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Cervus nippon.

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Cervus nippon Temminck, 1836

Sika Deer

Cervus nippon Temminck, 1836:xxii. Type locality "Isles of Japan."
Cervus pseudaxis Eydoux and Souleyet, 1841:64. Type locality Java.
Cervus sika Temminck, 1845:54, pl. 17. Objective synonym of *nippon*.
Cervus japonicus Sundevall, 1846:178. Objective synonym of *nippon*.
Cervus taiouanus Blyth, 1861:90. Type locality Formosa.
Cervus taevanus Sclater, 1862:152 (for *taiouanus* Blyth).
Cervus hortulorum Swinhoe 1864:169. Type locality Gardens of Summer Palace, Peking.
Cervus mantchuricus Swinhoe 1864:169. Type locality Newchang, Manchuria.
Cervus mandarinus Milne-Edwards 1871:184. Type locality northern China.
Pseudaxis taivanus Gray, 1872:70. Type locality Formosa.
Pseudaxis mantchurica Gray, 1872:72. Type locality northern China.
Pseudaxis sika Gray, 1872:72. Type locality Japan.
Cervus kopschi Swinhoe, 1873:574. Type locality Kienchang, eastern Kiangse, China.
Cervus euopis Swinhoe, 1874:151. Type locality "Newchang, Manchuria."
Cervus dybowskii Taczanowski, 1876:123. Type locality southern Ussuria district of Manchuria.
Cervus tai-oranus Heude, 1881:184. Type locality Formosa.
Cervus frinianus Heude, 1881:185. Type locality between Lake Poyang and the Yangtze River.
Cervus gracilis Heude, 1881:185. Type locality between Lake Poyang and the Yangtze River.
Cervus andreanus Heude, 1881:186. No location.
Cervus ignotus Heude, 1881:186. No location.
Cervus lacrymosus Heude, 1881:186. No location.
Cervus devilleanus Heude, 1881:187. Type locality Formosa.
Cervus joretianus Heude, 1881:187. Type locality northeast Lake Poyang.
Cervus cyclorhinus Heude, 1881:188. Type locality province of Chan-tong (Shantung).
Cervus hyemalis Heude, 1881:188. Type locality province of Shantung.
Sika brachyrhinus Heude, 1884:2. Type locality right bank of Yangtze River, below Lake Poyang, Prefecture of Tchetcheou; for this and the following six names.
Sika cycloceros Heude, 1884:2.
Sika grilloanus Heude, 1884:3.
Sika microdontus Heude, 1884:3.
Sika pouvrelianus Heude, 1884:3.
Sika oxycephalus Heude, 1884:4.
Sika yuanus Heude, 1884:5.
Sika dominicanus Heude, 1884:6. Type locality Formosa; for this and the following three names.
Sika morrisianus Heude, 1884:6.
Sika novioninus Heude, 1884:6.
Sika schulzianus Heude, 1884:6.
Sika fuscus Heude, 1884:7. Type locality "small islands south of Japan"; for this and the following four names.
Sika infelix Heude, 1884:7.
Sika schlegeli Heude, 1884:7.
Sika brachypus Heude, 1884:8.
Sika hollandianus Heude, 1884:8.
Sika orthopus Heude, 1884:8. Type locality Kobe, central Japan.
Sika blakistoninus Heude, 1884:9. Type locality "Nipon and Yeso"; for this and the following two names.
Sika dolichorhinus Heude, 1884:9.
Sika legrandianus Heude, 1884:9.
Sika aplodontus Heude, 1884:10. Type locality north of Tokyo, Japan.
Sika mitratus Heude, 1884:10. Type locality Tokyo, Japan.
Sika yesoensis Heude, 1884:10. Type locality Yeso Island.
Sika microspilus Heude, 1884:11. Type locality Nieou-tchouang, Manchuria.
Sika sylvanus Heude 1884:11. Type locality "Nipon and Yeso."
Sika xendaiensis Heude 1884:11. Type locality Sendai.
Sika grassianus Heude, 1884:12. Type locality Tsinglo-hsien, northern Shansi, China.
Sika granulosis Heude, 1888:pl. 0, Fig. 2. No type locality.
Sika surdescens Heude, 1888:pl. 1A, Fig. 9. No type locality.
Sika paschalis Heude, 1888:pl. 18, Fig. 1. Type locality Goto Islands, Japan.
Sika aceros Heude, 1888:pl. 18, Fig. 2. Type locality Goto Islands, Japan.
Sika minutus Heude, 1888:pl. 18, Fig. 3. No type locality.
Sika rex Heude, 1888:pl. 18, Fig. 5. Type locality Fukuye Island, Goto Islands, Japan.
Sika dejardinus Heude, 1888:pl. 18, Fig. 6. Type locality Goto Islands, Japan.

FIGURE 1. Sika buck showing shaggy neck mane in winter, numerous white spots, rump patch and gray metatarsal area. Photo by Leonard Lee Rue, III.

