



FAUNA *of* AUSTRALIA

62. BOVIDAE

C. P. GROVES



Swamp Buffalo—*Bubalis bubalis* [CSIRO Wildlife & Ecology]



European Cattle—*Bos taurus* [CSIRO Wildlife & Ecology]



Goat—*Capra hircus* [CSIRO Wildlife & Ecology]

DEFINITION AND GENERAL DESCRIPTION

Within the Pecora, the family Bovidae is differentiated by the presence of unbranched bony horns except in females of some taxa and some specialised breeds. These are apophyseal in nature, permanent and covered by keratinised sheaths (Fig. 62.1). There is usually a single lacrymal orifice. The anterior groove on the cannon bone (representing fused metatarsals) is open along its whole length.

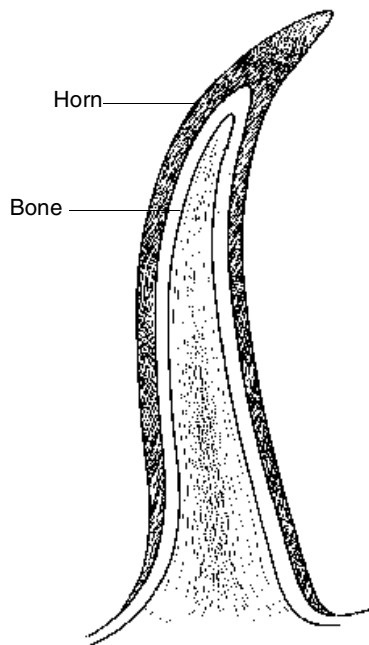


Figure 62.1 The internal structure of the bovid horn showing the lack of a junction as found in the Cervidae. (© ABRS) [M. Thompson]

HISTORY IN AUSTRALIA

The present feral populations are all descended from 19th Century escapees from domestic stock. European cattle (*Bos taurus*) have run wild, especially in Tasmania and the Riverina (New South Wales), with continual additions because of the free-ranging mode of its husbandry. The Zebu (*Bos indicus*) was brought to Australia by acclimatisation societies in the mid-19th Century; these species and their hybrids with European cattle are feral in the Northern Territory and Queensland. Bali Cattle (*Bos javanicus*) populations in Australia are derived from 20 individuals imported in 1849 to Victoria settlement, Northern Territory, from Bali (Calaby & Keith 1974). The Water Buffalo (*Bubalus bubalis*) was imported from Timor to Fort Dundas, Melville Island, Northern Territory, in 1826. In 1838, another import was made from Kissa Island, Indonesia, to Port Essington. The first import was of 16 animals, the second, 18 (Tulloch 1974). Sheep (*Ovis aries*) (Merino breed) were brought to Sydney district in 1779 from the Cape of Good Hope and subsequently supplemented by imports from Europe. Occasional escapes have not resulted in successful establishment of feral stocks except in a limited area. The Goat (*Capra hircus*) was introduced early in the 19th Century and herds supplemented in the mid-19th Century by Angora and Cashmere stock introduced by acclimatisation societies. Escapees established large feral populations; by 1869 there were some 60 000 Goats in Avoca Shire, Victoria, where they are still present. A large number also occur in Western Australia (Rolls 1969).

MORPHOLOGY AND PHYSIOLOGY

Details of basic anatomy and physiology of ruminants (Pecora) in general, and Bovidae in particular, are given by Frechkop (1955a).

External Characteristics

Members of the Bovidae are of varying build, from stocky and thickset to slender and gracile. The muzzle ends bluntly, with a naked moist rhinarium which, however, may be restricted to the rims of nostrils. The horns are set immediately behind prominent pointed-oval ears. The neck is distinct, held diagonally or horizontally in resting stance. The humerus and femur are enclosed in the body wall. The free portion of forelimb is divided almost evenly by the carpus, the hind limb by the tarsus (hock). The fore and hind limbs are not markedly unequal in length. A tail is present, varying in length and hairiness. Main hoofs are approximately symmetrical (cloven-hoofed). Size range in the Bovidae is considerable. In Australian examples, adults range from about 40 kg (Goats) to nearly one tonne (Cattle). Females are generally smaller than males, more lightly built and, where they occur, have horns that are more slender and generally more upright. At birth, the young are long-legged and shorter-bodied than adults and possess, at most, rudiments of horns which develop with age. The unbranched horns, enclosed in keratinous sheaths, and the robust build are externally diagnostic of Bovidae in Australia.

