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Body morphology and weight relationships of Sika deer in Maryland

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Abstract

Significant sexual dimorphism occurred by 1.5 years of age in free-ranging sika deer in Maryland in dressed body weight, total body length, tail length, ear length, shoulder height, hind foot length, width of front and rear hooves and chest girth. Growth rates for stags were greater than those of hinds for most parameters measured. Relative growth between total body length, shoulder height, hind foot length and chest girth was allometric. Isometric growth was found only between total body length and chest girth.

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Seasonal variation was noted in the correlations of whole vs. dressed weight of hinds; there was no seasonal difference for stags. Mean dressed weight of stags was about 72 % of whole weight.

Most yearling stags had spike antlers, while the maximum number of antler points seen in mature stags was six (three/antler). The possible significance of morphological characteristics is discussed relative to the founder effect of sika deer introduced in Maryland.

Introduction

Sika deer *(Cervus nippon)* have been introduced into numerous countries throughout the world. Nevertheless, very few age-related morphological characteristics of this species have been described. Age-related characteristics of a species may be of importance in the estimation of metabolic and physiological functions (Moen 1978), the estimation of individual live weight and population biomass (Jeffrey and Hanks 1981), and as baseline values for diagnoses of disease, toxic factors and nutritional deficiency (Anderson et al. 1974). The age-related body morphology of several species of deer has been described, including red deer *(Cervus elaphus)* (Dzieciolowski 1970), North American elk or wapiti (Blood and Lovaas 1966), roe deer *(Capreolus capreolus)* (Fruzinski et al. 1982), mule deer *(Odocoileus hemionus)* (Anderson et al. 1974), and white-tailed deer *(O. virginianus)* (Hamerstrom and Camburn 1950).

We describe body weight and skeletal growth, relationships between whole and dressed weights, and antler characteristics for an introduced, free-ranging population of sika deer in Maryland. Sika deer were first released in Maryland on James Island in 1916, and on Assateague Island about 1930 (Fig. 1). The distribution and population density of sika deer has since expanded greatly (Feldhamer et al. 1978), and in many areas, they have displaced native white-tailed deer. Sika deer in Maryland now occur in Dorchester, Wicomico, Worcester and Somerset Counties. They have always been hunted, but it was not until 1973 that separate harvest statistics were kept for sika vs. white-tailed deer. Currently,

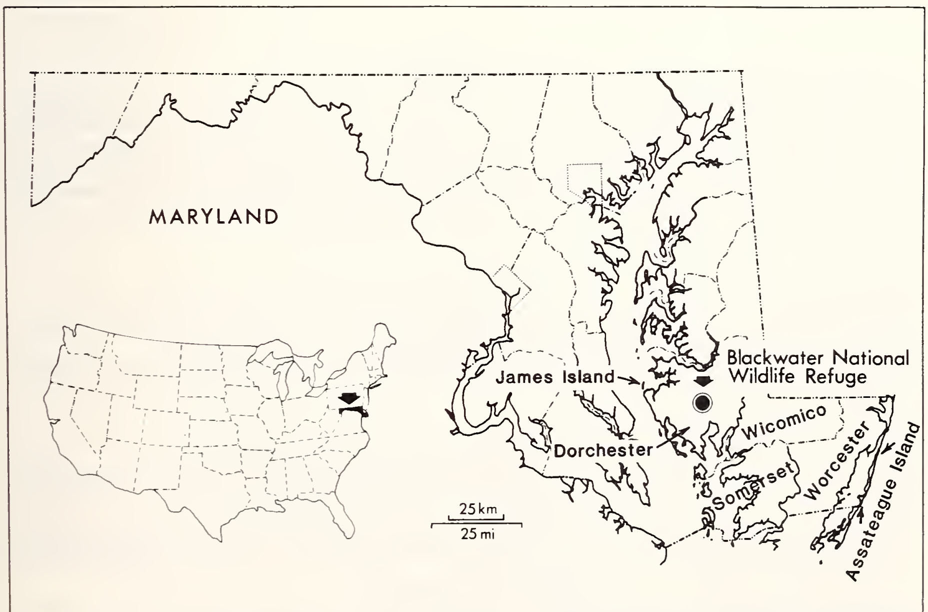

Fig. 1. Study area south of Blackwater National Wildlife Refuge, Dorchester County, Maryland, USA

there is a 13-week archery season, 1-week muzzle loader season and 1-week firearms season, with a total bag limit for the three seasons of nine sika deer of either sex.

Study area

The study was conducted in southern Dorchester County, Maryland, the center of the county being located at approximately 39°30′ N, 76°10′ W. This area ranges in elevation from sea level to about 3 m, with an average elevation of about 1 m. The southern portion of the county is interspersed with woodlands, brackish marsh and cultivated fields. The two major crops grown in the study area are soybeans and corn.

The woodland overstory is dominated by loblolly pine *(Pinus taeda)* interspersed with oak (*Quercus* sp.), red maple *(Acer rubrum)*, black gum *(Nyssa sylvatica)* and sweet gum *(Liquidambar styraciflua)*. Major understory species are bayberry (*Myrica* sp.), greenbriar (*Smilax* sp.), American holly *(Ilex opaca)* and poison ivy *(Rhus radicans)*. Woodlands typically have areas of standing water (about 15 cm deep) in them.

Predominant marsh vegetation includes three-square rush *(Scirpus olneyi)*, saltgrass *(Distichlis spicata)*, cattail *(Typha angustifolia)*, sedge (*Carex* sp.), spikerush *(Eleocharis parvula)* and reed *(Phragmites communis)*. Open water areas include shallow ponds and rivers. Controlled burning of marshes occurs on Blackwater National Wildlife Refuge, which encompasses 2,300 ha of marsh, on the adjacent Fishing Bay Wildlife Management Area and the Taylor's Island Wildlife Management Area.

It is quite humid in this area throughout the year. The mean yearly precipitation is about 109 cm, of which about 38 cm is snow. Highest mean monthly temperature is in July (25.8 °C) the lowest in January (±1.2 °C).

Methods of analysis

Carcass measurements were taken on sika deer examined at the Church Creek and Taylor's Island deer-check stations, Dorchester County, during the one-week firearms season (late November to early December) from 1977 through 1981, and from hunting camps in the study area during this period. We also collected deer by shooting in July and August 1979, and February and March 1980, to establish whole- vs. dressed-weight relationships. Original measurements were made in pounds or inches and converted to metric equivalents.

Carcass measurements

Deer brought to the check stations were weighed to the nearest 0.45 kg on a platform scale. Weights of deer in the field or in hunt camps were taken on a hanging Ohaus scale again to the nearest 0.45 kg. Measurements were taken with a flexible steel tape with the deer layed flat on its side. Hind foot, front hoof and rear hoof measurements were taken only once on each deer, usually on the left side; thus, no bilateral comparisons were made. Measurements were taken by several different individuals because of the number of deer and the length of the study. The following measurements were taken:

Whole weight. The weight of the live animal less blood loss from shooting. We shot most of the deer in the neck to minimize tissue and blood loss.

Dressed weight. The weight of the carcass after blood and all visceral organs had been removed.

Total length. Measured with the tape held flat against the mid-line contour of the body from the tip of the nose to the posterior edge of the last coccygeal vertebra.

Tail length. Measured on the ventral surface from the perianal region to the posterior edge of the last coccygeal vertebra.

Ear length. Measured from the notch to the tip.

Hind foot length. Measured from the calcaneum to the tip of the hoof.