Sika kematoceros Heude, 1888:pl. 19, Fig. 1. No type locality.
Sika modestus Heude, 1888:pl. 19, Fig. 4. No type locality.
Sika marmandianus Heude, 1888:pl. 19, Fig. 6. Type locality Goto Islands, Japan.
Cervus sica Lydekker, 1893:284. Emendation of *sika*.
Sika imperialis Heude, 1894:146. Type locality Manchuria.
Sika rivierianus Heude, 1894:153. Type locality Lake Poyang.
Sika dugenneanus Heude, 1894:156. No type locality.
Sika arietinus Heude, 1894:162. No type locality.
Sika sendaiensis Heude, 1897:98. (For *xendaiensis*, 1884.)
Sika schizodonticus Heude, 1897:101. Type locality Tokyo, Japan.
Sika orthopodicus Heude, 1897:101. (For *orthopus*, 1884.)
Sika elegans Heude, 1897:103. Type locality Sendai, Japan.
Sika ellipticus Heude, 1897:103. Type locality Sendai, Japan.
Sika minoensis Heude, 1897:104. Type locality Mino, Japan.
Sika rutilus Heude, 1897:105. Type locality Hokkaido, Japan.
Sika daimius Heude, 1898:101. Type locality Goto Islands, Japan; for this and the following four names.
Sika regulus Heude, 1898:103.
Sika sicarius Heude, 1898:105.
Sika consobrinus Heude, 1898:107.
Sika latidens Heude, 1898:108.
Cervus matsumotei Kishida, 1924:36. Type locality Hokkaido.
Cervus centralis Kishida, 1936:275. Type locality Nikko, north of Tokyo.
Cervus pulchellus Imaizumi, 1970:185. Type locality Are, Izuhara, Tsushima Islands, Japan.

CONTEXT AND CONTENT. Order Artiodactyla, Family Cervidae, Genus *Cervus*, Subgenus *Sika*. The number of subspecies of sika deer has yet to be resolved and some nomenclatorial assignments are uncertain (see Remarks) but generally between 6 and 14 subspecies are recognized. The following is after Corbet (1978) and Groves and Smeenk (1978). Names in synonymy are Heude's except where noted otherwise.

C. n. nippon Temminck, 1836:xxii, see above (*aceros*, *brachypus*, *centralis* Kishida, *consobrinus*, *daimius*, *dejardinus*, *fuscus*, *hollandianus*, *infelix*, *japonicus* Sundevall, *keramae* Kuroda, *latidens*, *mageshimae* Kuroda and Okada, *marmandianus*, *minor* Brooke, *orthopodicus*, *orthopus*, *paschalis*, *regulus*, *rex*, *schlegeli*, *sica*, *sicarius*, *sika* Gray, *typicus* Lydekker, and *yakushimae* Kuroda and Okada are synonyms).
C. n. aplodontus Heude, 1884:10, see above (*aplodonticus*, *centralis* Kishida, *elegans*, *ellipticus*, *minoensis*, *mitratus*, *schizodonticus*, *sendaiensis*, and *xendaiensis* are synonyms).
C. n. taiouanus Blyth 1861:90, see above (*devilleanus*, *dominicanus*, *morrisianus*, *novioninus*, *schulzianus*, *tai-oranus*, and *taivanus* Gray, are synonyms).
C. n. hortulorum Swinhoe 1864:169, see above (*andreanus*, *arietinus*, *brachyrhinus*, *cycloceros*, *cyclorhinus*, *dugenneanus*, *dybowskii* Taczanowski, *euopis* Swinhoe, *frinianus*, *gracilis*, *granulosus*, *grassianus*, *gilloanus*, *hyemalis*, *ignotus*, *imperialis*, *joretianus*, *kopschi* Swinhoe, *lacrymosus*, *mandarinus* Milne-Edwards, *mantchurica* Gray, *mantchuricus* Swinhoe, *microdontus*, *microspilus*, *oxycephalus*, *pouvrelianus*, *pseudaxis* Eydoux and Souleyet, *rivierianus*, *surdescens*, *swinhoei* Glover, 1956:104, not *swinhoii* Sclater, and *yuanus* are synonyms).
C. n. yesoensis (Heude, 1884:10), see above (*blakistoninus*, *dolichorhinus*, *legrandianus*, *matsumotei* Kishida, *rutilus*, *sylvanus*, and *yesoensis* are synonyms).
C. n. pulchellus (Imaizumi, 1970:185), see above.
C. n. sichuanicus Zhuopu, Enyu, and Youzhi, 1978:187. Type locality Ruoergai district, Sichuan, China.
C. n. of uncertain status are *hematoceros*, *minutus*, and *modestus*.

DIAGNOSIS. Sika deer are small to medium in size and exhibit much variation amoung subspecies. Pelage ranges from chestnut-brown to reddish-olive, grading to a yellow-brown, tan or gray, depending on the subspecies (Whitehead, 1972). Numerous white spots, occurring in seven or eight rows, are present on the upper sides (Fig. 1). Spots generally are more noticeable in the summer than in winter. The mid-dorsal area is darker than the rest of the coat and forms a line from the head to the rump, where a large white rump-patch is evident. This erectile caudal patch is ringed with the dark stripe. Chin, throat, and belly are off-white or gray. Both sexes have a dark neck mane in the winter.