Body Wall

Skin thickness in Water Buffalo is 6 – 6.4 mm (female), 6.5 – 8 mm (male). It is thinner in most other Bovidae, but up to 8 – 9 mm in Devon cattle (*Bos taurus*). Hairs grow singly, each associated with one sweat gland and one sebaceous gland in Cattle and Water Buffalo. The hairs occur in groups of one coarse primary associated with several fine secondary hairs. In Goats and Sheep, there is less than one sweat and one sebaceous gland per hair. Water Buffalo have 10–14 hairs/mm², European cattle 28–32 and Zebu 39–41. The sebaceous glands are complex with a cluster of alveoli in Water Buffalo, but are simpler, with only two lobes, in Cattle. Sebum is white (Water Buffalo) or yellow (Cattle). The sweat glands are oval with a twisted duct in Water Buffalo, straight in Cattle.

Skeletal System

The pre-maxillae exist as separate elements and often suture with nasals as well as with the maxillae. The orbits are fully ringed with bone, which generally is tubular (Fig. 62.2). The lacrymal orifice is nearly always single and located inside the orbit. Horns emerge above and behind the orbits, on the frontal bones. The interfrontal suture is patent. An interparietal bone is present. The post-cornal part of the cranium is shortened in Cattle and Water Buffalo and is always flexed downwards. Tympanic bullae are well developed and prolonged into a tubular auditory meatus. The dental formula is I 0/3 C 0/1 PM 3/3 M 3/3. The deciduous dentition is identical, except that true molars are absent. There are seven cervical and 13 thoracic vertebrae. In Cattle and Water Buffalo, six lumbar vertebrae are present, but Goats have seven and Sheep have six or seven. Sacral vertebrae number five in Cattle and Water Buffalo or four in Sheep and Goats. Caudal vertebrae number 18 to 20 in Cattle and Water Buffalo, 16 to 18 in Sheep or 12 in Goats. The spines of the posterior cervicals and anterior thoracics are elongated, considerably so in Cattle; their tips are slightly bifid in Zebu.

Clavicles are absent. The scapulae are long, oblong in shape with prominent cartilaginous dorsal margins (the suprascapulae). The ulna is fused with the radius and the fibula with the tibia. The navicular is fused to the cuboid in the

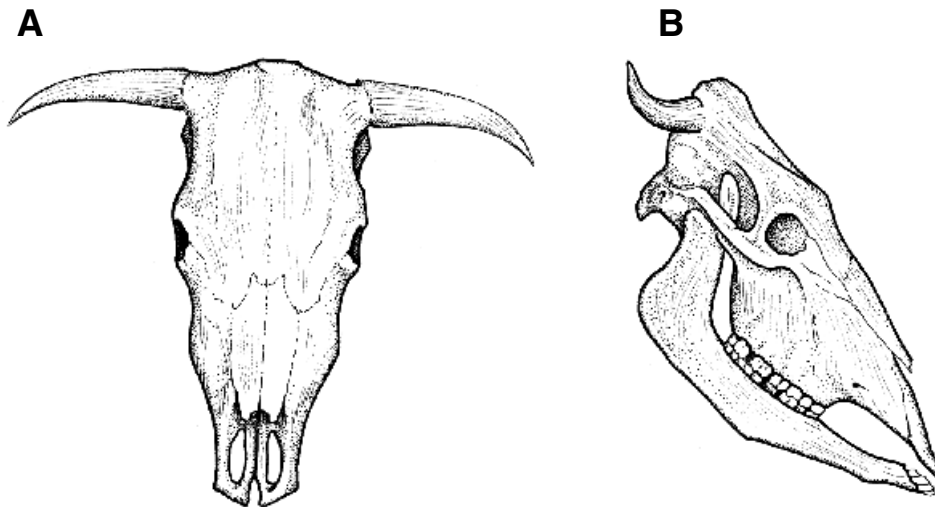


Figure 62.2 The skull of a cow, *Bos taurus*. **A**, dorsal view; **B**, lateral view. (© ABRS) [M. Thompson]

tarsus. Metapodials III and IV are fused along the midline, leaving a groove open to the distal end (compare with Cervidae); II and V are rudimentary. Phalanges III and IV are shortened, the proximal and medial ones stout and block-like, the distal ones conical and more backwardly extended than in the Cervidae (Leinders 1979). The phalanges are enclosed in hoofs; in the case of the rudimentary phalanges of II and V, the distal ones are encased in small hoofs.

Locomotion

Bovids walk primarily in diagonal couplets. They also trot and larger forms can canter. The central pair of digits (III and IV) on each foot are weight-bearing; laterals (II and V) are posterior in position and do not touch the ground except on soft substrata.

Feeding and Digestive System

Food is cropped between the mandibular incisor-canine row and a hard pre-maxillary pad. Different genera are predominantly browsers (Goats) or grazers (Cattle, Water Buffalo, Sheep). Grazers may crop directly, close to the ground through a midline cleft in the upper lip (Sheep), or after grass has been pulled into the mouth by the tongue (Cattle, Water Buffalo). The cheek teeth are hypsodont and selenodont, the axis upwardly concave. The mandible is narrower than the maxilla, so that the cheek teeth occlude on only one side at a time. Chewing is by lateral strokes, about half a dozen alternately on either side. The mandibular condyles are elevated well above the toothrow and are expanded transversely.

