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Capricornis crispus.

By Christopher N. Jass and Jim I. Mead

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Capricornis Ogilby, 1837

Capricornis Ogilby, 1837:139. Type species *Antilope thar* Hodgson, 1831 by original designation.
Antilope: Temminck, 1844:55, plates 18, 19. Part, not *Antilope* Pallas, 1766.
Nemorhaedus: Turner, 1850:173. Part, not *Nemorhaedus* H. Smith, 1827.
Naemorhedus: Jerdon, 1867:283. Part, not *Naemorhedus* H. Smith, 1827.
Nemotragus Heude, 1898:13. Type species *Capricornis erythropygius* Huede, 1894 by subsequent designation (Pocock 1908).
Capricornulus Heude, 1898:13. Type species *Antilope crispa* Temminck, by subsequent designation (Pocock 1908).
Lithotragus Heude, 1898:13. Type species *Capricornis maritimus* Huede, 1888 by subsequent designation (Pocock 1908).
Austritragus Heude, 1898:14. Type species *Antilope sumatrensis* Bechstein, 1799 by monotypy.

CONTEXT AND CONTENT. Order Artiodactyla, suborder Ruminantia, family Bovidae, subfamily Caprinae, genus *Capricornis* (Corbet 1978). Traditionally *Capricornis* is placed within the tribe Rupicaprini (Simpson 1945). *Capricornis* is distinct from *Nemorhaedus* (Gentry 1992; McKenna and Bell 1997; Mead 1989; Vrba and Schaller 2000). Various authors (Corbet and Hill 1992; Groves and Grubb 1985; Grubb 1993) considered *Capricornis* a junior synonym of *Nemorhaedus*, but few researchers follow this convention. Morphological data (Thomas 1994) do not support synonymy of *Capricornis* and *Nemorhaedus*.

Antilope goral (*A. goral* Hardwicke, 1825—Mead 1989) and *Antilope thar* were considered generically distinct by Ogilby (an address read in December 1836 but published in June 1837), who placed *Antilope thar* as the type of *Capricornis*. Heude (1898) divided *Capricornis* of Ogilby (1837) into several genera and described many new species. These included *Austritragus* for *sumatrensis*; *Capricornis* for *brachyrhinus*, *chrysochaetes*, *fargesianus*, *longicornis*, *nasutus*, and *thar*; *Capricornulus* for *crispus*, *pryerianus*, and *saxicola*; *Lithotragus* for *benetianus*, *berthelianus*, *marcolinus*, *maritimus*, and *rocherianus*; and *Nemotragus* for *argyrochaetes*, *cornutus*, *erythropygius*, *microdonticus*, *platyrhinus*, and *ungulosus*. Heude's elaborate system was subsequently dropped (Pocock 1908).

Capricornis contains 2 species, *C. crispus* and *C. sumatraensis* (Sumatran serow), although *C. crispus swinhoei* (Formosan serow) is sometimes given specific rank (Groves and Grubb 1985; Grubb 1993).

Capricornis crispus (Temminck, 1844)

Japanese Serow

Antilope crispa Temminck, 1844:55, plates 18, 19. Type locality "les parties de l'île de Nippon couvertes de hautes alpes, telle que la partie nommée Josino" [parts of Japan covered by high mountains, such as the part named Yoshino]; = Mt. Yoshino, Honshu, Japan.
Capricornis crispa: Gray, 1846:232. First use of current name combination.
Capricornus swinhoei Gray, 1862:320. Type locality "Formosa, on the central ridge of the Snowy Mountains."
Capricornis crispus: Swinhoe, 1870:647. Gender agreement.
Capricornulus crispus: Heude, 1898:13. Name combination.
Capricornulus pryerianus Heude, 1898:13. No type locality other than Japan.
Capricornulus saxicola Heude, 1898:13. Type locality "Hondo" (= Honshu) according to Ellerman and Morrison-Scott (1966).
Capricornis sumatraensis: Haltenorth, 1963:119. Part, not *Capricornis sumatraensis* (Bechstein, 1799).
Nemorhaedus swinhoei: Groves and Grubb, 1985:47. Name combination.
Nemorhaedus crispus: Groves and Grubb, 1985:48. Name combination.
Naemorhedus swinhoei: Corbet and Hill, 1992:272. Name combination.
Naemorhedus crispus: Grubb, 1993:407. Name combination.

CONTEXT AND CONTENT. Context as above. Two subspecies are recognized (Atoji et al. 1998; Corbet 1978; Lue 1987; Soma et al. 1987):

C. c. crispus (Temminck, 1844:55), see above (*pryerianus* and *saxicola* are synonyms).
C. c. swinhoei Gray, 1862:320, see above.

DIAGNOSIS. *Capricornis crispus* is smaller with relatively shorter ears compared with *C. sumatraensis*. *C. crispus* has a deeper narial notch, a longer nasal process of the premaxilla, and greater specialization of pedal glands than *C. sumatraensis* (Groves and Grubb 1985).