Antlers are narrow, stand erect over the head, and are directed slightly posteriorly. There are from two to five points per antler. An upswept brow tine arises about 25 mm above the coronet. The bay tine is absent. A forked, or sometimes palmated, tine surmounts the tray tine (Flerov, 1952). Antlers are fairly short, ranging from about 300 to 660 mm in height, depending upon subspecies and local conditions. They are about 25 mm in diameter at the base (Flyger, 1960) and a spread of 400 to 500 mm is exceptional (Page, 1964). Asymmetry, additional processes, and other abnormalities were described by Prisjazhnuk (1971).

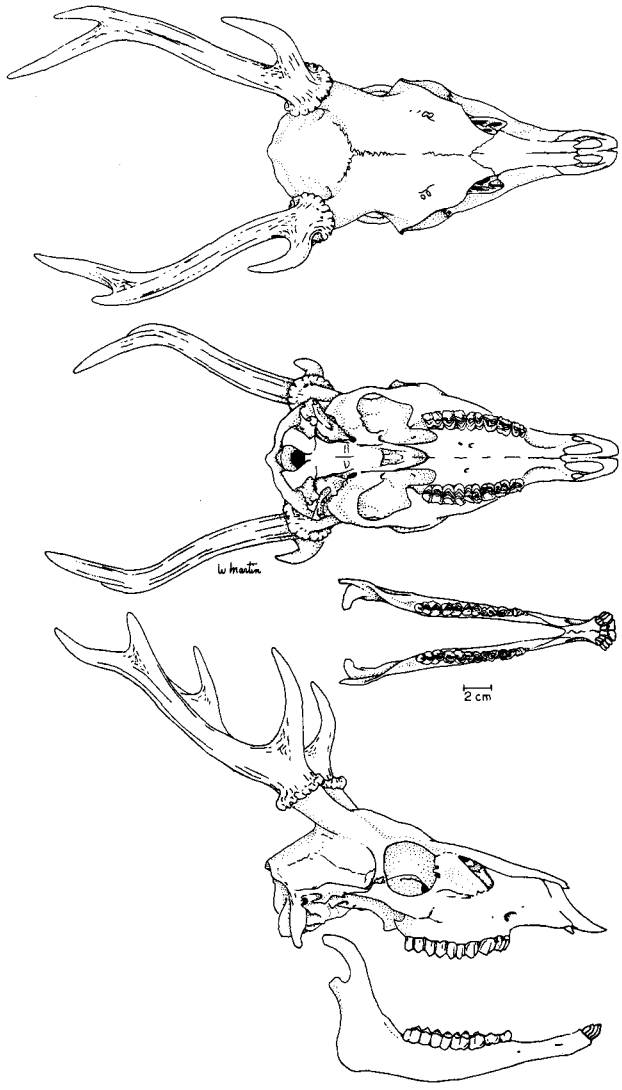

FIGURE 2. Skull and mandible of *Cervus nippon*. From top: dorsal surface, ventral surface and mandible, and lateral view. Drawn by Wilma Martin from a male (Appalachian Environmental Laboratory Museum #1073) taken from Dorchester County, Maryland, in December 1977.

The skull appears short; frontal-parietal region is rounded. Nasal bones do not protrude past maxilla; prelachrymal vacuity is fairly shallow; para-occipital processes extend below occipital condyles. Upper canines protrude from maxilla anteriorly; lower canines are incisiform; molariform teeth are high-crowned with crescentic ridges of enamel (Fig. 2).

GENERAL CHARACTERISTICS. Sika deer exhibit sexual dimorphism, with males being larger than females. Average body measurements of adult males (N = 21) and females (N = 27) from an introduced population in Maryland (*C. n. nippon*) were as follows (in mm): total length 1,357 (1,182 to 1,510) and 1,254 (1,029 to 1,433); length of tail 109 (76 to 130) and 97 (75 to 120); length of ear to notch 114 (90 to 135) and 106 (95 to 114); length of hind foot 362 (340 to 378) and 340 (317 to 363); and height of shoulder 759 (729 to 811) and 692 (640 to 754). Body measurements of adult males averaged 8.7% greater than those of females (Feldhamer, unpublished data). The mean adult body weights of

