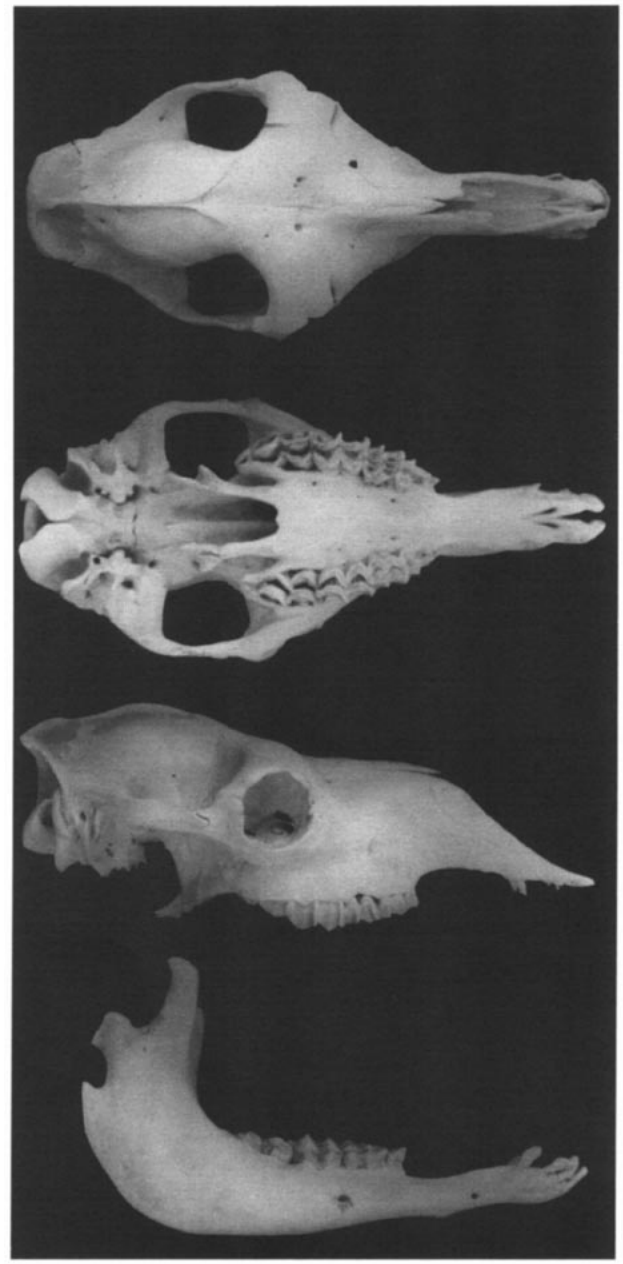

FIG. 2. Dorsal, ventral, and lateral views of cranium, and lateral view of mandible of *Camelus dromedarius* (Anatomical Museum, Veterinary Department, University of Brussels, no catalog number). Condylo-basal length is 469 mm.

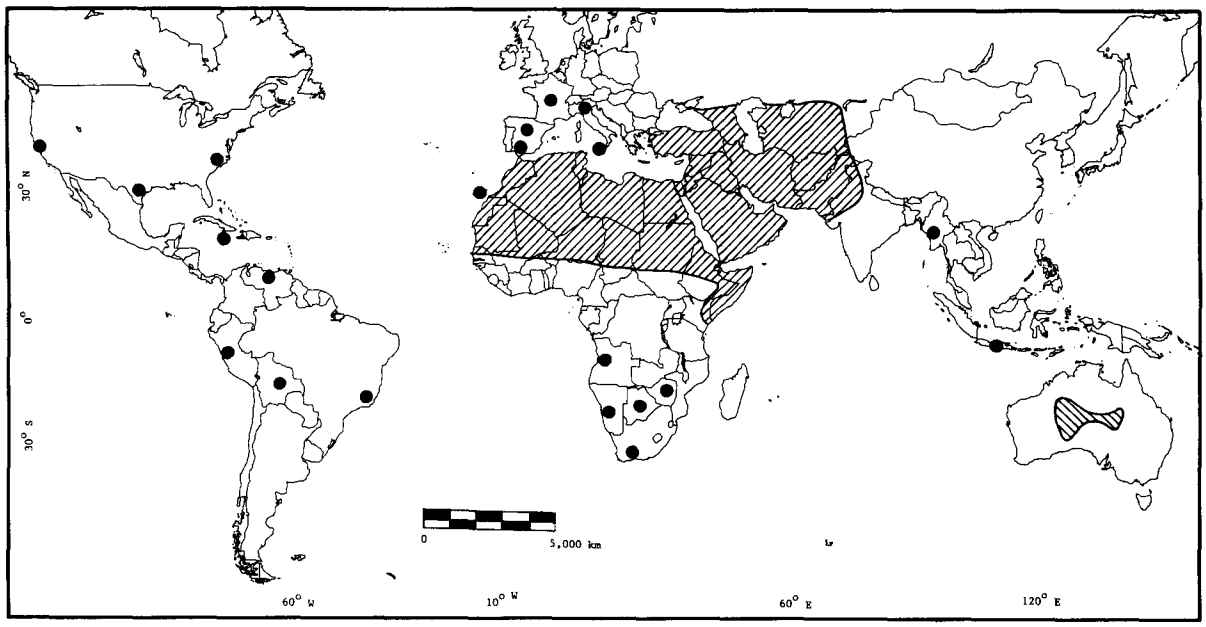


FIG. 3. Distribution of domesticated *Camelus dromedarius* (hatched area in Europe, Africa, and Asia), feral populations (hatched area in Australia), and areas of attempted introduction (solid circles; after Leese, 1927; McKnight, 1969). Drawn by D. Nelson.

long-thin legs, and broad-padded feet. The head is small in relation to body size, and the eyes are large and protected by prominent supraorbital ridges. There are slit-like nostrils, a split upper lip, and a pendulous lower lip. The upper-middle and inner incisors are replaced by a tough dental pad, and the canines, especially the upper ones, are massive and pointed. The hindquarters are much less developed than the weight-bearing front legs (Wilson, 1984).