Shoulder height. Measured from the superior angle of the scapula to the tip of the hoof, with the front leg straight and perpendicular to the carcass.

Front and rear hooves. Measured length along the ventral surface from a point opposite the posterior edge of the unguis to the tip of the hoof. Measured width from edge to edge across middle of hoof with digits held together.

Chest girth. Measured the circumference of the chest with the front legs perpendicular to the carcass and the tape posterior to the front legs.

Age estimation

Age of deer was estimated by wear and eruption of mandibular dentition, using criteria established for red deer by LOWE (1967). These criteria are believed to be applicable to sika deer (see FELDHAMER and CHAPMAN 1980). For adults, the cementum annuli also were examined as a cross-check on age estimation. A first incisor was removed and decalcified in ethylene dinitrotetra acetic acid, washed in distilled water and sectioned at 14_{μ} on an AO Cryo-Cut II Microtome. Sections were stained with Harris' hematoxylin and examined under a light microscope at 40×.

Statistical analyses

The von Bertalanffy equation was used to estimate growth of skeletal parameters of follows:

$$l_t = L_\infty \left[1 - e^{-K(t-t_0)}\right]$$

where:

l_t = length at age t
L_∞ = asymptotic length
K = a coefficient of catabolism, or "growth coefficient" (see RICKER 1975: 221)
t = age in years
t_0 = hypothetical age at which length would have been zero if growth had always been in the manner described by the equation (see HANKS 1972)

Asymptotic values were generally taken as the largest mean value of an age group for each parameter. From the von Bertalanffy equation above:

$$1 - \left(\frac{L}{L_\infty}\right) = e^{-K(t-t_0)}$$

and

$$\ln\left(1 - \frac{L}{L_\infty}\right) = Kt + Kt_0$$

where L = observed mean value of parameter at each age.
The coefficients K and t_0 were then calculated from the regression of t (independent variable) on

$$\ln\left(1 - \frac{L}{L_\infty}\right)$$

where:
$-K$ = slope of the line
t_0 = y intercept/K.

The cubic form of the von Bertalanffy equation was used for the dressed body weight parameter. Because of small sample sizes, individuals 9.5 years of age and older were combined for purposes of analyses. Once an equation was generated for a parameter, a regression of the predicted (theoretical) vs. observed, mean values for each age, weighted for sample size, was calculated and the R^2 values reported. For some parameters, different asymptotic values were attempted, and the equation which maximized the R^2 was used. Analyses were made using the New Regression program of Statistical Package for the Social Sciences Update 7–9 (HULL and NIE 1981) on a Univac 1180 computer.

Results

A total of 606 sika deer carcasses was measured including 125 calves (20.6 %), 229 yearlings (37.8 %) and 252 adults (41.6 %). However, sex of dressed calves generally could not be determined because antler (pedicel) development had not begun, and information on sex of calves from hunters was not reliable. Therefore, analyses of calves were based only on 6 known males and 5 known females of the 125 calves. There were 170 male and 59 female yearlings, and 141 male and 111 female adults, for an effective sample size of 492. For some individuals, certain measurements were not available, so sample sizes differed. The age-specific mean, one standard deviation and range for body parameters are given in Table 1 for each sex.

Dressed body weight

The mean dressed body weight of male calves (n = 6) was 15.4 kg, 2.2 kg greater than for female calves (n = 5). These estimates were not statistically different (Table 2), probably

Table 1

Mean ± one standard deviation, range and sample size for age-related body measurements of sika deer *(Cervus nippon)* from Dorchester County, Maryland

Data collected from 1977–1981

Age (years)	Sex	Dressed weight (kg)	Total length (cm)	Tail length (cm)	Ear length (cm)	Shoulder height (cm)	Hind foot length (cm)	Front hoof length (cm)
0.5	S	15.4 ± 1.6 (13.2 - 17.3) n = 6	105.3 ± 7.9 (914 - 1143) n = 6	9.8 ± 1.1 (8.9 - 11.5) n = 5	10.7 ± 0.6 (10.2 - 11.5) n = 6	62.9 ± 2.8 (59.1 - 66.0) n = 6	32.9 ± 1.6 (30.5 - 35.0) n = 6	5.1 ± 0.5 (4.4 - 5.7) n = 6
	H	13.2 ± 1.9 (10.0 - 14.9) n = 5	99.8 ± 9.3 (87.6 - 111.8) n = 5	9.2 ± 0.7 (8.3 - 10.2) n = 5	9.9 ± 0.9 (8.3 - 10.8) n = 5	58.9 ± 2.9 (55.9 - 62.9) n = 5	31.3 ± 1.3 (29.8 - 33.0) n = 5	4.8 ± 0.9 (3.8 - 6.3) n = 5
1.5	S	22.6 ± 3.1 (14.1 - 32.7) n = 166	124.3 ± 7.3 (95.9 - 137.8) n = 166	10.7 ± 1.4 (6.3 - 14.6) n = 161	11.2 ± 0.5 (10.0 - 12.1) n = 169	72.2 ± 3.4 (59.1 - 81.3) n = 169	35.4 ± 1.1 (33.0 - 38.7) n = 170	5.3 ± 0.8 (2.9 - 7.0) n = 166
	H	20.3 ± 3.0 (13.6 - 28.6) n = 54	117.8 ± 7.5 (87.0 - 128.3) n = 57	9.5 ± 1.4 (6.9 - 13.3) n = 55	10.7 ± 0.5 (9.5 - 12.1) n = 59	66.1 ± 4.1 (54.6 - 73.7) n = 59	33.6 ± 1.2 (29.2 - 36.8) n = 59	5.2 ± 0.5 (3.8 - 6.4) n = 57
2.5	S	28.3 ± 3.7 (21.8 - 37.6) n = 57	133.7 ± 9.1 (89.5 - 152.4) n = 54	10.9 ± 1.7 (7.3 - 17.7) n = 53	11.3 ± 0.5 (10.2 - 12.7) n = 58	75.2 ± 3.5 (61.6 - 82.6) n = 58	35.7 ± 0.9 (34.0 - 38.1) n = 58	5.5 ± 0.8 (3.5 - 7.0) n = 58
	H	19.9 ± 2.7 (15.4 - 26.8) n = 24	120.9 ± 8.4 (86.4 - 130.2) n = 25	9.7 ± 1.5 (6.4 - 12.7) n = 25	10.7 ± 1.0 (7.0 - 12.4) n = 25	69.0 ± 2.7 (62.2 - 73.7) n = 25	33.5 ± 1.6 (29.2 - 38.7) n = 25	5.1 ± 0.6 (3.5 - 6.2) n = 25
3.5	S	30.8 ± 2.9 (24.9 - 37.2) n = 42	135.1 ± 6.7 (121.9 - 154.9) n = 42	10.8 ± 1.2 (7.6 - 12.7) n = 42	11.5 ± 0.7 (9.0 - 13.5) n = 43	77.1 ± 3.2 (69.2 - 82.6) n = 43	36.2 ± 1.2 (33.0 - 38.1) n = 42	5.6 ± 0.9 (3.8 - 7.6) n = 43
	H	21.6 ± 4.6 (14.5 - 32.2) n = 31	123.1 ± 7.4 (104.1 - 142.2) n = 28	9.9 ± 1.1 (8.3 - 12.1) n = 28	10.8 ± 0.4 (10.0 - 11.4) n = 31	68.4 ± 3.6 (59.1 - 75.0) n = 31	33.4 ± 1.2 (31.1 - 36.2) n = 31	5.3 ± 0.7 (3.8 - 7.0) n = 31