The stomach, as in all Pecora, is divided into four compartments (Fig. 62.3). (1) The rumen comprises 80% of the total stomach capacity and lies transverse to the body axis. It is divided into sacs which have a ventrally papillated, non-glandular lining. The rumen contains bacteria and ciliates which ferment cellulose into short-chain fatty acids with emission of hydrogen and water. These fatty acids (acetic, lactic, etc.) are absorbed through the rumen wall. (2) The reticulum accounts for 5 – 7 % of total stomach capacity and is spherical in shape. Its lining is divided into polygonal, honeycomb-like alveoli, each containing papillae. A channel, the reticular groove, runs along the superior lining. When its marginal folds close, this groove acts as a conduit for liquid ingesta not in need of fermentation. (3) The psalterium or omasum is elongated

in shape, its lining deeply folded longitudinally and studded with short, blunt papillae which grind hard ingesta. This compartment accounts for 7– 8% (Cattle, Water Buffalo) or only 3% (Sheep, Goats) of total stomach capacity. (4) The abomasum is elongated and plicated and is the site for acidic digestion. It represents 7 – 8% (Cattle) or 12.5% (Sheep) of total capacity.

The oesophagus enters at the rumen-reticulum junction. The tongue has filiform, fungiform and vallate, but no foliate, papillae. Ingesta are forced, by a contraction of the reticulum, into the rumen, which then contracts at two to three times per minute, mixing the ingesta. Rumen activity is stimulated by hypoglycaemia. After rapid food ingestion is completed, successive boli are regurgitated from the rumen to be masticated at leisure (55 jaw movements per minute, compared with 78 to 94 during eating). About 4 – 9 hours (Cattle) or 8 – 10 hours (Sheep) per day are spent ruminating, over 15 or more separate periods. A bolus cycle takes 1 minute.

The lengths of the small intestine, colon and caecum in Cattle and Sheep are 29 – 49 m and 18 – 35 m; 10.5 m and 4.5 m; and 0.75 m and 0.25 m respectively.

Cattle graze eight times per day with a maximum intake of about 70 kg when grass is 100 – 120 mm high. The intake is only 30 kg when grass is 250 mm high because of sparser density of edible tips. Sheep graze 9 – 11 kg per day, in four to seven periods.

Circulatory System

The bovid heart comprises 0.3 – 0.5% of body weight. Blood haemoglobin concentration is affected by climate: for example, in Cattle it is 10.4 g / 100 ml in dry conditions and 9.8 / 100 ml in wet. Comparable figures for Water Buffalo are 12.3 and 10.8, respectively. Body temperature is affected by age and fluctuates over a 24 hour period. In Goats, it is 37.3 – 37.8°C in early morning, rising to 39.3 – 39.8°C at about 1600 hours (Quartermain & Broadbent 1974). Body temperature in Water Buffalo and Sheep rises less than 1°, but Water Buffalo need cooling by bathing or wallowing. Normal temperature of Cattle is 38.6°C and for Water Buffalo, 38.0°C (Mason 1984). Temperature is controlled primarily by sweating in Cattle and Water Buffalo, but by panting in Goats and Sheep (especially the former).

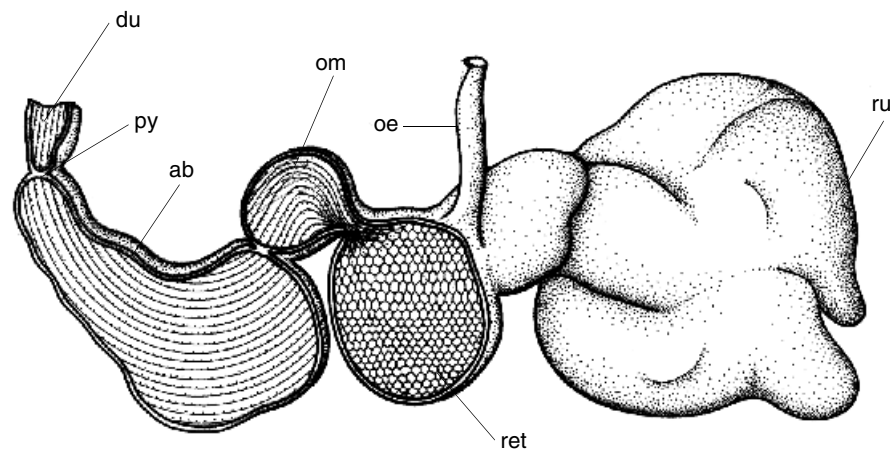


Figure 62.3 The stomach of a Sheep showing the internal structure. oe = oesophagus; ru = rumen; ret = reticulum; om = omasum; ab = abomasum; py = pylorus; du = duodenum. (© ABRS) [S. Collin]

Respiration

The larynx lacks a sacculus or middle or lateral ventricles. The right lung has four to five lobes and is some 1.5 times larger in size than the left, which has three lobes.

