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Bubalus mindorensis.

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Bubalus mindorensis Heude, 1888

Tamaraw

Bubalus mindorensis Heude, 1888:4, 50. Type locality "Mindoro," Philippines.

Anoa mindorensis Steere (*in* Sclater, 1889:364). Type locality above Calapan, Catuiran River, Mindoro, Philippines. Type specimen designated by Hooper (1941).

CONTEXT AND CONTENT. Order Artiodactyla, Superfamily Bovoidea, Family Bovidae, Subfamily Bovinae. The genus *Bubalus* includes two subgenera, *Anoa* and *Bubalus*. The subgenus *Anoa* includes the two species on the island of Sulawesi, the lowland anoa (*Anoa depressicornis*) and the mountain anoa (*Anoa quarlesi*). The subgenus *Bubalus* includes the Asiatic water buffalo (*Bubalus bubalis*), and the Mindoro buffalo or tamaraw (*Bubalus mindorensis*—Groves, 1969; Grubb, 1993). There are no subspecies recognized. Heude (1888) and Steere (1889) described the species independently, coincidentally giving it the same specific name.

DIAGNOSIS. The tamaraw superficially resembles the anoas because of the whitish markings on its face, neck, and legs (Fig. 1), but is larger than either species of *Anoa*. It is recognized as a member of subgenus *Bubalus* largely because of the shape of the horns, which are short and thick with an outward initial direction (Fig. 1), as opposed to the closely approximated and backwardly directed horns of anoas; molars that are short and high with square crowns (Fig. 2); broad ribs; forwardly directed hair on the anterior part of the back; and comparatively small ears. *B. mindorensis* differs from the Asiatic water buffalo (*B. bubalis*) by being smaller and more robust. Compared with *B. bubalis*, *B. mindorensis* has short, stocky limbs, has more hair on its body, and is dark brown to grayish black in color instead of pale gray (Fig. 1). Its horns are stout and short and grow in a "V" form instead of a wide "C" as in the water buffalo, with the base in a roughly triangular form as opposed to the rectangular form in domestic water buffalos. In comparison with the water buffalo, the adult tamaraw has a reduced parietal bone and a narrow occipital bone (Alcasid, 1977; Groves, 1969; Hollister, 1911; Popenoe, 1983).

GENERAL CHARACTERS. *Bubalus mindorensis* is a small buffalo; females have been estimated to weigh approximately 300 kg (Talbot and Talbot, 1966) and 180–220 kg (Roth and Montemayor-Taca, 1971). The dental formula is: i 0/3, c 0/1, p 3/3, m 3/3, total 32 (Rabor, 1986). Measurements (in cm) of the lectotype of *Anoa mindorensis* Steere are as follows: length of head and body, 220; length of tail, 60; length of hind foot from hock to distal hoof tip, 44.5; height at shoulder, 94.5; height at hindquarters, 98.3; girth behind shoulders, 165.5; and approximate length of ear from notch, 13.5. Skull measurements (in mm) are: greatest length of skull, 380; basal length, 354; palatal length, 237; breadth across zygomata, 162; breadth across mastoids, 185; distance from anterior border of orbit to tip of rostrum, 202; width of skull across lateral alveolar border of M2, 108; alveolar length of upper cheek-teeth, 101; and alveolar length of lower cheek-teeth, 114. Horn measurements (in mm) are: circumference of base of left horn, 335; length of left horn on outside curve, 420; and distance between tips of horn cores, 271 (Hooper, 1941).

Comparison of a single adult female and single adult male (Heller, 1889; Jentink, 1894) revealed that in the female the horn cores are inclined backwards with respect to the frontal bones; frontal bones are concave in the female and convex in the male; and nasal bones measure 155 mm in the female and 144 mm in the male. The bony palate ends at the last molars in the male, but extends beyond that in the female; the vomer is more prominent and twice as large in the female as in the male; and posterior palatine foramina are located more posteriorly in the female than in the male. In the female, coronoid processes are more curved, and incisors are more anteriorly inclined. In addition, bulls have a thicker neck than cows (Steere, 1890).