**DISTRIBUTION.** Domesticated dromedaries occur in the semi-arid and arid regions of the Old World, and a sizeable feral population exists in central Australia (Fig. 3). The population of camels in the world (including both dromedaries and Bactrian camels) numbers around $1.72 \times 10^7$ of which $1.28 \times 10^7$ live in the northern parts of Africa. All African camels are dromedaries; 84% of these occur in Somalia, Ethiopia, Sudan, Djibouti, and Kenya. Somalia ($5.7 \times 10^6$) and Sudan ($2.5 \times 10^6$) are the countries with the greatest densities of dromedaries. The southern limit of dromedaries that breed in Africa is determined by the degree of humidity and the occurrence of trypanosomiasis; the limit is demarcated by the 400-mm isohyet, following 15°N from Senegal to Niger and 13°N in Chad and Sudan. Only in the Horn of Africa do dromedaries exist as far south as 2°S where rainfall may be up to 550 mm/year. The $4.16 \times 10^6$ camels in Asia include a significant number of Bactrian camels; dromedaries occur from Turkey to the western parts of India, ranging as far north as Turkmenistan or 45°N (Food and Agriculture Organization, 1984).

Dromedaries were exported to the Canary Islands in 1405; their populations survive there today. Between the 17th and 19th centuries attempts were made to introduce the dromedary to the Caribbean, Peru, Bolivia, Colombia, and Brazil; they were imported to the western United States in the 1850s and to Namibia in the early 1900s, but in none of these places do dromedaries exist today (Leese, 1927). The Australian population, dating back to about 1860, was estimated to number between 15,000 and 20,000 in 1969 (McKnight, 1969).

**FOSSIL RECORD.** The earliest camelid, the jackrabbit-sized *Protylopus*, occurs in the Upper Eocene of North America (Scott, 1924). During the transition from the Pliocene to the Pleistocene, members of the genus *Camelus* migrated across the Bering Strait and dispersed widely in Asia, eastern Europe, and Africa. The oldest remains, *C. sivalensis* and *C. antiquus*, are present in the Pinjor Formation of the Siwalik Hills in India (Colbert, 1935). The subgenus *Paracamelus* retains an additional pair of lower premolars and is reported from western Siberia, China, near the Sea of Azov, and the northern coast of the Black Sea (Howell et al., 1969). In the Near East, camel remains date to 600,000 years ago in Ubeidiya in the Jordan Valley (Haas, 1966). In Africa, *Camelus* ranged as far south as Tanzania during the Pliocene (Gentry and Gentry, 1969). Most Pleistocene remains from North Africa are ascribed to *C. thomasi*, which because of its large size, is thought to resemble the Bactrian camel (Gautier, 1966).

**FORM AND FUNCTION.** Dromedaries most often are sand colored, but all shades of brown ranging from almost black to nearly white occur. Piebald specimens with mouse-colored necks and backs, white bellies, faces, and legs are known from Kordofan and Darfur in Sudan (Leese, 1927). Hairs are longer on the throat, shoulder, and hump, and they are arranged in clusters consisting of two to three cover hairs and two to five groups of wool hairs. Each cover hair has a separate follicle and is associated with a ring of sebaceous glands, a tubular sweat gland, and an arrector pili muscle (Dowling and Nay, 1962; Lee and Schmidt-Nielsen, 1962). The black skin is tightly attached to underlying tissues and modified into horny pads at the sternum, elbows, carpals, stifles, and tarsals. The epidermis is 0.038–0.064 mm thick; the dermis is 2.2–4.7 mm in thickness (Ghobrial, 1970). Dromedaries do not sweat until they have reached the upper limits of their heat storage and their body temperature has surpassed 42°C (Yagil, 1985). The sweat evaporates from the skin rather than the tips of the hair, which also reduces water loss; in shorn animals the water expenditure is about 50% greater than in unshorn ones (Schmidt-Nielsen, 1964).

The hump consists of fat bound together by fibrous tissue and stores fat for times of need; its size and shape vary with the nutritional status of the animal and it almost disappears in times of starvation. The accumulation of all body fat in one area, instead of the subcutis, also facilitates dissipation of heat (Macfarlane, 1977).

There are no face glands, but males have well-developed occipital glands situated 5–6 cm below the nuchal crest on either side of the midline of the neck. They appear to be modified apocrine sweat glands and secrete a pungent coffee-colored fluid during the rut. The gland masses increase during rut and with age, ranging from 20 to 115 g in uncastrated animals (Singh and Bharadwaj, 1978).

The feet are pad-shaped and equipped with two dorsal nails; the two terminal pairs of phalanges and a cushion of semi-fluid fatty pads and elastic tissue are encased by collagen layers and a thick rubbery epidermis. The front feet (18 cm long, 19 cm wide) are larger than the hind feet (16 cm long, 17 cm wide; Gauthier-Pilters and Dagg, 1981). Excellently adapted to sandy desert, the feet can easily be injured by sharp stones and are unsuitable in slippery or muddy conditions.