Excretion

The kidneys are either lobulated (Cattle, Water Buffalo) or smooth (Sheep, Goats). The right kidney weighs 700 g, the left 750 in Cattle; each weighs 100 – 150 g in Sheep. A renal pelvis is absent in Cattle though present in Sheep.

Sense Organs and Nervous System

The nostrils are subterminal on the muzzle. The rhinarium is either confined to the nasal rims as in Sheep and Goats or is large, extending back onto the dorsum nasi in Cattle and even more so in Water Buffalo. Jacobson's (vomeronasal) organ is well developed. The eyes are prominent, laterally placed high on the head, with a horizontally elongated pupil. The prominent ears are mobile. There are five pairs of endoturbinates in the nasal cavity. Brain weight represents less than 1% of body weight. There is little, simple patterned fissuration. The pons is small and the medulla short and wide. The olfactory bulbs are small in Cattle, though larger in Sheep.

Exocrine and Endocrine Systems

Sweat glands are well developed, especially in Water Buffalo. Invaginated glands are found between the main hoofs in Goats (where they are small) and Sheep. They also occur in front of the eye and behind the horn in Sheep and under the tail in Goats. Such glands are absent in Cattle or Water Buffalo.

Reproduction

Mammæ are inguinal and two pairs are usually present (but only one pair, well-developed and functional, occurs in Sheep and Goats). Bovids are polyoestrous; most Goats, Sheep and Water Buffalo follow a seasonal cycle, though Cattle is weakly or non-seasonal. Dioestrus lasts about 3 weeks in Cattle, Water Buffalo and Goats and 17 days in Sheep. Oestrus usually lasts about 18 hours (up to 36 hours in Sheep, 48 hours in Bali Cattle and 72 hours in Goats). Ovulation occurs 10 – 15 hours after the end of oestrus in Cattle and Zebu, but closer to the end of oestrus in other species. Oestrus occurs 3 – 4 weeks post-partum.

The penis is S-shaped when flaccid, with a high ratio of connective to cavernous tissue; erection consists mainly in straightening out the flexure. The scrotum is elongated, with a constriction at the base in Cattle. In Sheep and Goats, it is shorter; it is shorter and unconstricted in Water Buffalo. Testis weight is 250 – 500 g in Cattle and only 80 g in Water Buffalo (Bhattacharya 1974). The sperm are simple in shape with blunt-oval acrosomes. Ejaculate volume is 1 ml in Sheep, 1.8 in Water Buffalo and 3.9 in Cattle.

The vagina is about 250 mm long and 60 mm wide in Cattle and Water Buffalo; the cervix is more than 100 mm long in Cattle (Bhattacharya 1974).

Embryology and Development

Gestation lasts about 150 days in Sheep and Goats, 270 days in Cattle and Zebu, 286 days in Bali Cattle and 320 days in Water Buffalo.

The placenta is syndesmochorial and polycotyledonous, with more numerous cotyledons than in the Cervidae. The uterine endometrium is caruncular and the cervical mucosa is arranged in annular folds. Implantation occurs after 16 days in Sheep and 35 days in Cattle. Birth weights, male/female, are as follows: Bali Cattle 16 – 17 kg/14 – 15 kg; Cattle 33/29 kg; and Water Buffalo 28/23 kg. Neonatal Cattle and Water Buffalo follow the mother, but Sheep and Goat neonates are ‘hiders’, left lying inconspicuously while the mother grazes. Twin births are rare in Cattle and Water Buffalo, but usual in Goats and Sheep.

Milk contains 4 – 5% fat, 3.5% protein and 4.7% lactose, on average, in Cattle and Goats. The corresponding figures are 10.4, 6.8, 3.7% for Sheep and 7.6, 4.0, 4.8% for Water Buffalo. Suckling is prolonged in Cattle and Water Buffalo, but restricted to short periods in Goats (14 seconds at a time) and Sheep (25 seconds at a time in first week, dropping to 14 in second).

Infants graze from the first week after birth, weaning at 4 – 5 months in Sheep and 9 months in Cattle. Deciduous dentition begins to erupt at birth or within 2 weeks in Cattle. In Water Buffalo, it occurs at 1 – 3 weeks and from birth to 6 weeks in Sheep. In Sheep, the lower incisors erupt well before the other teeth. In Cattle, permanent molars erupt at 5 – 6 months, canines at 3.5 – 4 years; in Water Buffalo at 15 months and seven years, respectively (Cockrill 1974); in Sheep and Goats three to five months and 3.5 – 4 years, respectively.