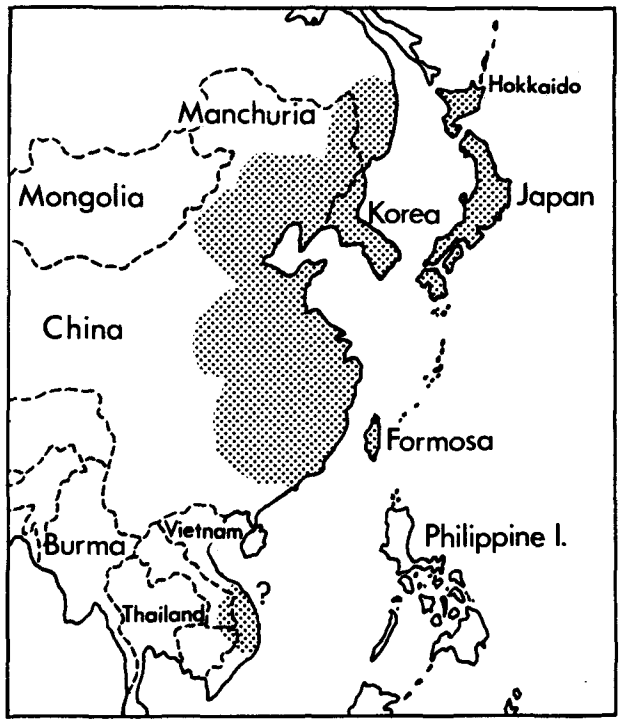

FIGURE 3. Original range of *Cervus nippon*. Modified from Whitehead (1972).

dressed carcasses (viscera and fluids removed) at the end of November in Maryland were: males 32.7 kg, females 26.2 kg. General descriptions of various subspecies of sika deer are given in Bromely (1956) and Flerov (1952) for *C. n. hortulorum*, in Kudo and Ohtaishi (1977) for *C. n. yesoensis*, Horwood and Masters (1970), Davidson (1973) and Whitehead (1972).

The following mean cranial measurements (in mm) are for adult male (N = 5) and female (N = 9) *C. n. nippon* from Maryland. All measurements are as described in Lowe and Gardiner (1974): Condylobasal length, 240 and 219; basilar length, 218 and 200; length of rostrum, 116 and 110; palatal length, 134 and 127; prosthion to p^2, 70 and 66; length of premaxillary, 59 and 58; length of nasal, 78 and 72; breadth of nasals, 29 and 24; breadth of frontals, 106 and 93; width of maxilla, 33 and 29; interorbital width, 70 and 58; breadth of braincase, 71 and 66; condylar breadth, 45 and 40; zygomatic breadth, 102 and 95; and palatal depth, 59 and 55. Cranial measurements of adult males averaged 8.9% larger than those of females (Feldhamer, unpublished data). Cranial measurements of other subspecies are listed in Imaizumi (1970). The dental formula is i 0/3, c 1/1, p 3/3, m 3/3, total 34.

Kiddie (1962) described the winter coat as very dense, with fine curly wool near the hide, and normal long guard hairs projecting through it. The length of hairs in the winter coat is 50 to 70 mm, and it is thicker than summer pelage (Flerov, 1952). Summer pelage is fine, straight, and no more than 30 mm in length.

Metatarsal glands are oblong, about 25 mm long, and surrounded by tufts of grayish-tan hairs. Paired suborbital or facial glands are present, and Kiddie (1962) described small lateral glands that gave the tail a rounded appearance. There are no tarsal or interdigital glands, however. The hooves of adult males are about 60 mm in length and 40 mm in width, while those of females are slightly smaller.

DISTRIBUTION. The original range of sika deer was described by Ellerman and Morrison-Scott (1951) as "the southern Ussuri district of eastern Sibieria; Japan, Manchuria, Formosa; in China-Chihili, Shansi, and the eastern Yangtze Basin from Chekiang and Kiangsu into northern Kwantung." Whitehead (1972) and Corbet (1978) included portions of Vietnam in the native range (Fig. 3). Numerous introductions of sika deer have been made; introduced populations currently are found in England, Scotland, Ireland, Denmark, France and other European countries, Australia and New Zealand. In the United States, introductions were made in several states and feral populations remain in Texas, Maryland, Wisconsin, and Virginia.

FOSSIL RECORD. Flerov (1952) stated that the Pleistocene deer of Asia were preserved almost unchanged in the form of *C. nippon*. Otsuka (1977) discussed features of fossil deer from late Pleistocene deposits of Japan that were very similar to the present Japanese deer (see also Matsumoto and Mori, 1971).

FORM AND FUNCTION. There are two molts annually. The molt into winter pelage occurs in north temperate climates during a two to four week period in September. The summer molt is less abrupt; summer pelage is acquired over a period as long as three months, beginning in March, and thus is worn for a relatively short period of time (Bromley, 1956). In New Zealand, sika deer are in winter pelage from the end of March until October; older animals are first to molt. Although males enter the rut in winter pelage, females occasionally are in summer pelage for the duration of the breeding season (Kiddie, 1962; Davidson, 1973).

In the Northern Hemisphere, males are in velvet antlers from May until August, when fraying begins. Most are in "hard horn" by early September prior to the rut. Thus, the growth phase lasts for approximately 130 days (Goss, 1969). Antlers are shed in May. Older individuals generally shed their antlers before younger animals do, and the new set begins growing immediately. Antler growth in sika deer was "entrained by increasing day lengths in deer previously sensitized by decreasing days" in experiments conducted by Goss (1969). Ohtaishi and Too (1974) found that the temperature of the "velvety" antlers of sika deer paralleled extreme ambient temperatures, while other portions of the body did not.