The mammary gland is composed of four quarters and divided into a left and right half by an intermammary ridge. The cone-

shaped, laterally-flattened teats have an average length of 2.4 cm and an average diameter of 1.5 cm at the base. No supernumerary teats were observed in 200 udders. Each teat possesses two or three spindle-shaped teat cisterns; streak canals open either into a common pouch or directly into the distal part of the teat (Saleh et al., 1971). The composition of dromedary milk (in percent) is: moisture, 85.6–88.5; fat, 2.0–4.5; lactose, 3.4–5.8; protein, 2.0–4.5; ash, 0.6–0.9; nonfat solids, 8.9–10.1 (Knoess, 1984). Dehydrated camels continue to lactate, producing milk with a water content of >90% (Yagil, 1985).

The cranium displays a postorbital bar and a tympanic bulla filled with spongiosa. The average cranial capacity of 14 dromedaries was 587.14 ml[3] (Sandhu and Dhingra, 1986). The mandible possesses a processus angularis and a hemispherical condyle. The dental formula is i 1/3, c 1/1, p 3/2, m 3/3, total 34; that of the deciduous dentition is i 1/3, c 1/1, p 3/2, total 22. Some dromedaries in Sudan have an additional pair of lower premolars (Cauvet, 1929). The upper jaw has laniariform incisors that are located on the premaxilla and forward pointing canines with a maximum length of 4 cm. The three pairs of premolars are pointed and spike-like; they have spaces between them. The molars are selenodont and hypsodont. In the lower jaw, the incisors are spatulate and procumbent; they wear down to stumps with age. The canines are less massive than the upper ones, and the first premolars are set apart (Wilson, 1984). The upper and lower first molars are the first permanent teeth and erupt in 12–15 months. The permanent lower incisors appear in 4.5–6.5 years. All teeth are in use by 8 years (Rabagliati, 1924).

The vertebral formula is 7C, 11–13 T, 6–7 L, 5 S, and 15–18 Ca, total 44–50. In the cervical spine, the canal for the vertebral artery runs through the side of the neural arch. There usually are eight sternal and four asternal pairs of ribs (Leese, 1927). The sternum consists of six sternebrae bound cranially by cariniform and caudally by xiphoid cartilage (Singh et al., 1985). The ulna is reduced distally, the fibula is reduced to a tarsal-like malleolar bone, the second and fifth digits are absent, and the third and fourth metapodials are confluent through the upper 75% of their length and diverge distally. Dromedaries are digitigrade (Simpson, 1984).

The heart has a mass of about 5 kg, two ventricular grooves, and its pointed apex curves to the left. It contains a slender bone in the right one-half of the aortic fibrous ring (Hegazi, 1954). The branches of the right and left interventricular arteries anastomose in the region of the apical vortex. The left coronary artery arises from the left aortic sinus and (after 5 cm) divides into interventricular and circumflex branches (Kanan, 1971). A triangular bone, measuring about 3 by 2.5 cm, is lodged in the tendinous fibers at the center of the diaphragm; it prevents compression of the interior vena cava and distributes the muscular pull over a larger tendinous surface area (Etemadi, 1966).

The crescent-shaped spleen has a mass <500 g in adult dromedaries, an average length of 40 cm, a width of 9 cm, and is of grayish-violet color. Its hard consistency is due to much interlobular tissue and a strong fibro-muscular capsule that sends thick strands of trabeculae into the interior (Hegazi, 1953).

The following mean blood values were found (Banerjee et al., 1962): total red cells, 7.24 × $10^6$/mm[3]; hematocrit, 27%; size of red blood cells, 7.7 by 4.2$\mu$; hemoglobin, 13.1 g/100 ml; mean corpuscular volume, 37.9$\mu^3$; mean corpuscular hemoglobin concentration, 47%; red cell sedimentation rate, 1.1 mm/h; total white blood cells, 18,100/mm[3]; neutrophils, 51%; eosinophils, 6%; basophils, 0.05%; lymphocytes, 40%; monocytes, 3%. Plasma analysis for electrolyte and mineral content yielded the following averages (Wahbi et al., 1984): sodium, 147 milliEquivalent/l (mEq/l); potassium, 5.3 mEq/l; calcium, 9.2 mg/100 ml; magnesium, 2.5 mg/ml; inorganic phosphates, 5.3 mg/100 ml; copper, 118.3 mg/100 ml; iron, 98.5 $\mu$g/100 ml; iron-binding capacity, 320.8 $\mu$g/100 ml. These parameters are affected by the state of hydration and seasonal and sexual variations. The blood pH is 7.1–7.6; specific gravity is 1.034–1.065 (Barakat and Abdel-Fattah, 1971).

The ability to withstand heat and dryness does not depend on water storage, but on numerous physiological peculiarities, including many mechanisms aimed at water conservation. The body temperature of dromedaries deprived of water fluctuates as much as 6°C (34.2–40.7°C) during the day, reaching its maximum in the afternoon and minimum in the early morning. This reduces the heat flow from the environment to the body and prevents the loss of water through perspiration. In well-watered dromedaries the temperature fluctuation amounts to only about 2°C. The dromedary can tolerate water loss >30% of its body mass, whereas a 15% loss is lethal in most other mammals. The expended water is drawn mainly from the interstitial and intracellular body fluids; the volume of blood plasma remains relatively constant maintaining circulation and the ability to cool (Schmidt-Nielsen, 1964). Dromedaries rehydrate quickly. They can take in water amounting to 30% of their body mass within minutes. Their erythrocytes have an extremely high osmotic resistance and swell to 240% of their initial size without hemolysis (Perk, 1963).