Table 1. (Continued)

Age (years)	Sex	Dressed weight (kg)	Total length (cm)	Tail length (cm)	Ear length (cm)	Shoulder height (cm)	Hind foot length (cm)	Front hoof length (cm)
4.5	S	32.6 ± 4.9 (23.6 - 40.8) n = 20	135.1 ± 8.1 (118.2 - 151.1) n = 19	11.3 ± 1.0 (10.0 - 13.0) n = 19	11.4 ± 0.4 (10.0 - 12.1) n = 20	78.4 ± 6.3 (72.0 - 99.9) n = 20	35.8 ± 1.1 (34.0 - 37.5) n = 20	5.6 ± 0.9 (3.8 - 7.0) n = 20
	H	22.3 ± 3.9 (17.2 - 32.2) n = 19	123.2 ± 5.2 (111.8 - 133.0) n = 19	9.7 ± 1.0 (7.9 - 11.5) n = 18	10.6 ± 0.7 (8.6 - 11.4) n = 19	68.9 ± 2.3 (64.0 - 73.7) n = 19	34.0 ± 1.2 (31.8 - 36.3) n = 19	5.3 ± 0.6 (4.4 - 6.8) n = 18
5.5	S	34.3 ± 4.3 (29.5 - 43.2) n = 11	136.0 ± 8.8 (117.5 - 148.6) n = 11	10.9 ± 1.4 (8.9 - 13.7) n = 11	11.3 ± 0.8 (10.2 - 12.7) n = 11	78.6 ± 6.4 (71.1 - 96.5) n = 11	36.2 ± 0.8 (34.9 - 38.1) n = 11	5.3 ± 0.7 (4.1 - 6.4) n = 11
	H	24.1 ± 4.6 (16.8 - 34.0) n = 14	126.2 ± 5.6 (114.3 - 133.7) n = 15	9.6 ± 1.1 (7.6 - 12.4) n = 14	10.8 ± 0.4 (10.2 - 11.4) n = 15	70.5 ± 2.2 (66.0 - 73.0) n = 15	34.0 ± 1.2 (32.4 - 35.6) n = 15	5.3 ± 0.4 (4.4 - 6.0) n = 15
6.5	S	33.1 ± 1.3 (32.2 - 34.0) n = 2	138.4 ± 3.6 (135.9 - 141.0) n = 2	11.1 ± 0.4 (10.8 - 11.4) n = 2	11.7 ± 0.5 (11.4 - 12.1) n = 2	74.9 ± 2.6 (73.1 - 76.8) n = 2	35.9 ± 0.4 (35.6 - 36.2) n = 2	5.4 ± 0.4 (5.1 - 5.7) n = 2
	H	30.3 ± 3.7 (27.3 - 36.4) n = 5	128.8 ± 15.1 (102.9 - 140.3) n = 5	9.7 ± 1.6 (7.9 - 12.0) n = 5	10.4 ± 0.8 (9.0 - 11.0) n = 5	72.4 ± 3.5 (69.0 - 77.1) n = 5	33.8 ± 1.1 (32.7 - 35.6) n = 5	5.5 ± 0.6 (5.0 - 6.4) n = 5
7.5	S	---	---	---	---	---	---	---
	H	22.8 ± 1.8 (20.9 - 24.9) n = 4	122.6 ± 3.9 (118.1 - 127.6) n = 4	10.5 ± 0.6 (10.2 - 11.4) n = 4	10.2 ± 1.2 (8.9 - 11.4) n = 4	66.6 ± 0.9 (65.4 - 67.3) n = 4	32.7 ± 0.8 (31.8 - 33.7) n = 4	5.4 ± 0.6 (5.1 - 6.3) n = 4
8.5	S	35.4 n = 1	144.8 n = 1	11.4 n = 1	11.4 n = 1	82.6 n = 1	40.0 n = 1	6.0 n = 1
	H	23.5 ± 3.6 (20.4 - 26.8) n = 4	126.5 ± 3.3 (123.1 - 130.8) n = 4	8.8 ± 1.1 (7.6 - 10.2) n = 4	10.7 ± 0.2 (10.5 - 10.8) n = 4	68.8 ± 2.2 (66.7 - 71.4) n = 4	33.9 ± 0.9 (33.0 - 34.9) n = 4	5.3 ± 0.9 (4.4 - 6.3) n = 4
≥ 9.5	S	35.5 ± 1.9 (33.6 - 38.1) n = 4	144.0 ± 10.6 (128.9 - 152.4) n = 4	10.8 ± 1.6 (8.9 - 12.1) n = 4	11.2 ± 0.7 (10.2 - 11.7) n = 4	82.6 ± 9.3 (76.2 - 96.5) n = 4	35.6 ± 0.0 (35.6) n = 4	5.8 ± 0.9 (4.4 - 6.4) n = 4
	H	18.9 ± 1.9 (15.4 - 21.4) n = 7	121.9 ± 5.1 (116.8 - 132.1) n = 6	10.6 ± 0.7 (9.5 - 11.4) n = 8	10.1 ± 0.3 (9.5 - 10.5) n = 8	68.8 ± 3.4 (61.0 - 71.4) n = 8	33.6 ± 1.2 (32.7 - 35.6) n = 8	5.4 ± 0.5 (5.1 - 6.5) n = 8

Table 1. (Continued)