During the fall rutting season, males quickly deplete reserves of body fat, and may lose 20 to 30% of their body weight (Chapman, 1970). Females, however, do not lose body fat until midwinter, when severe weather and increased fetal growth result in high energy demands; they lack excess fat in the spring. Fawns generally lack fat deposits during their first year (Bromley, 1956).

As in most other cervids, four mammae are present. Flerov (1952) described the milk as rather fatty. At the end of the lactation period it contains 30% fat as compared to 13% at the start of lactation.

ONTOGENY AND REPRODUCTION. The rut begins in late September and lasts for 6 weeks, with greatest activity in October. If unbred, females enter estrus again following a short diestrous period. The proportion of pregnant adult females is high in most feral populations (Kaznevskii, 1972), although sterility of up to 70% of a population has been noted for sika deer confined in parks (Bromley, 1956). The gestation period is about 30 weeks; calving occurs from May through June and occasionally as late as August (Evtushevksy, 1974; Maruyama et al., 1975*a*). This variation in parturition dates was noted in the Soviet Union (Bromley, 1956), and also in New Zealand, where Kiddie (1962) found that pregnant females, collected at the same time, carried fetuses that were from 3 to 12 weeks from parturition. Bromley (1956) discussed the ontogeny of sika deer (probably *C. n. hortulorum*), although apparently from limited samples. At about day 150 of gestation (310 mm total length; weight of 645.0 g) the fetus remained naked and without any pigmented areas. Long tactile hairs appeared around the chin, upper lip and eyes of a 170-day old fetus (390 mm total length; weight 1,300 g), which also had pigmented areas around the nostrils. In addition, the skull apparently was ossified by this stage. At day 180 of gestation (440 mm total length; weight 1,600 g), long vibrissae were present and faint spots were noted along the back and rump. At about day 190 (510 mm total length; weight 2,700 g), all fetuses had spotted pelage, with long hairs on the rump and muzzle (Bromley, 1956). At birth, calves weighed between 4.5 and 7.0 kg and averaged 570 mm in total length. Males were slightly larger than females (Bromley, 1956). A single calf is usually produced, although twins occasionally have been reported. The majority of calves are dropped in forested areas, but small outlaying patches of cover may be used, and some calves are born in open fields. Calves grow rapidly and by month 8 may be only 5 cm shorter at the shoulder and 9 kg lighter than their mother (Horwood and Masters, 1970). The following mean weights (kg) and measurements (mm) were derived from Bromley (1956) for male (N = 3) and female (N = 3) *C. n. hortulorum* in months 9 to 12: weight, 54.0 and 50.7; total length, 1,350 and 1,323; length of tail, 153 and 140; length of ear, 154 and 152; height at shoulder, 907 and 907; and girth of chest, 897 and 847. Skeletal growth is mostly completed by year 2. Males continue to increase in weight until years 7 to 10, whereas females increase in weight until years 4 to 6 (Flerov, 1952; Kudo and Ohtaishi, 1977). Kiddie (1962) stated that

calves were weaned prior to the upcoming rut. However, Flerov (1952) claimed they continued nursing for at least eight to ten months, or almost until the next parturition.

Sika deer attain sexual maturity between months 16 and 18 after birth. The testes and epididymides of sika calves are small but increase in size about 10-fold by the time they become sexually active (Chapman, 1970). Chapman and Horwood (1968) considered pregnancy in sika calves to be unusual, but Horwood and Masters (1970) felt that, in England, pregnant sika calves were not uncommon.

ECOLOGY. Sika deer are found at elevations ranging from sea level to 1,800 m. They prefer forested areas with dense understory, both within their native range and where introduced. However, they are quite adaptable and do well in a variety of habitats. In England, they are found in both deciduous and coniferous woodlands as well as estuarine reed beds and similar wet areas (Page, 1964). In Maryland, they are generally found in association with freshwater marshes, while in New Zealand, during certain times of the year they inhabit grasslands. They are not particularly gregarious. Single animals are seen about as often as small herds, and group size is variable. Throughout most of the year, adult males are solitary, although they sometimes band together when antlers are cast following the rut. During the calving season, females and their young form groups of two to three, possibly with the previous year's offspring, and remain separated from other members of the population. Larger groups may be seen at other times of the year (Ito, 1967; Miura, 1974). During the summer in Japan, Shibata (1969) observed a total of 68 animals in nine groups of from three to 15 individuals. For the 300 to 350 sika deer on Askold Island in the Soviet Union, groups of two to 10 were observed more often than groups of more than 10 (Prisjazhnuk and Prisjazhnuk, 1974). In Japan, the mean number of animals per group varied in relation to season, topography and vegetative type. The average numbers per herd were 1.7 in forests and 5.8 in open fields, with occasional congregations of 40 to 50. In contrast to rather unstable male groups, the temporary female groups displayed the only "clear social organization" (Ito, 1968), as was observed by Mitchell et al. (1977) for red deer (*Cervus elaphus*).