Sexual maturity varies with nutrition. In Cattle, females mature at anything from 37 – 72 weeks, when they are two-thirds of adult height and length. Bali Cattle mature after about 13 months and Water Buffalo not until 2 – 3 years. Goats attain sexual maturity in 4 – 12 months, but always in the first season. Sexual maturity occurs later in males than females.

NATURAL HISTORY

Life History

The sex ratio at birth is 104 males per 100 females in Cattle, 135:100 in Bali Cattle and 144:100 in Water Buffalo. In Water Buffalo, at least, there is excess female foetal (over male) mortality, with normal mid-term fetuses having a ratio of 63:100 (Bhattacharya 1974). Adult sex ratio is about 50 and 40 males per 100 females in Cattle and Water Buffalo, respectively.

Heaviest mortality of young occurs in their first 6 months; up to 50% of feral Goats die in this period compared with 33% intrauterine deaths. Mortality then declines until the cohort terminates at about 20 years of age in Cattle and Water Buffalo or 10 years of age in Goats and Sheep. Exact data on longevity and mortality in the wild are lacking. True wild bovids show different patterns of age-specific mortality; for example, for Sheep see Geist (1971) and Schaller (1977).

In feral Water Buffalo, the major cause of mortality is failure of the food supply, especially as the result of burning or overgrazing (Tulloch 1974). They also suffer death from disease, some predation and from getting inextricably bogged. Feral Goats encounter predation by dingoes. In arid areas, Goats appear to breed year-round, but in temperate areas, mating is restricted to the first 6 months of the year with a peak in February. The mating season of feral Water Buffalo lasts for 8 months with a peak in March.

Ecology

Sheep favour grassy areas, grazing mainly on forbs. Goats prefer areas of low woody vegetation throughout Australia.

Water Buffalo live in monsoon country, predominantly on flood plains. Their home range may change with season; and is restricted to rivers and swamps in the dry season, since most of the heat of the day must be passed wallowing or bathing. The home ranges of cow groups are marked by tracks between wallows, rubbing trees, feeding grounds, drinking points and defecation areas (Tulloch 1974). Bulls generally live in loose aggregations in less favourable country than the cow herds.

Bali Cattle live in monsoon forest. They rest by day, but by night and during cool periods emerge to graze in open areas. They favour Common Sedge, *Fimbricystis cymosa*, and also browse (Calaby & Keith 1974). At times, they graze seaweed and are capable of drinking water of high salinity (Popenoe 1983).

Behaviour

Bali Cattle form both mixed herds, of nine to 60 or so, and bull groups of two to nine; older bulls are more often solitary. Other behaviour is poorly known. Temperament is alert and nervous; they are easily stressed.

Cattle have a similar but more cohesive social organisation, usually with only one bull per cow group. Cows have a consistent rank order and the leading cow is not the dominant one (who travels in the centre of the herd). Much mutual grooming occurs among cows in the herd. The members of a grazing herd tend to stand and move forward all in a similar direction, but while resting, their body axes are randomly oriented. Each one grazes in a 60 to 90° arc, so that it mows a path of twice its body width. Individuals travel some 4 km per day when grazing in good pasture. In oestrus, a cow is tended by a bull, who follows her closely and mounts frequently. He throws dust over his back and chases away young bulls and non-oestrous cows. As a preliminary to mounting, the bull will rest his chin on the cow's rump, causing her to stand still.

Water buffalo have individual home ranges, but cow herds share wallows. Wallows are marked with dung and urine. Mating resembles that seen in Cattle, but with a harem system rather than tending behaviour. Mother-infant behaviour is noteworthy for 'baby-sitting': one cow, replaced at intervals, remains with all the calves while the other cows feed.

Sheep flocks are very cohesive, but there is no allo-grooming as in Cattle. In the mating season, the male (ram) sniffs the females' urine and performs Flehmen (a facial gesture in which the upper lip is curled upward, the animal standing motionless 'tasting' the olfactory sensation). He then follows the female (ewe), makes rhythmic tongue movements, noses her genitalia and rubs along her sides with bites and leg-kicks.

Goats have a less cohesive grouping than Sheep and there are many small differences in grooming movements (leg-scratch) and resting posture (foreleg extended). The flock is alerted to danger by a sentinel thumping the forefeet on the ground, as in Sheep, but the flock tends to scatter rather than bunch when fleeing. During rut, the male (billy) continually raises his tail to dissipate anal gland secretion and mouths his penis, even spraying urine into his mouth. Oestrus is much more obvious than in Sheep. On approach of the male, the female (nanny) bleats, waves her tail and urinates. Unlike Sheep, several males in succession may mount an oestrus female.