Capricornis crispus crispus has a larger body size than *C. c. swinhoei* (Lue 1987), but the ears of *C. c. crispus* are smaller (Atoji et al. 1998). *C. c. swinhoei* has a more trenchant ridge formed by lacrimal fossa than *C. c. crispus* and *C. sumatraensis* (Groves and Grubb 1985).

The presence of a lower canine generally distinguishes the dental formula of *Capricornis* from *Nemorhaedus*, although canines are occasionally present in *Nemorhaedus* (Geptner et al. 1961; Mead 1989). *Capricornis* has larger preorbital glands and a straighter facial profile than *Nemorhaedus* (Nowak 1999). Facial glands and preorbital fossae present in *Capricornis* are lacking in *Nemorhaedus* (Corbet 1978). *Capricornis* lacks skin glands of the posterior horn area of the head that are present in *Rupicapra* (Corbet 1978).

Compared with *Oreamnos americanus*, *Rupicapra rupicapa*, *R. pyrenaica*, and *Nemorhaedus goral*, species of *Capricornis* exhibit fewer behavior patterns (n = 13—Lovari 1984/1985; n = 14—Lovari and Apollonio 1994), and the genus is considered to be behaviorally primitive (Lovari 1984/1985).

FIG. 1. An adult *Capricornis crispus* in the Vienna Zoo, Austria. Photo taken in 1986 by K. Kutunidisz. Used with permission of the Mammal Slide Library of the American Society of Mammalogists.

FIG. 2. Dorsal, ventral, and lateral views of cranium and lateral view of mandible of an adult male *Capricornis crispus* (NSMT-M16026) from the National Museum, Tokyo, Japan. Horns appear shorter in ventral view because of the angle of the photo. Greatest length of skull = 232 mm. Photos courtesy of Hideki Endo of the National Museum, Tokyo.

GENERAL CHARACTERS. *Capricornis crispus* (Fig. 1) is a small bovid. The horns are arched anteroposteriorly relative to the frontals, and horn sheaths have a series of transverse rings (Fig. 2).

Four color variations in *C. c. crispus* occur, including black, black with a dorsal white spot, dark brown, and whitish (Sugimori and Maruyama 1971). The pelage of *C. c. swinhoei* is dark brown with lighter brown on the chin, throat, and neck (Lue 1987). Facial markings are varied (Iwase 1972).

Weight ranges from 30 to 45 kg in *C. c. crispus* (no sample size—Sugimura et al. 1987) and 35–39 kg in *C. c. swinhoei* (no sample size—Atoji et al. 1998). Body mass (in kg) of 4 age classes of Japanese serows was: 0.5 years old (males = 19.85 ± 4.20 *SD*, n = 70; females = 20.16 ± 3.50, n = 56), 1.5 years old (males = 31.49 ± 5.02, n = 57; females = 30.02 ± 5.22, n = 52), 2.5 years old (males = 35.79 ± 4.20, n = 47; females = 35.80 ± 4.96, n = 65), and ≥3.5 years old (males = 35.89 ± 4.46, n = 292; females = 38.43 ± 4.97, n = 279—Miura 1986). Two *C. c. swinhoei* adult males weighed 18 and 20 kg, respectively (Zuh-Ming 1963).

Height at shoulder (in cm) for 4 age classes of Japanese serows was: 0.5 years old (males = 60.03 ± 6.91, n = 68; females = 60.57 ± 5.34, n = 56), 1.5 years old (males = 69.96 ± 6.00, n = 56; females = 70.06 ± 6.42, n = 52), 2.5 years old (males = 73.78 ± 5.37, n = 50; females = 73.35 ± 4.75, n = 65), and ≥3.5 years old (males = 73.10 ± 4.98, n = 290; females = 73.98 ± 5.98, n = 275—Miura 1986). Range of body measurements (in mm) for 3 *C. c. swinhoei* (2 adult males, 1 subadult female) was: height at shoulder, 675–696; total length, 938–1,022; length of tail, 62–75; length of upper cheek toothrow, 56–64; length of lower cheek toothrow, 53–67; and greatest length of skull, 208–223 (Zuh-Ming 1963). Horn length (in mm) ranges from 74 to 112 in *C. c. swinhoei* (n = 3—Zuh-Ming 1963) and 120–160 in *C. c. crispus* (no sample size—Sugimura et al. 1987). Measurements of palatal length, nasal length, zygomatic width of skull, basal length of skull, front and hind hoof lengths, and hind foot length are available for 3 Formosan serows (Zuh-Ming 1963). Measurements of mandible length, diastema length, mandible height, horn weight, horn length, and chest girth are available for 4 age classes of Japanese serows (Miura 1986).

The tongue differs between *C. crispus* subspecies (Atoji et al. 1998). Differences based on 1 *C. c. swinhoei* specimen include greater length (ca. 1 cm) in *C. c. crispus*, U-shaped apex (*C. c. swinhoei*) versus V-shaped apex (*C. c. crispus*), fewer filliform (number not given) and fungiform papillae (340) in *C. c. swinhoei*, and lack of lenticular papillae on the torus linguae in *C. c. swinhoei* (Atoji et al. 1998).