Altitudinal movements of sika deer have been investigated in mountainous areas of Japan. Summer ranges are generally larger than winter ranges. Seasonal factors affecting yearly movements include snowfall and subsequent melt, differential development of forage, reproductive periods, and plant defoliation (Maruyama et al., 1976; Miura, 1974). These movements in Japan involved an elevational range of about 700 meters. Except for transient males, however, no migrational movements of sika deer were noted in New Zealand (Wodzicki, 1950).

The sex ratio of calves is probably 1:1 (Bennetsen, 1976). The ratio of males to females to calves reported on Askold Island was 1.3:6:1.3. This is not an unusual adult sex ratio for ungulate populations. Horwood and Masters (1970) reported the following male to female sex ratios for three age classes of sika deer: fetal, 90.0:100; calves, 82.1:100; and adults, 86.2:100. However, the difficulties involved in censusing sometimes precluded recognition of males in the older age categories.

Sika deer forage primarily from dusk until dawn, although they also may be active at times during the day. They are highly adaptable in their feeding habits, and consume a wide variety of vegetation. In the Soviet Union, sika deer on the Khopersk Reserve consumed 57 species of plants. Grasses and fallen leaves predominated during the spring and summer, and included Siberian squill (*Scilla sibirica*) and common comfrey (*Symphytum officinale*). During the winter, the diet consisted almost exclusively of trees and brushy vegetation: the evergreen shrub, Euonymus (*Euonymus* sp.), oak (*Quercus* sp.), willow (*Salix* sp.), maple (*Acer* sp.), and others (Protoklitova, 1961). The herd on Askold Island consumed 97 different plant species (Prisjazhnuk and Prisjazhnuk, 1974). Bromley (1956) tabulated 99 species of plants consumed by sika deer, the seasonal extent of utilization and part of the plant consumed. The great diversity of forage plants also was noted in Japan. Maruyama et al. (1975*b*) recorded 57 species of trees, 24 species of herbs, and one species of fungus consumed by the deer. There were seasonal differences in the preferred plant species, although sedges (*Carex* sp.) and arrow bamboo (*Sasa nipponica*) were grazed throughout the year. The latter species was considered to be the most important forage item both in quantity and quality. Mikuriya (1975), working with captive sika deer, reported that 114 plant species, from 46 families, were utilized from May to August. Sika deer in the Tanzawa Mountains, Japan, utilized 72 species of trees and shrubs, and 34 species of forbs and grasses (Furubayashi and Maruyama, 1977). Twenty-three species of generally unpalatable plants were recorded on Kinkazan Island, Japan (Ito, 1967, 1975), and included thorn-shrubs (*Zanthoxylum piperitum* and *Z. schinifolium*), Japanese barberry (*Berberis thunbergi*), fetter-bush (*Leucothoe grayana*) and sunflower (*Senecio cannabifolius*). Sika deer also did not eat pampas grass (*Miscanthus sinensis*), the grass *Pteridium* or the broad-leaf evergreen, *Illicium relgiosum*. Bamboo (*Arundinaria chino*) and zoysia grass (*Zoysia japonica*) were more readily grazed by sika deer, while resistant shrubs such as dockmackie (*Viburnum dilatatum*) and rhododendron (*Rhododendron kaempferi*) were heavily used (Ito, 1968).

In New Zealand, plant species commonly browsed include fivefinger (*Nothopanax arboreum*), konini (*Fuchsia excorticata*), karamu (*Coprosma lucida*), catsear (*Hypochaeris radicata*), ragwort (*Senecio jacobeus*), violet beechtuft (*Rhizopogon violaceus*), and seedlings of red and silver beech (*Nothofagus* spp.). Even generally unpalatable species, such as ground ferns (*Blechnum discolor*) and hookgrass (*Uncinia* sp.), were eaten during certain periods of the year (Kiddie, 1962; Wodzicki, 1950).

Little work has been done on the food habits and preferences of sika deer in the United States. In Maryland, Flyger and Warren (1958) felt that poison ivy (*Rhus radicans*), Japanese honeysuckle (*Lonicera japonica*), and greenbrier (*Smilax* sp.) may be preferred food species. They also reported that pokeweed (*Phytolacca americana*), wax myrtle (*Myrica* sp.), American holly (*Ilex opaca*), bark of loblolly pine (*Pinus taeda*) and large-toothed aspen (*Populus grandidentata*), and cordgrass (*Spartina patens*) were browsed, although some of these species may have been low-preference, "starvation" foods. During the spring and early summer, sika deer favor emerging agricultural crops, especially soy beans (*Glycine max*) and corn (*Zea mays*). In feeding trials conducted on penned sika deer, Self (1975) concluded that the following Louisiana marsh plants were of importance: *Distichlis spicata, Echinochloa walteri, Eleocharis quadrangulata, Leptochloa fascicularis, Nelumbo lutea, Paspalum vaginatum, Phragmites communis, Polygonum hydropiperoides, Salix nigra, Scirpus americanus, S. olneyi, Spartina alterniflora,* and *Typha angustifolia.*