The spinal cord reaches an average length of 213.6 cm; it terminates at the junction between the 2nd and 3rd sacral vertebra (Hifny et al., 1985). The nostrils are surrounded by sphincter muscles and can be closed to prevent the entering of sand and dust. The nasal cavities are connected with a pair of fluid producing, 14–18-cm long blind sacs (Arnautović and Abdalla, 1969) and a pair of lateral nasal glands and sacs (Abdel-Magid and Abdel Razag, 1975), which moisten the incoming air. The thyroid glands are dome-shaped, measuring 8–10 cm in length, 4.5 cm in width, and located laterally of the 4th to 6th tracheal rings. The trachea is 130–150 cm long and has a diameter of 2–2.5 cm; it is situated in a cervical groove formed by the transverse processes of the vertebrae and the musculus longus colli and the musculus intertransversus colli. A small bronchus trachealis is present on the right side (Tayeb, 1964). The lungs are not lobed (Leese, 1927). Dehydrated dromedaries have a depressed respiratory rate (Schmidt-Nielsen et al., 1967).

A deep median fissure divides the upper lip into two independently movable halves (Tayeb, 1964). The soft palate is about 18 cm long and has a protrusible oroventral projection (dulaa) that males inflate and project outside the mouth during the rut (Arnautović and Abdel-Magid, 1974). The long and wide epiglottis partly overlaps the posterior part of the soft palate; the esophagus has a one-lipped groove and discharges food directly into the rumen (Wilson, 1984).

The stomach is not homologous to that of ruminants (Bohlken, 1960). The rumen and the reticulum are equipped with "glandular sac" areas that are diverticula divided into a number of smaller chambers by mucosal folds. Their function is unknown, but it is not water storage (Schmidt-Nielsen, 1964). The long cylindrical omasm is not externally distinguishable from the small abomasum.

The liver is four-lobed, triangular-shaped, with mean dimensions (in cm) of: length, 60; width at base, 42; width at apex, 18; average mass, 6.5 kg (Abdalla et al., 1971). The gallbladder and left lateral ligament are absent; the bile duct is joined by the pancreatic duct (Radmanesh, 1974).

Volumes of kidneys average 858 cm[3]. One-half of the volume consists of cortex; the medullary thickness ratio is 4:1 (Abdalla and Abdalla, 1979). The kidneys can produce urine with a chloride content of up to 1,000 mEq/l. In experiments, dromedaries could drink sodium chloride solutions (3.5–5.5%) even more concentrated than seawater (Maloiy, 1972). The dehydrated dromedary has a 73% decrease in tubular reabsorption of sodium, increasing urinary sodium excretion by 42% (Yagil, 1985). The excretion of urea can be kept to <1 g/day and urea can be recycled from the kidneys into the rumen for protein synthesis (Schmidt-Nielsen, 1964) and water recirculation (Yagil, 1985). The amount of urine produced depends on the amount of water ingested; it is greatly reduced in dehydrated dromedaries. Averages of 450 ml (Schmidt-Nielsen et al., 1956) and 250 ml/micturition are reported, and daily quantities of 1.1–7.0 l. The largest quantity observed was 650 ml (Gauthier-Pilters and Dagg, 1981). In a dehydrated state, dromedaries excrete less water in the feces; 89 ml of water/100 g of dry matter compared to 218 ml/100 g of dry matter (Farid, 1984).

The ovaries are reddish, circular, flattened, lobular, and measure about 4 by 2.5 by 0.5 cm during anestrus (Arthur et al., 1985). They are enclosed in a conical bursa. The oviducts are 25–28 cm in length. The uterus is bicornuate and T-shaped; its upper surface is convex, the lower surface flat, and the right cornum shorter than the left. The cervix is about 5 cm in length with three to four ridges. The vagina measures 3–3.5 cm in length and has well-developed Bartholin's glands (Novoa, 1970). The vulva is 3–5 cm deep with a small clitoris (Wilson, 1984). The placenta is diffuse and epitheliochorial with a crescent-shaped chorion (Morton, 1961).

The scrotum is situated high in the perineal region and contains the testicles in separate pouches. The testicles are 7–10 cm in length, 4.5 cm in depth, and 5 cm in width. The mass varies seasonally from 165 to 253 g (for both testicles) during the rut and <140 g, otherwise (Charnot, 1963). The prostate gland is dark

yellow, usually disc-shaped, and bilobate. The bulbourethral gland is almond-shaped and white; there are no seminal vesicles. The ampullae ductus deferentis are about 14 cm in length (Elwishy et al., 1972). The pelvic part of the urethra is spindle shaped and about 14.5 cm in length. The penis is covered by a triangular sheath that opens backwards; it is about 60 cm in length with a transverse hook-shaped gland that is well separated from the body (Wilson, 1984).

**ONTOGENY AND REPRODUCTION.** Under most circumstances males and females are seasonal breeders. The breeding season usually occurs in winter, often overlapping the rainy season. The exact factors leading to the onset of rut and estrus are not known, but nutritional status and length of day are likely to be involved. In Morocco, males rut from mid-December to May (Charnot, 1963); in Egypt, from March to April (Abdel Raouf and El-Naggar, 1964); in India, from November to February (Singh and Prakash, 1964); and in Australia, from June to September (McKnight, 1969). In countries close to the equator, two breeding seasons occur; for example, in Somalia during June and from September to November (Hartley, 1984; Leese, 1927). In Saudi Arabia (Arthur et al., 1985) and Kenya (Wilson, 1986), males may be capable of mating and fertilizing throughout the year; spermatogenesis is continuous throughout the year (Osman and Plöen, 1986).