In bulls, the triangular horns tend to be longer, thicker, more flattened, and closer together at the base than in cows, and thus may be used for determining the sex of skulls (Kuehn, 1976; Steere, 1889). The horns are directed downward and straight backward, turning slightly toward each other at the tips (Fig. 1). They are short (35.5, 38, 40, and 43 cm—Sclater, 1889; Steere, 1891; Taylor, 1934) and stout with deep, irregular, transverse grooves and pits on the anterior, lateral, and posterior surfaces; the inner surface is very rough. Horns are black in color (Lydekker, 1898; Rabor, 1977, 1986; Steere, 1889; Taylor, 1934).

The vertebral column consists of 13 T (which have spinous processes with enlarged tips that diminish in size towards the lumbar vertebrae), 7 C, 6 L, 5 S, and 18 or 19 Ca, total 49–50. Ribs are attached to all thoracic vertebrae, and in the female, the first lumbar vertebra has a movable, well-developed rib on the left side. The ribs are broad, measuring 55 mm at the widest portion. The sternum consists of seven bones ending in a sickle-shaped xiphisternum (Jentink, 1894). Limb proportions relative to metacarpal length are: humerus 1.9, radius 1.8, femur 2.3, tibia 2.1, and metatarsal 1.2. The metacarpal is 45.8 mm in length, metatarsal 32.0 mm, and humerus 253.5 mm. Body size and limb proportions in adults are not sexually dimorphic (Heller, 1889). The skeleton has been described in detail by Sumulong (1931).

Pelage of adult tamaraws is dark brown to grayish black in both sexes. A gray-white stripe runs from the inner corner of the eye toward (but does not reach) the base of the horn. Gray-white or white patches are found above the hooves, on the insides of the lower forelegs, on each side of the lower jaw and lip, and on the throat and inner surfaces of the ears. The skin and hair of the groin are white, and the bare skin of the nose and lips is black (Lydekker, 1898; Steere, 1889, 1890). At birth, calves are reddish-brown, becoming brown in a few weeks, turning slate-colored in about 3 years, and finally attaining adult coloration in about 5 years (Kuehn, 1976).

The hair is short and dense with hairs on the dorsum somewhat longer and more closely set. Like domestic water buffalos, the hair of tamaraws is directed forward from the neck to the hind-

FIG. 1. Photograph of a female tamaraw, taken in 1992 at the tamaraw captive breeding center in Mt. Iglit-Baco National Park, Mindoro by V. G. Momongan.

quarters instead of backward (toward the tail). Hairs in posterior parts are directed forward, downward, and backward, resulting in whorls (Jentink, 1894; Lydekker, 1903).

DISTRIBUTION. The tamaraw is restricted to Mindoro Island in the Philippines (Fig. 3; Bourns and Worcester, 1894; Heaney et al., 1987; Steere, 1889), an island of 9,735 km² that is a distinct faunal region with at least 43% endemism among its indigenous non-volant mammals (Heaney, 1986). The tamaraw was formerly numerous and widespread on Mindoro (Meyer, 1896), but at present is restricted to three areas designated as reserves for this species: Mt. Iglit/Mt. Baco (75,450 ha), Mt. Calavite (35,000 ha), and the Mt. Mitchell (Sablayan) area (100,000 ha), all in Occidental Mindoro Province (Alcasid, 1977; Popenoe, 1983; Sitwell, 1975; the last of these does not have mapped boundaries; Fig. 3).

FOSSIL RECORD. Beyer (1957) referred several fossilized bovid teeth from surface accumulations in Novaliches Municipality and Pangasinan Province, Luzon, to *B. mindorensis*, suggesting that tamaraw occurred on Luzon as well as Mindoro during the Pleistocene. However, there has been no critical examination of these specimens, some of which are on display (in 1994) at the Philippine National Museum.