Age (Years)	Sex	Front hoof width (cm)	Rear hoof length (cm)	Rear hoof width (cm)	Chest girth (cm)	Total length/ dressed weight	Total length/ chest girth
0.5	S	3.1 ± 0.4 (2.5 - 3.8) n = 6	4.8 ± 0.5 (4.4 - 5.4) n = 6	3.1 ± 0.5 (2.9 - 3.8) n = 6	63.6 ± 3.7 (59.7 - 68.6) n = 6	6.9 ± 0.8 (5.7 - 8.1) n = 6	1.6 ± 0.2 (1.5 - 1.9) n = 5
	H	2.9 ± 0.4 (2.5 - 3.2) n = 5	4.4 ± 0.5 (3.8 - 5.1) n = 5	3.0 ± 0.2 (2.8 - 3.2) n = 5	60.9 ± 5.9 (54.6 - 69.2) n = 5	7.7 ± 1.4 (5.9 - 9.6) n = 5	1.7 ± 0.3 (1.3 - 1.9) n = 5
1.5	S	3.5 ± 0.3 (2.2 - 4.8) n = 166	5.1 ± 0.7 (2.9 - 7.6) n = 166	3.4 ± 0.4 (2.5 - 4.8) n = 166	74.5 ± 4.3 (60.3 - 84.5) n = 133	5.6 ± 0.7 (3.5 - 7.9) n = 162	1.7 ± 0.3 (1.3 - 2.1) n = 131
	H	3.2 ± 0.2 (2.5 - 3.8) n = 57	4.8 ± 0.5 (3.5 - 5.7) n = 57	3.1 ± 0.3 (2.5 - 4.4) n = 57	71.1 ± 5.4 (52.1 - 83.8) n = 48	5.9 ± 0.7 (4.1 - 7.2) n = 52	1.7 ± 0.1 (1.4 - 1.9) n = 46
2.5	S	3.6 ± 0.3 (2.9 - 4.4) n = 58	5.1 ± 0.5 (3.8 - 6.5) n = 58	3.5 ± 0.3 (2.9 - 4.4) n = 58	79.5 ± 4.2 (69.8 - 88.9) n = 52	4.8 ± 0.6 (3.2 - 5.9) n = 53	1.7 ± 0.1 (1.1 - 1.9) n = 50
	H	3.2 ± 0.3 (2.9 - 3.8) n = 25	4.6 ± 0.5 (3.5 - 5.7) n = 25	3.1 ± 0.4 (2.0 - 3.8) n = 25	73.6 ± 4.4 (66.0 - 82.6) n = 24	6.2 ± 0.9 (4.3 - 8.2) n = 24	1.6 ± 0.2 (1.2 - 1.9) n = 24
3.5	S	3.7 ± 0.4 (2.9 - 4.8) n = 43	5.2 ± 0.7 (3.2 - 7.0) n = 43	3.5 ± 0.3 (2.9 - 4.0) n = 43	81.8 ± 3.6 (76.2 - 91.4) n = 31	4.4 ± 0.4 (3.7 - 5.5) n = 41	1.7 ± 0.01 (1.5 - 1.8) n = 31
	H	3.3 ± 0.3 (2.9 - 4.4) n = 31	4.7 ± 0.6 (3.5 - 6.0) n = 31	3.2 ± 0.4 (2.5 - 4.4) n = 31	72.7 ± 4.5 (61.6 - 81.3) n = 25	5.8 ± 1.2 (3.9 - 8.1) n = 28	1.7 ± 0.1 (1.4 - 2.1) n = 23
4.5	S	3.7 ± 0.3 (3.2 - 4.4) n = 20	5.5 ± 0.4 (4.9 - 6.7) n = 20	3.7 ± 0.4 (3.1 - 4.4) n = 20	82.9 ± 4.2 (76.2 - 90.2) n = 12	4.3 ± 0.6 (3.3 - 5.4) n = 19	1.6 ± 0.9 (1.5 - 1.8) n = 12
	H	3.4 ± 0.4 (2.9 - 4.4) n = 18	5.0 ± 0.6 (3.8 - 6.5) n = 18	3.4 ± 0.4 (2.7 - 4.4) n = 18	71.9 ± 4.8 (66.0 - 80.0) n = 12	5.7 ± 0.9 (3.8 - 7.3) n = 19	1.7 ± 0.1 (1.6 - 1.9) n = 12
5.5	M	3.7 ± 0.4 (3.2 - 4.4) n = 11	5.0 ± 0.8 (4.1 - 6.4) n = 11	3.7 ± 0.5 (3.2 - 4.9) n = 11	84.3 ± 2.6 (81.3 - 90.2) n = 9	4.0 ± 0.4 (3.4 - 4.6) n = 11	1.6 ± 0.1 (1.5 - 1.8) n = 9
	H	3.3 ± 0.2 (2.9 - 3.8) n = 15	5.0 ± 0.6 (3.5 - 5.7) n = 15	3.3 ± 0.3 (2.9 - 3.8) n = 15	76.9 ± 6.0 (64.8 - 85.1) n = 15	5.4 ± 0.9 (3.5 - 7.5) n = 14	1.6 ± 0.1 (1.5 - 2.0) n = 15

because of small sample size. Significant sexual dimorphism in dressed body weight was evident by 1.5 years of age. Stags attained 95 % of their estimated asymptotic weight (35.6 kg) by the age of 5.5 years; hinds (24.2 kg) by the age of 7.5 years (Fig. 2). The asymptotic dressed body weight of stags was 32.0 % greater than in hinds.

Total length

As with dressed body weight, significant differences in total length between stags and hinds were evident for all age classes except calves (Table 2). The asymptotic total length value of stags (145.0 cm), was 12.8 % greater than that of hinds (126.5 cm). Hinds attained 95 % of their asymptotic total length by 2.5 years of age, stags by 4.5 years of age (Fig. 3).

Table 1. (Continued)

Age (Years)	Sex	Front hoof width (cm)	Rear hoof length (cm)	Rear hoof width (cm)	Chest girth (cm)	Total length/ dressed weight
6.5	S	3.8 ± 0.0 (3.8) n = 2	5.5 ± 0.6 (5.5 - 6.0) n = 2	3.5 ± 0.4 (3.2 - 3.8) n = 2	84.7 ± 0.5 (84.4 - 85.1) n = 2	4.2 ± 0.3 (4.0 - 4.4) n = 2
	H	3.2 ± 0.2 (3.0 - 3.5) n = 5	4.9 ± 0.8 (3.8 - 6.0) n = 5	3.1 ± 0.2 (2.9 - 3.5) n = 5	---	4.3 ± 0.7 (3.3 - 4.9) n = 5
7.5	S	---	---	---	---	---
	H	3.2 ± 0.0 (3.2) n = 4	4.9 ± 0.6 (4.4 - 5.7) n = 4	3.1 ± 0.2 (2.7 - 3.2) n = 4	72.6 ± 4.4 (68.6 - 78.1) n = 4	5.4 ± 0.6 (4.7 - 6.1) n = 4
8.5		3.5 n = 1	5.7 n = 1	3.8 n = 1	81.3 n = 1	4.1 n = 1
	H	3.4 ± 0.4 (2.9 - 3.8) n = 4	4.8 ± 0.6 (4.1 - 5.4) n = 4	3.3 ± 0.4 (2.9 - 3.8) n = 4	73.9 ± 3.9 (69.2 - 78.7) n = 4	5.5 ± 0.9 (4.7 - 6.4) n = 4
9.5	S	3.8 ± 0.0 (3.8) n = 4	4.9 ± 0.7 (4.1 - 5.4) n = 3	3.7 ± 0.3 (3.5 - 4.1) n = 4	86.7 ± 5.6 (81.3 - 92.1) n = 4	4.1 ± 0.4 (3.7 - 4.5) n = 4
	H	3.4 ± 0.3 (2.9 - 3.8) n = 8	4.6 ± 0.9 (3.2 - 6.2) n = 7	3.1 ± 0.9 (1.3 - 3.8) n = 7	71.4 ± 3.8 (66.0 - 76.2) n = 6	6.5 ± 0.7 (6.0 - 7.7) n = 6

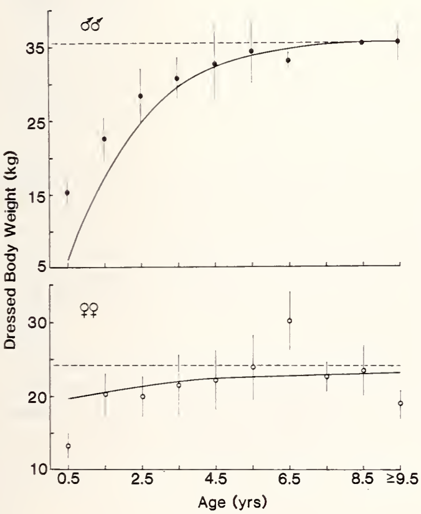

Fig. 2. Von Bertalanffy growth curves for dressed body weight of sika deer *(Cervus nippon)* in Maryland. Circles denote observed means at each age for stags (above, closed circles) and hinds (below, open circles). Vertical lines denote one standard deviation on either side of the mean. Dashed lines denote asymptotes. For males (n = 309): $W_t = 35.6\,[1-e^{-0.662(t+0.748)}]^3$ kg. For females (n = 167): $W_t = 24.2\,[1-e^{-0.184(t+14.439)}]^3$ kg. Correlation coefficients for the regression of predicted values vs. observed, weighted means at each age were: stags, $R^2 = 0.998$; hinds, $R^2 = 0.363$

Shoulder height

The asymptotic shoulder height for stags (82.7 cm) was 12.3 % greater than that of hinds (72.5 cm). This was the only parameter that was significantly greater for stags of all ages, including calves (Table 2). Hinds attained 95 % of their asymptotic shoulder height by 3.5 years of age, stags by 4.5 years of age (Fig. 4).