Follicular activity is present all year, but it peaks during certain periods, usually during winter and spring (Nawar et al., 1978). Ovulation is induced by mating and occurs within 30–40 h afterwards (El-Amin, 1984); estrus may cease 3 days later (Arthur et al., 1985). If no mating occurs, estrus lasts up to 2 weeks. In a study of five unmated dromedaries from Sudan, length of cycle averaged 28 days; the follicle matured within 6 days, maintained its size for 13 days, and regressed over 8 days (Musa, 1984). The length of the cycle varies seasonally; in Egypt, it is longest in spring and shortest in summer (Nawito et al., 1967). The optimal time for mating is during the first 2 days of estrus; in India, conception required an average of 1.9 copulations on the first day, 1.8 on the second day, and >2 on the last 3 days (Gupta et al., 1978).

The left and right ovaries are equally active and alternate in the production of follicles. Twin ovulation had occurred in 14% of pregnant females in Saudi Arabia (Arthur et al., 1985). In 482 pregnancies, 99% of the fetuses were situated in the left horn. Egg migration appears to be frequent, for in 50% of left-horn pregnacies, the corpus luteum was in the right ovary. Although twin ovulations occur, twin pregnancies are reported only in 0.4% of cases (Musa, 1984). Leese (1927) never found twin births.

In Kenya, pregnancy lasts 360–411 days (average, 377 days; Wilson, 1986). The average length of pregnancy in India is 390 days (Mehta et al., 1962). It does not vary significantly with sex of calf or sequence of calving (Mehta et al., 1962; Wilson, 1986), but it is highly heritable (Ram et al., 1977).

Up to a crown-rump length of 50 cm, posterior and anterior positions of the fetus in the uterus are of the same frequency, but at a crown-rump length of 61–70 cm anterior positions are the rule. During the last 8 months of pregnancy most fetuses lie on their right side. The total quantity of fetal fluid is about 9 l, of which 80–90% is allantoic fluid; there is never >1 l of amniotic fluid (Musa, 1984).

The normal calving interval is 2 years, although in countries with two breeding seasons two calves may be produced within 2.5 years if conditions are favorable. In Kenya the mean interval was 20.2 months. Females successfully rearing calves had a significantly longer interval than others (Wilson, 1986). In Kenya, estrus occurred 4.5–10 months after parturition, but in one instance a nonlactating female attained the estrous condition within 109 days (Evans and Powys, 1984).

In India, the mean mass at birth is 37.3 kg (26.4–52.3 kg), and males do not weigh significantly more than females. For male young, the average height at the hump was 123 cm, for female young, 118 cm (Bhargava et al., 1965). In Tunisia, mass at birth averages only 25.8 kg (Burgemeister, 1975).

Overall, there is a high rate of egg and early embryonic death; abortions and stillbirths occur in 18.2% in Somalia and 19.5% of pregnant females in Mali (Wilson, 1984). In Sudan, the annual calving rates range from 35 to 40% (El-Amin, 1984).

Spontaneous motor patterns of the young after birth are (in min): chewing, 10; grinding teeth and head shaking, 18; shifting on the ground, 74; "vacuum activity sucking," 100; kicking, 156; yawning, 160; urinating, 185; tail beating, 198; rubbing neck against mother, 294; body shaking, 304; rolling on the ground at 85 h. First attempts at standing are made at 10 min; standing for a few seconds at about 90 min; uncoordinated steps at 3.5 h; fairly regular steps at 5 h. First successful sucking occurs nearly 5 h after birth; scratching movements, sucking, and nibbling at objects and vegetation are performed during the first day of life. On the second day, calves drink and urinate at regular intervals, jump around, but spend most of the time resting (Gauthier-Pilters and Dagg, 1981).

Growth rates depend on maternal milk supply and the proportion of milk allocated to the young. Dromedaries kept by pastoralists often are fed only a small amount of their mother's milk yield, resulting in growth rates of 0.19–0.31 kg/day over a 1-year period compared with 0.44–0.58 kg/day in calves that can suckle ad libitum (Field, 1984).

In free-ranging herds, young stay with their mothers until they are 2-years old (Gauthier-Pilters and Dagg, 1981); dromedaries in Somalia are weaned by pastoralists at the age of 9–11 months by tying the mother's teats or fitting the calf with a thorny noseband. In young with free access to their mother's milk, weaning slows down growth (Hartley, 1984).

Females reach sexual maturity in 3 years and usually are mated for the first time at 4–5 years; they reproduce until 20 (Musil, 1928) or 30 years (Yasin and Wahid, 1957). In Kenya, the age at first parturition was 45.6–71.3 months (average, 54.2 months; Wilson, 1986). Males start rutting by 3 years, but are not fully active until 6–8 years old (Hartley, 1984; Novoa, 1970). The number of spermatozoa increases until 10 years of age, and the diameter of the seminiferous tubules until 9 years of age (Abdel-Raouf and El-Naggar, 1965). One male serves about 40 females, but occasionally up to 100 and remains in service for 7 years (Hartley, 1984) or until 18–20 years of age (Leese, 1927). The maximum age for both males and females is 40 years (Gauthier-Pilters and Dagg, 1981; Wilson, 1984).

**ECOLOGY.** Dromedaries have been extinct in the wild for about 2,000 years. Except for the feral dromedaries in Australia, all herds are exploited by humans; therefore population structure is the subject of much human manipulation (Köhler, 1981).

Of 205 young born in India, 16.1% died before 6 months of age and another 3.4% did not survive until the age of 3 years (Bhargava et al., 1963). In Kenya, pre-weaning deaths average 14% (Wilson, 1986). Because of the long calving intervals and high infant mortality, the maximum annual growth rate of a dromedary herd has been calculated at 8%. In some pastoral societies male young may be killed at birth to retain all of their mother's milk for human consumption. Males used for work purposes usually are castrated at 4–6 years of age (Dahl and Hjort, 1976).