Ryabov (1974) reported that 80% of the diet of wolves (*Canis lupus*) on the Khopersk Reserve, Soviet Union, consisted of sika deer, and wolves accounted for 60 to 86% of known predation on sika deer. Feral dogs (*Canis domesticus*) also were of importance as predators (Bromley, 1956). Calves also may fall prey to smaller carnivores, including foxes (*Vulpes* spp.), lynx (*Felix lynx*), or large raptors. Isolated instances of calves being killed by flocks of crows (*Corvus levaillantii*) have been reported (Shibata, 1969). Deaths of males, females, and calves on the Khopersk Reserve occurred in the ratio 1:1:1.5 (Kaznevskii, 1974), although not all were attributed to predation. Kaznevskii (1972) estimated that under normal conditions, 50% of each calf crop failed to survive their first year, in part because of predation. However, populations of sika deer generally did not appear to be adversely affected by normal predation pressure.

Ovcharenko (1963) distinguished two groups of nematodes afflicting sika deer, those such as *Setaria cervi* and *Onchocerca* sp., present at all ages, and those that are not specific for cervids and generally do not occur in deer more than three years of age. This latter group included species such as *Nematodiurus helvetianus* and *Capillaria* sp. Ticks (*Dermacentor sylvarum* and *Ixodes persulcatus*) were found on 23 of 30 sika deer examined by Bromley (1956). Other ectoparasites noted were bloodsuckers (*Zipoptema cervi*), blackflies (*Simulium maculatum*), and the biting midge (*Culicoides obsoletus*). Endoparasites included nasal botflies (*Pharyngomia hicta*), the liver fluke (*Dicrocelium lanceolatum*), and abdominal nematodes (*Cysticercus tenuicolus* and *C. setaria*).

A tick, *Haemaphysalis mageshimaensis*, specific to sika deer on Mage Island, Japan, was described by Saito and Hoogstraal (1973). Ohbayashi (1966) described two nematodes, *Rinadia japonica* and *Spiculopteragia yamashita*, found in the small intestine of a sika deer from Hokkaido, Japan. Of six sika deer examined in Czechoslovakia, one simple infection of footworm (*Wehrdickmansia cervipedis*) and one mixed infection of *W. cervipedis* and *Onchocerca flexuosa* were found (Dykova and Blazek, 1972). Robinson et al. (1978) found *Elaeophora schneideri* in sika deer from Texas, and considered this species of deer to be an aberrant host. Sika deer also may be infected with several species of spirochetes. Vysotskii and Ryashchenko (1961) examined blood samples from 450 sika deer and found 38 reacted to *Leptospirosis pomona* antigens, 23 to *L. tarrasowi* antigens, and four to *L. saxkoebing* antigens. In New Zealand, however, sika deer are of

little significance as reservoirs of *Leptospirosis* sp. or of *Brucella abortus* and *Salmonella* sp. (Daniel, 1967). Piroplasmosis was reported by Flerov (1952) to be extremely widespread among sika deer populations in their native range. Malignant catarrhal fever (MCF), a viral infection of domestic ruminants, was noted in three captive sika deer that had been in contact with domestic species (Sanford et al., 1977). Antibodies to *Myxovirus parainfluenza* 3, a virus associated with man and domestic livestock, were detected in only one of 12 sika deer tested from the Maryland-Virginia area (Shah et al., 1965).

BEHAVIOR. During the summer, adult males begin to establish territories for the upcoming rut. Males dig holes up to 1.6 m wide and 0.3 m deep with their antlers and forefeet, into which they urinate frequently. These holes, together with the thrashing of surrounding ground cover with the antlers, delimit the boundaries of individual territories. Kiddie (1962) felt that 2 ha represented the size of the largest manageable territory in New Zealand, although Horwood and Masters (1970) felt sika bucks on their study area in England may have defended territories as large as 8 to 12 ha. No quantitative studies have confirmed these estimations, however. Subordinate bucks are often found around the periphery of territories or in the breeding groups. During the rut, behavioral interactions between rival, breeding males are not simply ritualistic. Kiddie (1962) reported that fights were often "spectacular" for their "speed and fierceness." Fighting with antlers and hooves sometimes resulted in fatal wounds; and blinded eyes, torn nostrils, and severe puncture wounds were not uncommon results of territorial challenges.