Economic Significance

Cattle and Sheep are the traditional domesticates of northern Europe and so of Australia. Feral individuals are not utilised as such, but, if disease-free, are reincorporated into the domestic gene-pool or dispatched. Zebu are more suited

to hot, dry conditions than Cattle and its hybrids with the latter (for example, 'Droughtmasters') are now the mainstay of the Cattle industry in northern Australia.

Bali Cattle could play a greater part for the economy of the Northern Territory than they have hitherto. Though growth is slower and the species is comparatively small in size, it has a much greater fertility than other Cattle (80 – 90% conception rate as compared with only 50 – 60% in both other species), perhaps because of much longer oestrus. Bali Cattle also utilise low quality feeds and lose less condition during lactation. They are less subject to ectoparasite infection and less debilitated by liver flukes and intestinal worms (Popenoe 1983).

Water buffalo are Australia's only 'big-game' species and licensed hunting contributes to the revenue of the Northern Territory. Their environmental impact, however, is considered wholly detrimental (for example, erosion, draining of wetlands by making channels), so that their future role in the economy is considered more likely to be as a domesticate. In this respect, they are likely to become the mainstay of the pastoral industry of the Australian wet/dry tropics due to their adaptation, both morphologically (body build, hoof form) and physiologically (tolerance for humidity) to the prevailing monsoonal conditions. They have a feed conversion equal to that of Cattle (seven to eight Food Units per kg gain) and gain weight at twice the rate of those Cattle breeds tested as controls (Ognjanovic 1974). Muscle is 36% of empty live-weight, compared with 33% for Cattle. After the failure of the buffalo hide industry in 1955, the establishment of a buffalo meat industry in 1959 earned over \$500 000 by 1964/5, 1 million dollars by 1972 and in the late 1980s is worth over 7 million dollars.

Feral Goats (Fig. 62.4) are generalist herbivores capable of surviving in a wide range of environments. Although limited by vegetation type, availability of water, predators such as dingoes and dogs, and perhaps diseases and parasites in wetter areas (Parkes, Henzell & Pickells 1996), they are widely distributed over much of Australia. Estimated numbers are considerable, at 2.6 million, and evidence suggests that goats are competing significantly with native species and degrading ecological communities, with consequent soil erosion.

BIOGEOGRAPHY AND PHYLOGENY

Distribution

Feral Cattle and Zebu (and their hybrids) exist in small numbers throughout the continent. Ownership, in fact, is claimed over many of the herds. Bali Cattle are restricted to the Cobourg Peninsula, Northern Territory. Their range has never extended beyond the peninsula since their feralisation after the abandonment of Port Essington in 1849. Water buffalo live in the northern (monsoonal) part of the Northern Territory, mainly between 11 to 14°S and 130 to 134°E (Tulloch 1974).

Goats live in the feral state over much of the continent, except in extremely arid areas and in rainforest (see Holst *et al.* 1982). There are a few feral Sheep in the Snowy Mountains and a small population in Western Australia (East Kimberley: Rudge 1984). Genuinely wild representatives of these taxa do not occur in Australia.

On the recommendation of Corbet & Clutton-Brock (1984), different specific names are employed for wild and feral domestic representatives of what are in most respects the same species. The ancestor of Cattle was *Bos primigenius*, which survived in Poland until 1627. Zebu was probably descended from the