Capricornis crispus has little sexual dimorphism. Males and females have horns of similar size. Total length of scapula (males, n = 12; females, n = 6), humerus (males, n = 14; females, n = 5), radius (males, n = 14; females, n = 5), ulna (males, n = 13; females, n = 4), and metacarpal (males, n = 13; females, n = 5) of *C. c. crispus* had overlapping *SD* (Matsuo et al. 1983). The spinous process of cervical vertebrae is consistently higher in males (males, n = 17; females, n = 26—Iwahana et al. 1988). Sexual dimorphism is present in the wing and auricular surface of the sacrum (Morishita et al. 1984). Horns of males over 3.5 years of age have greater mean basal diameter (31.82 mm) than do those of females (30.61 mm), although overlap exists (Miura 1987). Qualitatively, horns of males show greater wear than those of females; grooves of annual rings are more distinct in females (Miura 1987). Morphometric differences in the skull, vertebral column, and appendicular skeleton exist (Sugano et al. 1982; Tsuchimoto et al. 1982). Genitalia and sexual behavior are most often used for distinguishing males and females in the field (Kishimoto 1988).

DISTRIBUTION. The geographic distribution of *C. crispus* is limited to mountainous areas of Japan and Taiwan. *C. c. crispus* is endemic to the Japanese islands of Honshu, Shikoku, and Kyushu (Fig. 3). Estimates of total distribution for *C. c. crispus* are up to 40,000 km² (Tokida and Ikeda 1992). The geographic distribution of *C. c. crispus* largely overlaps the cool temperate forest zone of Japan and predominantly occurs within forested areas containing >80% coverage (Tokida and Ikeda 1992). Distributional studies for specific geographic regions included the Tanzawa Mountains (Sugimori and Maruyama 1971), the island of Shikoku (Furuya 1978), the island of Kyushu (Doi et al. 1987), and the northeast region of Japan (Ito and Sato 1980).

Capricornis crispus swinhoei is endemic to Taiwan and is found in 11 of Taiwan's 16 counties at elevations from 200 to 3,870 m (Lue 1987). This altitudinal range is greater than that of *C. c. crispus* (Lue 1987).

FOSSIL RECORD. All fossil specimens of *Capricornis* are Pleistocene records that are identified as *C. sumatraensis* (Colbert and Hooijer 1953; Hooijer 1958; Wanpo et al. 1983). No fossil record of *Capricornis* is known from Japan (Soma et al. 1994), and comments concerning the evolutionary and biogeographic history of Japanese and Formosan serows are speculative (Groves and Grubb 1985; Lue 1987; Soma et al. 1987).

FORM AND FUNCTION. A summary of gross anatomy (Sugimura et al. 1987) and descriptions of the skeletal anatomy are available (Matsuo and Morishita 1985; Matsuo et al. 1983, 1984; Morishita et al. 1984; Takada and Koyasu 1990). Descriptions of the brachial plexus, lumbosacral plexus, and brain are available (Atoji et al. 1987b, 1987c). Female Japanese serows have 2 pairs of mammae. Immunocytochemistry of the pancreatic islets was described (Atoji et al. 1990). Other anatomical studies on the pineal gland (Ohshima and Matsuo 1987), laminations of the masseter muscle (Suzuki 1989), tongue (Funato et al. 1985), thymus (Sugimura et al. 1983a), major arteries of the thoracic region (Kawashiri et al. 1986), lungs (Nakakuki 1986), morphology of the forestomach (Yamamoto et al. 1998), pancreas (Wakuri et al. 1980), adrenal glands (Toyoda et al. 1986), morphology of the kidney (Takahashi