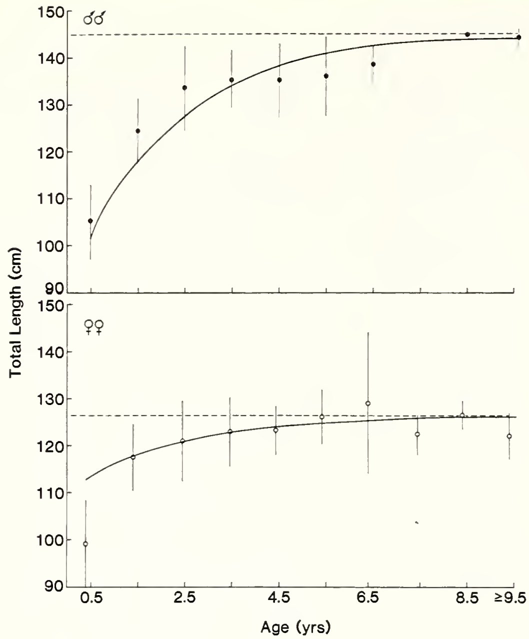

Fig. 3. Von Bertalanffy growth curves for total length of sika deer *(Cervus nippon)* in Maryland. Circles denote observed means at each age for stags (above, closed circles) and hinds (below, open circles). Vertical lines denote one standard deviation on either side of the mean. Dashed lines denote asymptotes. For stags (n = 305): $1_t = 145.0 [1-e^{-0.460(t+2.130)}]$ cm. For hinds (n = 169): $1_t = 126.5 [1-e^{-0.430(t+4.695)}]$ cm. Correlation coefficients for the regression of predicted values vs. observed, weighted means at each age were: stags, $R^2 = 0.908$; hinds, $R^2 = 0.742$

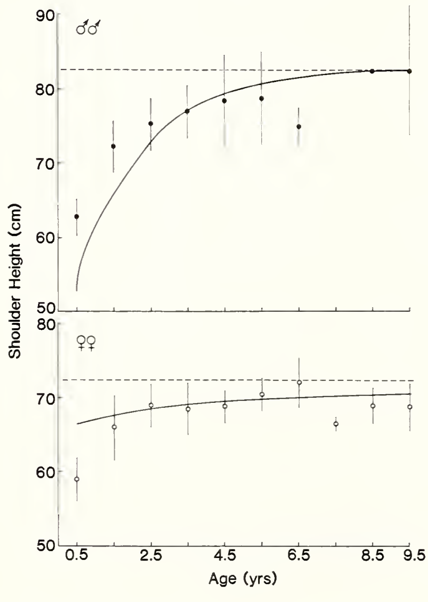

Fig. 4. Von Bertalanffy growth curves for shoulder height of sika deer *(Cervus nippon)* in Maryland. Circles denote observed means at each age for stags (above, closed circles) and hinds (below, open circles). Vertical lines denote one standard deviation on either side of the mean. Dashed lines denote asymptotes. For stags (n = 314): $h_t = 82.7 [1-e^{-0.556(t+1.337)}]$ cm. For hinds (n = 175): $h_t = 72.5 [1-e^{-0.150(t+16.040)}]$ cm. Correlation coefficients for the regression of predicted values vs. observed, weighted means at each age were: stags, $R^2 = 0.944$; hinds, $R^2 = 0.488$

Chest girth

Stags had a significantly greater chest girth than hinds for all age classes except calves (Table 2). The asymptotic chest girth for stags (86.8 cm) was 14.7 % greater than that of hinds (74.0 cm). Chest girth in hinds did not increase significantly with age; 95 % of the asymptotic value was attained by 0.5 year of age. In stags, 95 % of the asymptotic was attained at 4.5 years of age (Fig. 5).

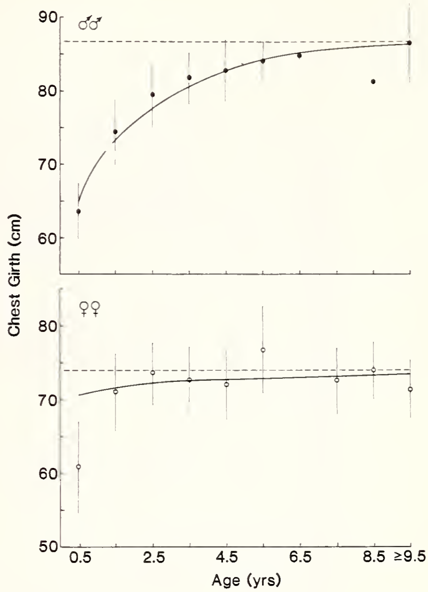

Fig. 5. Von Bertalanffy growth curves for chest girth of sika deer *(Cervus nippon)* in Maryland. Circles donate observed means at each age for stags (above, closed circles) and hinds (below, open circles). Vertical lines denote one standard deviation on either side of the mean. Dashed lines denote asymptotes. For stags (n = 250): $1_t = 86.8\,[1-e^{-0.414(t+2.869)}]$ cm. For hinds (n = 143): $1_t = 74.0\,[1-e^{-0.210(t+14.960)}]$ cm. Correlation coefficients for the regression of predicted values vs. observed, weighted means at each age were: stags, $R^2 = 0.961$; hinds, $R^2 = 0.339$

Stags had a larger growth coefficient than hinds for dressed body weight, shoulder height, chest girth, hind foot length, width of front hooves and length and width of rear hooves. Growth coefficients of equations for stags and hinds were about equal for total length and front hoof length. Hinds had a larger growth coefficient than stags only for tail length (Table 3).

There were no consistent differences in the ratio of total body length/chest girth between stags and hinds relative to age (Table 2). Chest girth increased isometrically relative to total length for both sexes; slopes of both correlations did not differ from zero. Allometric growth was noted relative to other major skeletal measures of both stags and hinds, including: total length vs. hind foot length, total length vs. shoulder height, shoulder height vs. hind foot length, shoulder height vs. chest girth, and hind foot length vs. chest girth.

Whole vs. dressed weight relationships

Whole weights and associated dressed weights were obtained for 20 stags and 31 hinds during winter (25 November to 3 December 1978) and summer (July through August 1979).