Dromedaries are found only in areas with a long dry season and short rainy period; they are sensitive to cold and humidity (Wilson, 1984). Dromedaries primarily are browsers, with shrubs and forbs composing as much as 70% of their diet in winter and 90% in summer. They also graze, "sucking up" grass and succulents with a "vacuum cleaner like technique" (Newman, 1984:253). The 332 forage plants that have been recorded for the dromedary include *Aristida pungens*, *Acacia tortilis*, *Panicum turgidum*, *Launaea arborescens*, and *Balanites aegyptiaca* in the Sahara (Gauthier-Pilters, 1984). Feral dromedaries in Australia favor *Trichodesma zeylanicum* and *Euphorbia tannensis*; forage plants fed to dromedaries in India include *Vigna aconitifolia*, *V. mungo*, *Cyamopsis tetragonolaba*, *Melilotus parviflora*, *Eruca sativa*, *Trifolium* sp., and *Brassica campestris*. Regardless of area, *Acacia*, *Atriplex*, and *Salsola* are common in the diet (Newman, 1984).

Food intake in relation to body mass is low. About 5–10 kg of dry matter are sufficient to perform a day's work of carrying 120 kg over 30 km, but dromedaries can live on 2 kg of dry matter for limited periods. Under lush conditions they tend to eat beyond their immediate needs and store this in their hump (Gauthier-Pilters, 1984).

Dromedaries need about six to eight times as much salt as other animals and one-third of their food intake must be from halophytes, such as *Tragama nudatum*, *Atriplex halimus*, *Nucularia perrini*, and *Anabasis aretioides*. In the absence of this, 45–60 g of salt has to be substituted (Leese, 1927), as salt is imperative for alimentary absorption of water (Yagil, 1985) and salt deficiency leads to cutaneous necrosis and cramps (Peck, 1939).

Although even small amounts of grain may lead to indigestion

in animals not accustomed to it, the diet of working dromedaries must be supplemented with about 2 kg of grain/day (Leese, 1927). Dromedaries also can utilize a wide variety of agricultural feeds, by-products, and waste (Newman, 1984).

The most important parasitic disease is trypanosomiasis caused by *Trypanosoma evansi, T. brucei, T. congolense,* and *T. simiae*; it is transmitted by *Glossina* sp. and various Tabanidae. Manifested by weakness, recurrent fever, and anaemia, it usually ends in death. Other internal parasites include trematodes (*Fasciola gigantica*), cestodes (*Echinococcus polymorphous* and *Taenia marginata*), and nematodes (*Trichuris, Nematodirus, Strongyloides, Haemonchus,* and *Onchocerca*). Among external parasites, the mange mite *Sarcoptes* is of greatest economic importance. The flea *Vermipsylla alakurt* and ticks, such as *Rhipicephalus, Amblyomma,* and *Hyalomma,* cause physical irritations. Larvae of the camel nasal fly *Cephalopsis titillator* can cause brain compression, nervous disorders, and death. Other illnesses with an impact on dromedary productivity are: pyogenic diseases and wound infections with *Corynebacterium* and *Streptococcus*; pulmonary afflictions caused by *Pasteurella* (haemorrhagic septicaemia) and *Rickettsia*; camelpox caused by an oriole virus; anthrax, an infection with *Bacillus anthracis*; and cutaneous-skin necrosis caused by *Streptothrix* sp. and lack of salt in the diet (Curasson, 1947; Richard, 1984; Wilson, 1984).

As a means of communication and transport, dromedaries have played a significant role in human history. Their potential to provide milk and meat under extremely arid conditions has enabled humans to inhabit otherwise unexploitable deserts. Today, dromedary husbandry is increasingly recognized as an ecologically-sound method of producing protein-rich food in drought-stricken areas (Köhler, 1981).

The earliest tentative evidence for domestication of dromedaries comes from an archaeological site on a small island off the Abu Dhabi coast, where camel bones and two stelae depicting dromedaries dating to about 4,000 years ago were unearthed (Hoch, 1979). By about 3,100 years ago, northern Arabian tribes had adopted the dromedary as a riding animal and made use of it on raids. By about 2,900 years ago, dromedary caravans transported incense from southern Arabia to the Mediterranean Sea. Trade along the Silk Route started about 2,000 years ago. Although at first both dromedaries and Bactrian camels were employed, the Parthians soon started breeding hybrids that proved to be superior beasts of burden (Bulliet, 1975). Rockdrawings of dromedaries hunted by horsemen are known from the Arabian peninsula; dated to about 3,000 years ago, they provide the most recent evidence for wild dromedaries (Köhler, 1981).

Dromedaries can produce large quantities of milk under intensive and extensive management conditions. Their lactation period of 9–18 months enables pastoralists to subsist on milk practically all year. While the normal milk yield is about 3.5–4 kg/day, daily yields of up to 35 kg (or 7.8% of the body mass) and yearly yields of 12,775 l are reported from Pakistan (Knoess, 1984). Dromedary milk is white and froths when shaken. The specific gravity is 1.0305, the pH is 6.5–6.7, and it contains 70 cal/100 g (Shalash, 1984*a*). Four liters provide the caloric requirements of one adult and 1.8 l meets the protein needs (Dahl and Hjort, 1976).

Dromedaries are systematically exploited for milk in large dairy farms in the Soviet Union, especially Uzbekistan, Kazakhstan, and Turkmenistan, where they are kept in herds of 3,000–5,000 animals (Dahl and Hjort, 1976; Gauthier-Pilters and Dagg, 1981). Attempts at large-scale dromedary milk production also have been made in Pakistan (Knoess, 1984).