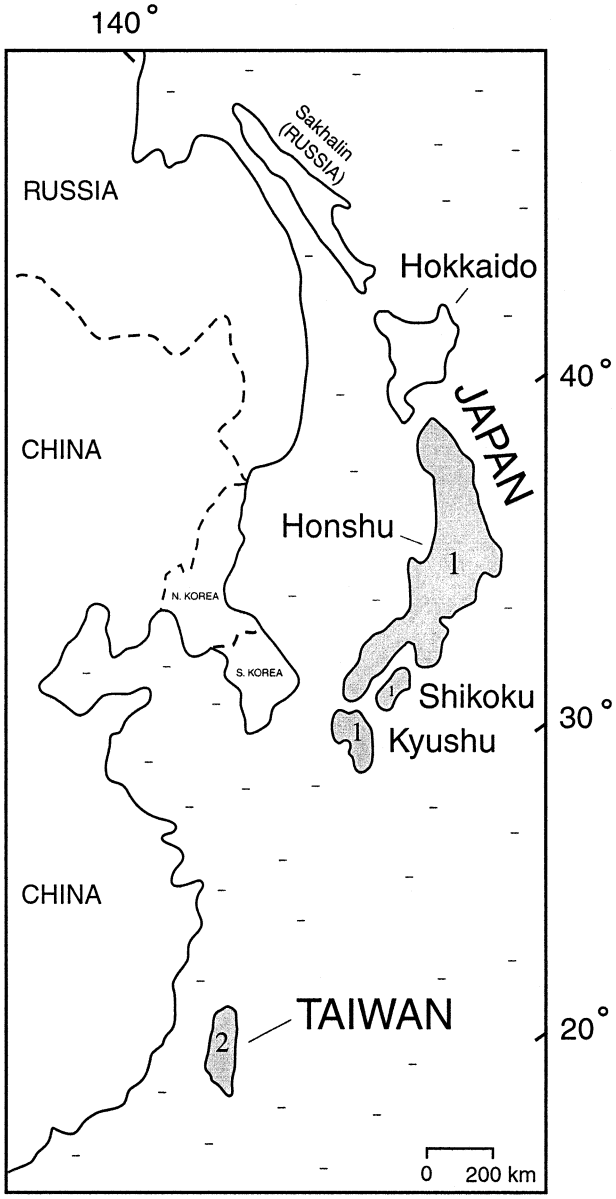

FIG. 3. Geographic distribution of *Capricornis crispus*. 1, *C. crispus crispus*; 2, *C. c. swinhoei*.

et al. 1986), vascular distribution of the pelvic region (Iwahana et al. 1986), and genitalia (Tsunenari et al. 1986; Uno et al. 1984) are available.

Capricornis crispus has 3 specialized skin glands, including the infraorbital gland, interdigital gland, and preputial gland. Various aspects of morphology, histology, and chemistry of these glands are available (Atoji et al. 1987a, 1988, 1989a, 1989b, 1993, 1995, 1996; Atoji and Suzuki 1990; Yokohata et al. 1987).

Histological differences in infraorbital glands occur between male and female Japanese serows (Kodera et al. 1982). In females, mass of the sebaceous portion of the infraorbital gland increases until sexual maturity, whereas in males, it is constant (Kodera et al. 1982). The mass of infraorbital glands might be correlated with social status (Kodera et al. 1982). Infraorbital glands of *C. c. swinhoei* secrete fluids containing melanin (Atoji et al. 1996). Infraorbital glands of *C. c. crispus* secrete clear fluids (Atoji et al. 1987a). A serous zygomatic salivary gland is present in *C. crispus* (Tsuchimoto et al. 1984). Pedal glands are present in all 4 feet of *C. c. swinhoei* (Zuh-Ming 1963). Dental formula of adult is i 0/3, c 0/1, p 3/3, m 3/3, total 32.

ONTOGENY AND REPRODUCTION. Age of 1st reproduction for captive female *C. crispus* ranged from <2 to 4 years (Komori 1987). Females (n = 152) from natural populations exhibit similar dates of sexual maturation; 10% of 1.5 year olds ovulated, 50% of female Japanese serows reached maturity by 2.5 years, and at 4.5 years, the majority of female serows were mature (Kita et al. 1987a). In Gifu Prefecture, Japan, sexual maturity was reached by females in the autumn of the breeding season at 2.5 years (female n = 52—Sugimura et al. 1981). On the basis of 152 animals, ranging in age from 0.5 to 19.5 years, the reproductive life of females ranged from 2.5 to 19.5 years (Kita et al. 1987a). Elastoid and pseudoelastoid bodies in the ovaries of *C. crispus* suggest that adult serows give birth 2 out of every 3 years (Kita et al. 1987b). Reproduction in females <2.5 and >14.5 years is depressed (Kita et al. 1987a). The estrous cycle lasts 20 to 21 days (Ito 1971). The histology of 2 types of retrograde corpora lutea is available (Sugimura et al. 1984).

Males attain sexual maturation more rapidly than females, and puberty begins 6 months after birth (Tiba et al. 1981a, 1988). The seminiferous epithelial cycle of *C. crispus* has 8 stages (Tiba et al. 1981b). Spermatogenic function varies depending on time of year and age. In February and March, spermatogenic function is lower (Tiba et al. 1981a). Advanced age depresses spermatogenesis (Tiba et al. 1981a).

The breeding season ranges from September to January, with peak conception from late October to early November (Kita et al. 1987a). Females ovulate 1–6 times per breeding season (Kita et al. 1987a). Gestation averages ca. 215 days (no sample size—Kita et al. 1987a; Sugimura et al. 1981). A range of 210–220 days is known for captive populations (Ito 1971; Komori 1975). Progesterone levels peak (4.2 ng/ml) 4 months into gestation (Kanomata et al. 1990). In both captive and wild populations, parturition peaks in May and June (Kita et al. 1987a; Komori 1987; Sugimura et al. 1981). Correlation between characters of the mammary glands and reproductive history occurs (Kita et al. 1995). From 1950 to 1984, 43.8% of captive juveniles died; acute enteritis was the most frequent cause of death (Komori 1987).

A single offspring is most common; twins are rare. Of 259 pregnant females, 257 carried a single offspring and only 2 carried twins (Kita et al. 1987a). Sex ratio at birth was 1.03:1.00 (n = 261—Kita et al. 1987a). Estimated length at birth ranges from 48 to 50 cm, and mass at birth ranges from 3,313 to 3,708 g (n = 261—Kita et al. 1987a). Newborn Formosan serows at the Taipai Zoo weighed ca. 1,300 g (n = 6—Pao-Chung 1987). The timing in development of external features of serow embryos and fetuses is known (Sugimura et al. 1983b).