ONTOGENY AND REPRODUCTION. Tamaraws breed early in Mindoro's 6-month dry season (December–May) and cows bear their single calves in the rainy season (June–November) when vegetation is lush and weather is cool (Kuehn, 1976, 1986; Talbot and Talbot, 1966). Gestation is from 276 to 315 days (MacDonald, 1984). A cow tamaraw usually bears calves once every 2 years and young separate from their mother between the ages of 2–4 years (Nowak, 1991; Rabor, 1986). Tamaraws have bred successfully only once in captivity (Harrisson, 1969a; Oliver, 1993; World Conservation Monitoring Centre, 1994).

ECOLOGY. In the 1890s, the tamaraw was moderately common in virgin forests that covered most of Mindoro (Thomas, 1898). It occurred from sea level to nearly 2,000 m, near rivers, marshes, in bamboo thickets of secondary growth, and in grasslands (Alcasid, 1977; Grzimek, 1972; Lydekker, 1898; Rabor, 1977, 1986; World Conservation Monitoring Centre, 1994).

Current populations are confined primarily to Mt. Iglit-Baco National Park, an area of rugged topography with mountain peaks rising to about 1,000 m. The original lowland dipterocarp forest vegetation has largely been cleared by logging and fire, as has occurred throughout Mindoro (Fig. 3); three common grassland types now cover 90% of the Mt. Iglit reserve area. A tall, coarse grass called talahib (*Saccharum spontaneum*) dominates the wettest areas, and cogon (*Imperata cylindrica*) dominates the dryer areas. Shorter grasses, including *Themeda* spp., *Paspalum* spp., and *Alloteropsis semialata*, are common along the upper slopes of the ridges. Bamboo (*Dinochloa* spp. and *Schizostachyum* spp.) and secondary dipterocarp forest occur along the rivers and in small pockets along limestone ridges. There are both permanent and seasonal streams. The Mt. Iglit area has a dry season from December through May and a rainy season from June through November. Rainfall averages 300 cm annually (Kuehn, 1986; Talbot and Talbot, 1966).

Transformation of the Mt. Iglit area from forest to grassland has been attributed partially to agricultural practices of the Batangans, a tribal group that engages in shifting agriculture. Because fields are fertile for only a few years, the Batangans have opened up large areas of forest. Burning grassland prevents tree reproduction and promotes grass (Talbot and Talbot, 1966). Sitwell (1975) believed that the transformation from forest to grassland, which took place prior to 1970, was not necessarily disadvantageous to the tamaraw because young grass that covers the burned area provides food for grazing, and longer grass (which can grow to >4 m) provides cover during daylight. Tamaraws reportedly feed on *Cynodon arcuatus, Digitaria sanguinalis, Eleusine indica, Sorghum nitid-*