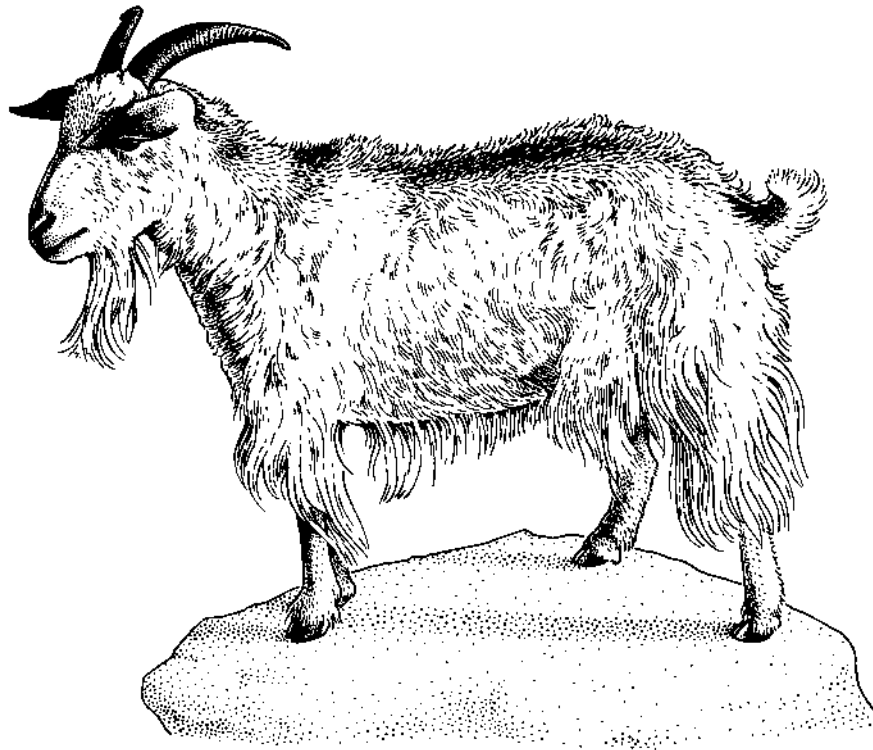


Figure 62.4. Feral goats are responsible for a range of impacts on native fauna and flora. Under the Endangered species Protection Act of 1992, the Commonwealth promotes the recovery and conservation of native species and ecological communities. Threat abatement plans are a key mechanism in this process. The plan for feral goats (Environment Australia 1999d) may be viewed at http://www.biodiversity.environment.gov.au/plants/threaten/plans/threat_abatement_plans/land_degradation_by_feral_goats/index.htm.
(© Environment Australia). [K. McInnes]

now extinct *Bos namadicus* of India (Grigson 1980). Bali Cattle live wild in Java, Borneo and the south-eastern Asian mainland. The domestic form, of which the Australian population is a feral derivative, is derived from the Javanese Bali Cattle. Wild Goats, *Capra aegagrus*, range from Turkey to Pakistan. Wild Sheep extend from Turkey through Central Asia to western North America, but the ancestor of *Ovis aries* is *Ovis orientalis* of Turkey, Iraq and north-western Iran.

Affinities with other Groups

The family Bovidae belongs to the suborder Pecora, the ruminants, along with the Cervidae (deer), Giraffidae (giraffes), Antilocapridae (prongbuck), Moschidae (musk-deer) and Tragulidae (mouse-deer). There is controversy over the interrelationships of these six families (Leinders 1979). Other suborders of Artiodactyla are Tylopoda (camels) and Suiformes (pigs and hippopotamuses).

Affinities within the Bovidae

Cattle and Water Buffalo belong to tribe Bovini with Sheep and Goats are assigned to the tribe Caprini. Both tribes contain additional genera (see below). Almost all other Bovidae are loosely referred to as antelopes, but some (for example, the Chamois, *Rupicapra*) are close to Caprini, some (for example, the Eland, *Taurotragus*) to the Bovini. Others are difficult to relate to either group. There is consequent dispute over how the various tribes of Bovidae should be allocated to subfamilies and how many subfamilies there should be.

Fossil Record

The earliest Bovidae are Early Miocene in age and differentiation of the Bovini and Caprini probably occurred shortly thereafter. There is, of course, no fossil record of Bovidae in Australia.

CLASSIFICATION

A provisional classification of Bovidae follows:

Subfamily Bovinae

Tribe Bovini

Bos (includes several non-Australian species; for example, Bison)

Bubalus (includes three south-east Asian wild species)

Syncerus (African Buffalo)

Tribe Tragelaphini

Taurotragus (Eland); *Tragelaphus* (Kudu, Bushbuck)

Tribe Boselaphini

Boselaphus (Nilgai); *Tetracerus* (Four-horned Antelope)

Subfamilies Cephalophinae, Alcelaphinae, Antilopinae, Hippotraginae, Reduncinae: all 'antelopes'

Subfamily Caprinae

Tribe Caprini

Capra (includes several non-Australian species)

Hemitragus (Tahr, introduced to New Zealand)

Ammotragus (Barbary Sheep, North Africa)

Pseudois (Blue Sheep, Central Asia)

Ovis

Tribe Rupicaprini (Chamois group)

Tribe Ovibovini (Musk-ox, North America)

KEY TO AUSTRALIAN TAXA

- 1 Parietals descend steeply behind horns, making a right angle between their dorsal plane and that of frontals; molars broader, with an accessory pillar on lingual surface between the convexities of the two crescents; lacking specialised cutaneous glands; with broad, extensive rhinarium; tail rounded in section, tufted at tip; four functional mammae Subfamily Bovinae (tribe Bovini) 2
 Parietals long, their dorsal plane forming an obtuse angle with that of frontals; molars narrow with no accessory pillar; possessing specialised cutaneous gland between hoofs and elsewhere; rhinarium restricted to rims of nostrils; tail untufted; two functional mammae Subfamily Caprinae (tribe Caprini) 3
- 2 Skull elongated, raising postorbital foramina and horn bases high above orbits; horns oval in cross-section; neck long, with dewlap; head carried diagonally; hoofs relatively small; scrotum long, pendulous *Bos*
 Skull not elongated, postorbital foramina immediately caudal to orbits; horns triangular in cross-section; neck short with no dewlap; head carried horizontally; hoofs enormous, crescentic; scrotum short, sessile ... *Bubalus*
- 3 Nasals narrowed anteriorly, convex; lacrymals with fossae; lacrymal orifice within orbit; premaxillae usually fail to contact nasals; atlas broadened anteriorly; metapodials relatively slender; tail rounded in section, haired dorsally and ventrally; inguinal, interdigital and preorbital glands well developed *Ovis*