Characters of the horns, including size, curvature, thickness of transverse horn rings, and number of transverse rings are indicative of age. Changes in horn sheath morphology were correlated with age classes (Kishimoto 1988). Horns begin to develop at ca. 4 months old in both males and females (Miura 1985). Horn sheaths developed 1 to 2 thick transverse rings in 5 of 15 kids (<1 year old—Kishimoto 1988). Size of the 1st growth ring is influenced by environment (Miura 1987). Yearling horn sheaths contain 1–3 thick, transverse rings and retain a visible swelling in the distal sheath (Kishimoto 1988). Subadults (2 years old) are distinguished by more thickened transverse rings, greater length, and greater flexion (Kishimoto 1988). As adulthood is reached, the thicker transverse rings are forced upward by development of thinner horn rings at the base, and distal swelling is lost (Kishimoto 1988). For males, size of annual growth increments relative to age decreases during maturation, but for females, size of growth increments decrease sooner (at 2 years of age—Miura et al. 1987, 1991). The mineralization of crystalline inorganic components of the horn sheath was described by Hashiguchi and Hashimoto (1995).

Tooth eruption in *C. crispus* is similar to other bovids, but succession is faster (Miura and Yasui 1985). Fawns from 6 to 9 months old have an entirely deciduous dentition, which gives way to the permanent dentition by 30 months (Sugimura et al. 1981). Mandibular deciduous dentition, i3, c1, p3, m0, total 14, is complete at birth (Miura and Yasui 1985). The sequence of permanent mandibular dentition begins with eruption of m1, followed by eruption of m2, replacement of i1, eruption of m3 and replacement of i2, replacement of i3 and p2–4, and finally replacement of c1 (Miura and Yasui 1985). Some variation exists in this pattern. In some cases (n = 7) p4 was the last premolar to erupt, whereas in others (n = 3), p2 was (Miura and Yasui 1985). A method for determining age by tooth cementum is available (Takahashi and Ono 1989).

Timing (in months) of epiphyseal fusion for several postcranial

elements is as follows: scapula, 6–8; proximal humerus, 31–32; distal humerus, 6–8; proximal radius, 6–8; distal radius, 31–32; proximal ulna, 31–32; distal ulna, 40–45; distal metacarpal, 31–32; and proximal 1st phalanx, 18–20 (male, $n = 22$ for each element; female, $n = 19$—Matsuo et al. 1983). Body growth in males stops at 2.5–3 years (Tiba et al. 1988).

Lamb mortality rates differ between males (15.3%) and females (36.5%, $n = 30$—Tokida and Miura 1988). Mortality patterns are similar for adult males and females. Examination of 124 dead Japanese serows from Iwate Prefecture suggests life expectancies at birth were 5.3 years for males and 4.8 years for females (Tokida and Miura 1988). Maximum longevity for males (20 years) was lower than for females (21 years—Tokida and Miura 1988). Estimated longevity for males and females can range as high as 20.5–24.5 years (Miura and Tokida 1992).

ECOLOGY. Japanese serows prefer rugged, mountainous areas; caves are used for resting (Akasaka and Maruyama 1977). Observation of *C. crispus* in natural habitats is reported only for spring, summer, and fall months because most of their habitat is covered by deep snow in winter.

Population density is variable. For 1980–1984, mean density was 2.6 individuals/km^2 $\pm$ 0.2 *SE* ($n = 568$ for points examined), and total estimated population was 100,000 $\pm$ 40,000 individuals (Tokida and Ikeda 1992). On Kyushu, average density estimates ranged from 1.7 to 1.9 individuals/km^2 ($n = 71$ study sites—Doi et al. 1987). In Wakinosawa Village, Amori Prefecture, density ranged from 10.2–10.9 (July to December) to 15.6 head/km^2 (March), which is higher than in other areas of Japan (Hanawa et al. 1980). Mean density in Wakinosawa, Amori Prefecture, was 12.5 serows/km^2 (Ochiai et al. 1993a). Density in Nagano Prefecture was discussed (Haneda et al. 1985).

Food supply on the basis of vegetation cover is the most important determinant of Japanese serow density (Ochiai et al. 1993a). High snowfall depresses population density in the short term (Ochiai et al. 1993a). Effects of human activity on serow population density vary. Distribution and density of serows was negatively affected by logging and positively affected by the presence of endemic primary forest (Doi et al. 1987). Young tree plantations provide large supplies of food (Haneda et al. 1976) and higher Japanese serow densities occur 5–10 years after clear-cut logging in plantations (Ochiai et al. 1993b). However, Japanese serow densities decreased over time as plantation vegetation such as Japanese cedar (*Cryptomeria japonica*) matured (Ochiai et al. 1993b). Planted stands were affected by *C. crispus* in Aichi Prefecture (Ito et al. 1992). Japanese serows might preferentially select crops with high crude protein, nitrogen-free extract content, and dry matter content (Deguchi et al. 2001).