The acidity of dromedary milk stored at 30°C increases more slowly than that of *Bos taurus* milk with little change in taste. Converting milk into butter can be difficult, but is successfully practiced in the U.S.S.R. where the cream of milk with a fat content of 4.2% yielded 25.8% butter (Kuliev, 1959). Dromedary milk has been successfully coagulated through the use of bovine calf rennet (Ramet, 1987), and can be stored as curds (Shalash, 1984*a*). In India, dromedary milk is ascribed certain therapeutic effects and used to cure jaundice, spleen trouble, dropsy, tuberculosis, and asthma (Knoess, 1984).

Pastoralists themselves rarely eat dromedary meat and reserve slaughter for ritual occasions and food shortages. The main dromedary exporting countries are Sudan and Somalia. Sudan yearly exports about 60,000 dromedaries to Egypt, 10,000 to Libya, and an unidentified number to Saudi Arabia for slaughter (El-Amin, 1984). Dromedary meat resembles beef in taste, but contains less fat. The meat of dromedaries older than 5 years contained a mean of 76.2% water, 22.0% protein, 1.0% fat, and 0.9% ash. The mean carcass mass is 208.5 kg (141.0–310.0 kg). The dressing percentage is 55–70% (Shalash, 1984*b*).

Bleeding live dromedaries is common among some dromedary herders in East Africa, such as the Turkana, Rendille, Gabbra, and Sakuye Borana (Dahl and Hjort, 1976). The annual blood yield from one dromedary can be as much as 35 l (Schwartz, 1984).

Wool and skins are by-products. An annual yield of 3 kg of wool for younger animals and 2 kg for older animals is reported from Tunisia (Burgemeister, 1975), but dromedaries in the Sudan produce only 0.5–1 kg/year. Dromedary wool is used to make blankets, robes, and tents. Dromedary leather is used for sandals, whips, and saddlery (El-Amin, 1984).

Dromedaries are used as riding animals and beasts of burden and also for traction; they pull carts and ploughs, and provide power for oilmills and wells (Wilson, 1984). They played an important role in military history, and the Romans, British, and French had dromedary corps in Africa. In nomadic societies, dromedaries carry women and children during migration. Riding dromedaries travel at a speed of 65–80 km/day over a period of 2 weeks (Gillespie, 1962). Larger daily distances can be covered, up to about 144 km on 1 day or 224 km over 2 days, but dromedaries require adequate rest periods. In a dromedary race in Saudi-Arabia, the winner covered 22 km in 45 min (El-Amin, 1984). Pack dromedaries move at a pace of 2–3 km/h and usual loads are around 200 kg, but frequently 400 kg or more are transported over long distances. For ploughing, dromedaries are often harnessed together with oxen or donkeys, although one dromedary is supposed to be more efficient than a pair of oxen, able to plough 1 ha in 20 h (Wilson, 1984).

**BEHAVIOR.** Dromedaries that are allowed to roam without supervision form stable groups of 2–20 individuals (Gauthier-Pilters and Dagg, 1981). The basic social unit is the family group consisting of one male, one to several females, subadults, and young. Surplus males are solitary or form bachelor herds (Klingel, 1985). Of 28 herds studied in Algeria, 13 consisted of males, females, and young; six of males and females without young; five of females and young; and four of males only (Gauthier-Pilters and Dagg, 1981). In Turkmenistan, herds include one male and 10–15 females with young, or males only (Baskin, 1974). During studies in Australia, no spontaneous changes of group membership were recorded. Family groups tend to stay by themselves, but they may coalesce to larger groups when disturbed (Klingel, 1985). During droughts, herds of up to 500 were observed in Australia (McKnight, 1969). Dromedaries graze for 8–12 h/day and spend an equal amount of time ruminating. They spread out over large areas and, especially when vegetation is poor, split up into groups of one or two. In guarded herds they rest at night and feed during the day, lying down during the hottest hours of the day. Herds allowed to graze at night rest during daytime (Gauthier-Pilters, 1984).

The feral dromedaries in Australia are not territorial and do not monopolize a particular area or resource. Short-term home ranges are 50–150 km$^2$, and annual home ranges are estimated at several thousand km$^2$ (Klingel, 1985).

Dromedaries browse up to a height of 3.5 m. They grasp the food with their lips and chew each bite 40–50 times, occasionally changing from one side of the jaw to the other. If the food is thorny, the mouth is kept open while chewing. They either break off branches or strip off the leaves in one movement (Gauthier-Pilters and Dagg, 1981).

In the Sahara, dromedaries often remain without drinking water from October to April or May, existing solely on the water content of the forage (Gauthier-Pilters, 1984). In temperatures of 30–50°C, they can go for 10–15 days without water, and only during the hottest temperatures of the year do they need to drink every 4–7 days. They take in large quantities of water, drinking at a speed of 10–20 l/min. The maximum quantity drunk in one session was 130 l (Gauthier-Pilters and Dagg, 1981).

Except for rutting males, there is little aggressive behavior. Gauthier-Pilters and Dagg (1981) never observed any quarrels among females, or between females and males, and only rarely between castrated males. Dromedaries push each other with their whole body or with lowered head and neck; they might snap at each other without biting. They do not deliberately split, but they might vomit cud if hurt or excited (Gauthier-Pilters and Dagg, 1981).

Males in family herds prevent contacts of their females with bachelor males by standing or walking between them and drive them away, even outside the breeding season. In family groups, the male is dominant and directs his group from the rear, while the females take turns in leading (Klingel, 1985). Dromedaries have a natural tendency to walk single file, especially when approaching wells (Gauthier-Pilters and Dagg, 1981).