For all stags, the mean difference between whole and dressed body weights was not significantly different between winter and summer ($t = 0.426$, $P > 0.30$). During both seasons, mean dressed weight was about 72 % of the whole weight (Table 4). This relationship also occurred when considering adult ($AC \geq 2$) vs. immature ($AC \leq 1$) stags. No difference in whole vs. dressed body weights of adult stags was found between summer ($N = 6$, $\bar{x} = 71.4$ %) and winter ($N = 3$, $\bar{x} = 75.4$ %) ($t = -1.542$, $P > 0.05$). There also was no difference in immature stags in summer ($N = 3$, $\bar{x} = 69.4$ %) vs. winter ($N = 8$, $\bar{x} = 70.1$ %) ($t = -0.354$, $P > 0.05$). For hinds, however, the mean percentage difference between whole and dressed weights changed seasonally. In the winter the mean dressed weight of hinds was 70.2 % of mean whole weight. In the summer this figure declined to 64.5 % ($t = 3.89$; $P < 0.001$) (Table 4). The winter sample of hinds ($N = 6$) included only two adults ($AC \geq 2$), however. Conversely, the summer sample ($N = 21$) had 18 adults, of which 14 were lactating. Considering only adult hinds, the mean dressed/whole weight

Table 2

Age-related mean values of observed body measurements of stag and hind sika deer from Dorchester County, Maryland, and calculated student-t values

Degrees of freedom are in parentheses

Body measurement		Age (Years) 0.5	1.5	2.5	3.5	4.5	5.5	6.5	≥9.5*
Dressed Weight (kg)	S	15.4	22.6	28.3	30.8	32.6	34.3	34.3	34.6
	H	13.2	20.3	19.9	21.6	22.3	24.1	23.5	18.9
	tcal (df)	2.02(9)	4.85[a](218)	10.04[a](79)	9.76[a](47)[d]	7.15[a](37)	5.65[a](23)	7.82[a](26)[d]	11.94[a](10)
Total Length (cm)	S	105.3	124.3	133.7	135.1	135.1	136.0	142.4	143.3
	H	99.8	117.7	120.9	123.1	123.2	126.2	124.7	121.9
	tcal(df)	1.04(9)	5.89[a](221)	5.91[a](77)	7.00[a](68)	5.41[a](36)	3.51[b](24)	5.54[a](27)	5.72[a](11)
Tail Length (cm)	S	9.8	10.7	10.9	10.8	11.3	10.9	11.1	11.0
	H	9.2	9.5	9.7	9.9	9.7	9.6	9.9	10.5
	tcal(df)	1.10(8)	5.34[a](214)	3.24[b](76)	2.98[b](68)	4.70[a](35)	2.64[c](23)	2.30(25)	0.74(9)
Ear Length (cm)	S	10.7	11.2	11.3	11.5	11.4	11.3	11.3	11.2
	H	9.9	10.7	10.7	10.8	10.6	10.8	10.3	10.1
	tcal(df)	1.58(9)	7.00[a](226)	2.93[b](29)[d]	5.11[a](70)[d]	4.47[a](29)[d]	1.87(13)[d]	4.31[a](28)	4.84[a](12)
Shoulder Height (cm)	S	62.9	72.2	75.2	77.1	78.4	78.6	79.2	80.1
	H	58.9	66.1	69.4	68.9	68.4	70.5	69.3	68.8
	tcal(df)	2.32[c](9)	11.20[a](226)	7.86[a](81)	10.96[a](72)	6.32[a](72)	4.06[b](12)[d]	4.02[b](10)[d]	3.14[c](6)[d]
Hind Foot Length (cm)	S	32.9	35.4	35.7	35.9	35.8	36.2	36.5	36.0
	H	31.3	33.6	33.5	33.4	33.9	34.0	33.5	33.6
	tcal(df)	1.76(9)	10.14[a](227)	6.68[a]31)[d]	5.52[a](63)	4.93[a](37)	5.29[a](24)	5.69[a](26)	0.98(11)
Front Hoof Length (cm)	S	5.1	5.3	5.5	5.6	5.6	5.3	5.7	57.2
	H	4.8	5.2	5.1	5.3	5.3	5.3	5.4	53.9
	tcal(df)	0.72(9)	0.98(221)	2.31[c](81)	1.53(72)	1.52(36)	-0.13(15)[d]	1.16(28)	0.98(12)

Table 2. (Continued)

Body measurement		Age (Years) 0.5	1.5	2.5	3.5	4.5	5.5	6.5	≥9.5*
Front Hoof Width (cm)	S	3.1	3.5	3.6	3.7	3.7	3.7	3.8	3.8
	H	2.9	3.2	3.2	3.3	3.4	3.3	3.3	3.4
	tcal (df)	1.14(9)	6.59[a] (142)[d]	6.34[a](81)	5.45[a](72)	2.42[c](36)	4.00[b](24)	5.62[a](27)[d]	3.15[c](9)[d]
Rear Hoof Length (cm)	S	4.9	5.1	5.1	5.2	5.5	5.0	5.3	5.2
	H	4.4	4.8	4.6	4.7	4.9	5.0	4.8	4.6
	tcal(df)	1.63(9)	3.05[b](132)[d]	3.94[a](81)	3.18[b](72)	3.05[b](36)	-0.11(24)	1.85(26)	1.16(10)
Rear Hoof Width	S	3.1	3.4	3.5	3.5	3.7	3.7	3.7	3.8
	H	3.0	3.1	3.1	3.1	3.4	3.3	3.1	3.1
	tcal(df)	0.28(9)	4.46[a](221)	4.80[a](81)	4.30[a](50)[d]	2.67[c](36)	2.81[c](24)	2.78[c](26)	1.61(10)
Chest Girth (cm)	S	63.6	74.5	79.5	81.8	82.9	84.3	84.9	85.5
	H	60.9	71.1	73.6	72.7	71.9	76.9	73.4	71.4
	tcal(df)	0.85(8)	4.44[a](179)	5.57[a](74)	8.46[a](54)	5.95[a](22)	4.12[b](20)[d]	5.67[a](22)	5.62[a] (10)
Total Length/ Chest Girth	S	1.65	1.67	1.68	1.65	1.64	1.62	1.63	1.7
	H	1.65	1.65	1.65	1.71	1.73	1.65	1.62	1.7
	tcal(df)	-0.07(8)	0.80(175)	1.02(72)	-1.66(36)[d]	-2.09[c](22)	-0.51(22)	0.24(1)	0.70(10)

* - insufficient samples of stags at ages 7.5 and 8.5 for analyses. a - $P < 0.001$ b - $P < 0.01$ c - $P < 0.05$

d - t-values calculated with separate variance estimates, thus reduced degrees of freedom.

Table 3

Von Bertalanffy equations for growth with age of several body parameters of sika deer *(Cervus nippon)* from Dorchester County, Maryland

Parameter	Sex	n	von Bertalanffy equation	Age (years) which 95% of asymptotic attained	Correlation coefficient (R^2) of predicted vs. observed means
Tail length (cm)	S	298	$l_t = 11.5\ [1-e^{-0.159(t+15.00)}]$ cm	3.5	0.473
	H	160	$l_t = 10.6\ [1-e^{-0.441(t+2.54)}]$ cm	4.5	0.484
Ear length[a] (cm)	S	314	$l_t = 11.8\ [1-e^{-0.080(t+36.850)}]$ cm	0.5	0.149
Hind foot length (cm)	S	313	$l_t = 40.1\ [1-e^{-0.218(t+7.197)}]$ cm	6.5	0.497
	H	174	$l_t = 34.1\ [1-e^{-0.122(t+30.70)}]$ cm	0.5	0.098
Front hoof length (cm)	S	311	$l_t = 5.8\ [1-e^{-0.352(t+4.890)}]$ cm	3.5	0.748
	H	172	$l_t = 5.5\ [1-e^{-0.360(t+3.470)}]$ cm	5.5	0.585
Front hoof width (cm)	S	311	$w_t = 3.8\ [1-e^{-0.484(t+3.489)}]$ cm	3.5	0.893
	H	172	$w_t = 3.4\ [1-e^{-0.313(t+7.058)}]$ cm	2.5	0.616
Rear hoof length (cm)	S	315	$l_t = 5.5\ [1-e^{-0.146(t+19.24)}]$ cm	1.5	0.251
	H	171	$l_t = 5.0\ [1-e^{-0.084(t+38.65)}]$ cm	0.5	0.131
Rear hoof width (cm)	S	310	$w_t = 3.7\ [1-e^{-0.427(t+4.765)}]$ cm	2.5	0.854
	H	171	$w_t = 3.4\ [1-e^{-0.040(t+69.86)}]$ cm	5.5	0.270

a - von Bertalanffy equation could not be fitted to data on female ear length. This parameter was best defined by y_t, female ear length = $9.95 + 0.48X - 0.07X^2 + 0.0002X^4$, where X is age in years, SE = 0.64, R^2 = 0.159.