Sika deer are polygamous. The breeding group of a successful territorial male may number as many as 12 females (Kiddie, 1962). Bucks follow available females and attempt to drive them to their territories, where mating takes place. Chases may be prolonged, or a female may rub her flanks against the buck in an apparent effort to initiate mating (Horwood and Masters, 1970). A male may mount a female several times unsuccessfully, with each attempt followed by an interval of from 10 to 15 min of relative inactivity. A successful copulation lasts only about 4 s and may occur at any time of the day or night (Kiddie, 1962). Bucks remain on their territories and often do not feed until the latter stages of the rutting season. Females, however, appear to feed normally throughout this period, and may move through adjacent territories and associate with other bucks to do so. Kiddie (1962) reported that when a territorial buck had three or more females in a group, it was not uncommon to also find two or three younger bucks in the group. These subordinate males did a majority of the "roaring" vocalizations and investigated preliminary territorial challenges. Young bucks apparently do not breed, however (Kiddie, 1962). Bucks wallow during the rut and usually have a "filthy, matted appearance, particularly around the neck and shoulders" (Horwood and Masters, 1970).

Pregnant or lactating females apparently engage in behavior that minimizes intrusion into their calving area by other females, and which aids in dispersing these females. During this period, adult does face each other and strongly stomp the ground with the forefeet (Maruyama et al., 1975*a*). Dispersion also may be facilitated by vocalizations of females.

This species probably is one of the most vocal members of the Cervidae, especially during the breeding season. Kawamura (1957) recorded 10 different vocalizations from a herd of sika deer, although only two types of voices were considered to be common. Kiddie (1962) noted up to five distinct calls from individual deer. Vocalizations range from soft whistles between females, to "goat-like bleats" from doe to fawn and "soft horse-like neighs" from fawn to doe (Kiddie, 1962). During the rut, both dominant and subordinate males may emit "blood-curdling screams" (Flyger and Davis, 1964). Approximately one month prior to the beginning of the rut, bucks go through the physical motions of roaring but produce no sounds (Kiddie, 1962). Kiddie felt this behavior served to exercise the proper muscles before initiation of the roar. The alarm call, which may be uttered by either sex and which is audible up to 0.8 km, has been described as a "sharp scream" (Page, 1964), a "high-pitched whistle followed by a guttural bark" (Kiddie, 1962), and a "chirp-like sound" (Flyger and Davis, 1964).

When running at slow to medium speed, sika deer use a stiff gallop, making bounds of up to 3 m in length. At slightly increased speed they exhibit a rather stiff-legged, quadrupedal hopping, with all four hooves simultaneously about 0.3 m off the ground. Bromley (1956) stated that, in this gait, sika deer made bounds up to 6 m in length and were able to clear obstacles up to 1.7 m in height. Sika deer are reported to be excellent swimmers; they readily enter the water, either to escape predators or of their own volition, and are capable fo swimming up to 12 km in the sea (Flerov, 1952).

GENETICS. Gustavsson and Sundt (1969) found variation from 64 to 68 in the diploid chromosome number of 11 *C. n. hortulorum*. Two autosomes and the Y-chromosome of males were metacentric, while the remaining chromosomes were telocentric (for 2N = 68). Observed variations in number were the result of centric fusions. A female *C. n. nippon* investigated by Koulischer et al. (1972) had a 2N of 66, with two pairs of metacentrics and 31 pairs of telocentrics. In two *C. n. nippon* studied by Gustavsson and Sundt (1968), the modal 2N chromosome number was 67 (range was 65–68), and chromosome structure was similar to that described for *C. n. hortulorum*.

Taylor and Easley (1977) investigated the hemoglobin α-chains of captive sika deer in Florida. A minimum of five and possibly seven, different α-chains were found in the relatively small sample of 10 animals. They also determined that three individuals had two, and possibly as many as four, separate α-chains.

Polydactylism was reported by Davidson (1971) for a sika deer in New Zealand.

Flerov (1952) noted that hybrids between sika deer and red deer (*Cervus elaphus*) occurred quite frequently in northern Asia. This phenomenon has also been noted relative to sympatric populations of these species in New Zealand (Davidson, 1973; although see Howard, 1965; Kiddie, 1962), Ireland (Harrington, 1973), and possibly in Scotland (McNally, 1969). Lowe and Gardiner (1975) tested measurements from the skulls of sika deer, red deer and their hybrids by multivariate analysis. They concluded that much hybridization occurred between these species, but that in England "the degree of hybridization exhibited by the skulls was not reflected in coat color or other body features, and in fact, appeared to be completely independent of them" (Lowe and Gardiner, 1975). They concluded that hybrid offspring were common between females of the mainland subspecies of sika deer and male red deer. Sika females of the island subspecies (*C. n. nippon*) apparently did not hybridize with red deer. It should also be noted that sympatric populations of *C. n. hortulorum* and *C. n. taiouanus* in England apparently do not interbreed (Gustavsson and Sundt, 1969).

REMARKS. As noted by several researchers, the relationships of populations of the sika deer need further investigation. The situation has been complicated by extensive transplantations and hybridization with red deer.

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[An unfortunate nomenclatorial exuberance is apparent in the history of this species, as displayed in the lengthy synonymy. The editor considered changing the regular format in order to shorten this, but decided not to make an exception.]

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