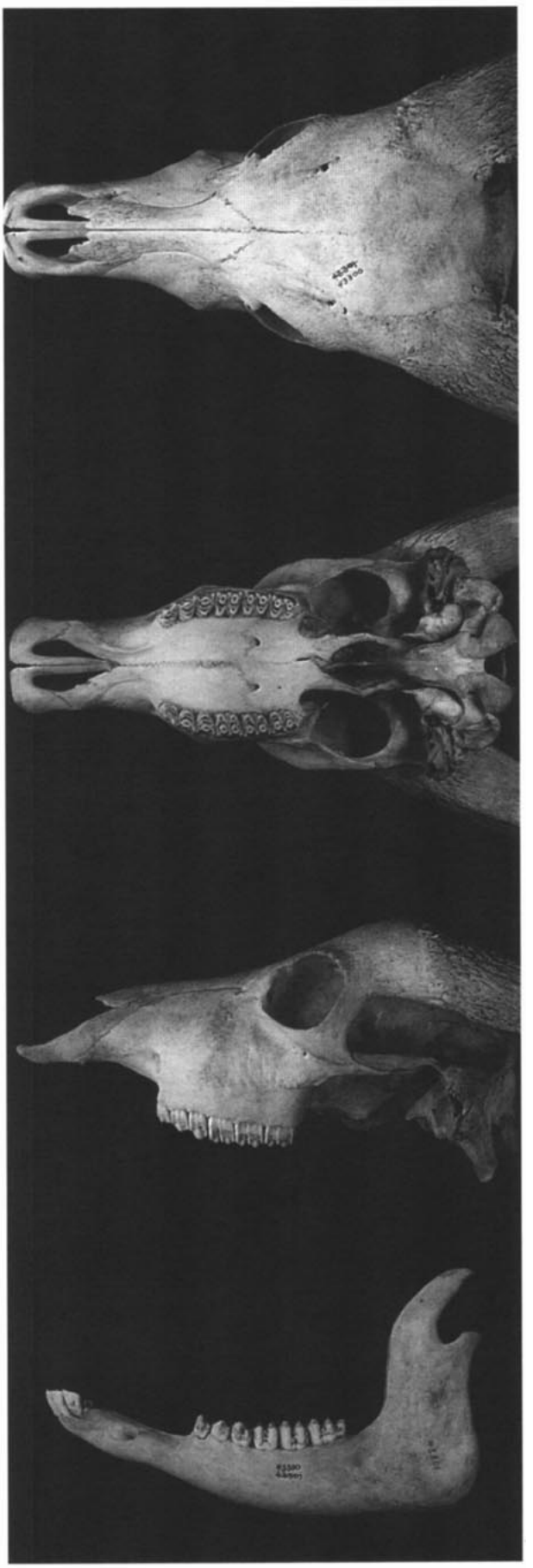

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FIG. 2. Dorsal, ventral and lateral view of the skull and lateral view of the mandible of *Bubalus mindorensis*; (43300 in The Field Museum, Chicago, taken in 1935 at an unknown locality on Mindoro). Length of upper left toothrow is 102 mm.

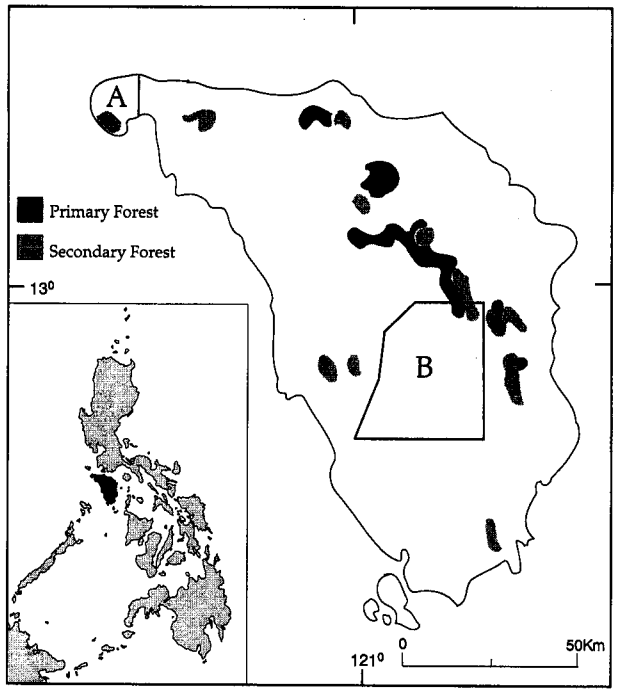

FIG. 3. Map of Mindoro Island, Philippines, showing the locations of Mt. Calavite Tamaraw Reserve (A) and Mt. Iglit-Baco National Park (B). Forest cover estimates from National Mapping and Resource Information Authority, 1988.

um, Paspalum scrobilatum, Alloteropsis semialata, and *Vetiveria zizanoides.* During the wet season, tamaraws feed on new shoots of climbing bamboo (*Schizostachyum* spp.—Talbot and Talbot, 1966). Several authors have inferred that the tamaraw's preferred habitat would be on the forest edge where safe cover, open pasture, and water to drink and wallow in are close together (Popenoe, 1983; Talbot and Talbot, 1966).