Table 4

Mean difference in whole vs. dressed body weight (kg) of sika deer stags and hinds during winter and summer periods from Dorchester County, Maryland

Sex		Season	
		Winter 1978 (n = 11)	Summer 1979 (n = 9)
Stags	$\bar{x}$ whole weight	33.8	34.5
	$\bar{x}$ dressed weight	24.3	24.7
	dressed/whole	71.9%	71.6%
		Winter 1978 (n = 6)	Summer 1979 (n = 21)
Hinds	$\bar{x}$ whole weight	25.5	30.4
	$\bar{x}$ dressed weight	17.9	19.6
	dressed/whole	70.2%	64.5%

ratio in winter ($N = 2, \bar{x} = 72.5$ %) remained significantly higher than in summer ($N = 18$, $\bar{x} = 64.0$ %) ($t = 3.37$, $P < 0.005$). For immature hinds ($AC \leq 1$), there was no difference in the dressed/whole weight ratio between the winter sample ($N = 4$, $\bar{x} = 69.4$ %) and the summer sample ($N = 3$, $\bar{x} = 63.2$ %) ($t = 1.72$, $P > 0.05$).

For both sexes there appeared to be an age-related difference in the whole vs. dressed weight relationships. The internal organs accounted for a larger percentage of the whole weight in younger animals than in older animals, regardless of season (Table 5).

The linear regression lines of dressed vs. whole weight for stags and hinds were not significantly different in variance, slope or elevation during the winter sample period, and data were combined (Fig. 6). However, the dressed vs. whole weight regression for stags and hinds collected during the summer of 1979 could not be combined (Fig. 7) because of statistically significant differences in the slopes ($F = 31.68$, $P < 0.001$) and the elevations ($F = 12.29$, $P < 0.001$) of the lines.

Table 5

Mean percentage of body weight accounted for by visceral organs in different age classes of sika deer from Dorchester County, Maryland

	Season		
	Winter[a]	Summer[b]	
Age (years)		Stags	Hinds
0.5	32.6 (2)[c]	-	44.4 (1)
1.5	29.6 (10)	30.5 (3)	39.2 (2)
2.5	26.9 (3)	29.9 (3)	37.1 (8)
≥ 3.5	25.0 (1)	26.6 (2)	35.2 (9)

[a] sexes combined

[b] sexes separate in summer because slopes of regression of dressed vs. whole weight are significantly different for stags and hinds

[c] sample size

Antler characteristics

Stag sika deer in Maryland form spike antlers as yearlings. By 2.5 years old, the complete rack is often evident. It consists of an upswept brow tine and a forked main beam. The bay tine is absent (see Fig. 3 in Feldhamer 1982). For *C. n. nippon* in Maryland, we saw no stag with more than six points (3/antler) during the five-year study period (Table 6), or in the follow-

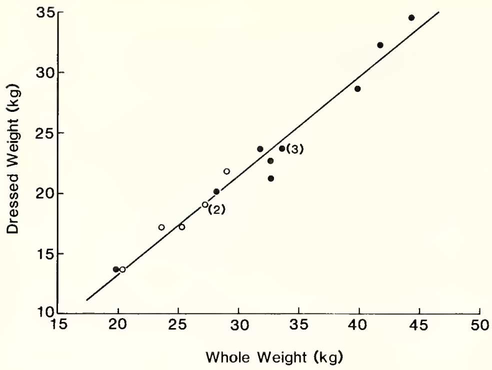

Fig. 6. Dressed vs. whole body weight regression for sika deer collected in late November – early December, 1978, sexes combined. The estimated relationship is ŷ, estimated dressed body weight (kg) = −3.031 + 0.814x, where x is the whole body weight (kg), $R^2 = 0.971$. Stags (●), hinds (○). Parentheses indicate number of individuals at the same point

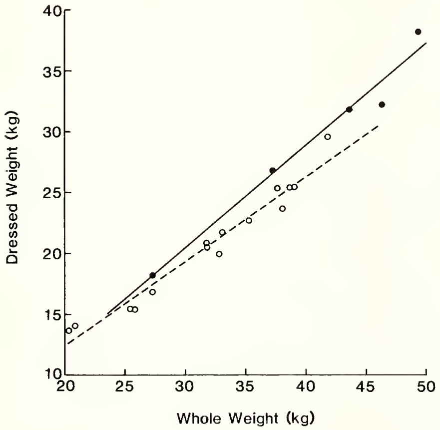

Fig. 7. Dressed vs. whole body weight regressions for sika deer collected July–August, 1979. The estimated relationships are: *stags* ŷ, estimated dressed body weight (kg) = −4.747 + 0.838x, where x is the whole body weight (kg), $R^2 = 0.976$; *hinds* ŷ, estimated dressed body weight = −1.675 + 0.699x, $R^2 = 0.963$. Stags (●, –); hinds (○, – – –)

ing three years. Of 155 stag yearlings, 144 (92.9 %) had spike antlers. This was consistent each year of the study (91.9 %; 91.9 %; 92.0 %; 97.3 %; 91.7 %). The remaining 11 yearlings had "button" antlers. No yearling was seen with forked antlers or additional tines. Ohtaishi (1976) also found that all yearling sika stags at Nara Park, Japan (N = 90) had spike antlers. This is unlike the situation in closely related elk, however, where yearling bulls occasionally may have more points than the typical spike (Boyd 1978). Although the full rack may be in place by 2½ years of age in sika deer, there were more 2½-year-old stags (N = 16) with spike antlers than with six-point racks (N = 14). Of 74 stags 3½ years of age or older, the majority (54.1 %) had six-point racks.

Discussion

General morphology

In sika deer, as in many other cervids, the period of most rapid growth takes place during the first year of life. Sexual dimorphism was evident in most body measurements by 1.5 years of age. Only the mean front hoof length showed no dimorphism regardless of age. Anderson et al. (1974) also found no significant sexual dimorphism in most body measurements of mule deer in Colorado until they were yearlings or older.

The small sample sizes for calves in our study may have masked significant dimorphism in this age class. The percentage difference in mean values between males and females for many body parameters of calves was equal to the difference at older ages. However, Barus

Table 6

Age-related antler characteristics for stag sika deer brought to check stations in Dorchester County, Maryland, from 1977 through 1981[a]

	Age (years)							
Antler form	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5+
button		11						
spike	2	114	16	1		1		
3-point			6	1				1
4-point			10	6	2	2		1
5-point			1	5	4	2		1
6-point			14	22	8	5	2	3

[a]n = 242, which represented 86.7% of all stags brought to check stations in Dorchester County during this five-year period.

et al. (1982) found the mean dressed body weight of 14 stag calves *(C. n. nippon)* from Czechoslovakia was not significantly different from that of 12 hind calves. They noted, however, that all stags were weighed without the head and antlers. Thus, sexual dimorphism of sika calves, at least in the dressed body weight, may again have been masked.