Rutting males threaten each other by making themselves as tall as possible, uttering low noises, and displaying a typical sequence of lowering, lifting, and bending their necks backwards. Other elements of threatening behavior are teeth grinding with excessive salivation, inflation of the dulaa, and rubbing the poll glands on the shoulders. When male dromedaries approach each other or females, they stop several meters apart, spread their hindlegs, urinate on their tails and then flap these onto their backs. Males eager to fight move in circles, frothing at the mouth, and hold the chin near the ground. Fighting males try to bring their opponent to the ground by biting at his legs and taking his head between their jaws. They attack each other either from the front or from the side. One serious fight was observed in which two males unbalanced each other and then interlocked their necks; if they had not been separated by humans they would have suffocated (Gauthier-Pilters and Dagg, 1981).

Dromedaries develop attachments to their home areas and to places they associate with certain experiences; they return there over long distances. A dromedary returned to a herder in Timbooktoo (Mali) over a distance of 1,400 km after it had been sold (Gauthier-Pilters and Dagg, 1981). Similar observations were made in Australia (Barker, 1964). Female dromedaries tend to return to the place where they first gave birth (Gauthier-Pilters, 1984) or last suckled their young (Baskin, 1974).

Dromedaries have no special locations for defecating and urinating, and do not assume any particular postures for these functions. No marking behavior was observed in free-ranging dromedaries in the Sahara (Gauthier-Pilters and Dagg, 1981), but male dromedaries in Israel mark areas with secretions of their poll glands (Yagil and Etzion, 1980).

The most frequent comfort movement is scratching parts of the body with the front or hind legs, or with the lower incisors. The legs often are rubbed against each other or on trees. Dromedaries also like to roll in sandy places and form lines waiting for their turns (Gauthier-Pilters, 1984).

Dromedaries pace naturally. They walk at a speed of about 5 km/h or 40 strides/min; while pacing they can cover 7–25 km/h. They gallop only under exceptional circumstances (Dagg, 1974).

When lying down, dromedaries select smooth places. They go down slowly, first falling onto their carpals, then bending their hind legs, and finally settling down on their front quarters. They reverse this sequence for rising. They are good swimmers (Lesley, 1929).

The signs of estrus include restlessness, bleating, vulval swelling, and vaginal-mucus discharge (Arthur et al., 1985). Rutting males sniff at the female's genitals or excretions and subsequently display flehmen. Occasionally, they bite the female on the hump or vulva, utter low noises, and protrude the dulaa, or rub the poll glands on their shoulders. Receptive females often spread their hind legs and present their genital regions while also urinating. On approach of a male, they rapidly move their tails up and down. During copulation, the female lies down in sternal recumbency. If she does not go down spontaneously, the male slides his nose along her head, neck, and back to her genital region and nuzzles his neck on her vulva; he might force her down with his neck, or bite her stifles. He mounts putting his frontlegs on either side of her shoulders, then sits on her with his sternum on her hump, while his hind legs are flexed and his stifles on the ground. Copulation lasts 7–35 min, averaging 11–15 min. The female ruminates during this time and might grunt or nibble at the male's neck, whereas the male often cries out, salivates, blows his dulaa (Gauthier-Pilters and Dagg, 1981) or gurgles (Abdel-Raouf and El-Naggar, 1964). Often, the rest of the herd forms a circle around the mating couple (Arthur et al., 1985).

Information on the duration of labor and delivery is not consistent; reported time spans vary from 302 (Sharma and Vyas, 1970) to 374 (Elias and Cohen, 1986) to 490 min (Musa, 1983) for the period between the first signs of discomfort and the expulsion of the allantochorionic sac. The first stage of labor is characterized by restlessness, frequent urination, and interruption of feeding. Some females lie on their sides and roll around. Signs of discomfort include moans and facial expressions of pain. In births observed by Elias and Cohen (1986), the cervix was completely dilated about 95 min after the first signs of discomfort, and straining occurred 2–3 times/min after the head had appeared in the birth canal. Expulsion lasts about 30 min during which the dromedary adopts a sitting position. The nose of the fetus appears before the front feet; the whole body is expelled almost as soon as the head appears. Birth is relatively easy because the fetus is well lubricated and streamlined (Arthur et al., 1985). Expulsion of the allantochorionic sac occurs after another 30–65 min. The mother noses and nibbles her young, but does not lick it (Gauthier-Pilters and Dagg, 1981).

**GENETICS.** The diploid number of chromosomes is 74. The autosomes consist of 5 pairs of small to medium-sized metacentrics and submetacentrics and 31 pairs of acrocentrics (Hsu and Benirschke, 1974). The X chromosome is the largest of the metacentric and submetacentric group. The karyotype is notably uniform, not only among *C. dromedarius* and *C. bactrianus*, but also among the Old World and New World Camelidae (Taylor et al., 1968).

For about 1,000 years, first-generation hybrids between dromedaries and Bactrian camels have been systematically bred in regions where they are sympatric (Turkmenistan, Iran, Afghanistan; Bulliet, 1975). These hybrids are characterized by either a long hump with a slight indentation or a small and a large hump, and exceed their parents in size and strength; they are excellent work and pack animals. Another useful hybrid is the cross between a first-generation hybrid female and a male Bactrian camel, and a subsequent cross between a female of this type and a male Bactrian camel. Other types of hybrids are either bad-tempered or runts (Kolpakov, 1935).

The well-documented data from Turkmenistan contradict frequent statements in the literature (for example, Gray, 1972) that hybrid males are sterile. They also suggest that there is no genetic barrier between Bactrian camels and dromedaries, or if one exists, it is partial at best (Köhler, 1981).

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