Nasals parallel-sided throughout their length, not convex; no lacrymal fossae; lacrymal orifice on margin of orbit; premaxillae in contact with nasals; atlas broader posteriorly than anteriorly; metapodials more robust; tail short, triangular, flat, naked on underside; interdigital glands small; inguinal and preorbital glands reduced or absent; a pair of subcaudal glands present *Capra*

LITERATURE CITED

- Bhattacharya, P. (1974). Reproduction. Pp. 105-158 in Cockrill, W.R. (ed.) *The Husbandry and Health of the Domestic Buffalo*. FAO Publications : Rome
- Calaby, J.H. & Keith, K. (1974). Mammals. Pp. 179-208 in Frith, H.J. & Calaby, J.H. (eds) *Fauna Survey of the Port Essington District, Cobourg Peninsula, Northern Territory of Australia*. Division of Wildlife Research Technical Paper No.28. . CSIRO Publications : Canberra
- Cockrill, W.R. (1974). Management, conservation and use. Pp. 276-312 in Cockrill, W.R. (ed.) *The Husbandry and Health of the Domestic Buffalo*. FAO Publications : Rome
- Corbet, G.B. & Clutton-Brock, J. (1984). Taxonomy and nomenclature. Pp. 435-438 in Mason, I.L. (ed.) *Evolution of Domesticated Animals*. Longman : London
- Environment Australia (1999d). Threat abatement plan for competition and land degradation by feral goats. National Feral Animal Control Program, Biodiversity Group, Environment Australia : Canberra iv 39 pp.
- Frechkop, S. (1955a). Order des Artiodactyla, Sous-order des Selenodontia, Famille des Bovidae. Pp. 630-1004 in Grassé, P.-P. (ed.) *Traité de Zoologie* Tome XVII Fascicle 1. Masson et Cie : Paris
- Geist, V. (1971). *Mountain Sheep*. University of Chicago Press : Chicago xv 425 pp.
- Grigson, C. (1980). The craniology and relationships of four species of *Bos*. 5. *Bos indicus* L. *Journal of Archaeological Science* 7: 3-32
- Holst, P.J., Harrington, G.N., Turner, H.N., Clarke, W.T. & Smith, I.D. (1982). The feral goat. Pp. 3-75 in Harrington, G.N. (ed.) *Goats for Meat and Fibre in Australia*. Standing Committee for Agriculture in Australia Technical Report Series No. 11
- Leinders, J.J.M. (1979). On the osteology and function of the digits of some ruminants and their bearing on taxonomy. *Zeitschrift für Säugetierkunde* 44: 305-318
- Mason, I.L. (1984). Goat. pp 85-99 in Mason, I.L. (ed.) *Evolution of Domesticated Animals*. Longman : London
- Ognjanovic, A. (1974). Meat and meat production. Pp. 377-400 in Cockrill, W.R. (ed.) *The Husbandry and Health of the Domestic Buffalo*. FAO Publications : Rome
- Parkes, J., Henzell, R. & Pickles, G. (1996). *Managing Vertebrate Pests: Feral Goats*. Australian Government Publishing Service : Canberra 129 pp.
- Popenoe, H. (1983). *Little-known Asian Animals with a Promising Economic Future*. National Academy Press : Washington, D.C. xiv 131 pp.
- Quartermain, A.R. & Broadbent, M.P. (1974). Some patterns of response to climate by the Zambian goat. *East African Agricultural and Forestry Journal* 40 : 115-124
- Rolls, E. (1969). *They All Ran Wild. The Story of Pests on the Land in Australia..* Angus & Robertson : Sydney 444 pp.

- Rudge, M.R. (1984). The occurrence and status of populations of feral goats and sheep throughout the world. Pp. 55-84 in Munton, P.N. (ed.) *Feral Mammals — Problems and Potential*. IUCN : Morges
- Schaller, G.B. (1977). *Mountain Monarchs*. University of Chicago Press : Chicago xviii 425 pp.
- Tulloch, D.G. (1974). Australia. Pp. 493-505 in Cockrill, W.R. (ed.) *The Husbandry and Health of the Domestic Buffalo*. Rome : FAO Publications