Capricornis crispus is a generalist herbivore. Japanese serows from the Shimokita Peninsula in northern Japan had 114 species of plants in their diet and were considered browsers (Ochiai 1999). In the Japanese North Alps, diet consists of 95 plant species, with *Carex* and *Sasa* heavily favored when snow was present (Chiba and Yamaguchi 1975). *Sasa kurilensis* and *Thuja standishii* were the most common plants among 11 identified from the rumen and reticulum of a female carcass from Nikko National Park (Mikuriya and Obara 1970). Leaves of the plantation genus *Chamaecyparis* are also eaten (Doi et al. 1987). Oak shrubbery and Japanese white pine forest might be an important habitat for Japanese serows (Akasaka and Maruyama 1977). *Quercus serrata* is an important component of the home range of Japanese serows in Yamagata Prefecture (Ito 1995). A dietary analysis of fecal pellets from Mt. Zao in Yamagata Prefecture included *Acuba japonica* var. *borealis*, *Carex*, *Cephalotaxus harringtonia* var. *nana*, *Morus bombycis*, and *Sasa* (Takatsuki et al. 1988). Diet varies between summer and winter (Takatsuki et al. 1988). Herbs are a common component of the summer diet (Miyao 1976). In general, food habits of Japanese serows vary regionally, depending on the types of vegetation available (Ochiai 1999). Whole-body concentrations of heavy metals in Japanese serows are influenced by metal concentrations in food plants (Honda et al. 1987). Additional factors influence the concentration of heavy metals in organs and tissues of *C. crispus* (Honda et al. 1987).

Capricornis crispus swinhoei is associated with alpine grasslands of *Yushania niitakaymensis* and areas of *Juniperus* (Lue 1987). *C. c. swinhoei* uses a poisonous plant, *Urtica fissa*, without ill effects (Lue 1987).

The Japanese serow has diurnal and nocturnal feeding periods (Maita 1987). Daily food intake (in g/individual) in captive *C. crispus* ranged from 5,610 to 6,300 in adult females ($n = 3$) and 4,150 ($n = 1$) in a subadult male (Kanomata and Izawa 1990). Defecation rates vary in captive *C. crispus*, with highest rates in the fall (Takatsuki et al. 1981). *C. crispus* will establish and reuse specific areas as latrines (Matsumoto et al. 1984; Pao-Chung 1987). Passage rates of summer succulents were 50% by 30–40 h and 80% by 50 h (Suzuki 1987). Body temperature varies seasonally, with highest temperatures (38.36–38.73°C) in summer and slightly lower temperatures (38.21–38.36°C) in winter (Kanomata and Izawa 1982).

Humans threaten *C. crispus* through hunting and habitat destruction. In Taiwan, potential nonhuman competitors for food and space include *Cervus unicolor swinhoei* and *Muntiacus reevesi micrurus* (Lue 1987). Predators of the Formosan serow include *Neofelis nebulosa brachyurus*, which might now be extinct, and weasels (*Mustela sibirica*), which take trapped animals (Lue 1987). Formosan serows can die from the venomous bite of the snake *Trimeresurus stejnegeri* (Lue 1987).

From 1984 to 1985, parapox virus occurred in 155 of 402 serows in Gifu Prefecture, but few cases were fatal (Suzuki et al. 1986). Among the population of Japanese serows from Gifu Prefecture, females and juveniles had higher infection rates than did males (Maruyama et al. 1988). From 1996 to 1999, parapox virus was widespread (Inoshima et al. 2001). Papular and nodular lesions occurred in interdigital glands of a Japanese serow infected with parapox virus (Suzuki et al. 1997). Cutaneous papillomatosis, a form of papovavirus, occurred in an adult male serow (Chihaya et al. 1976). Contagious papular dermatitis occurred in both captive and wild populations (Okada et al. 1984a). The structure of papular lesions of contagious papular dermatitis in *C. crispus* is known (Okada et al. 1984b). *Escherichia coli* is present in *C. crispus* (Kinjo et al. 1992). *Toxoplasma gondii* was reported in captive Japanese serows (Murata 1988). Antibodies against *Brucella abortus*, *Chlamydia psittaci*, *Leptospira interrogans*, *T. gondii*, and Japanese encephalitis are known (Kinjo et al. 1987). *Lyme borreliosis* is prevalent in wild Japanese serows (Sugiyama et al. 1998). No antibodies to *Coxiella burnetii* were found in Japanese serows (Ejercito et al. 1993).

A new form of ciliate protozoan, *Epidinium ecaudatum* forma *capriconisi* from the rumen of *C. c. crispus* was described (Imai et al. 1981). Total number of ciliates ($n = 1.4 \times 10^5$ ciliates/ml) present in the rumen is consistent with a nitrogen source role similar to that known for domestic ruminants (Imai et al. 1981).