Many tamaraws fell victim to a rinderpest epidemic that swept Mindoro around 1930 (Harper, 1945; Parker, 1990). Life expectancy for tamaraw is reported to be 20 years (World Conservation Monitoring Centre, 1994).

The tamaraw is listed in Appendix I of the Convention on International Trade of Endangered Species of Fauna and Flora (World Conservation Monitoring Centre, 1994). Its population has declined from an estimated 10,000 in 1900 (Harrisson, 1969b), to 1,000 in 1949 (Manuel, 1957), 244 in 1953 (Manuel, 1957), 100 in 1969 (Harrisson, 1969b), 100 in 1970 (Alvarez, 1970), 148 in 1971 (Popenoe, 1983), 125 in 1975 (Sitwell, 1975), and 150–200 in 1983 (Popenoe, 1983). A 1987 estimate of 356 individuals is said to be "of questionable reliability" (Oliver, 1993:139). A reported decline in tamaraw populations at the end of the last century was primarily attributed to sport-hunters and a few professional hunters (Thomas, 1898). During the American colonial period in the early 1900s, a bag limit of one male tamaraw per hunter per year was set and Calavite Mountain was declared a reserve where no hunting of tamaraw was allowed. Commonwealth Act No. 73, enacted in 1936 and still in effect (La Vina, 1991), provides for complete protection of both sexes, except for protection of human life and property or for scientific purposes, with proper authorization from the Secretary of Agriculture and Commerce (Grzimek, 1972; Harper, 1945; Kuehn, 1976; World Conservation Monitoring Centre, 1994).

As the population declined from 1940 to 1975, sport hunting, logging, poaching for food, and settlement of a large part of its range were identified as main causes of depletion (Harper, 1945; Kuehn, 1976; Talbot and Talbot, 1966). Soaring human populations, logging, and ranching have devastated habitats up to 1,000 m on Mindoro (Harrisson, 1969*a*, 1969*b*; Kuehn, 1976; Talbot and Talbot, 1966). As recently as the 1960s, farmers and ranchers on Mindoro regularly hunted tamaraws (Grzimek, 1972; Talbot and Talbot, 1966). Hunts using helicopters were also reported in 1968 (Harrisson, 1969*b*). In the 1960s and 1970s, poaching was aggravated by availability of firearms (Popenoe, 1983; Sitwell, 1975; Talbot and Talbot, 1966).

In 1969, the International Union for the Conservation of Nature and Natural Resources, World Wildlife Fund, and Philippine government developed a plan to protect the tamaraw (Alcasid, 1977; Harrisson, 1969*a*, 1969*b*). Although the population in the Mt. Iglit area appeared to have increased substantially during the early 1970s due to active protection efforts (Kuehn, 1976, 1986), success declined in the late 1970s. Popenoe (1983) and Oliver (1993) described a project begun in 1979 that established a small semi-captive population in an enclosed 400-ha area in the Mt. Iglit refuge that could be guarded, studied, and managed. Nearly all 20 animals captured for this project had died by 1993, and the project was declared a failure (Oliver, 1993). Current evidence indicates that the tamaraw population continues to decline (Heaney and Utzurrum, 1991; Oliver, 1993).