Numerous parasites are associated with *C. crispus*. A new lungworm, *Protostrongylus shiozawai*, was found in the Japanese serow (Ohbayashi and Ueno 1974). Lesions associated with *P. shiozawai* appear as white to yellowish-white atelectatic areas (Shiozawa et al. 1975). Lungworm disease might be epidemic in Japanese serows (Suzuki et al. 1981). The nematode *Trichuris discolor* was found in the Japanese serow (Tenora et al. 1992). Additional parasites of Japanese serows include a chewing louse (*Bovicola orientali*—Emerson and Price 1982), *Capillaria bovis* (Wang et al. 1975), 5 *Cercopithifilaria* species (*C. bulboidea*, *C. minuta*, *C. multicauda*, *C. shohoi*, *C. tumidicervicata*—Uni et al. 2001), 4 species of eimerid parasites (*Eimeria capricornis*, *E. kamoshika*, *E. naganoensis*, *E. nihonis*—Inoue 1989), a rare cestode (*Moniezia monardi*—Machida et al. 1974), 2 helminth parasites (*Ogmocotyle capricorni*, *Okapinema japonica*—Machida 1970), and 2 species of *Onchocerca* (Suzuki et al. 1982). *Eimeria gozaishoensis* parasitizes *C. c. swinhoei* (Inoue and Imura 1991).

BEHAVIOR. The basic social units of *C. crispus* include solitary individuals or mother and child (Hanawa et al. 1980; Ochiai 1983a, 1983b), even though male and female home ranges generally overlap. In 3,259 sightings, 79.3% were of single animals (Kishimoto and Kawamichi 1996). Other social units form, including pairs (male and female) and families (male, female, and offspring), but are generally temporary. Pairs may form in late autumn to early winter and stay together through the spring, although males and females will frequently move independently (Akasaka and Maruyama 1977). Scent marking from the preorbital gland can indicate the sexual condition of females to males (Yokohata et al. 1987). Courtship and mating behaviors were described (Hama 1976; Masui 1978). Family units appear after parturition and are maintained until the fall, when males leave (Akasaka and Maruyama 1977).

Male home ranges can overlap with 1 or 2 females (Kishimoto

1987). Home ranges in Akita Prefecture had a mean of 13.8 ha for adult males (n = 71; range, 1.6–33.5 ha) and 9.3 ha for adult females (n = 71; range, 1.2–24.5 ha—Kishimoto 1987). Home ranges for male serows (n = 4) in early winter in Yamagata Prefecture were 14.5, 19.4, 23.0, and 47.9 ha (Ito 1995). Home range size varies over time and among individuals (Ito 1995). Home ranges roughly correspond with territories (Kishimoto 1987), which are demarcated by secretions from the preorbital glands (Akasaka and Maruyama 1977). Marking with the interdigital gland was infrequently observed in captive Japanese serows, and males tended to mark more than females (Berg 1987).

Both sexes hold intrasexual territories (Kishimoto and Kawamichi 1996) that exist to protect feeding areas and maintain stable male–female pair bonds (Ochiai 1983b). Intrasexual breaches of territories can be met with hostility, although aggressive behavior is not frequent (Sakurai 1981). An adult female of a family chased a solitary, adult female that had intruded into the home range of the family (Akasaka and Maruyama 1977). Territoriality contributes to stable population densities (Ochiai et al. 1993a).

Capricornis crispus crispus is often considered monogamous (Miura and Tokida 1992), although in a study by Kishimoto and Kawamichi (1996), ca. 20% of territorial males were polygynous with 2 territorial females. Monogamous pairs are maintained by overlap between home ranges of solitary males and solitary females (Kishimoto and Kawamichi 1996). The size and spacing of female territories might prohibit males from maintaining polygynous groups for long periods (Kishimoto and Kawamichi 1996). Young and mature offspring occur within the home range of an adult pair (Kishimoto and Kawamichi 1996), although offspring will eventually disperse or establish their own territories within the home range of an adult.

Newborn Japanese serows were classified as "followers" by Kishimoto (1989), although hiding behavior was observed. Suckling bouts have a mean of 164.3 s (n = 38; range, 2–560 s—Kishimoto 1989). The time between suckling episodes increased from 3 h (19 days old) to 6 h (45 days old) and coincides with less dependence on the mother (Chiba 1974). Aggressive chases can force dispersal of young Japanese serows, or offspring can disperse on their own.

Dispersal of offspring is often the choice of the young, with no aggression of mothers toward offspring (Ochiai 1983a). However, mothers are often intolerant of yearlings if a newborn is present (Kishimoto 1987). Young might remain in their mother's territory but become independent (Kishimoto 1987).

Sex of the offspring can influence the length of time the offspring is tolerated within a home range. Adult males will aggressively chase male offspring that are >1 year old (Kishimoto 1987). Males are more tolerant of female offspring and will become polygynous with female offspring if they establish territories within the home range of mothers (Kishimoto 1987). By 5 years, offspring establish independent territories (Kishimoto 1987). Additional information on territoriality and repeated use of defecation sites is available (Baba et al. 1997).

A young male chased an estrous female, kicked her legs, and then mounted (Kanomata 1989). Lip curling (flehmen) was observed in males (Berg 1987; Kanomata 1989) and females (Kanomata 1989). Additional details regarding sexual interactions of Japanese serows are available (Berg 1987).

A Japanese serow swam in a lake after it had been startled (Ikeda 1988). In captivity, the approach of large deer (*Cervus elaphus*, *C. nippon*, and *Dama dama*) led to marking, withdrawal, and flight behavior in Japanese serows (Berg 1987). When chased by these larger deer, Japanese serows emitted snorting sounds and fled to rocky ground (Berg 1987). Japanese serows chased gorals in captivity (Berg 1987).

The behavioral repertoire of *C. crispus* includes head butt, butt (other than head), chase, head-down (static), head up, hook, hop, horning (vegetation), kick, lip-curl, low-stretch, marking, nasogenital contact, and nasonasal contact (Lovari and Apollonio 1994). Japanese serows will stand on tree stumps and rocks (Masui, 1987).

GENETICS. Serum protein components show that Japanese serows are phylogenetically nearer to domestic sheep and goats than domestic cattle (Sasaki and Yasuda 1983). Diploid chromosome number is 50 (FN = 60) with 5 pairs of metacentrics and submetacentrics, the remainder being acrocentric (Benirschke et al. 1972; Ito et al. 1972; Soma et al. 1981, 1987). Genetic difference between *C. c. crispus* and *C. c. swinhoei* is small (Lue 1987). The karyotype of *C. c. swinhoei* is essentially identical to *C. c. crispus* (Soma et al. 1981, 1987, 1994).

REMARKS. Etymology of the generic name is *capri* (Latin, a he-goat) and *cornu* (Latin, horn). The phylogenetic affinities of genera traditionally classified within Rupicaprini are uncertain, and various tribal classifications have been proposed for *Capricornis*. *Capricornis*, *Nemorhaedus*, and 2 fossil genera (*Nesogoral* and *Gallogoral*) were placed in the tribe Naemorhedini (= Nemorhaedina Pilgrim, 1939; = Nemorhaedini Sokolov, 1953). *Capricornis* was placed within Capricornini by Duvernois and Guérin (1989).

In 1987, Japanese serows were housed in 35 institutions. Between 1950 and 1984, 217 births occurred in 24 institutions (Komori 1987). In 1987, only 3 institutions outside Japan (Beijing Zoo, Los Angeles Zoo, and San Diego Wild Animal Park) housed *C. c. crispus* (Berg 1987).

Japanese serows were excluded as a game species in 1925 and were designated a natural monument in 1934 (Hirakawa 1992); they have been protected by law as a "special national monument" since 1955 (Tokida and Miura 1988), at which time the population had decreased to 3,000 individuals (Hirakawa 1992). As a result, populations increased to ca. 100,000 by 1983 (Takayanagi 1994). Since 1978, controlled hunting has been permitted in Gifu and Nagano Prefectures, Honshu (Tokida and Ikeda 1992). A 1979 policy allows hunting of Japanese serows outside of protected reserves in Japan (Takayanagi 1994). The Formosan serow is protected by law in Taiwan. The Taipei Zoo began breeding *C. c. swinhoei* in 1974 (Pao-Chung 1987).

Temminck (1844) is most often cited as the 1st description of *C. crispus* (*Antilope crispa*—Corbet 1978), although an additional date (1845) was also used (Grubb 1993). Confusion surrounding the publication date stems from the publication of 4 fascicles from 1842 to 1844 of the Mammalia volume of *Fauna Japonica* (Holthuis and Sakai 1970). Plates 18 and 19 of the Mammalia volume, including the name *A. crispa*, were part of the 2nd fascicle that was published in 1844 (Holthuis and Sakai 1970). The actual description of *A. crispa* was part of the 4th published fascicle of the Mammalia volume, although the 4th fascicle might not have been regarded as a separate fascicle because it did not contain plates (Holthuis and Sakai 1970). As a result, the actual date of publication for this section is not certain. However, information summarized and presented by Holthuis and Sakai (1970) indicates that a publication date of 1844 is the most applicable for the portion of the Mammalia volume that describes *A. crispa*.

The citations for the 1st use of the name combination (*C. crispa*) and gender agreement (*C. crispus*), represent the earliest records we could find that used those specific spellings.

The status of *C. c. swinhoei* is problematic. Nowak (1999) classified the Formosan serow as a distinct species, but chromosomal data support a subspecific assignment (Soma et al. 1987).

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Associate editors of this account were LUI MARINELLI, KAREN MCBEE, and KRIS HELLGREN. Editor was VIRGINIA HAYSSEN.

CHRISTOPHER N. JASS, DEPARTMENT OF GEOLOGICAL SCIENCES (C1140), 1 UNIVERSITY STATION, THE UNIVERSITY OF TEXAS AT AUSTIN, AUSTIN, TEXAS 78712, UNITED STATES. JIM I. MEAD, QUATERNARY SCIENCES PROGRAM AND DEPARTMENT OF GEOLOGY, P.O. BOX 4099, NORTHERN ARIZONA UNIVERSITY, FLAGSTAFF, ARIZONA 86011, UNITED STATES.