BEHAVIOR. Tamaraws are traditionally described as ferocious and aggressive (Alcasid, 1977; Bureau of Insular Affairs, 1903; Harrisson, 1969*b*; Kuehn, 1976; Lydekker, 1898; Rabor, 1986; Sitwell, 1975; Steere, 1889; Talbot and Talbot, 1966; Worcester, 1914). Although some reports state that aboriginal people of Mindoro never attacked tamaraws (Bureau of Insular Affairs, 1903; Thomas, 1898), other reports describe natives capturing them by means of rope snares suspended from trees, corral traps, and pitfalls (Harper, 1945). Hunting tamaraws with firearms is described as difficult and dangerous (Bureau of Insular Affairs, 1903).

Adult tamaraws are largely solitary; 82% of 218 observations of adult bulls were of lone individuals, and 66% of 107 observations of adult cows were of individuals alone or with calves (Kuehn, 1986). The largest aggregation seen during the most intensive study consisted of an adult bull, three subadult bulls, an adult cow, and a calf (Kuehn, 1986); Talbot and Talbot (1966) reported a grouping of 11 animals. A bull and a cow may be seen together any time of year, but the association is casual and frequently breaks up within hours except during breeding. Adult females have been seen accompanied by three young of different ages (Kuehn, 1976, 1986). Groups of juvenile tamaraw sometimes persist for a year or longer, but as animals grow older they become less social, especially after they reach adulthood at about 6 years (Bureau of Insular Affairs, 1903; Kuehn, 1976, 1986; Rabor, 1986; Talbot and Talbot, 1966).

Although fights between bulls have not been observed, agonistic behavior between bulls is commonly associated with breeding, with habitat reduction caused by annual fires, and with range expansion by juvenile bulls (Kuehn, 1986). Tamaraws have not been seen to use earth-tossing or vertical head movements as threats, as do water buffalo. Cow tamaraws threaten conspecifics by lowering their heads until their horns are nearly vertical and then shaking the horns laterally, a behavior similar to that of domestic cattle (Kuehn, 1986). Male tamaraws older than 3 years and female tamaraws older than 4.5 years were not observed in family groups; individuals of either sex older than these ages apparently are driven off (Kuehn, 1986). The observation of a tamaraw cow grazing 50 m from her neonate, which lay stretched out along the ground, suggests that calves behave as typical "hider" species (Kuehn, 1986).

Traditional descriptions of tamaraws emphasize their aggressive and suspicious behavior toward humans. For example, they are often said to turn about and face back down their own trail before lying down to sleep (Bureau of Insular Affairs, 1903; Worcester, 1914). Worcester (1914:826, 827) further reported that tamaraws circle back on their trail "before lying down, so that while one is still a mile or two from it by the line which it followed, it may in reality be not more than fifty or hundred yards away." When being pursued, a tamaraw "will almost invariably back off at right angles to its own trail, waiting for pursuers to come up, and charge them, giving them no time to fire."

Most authors state that tamaraws sleep during the day in dense vegetation, feed at night, and visit nearby water courses before morning in order to drink (Bureau of Insular Affairs, 1903; MacDonald, 1984; Talbot and Talbot, 1966; Worcester, 1914). Steere (1889), however, stated that they may feed and move about during both day and night. Ranchers on Mt. Iglit reported that when ranches were first established in the early 1960s, tamaraws were relatively tame and could be seen grazing in the open during daylight. With continued hunting, they became more secretive and aggressive in their habits (Talbot and Talbot, 1966).

Tamaraws wallow in mud like water buffalos (Lydekker, 1898;

Steere, 1889), and mud wallows are often present within tamaraw habitat (Talbot and Talbot, 1966). Captive individuals feed most frequently from 06:00 to 10:00 and 18:00 to 22:00; feeding and rumination occupy 24 and 26% of the day, respectively. Wallowing is more frequent during the day than during the night; running and pawing dirt are most often observed during the night (Momongan and Walde, 1993).

GENETICS. A female tamaraw had a karyotype of 2n = 46; this differs from the karyotype of *Bubalus (Anoa) depressicornis*, which has 2n = 48, by the lack of one acrocentric pair (Fischer and Hohn, 1976).

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