We found that 95 % of the asymptotic weight of stags was attained by 5.5 years of age, and by 7.5 years for hinds. Ohtaishi (1976: 122) also found the body weight of sika deer increased until ". . . about the size of six years old". Barus et al. (1982) found body weight of sika stags increased slightly until at least eight years of age. For red deer, Dzieciolowski (1970) found maximum mean dressed body weights of stags and hinds were attained at eight years of age. Thus, sika deer adhere to the general pattern in cervids of maximal body growth and condition between 5–10 years of age. For most parameters measured, sika deer stags reached significantly higher mean values as yearlings, and had larger growth coefficients, than hinds. In hinds, growth was negligible for many parameters after 1.5 years of age. The adaptive significance of increased size relative to dominance rank of stags, and subsequent reproductive success has been noted for red deer (Clutton-Brock et al. 1979) and no doubt applies also to sika deer in Maryland.

Combining all age groups, the mean length of front hooves was significantly greater than the mean length of rear hooves both for stags ($t = 7.01$, $df = 330$, $P < 0.001$) and hinds ($t = 11.64$, $df = 298$, $P < 0.001$). In stags, front hooves averaged 5.3 % longer than rear hooves, while in hinds the difference was 8.0 %. Likewise, the mean width of front hooves was significantly greater than rear hooves in males ($t = 4.37$, $df = 330$, $P < 0.001$) and females ($t = 3.58$, $df = 298$, $P < 0.001$). In both sexes, front hooves averaged about 2.6 % wider than rear hooves. A similar finding was reported for black-tailed deer (McCullough 1965), and has been attributed to the greater amount of weight supported by the front hooves compared to the rear (Linsdale and Tomich 1953).

Possible sources of variation

Many of the von Bertalanffy equations had very low R^2 values, that is, the amount of variability accounted for by the relationship with age was small. Variability probably was attributable to several factors: 1. possible measurement errors due to the number of people taking measurements, and general difficulty of taking measurements under often adverse field conditions; 2. a possible span of more than 1 month in parturition dates, and resultant ages of individuals within each age group; and 3. differences in summer or winter weather between years of the study (Clutton-Brock and Albon 1983; Feldhamer in press). The latter factor would have the potentially greatest affect on dressed body weights, which are probably cyclic throughout the year in sika deer as in other cervids (Bandy et al. 1970;

MOEN and SEVERINGHAUS 1981). Skeletal parameters are not cyclic and certainly less influenced by weather.

Whole vs. dressed body weight

Given the same initial whole weight, animals in "good" condition will have a higher dressed weight than animals in "poor" condition. This relationship has been described previously relative to white-tailed deer (HAMERSTROM and CAMBURN 1950) and red deer (RINEY 1955). Thus, although mean whole weight of all hinds was 30.4 kg in the summer vs. 25.5 kg in the winter, based only on the dressed weight relationships, hinds were in relatively poorer condition in the summer. This may have been due to: (1) the metabolic demands of gestation, parturition and subsequent lactation in adults, especially considering that there was no difference seasonally between immature hinds, and (2) body fat being metabolized before visceral fat (HARRIS 1945; BLOOD and LOVAAS 1966). It should be emphasized, however, that all deer collected were judged to be in excellent condition, based on body fat, pelage and general conformation, regardless of season.

Given reduced forage intake of sika stags during the rut (KIDDIE 1962), it would be expected that a seasonal difference in dressed weights in relation to whole weights would occur, with stags in relatively poorer condition during the fall-winter. However, this was not apparent for our data. Data derived from KIDDIE (1962) for adult sika stags (*C. n. hortulorum*, the larger Manchurian sika) in New Zealand also failed to show any significant seasonal differences in the dressed- vs. whole-weight relationship. However, it is possible that dominant, breeding stags were not included in the limited samples taken during the rutting season. Sample size was limited to three deer each season. The mean dressed weight of *hortulorum* stags was 74 % of whole weight, similar to that of the smaller subspecies of sika deer found in Maryland. Mean dressed weight of hind *hortulorum* in New Zealand, again derived from data in KIDDIE (1962), was 62.4 % of whole weight. Despite sample sizes of only three deer per season, however, significant seasonal differences were apparent. Dressed weight as a percentage of whole weight in adult *hortulorum* hinds was 60.6 % in the winter and 64.1 % in the summer. Thus, the seasonal trend was reversed from that observed for hinds in Maryland (even after taking into account the "reversal" of seasons between the northern and southern hemispheres).

Variability in dressed weight in relation to whole weight may arise from differences in stomach fill as well as physical condition. In our study, as previously noted, all sika deer were considered to be in excellent condition throughout the year. Also, there were relatively minor differences in the amount of stomach fill between individuals (FELDHAMER, unpub. data). As a result, we believe there was minor variability within sex and age groups during summer and winter because of stomach fill.

Antler characteristics

Adult sika stags in other parts of the world may have more than the maximum six points (three points/antler) observed in Maryland (FLEROV 1952; IMAIZUMI 1970). OHTAISHI (1976) reported that 218 of 292 (74.7 %) adult stags *(C. n. nippon)* in Japan had eight-point racks (four points/antler). Although 8-point antlers are the normal maximum for sika deer in Japan, half the sika deer of Kyushu have 6-point racks as a maximum (OHTAISHI, personal communication). In Denmark, BENNETSON (1976) found most introduced sika deer stags 3.5 years and older had 8- to 10-point racks. In Maryland, the maximum six-point characteristic may have been an individual trait peculiar to the one or two stags originally introduced, with a resultant founder effect. Such phenotypic homogeneity in this herd is suggested by the apparent lack of polymorphism and heterozygosity in tissue enzymes (FELDHAMER et al. 1982). It is further suggested by consistency of karyotype in our population (VAN TUINEN et al. 1983), as opposed to other populations (GUSTAVSSON and SUNDT 1968).

Although six-point racks may not be typical of all *C. n. nippon*, it is also possible that stags with eight-point racks may not be "pure" sika deer. Such antler development may be the result of "F_n generation hybridization" with red deer (see BARTOS and ZIROVNICKY 1981), or introgression with the much larger *C. n. hortulorum*. This is further suggested by comparison of the mean dressed body weights of sika stags in Maryland with those of the introduced population in Moravia, Czechoslovakia (BARUS et al. 1982). For yearlings and all adult age groups, mean weights of deer in Czechoslovakia were significantly higher ($P < 0.001$) than in Maryland. Although BARUS et al. (1982: 206) felt the sika deer they sampled "... showed no signs of crossing with either the bigger race *Cervus nippon hortulorum* or with *Cervus elaphus*", they could not exclude the possibility of *C. n. nippon* and *hortulorum* introgression during initial introduction around 1900. Thus, the sika deer in Maryland may be a relatively unique population of *C. n. nippon* without introgressive characteristics.

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Zusammenfassung

Körpermaß- und Gewichtsrelationen beim Sikawild in Maryland

Die Beziehungen zwischen Alter, Geschlecht, verschiedenen Körpermaßen und dem Gewicht wurden bei in Maryland, USA, eingebürgertem Sikawild untersucht. Bereits im Alter von 1,5 Jahren unterschieden sich Männchen und Weibchen von *Cervus nippon* signifikant im Wildpretgewicht (aufgebrochen), in der Körperlänge, der Schwanzlänge, der Ohr- und Hinterfußlänge, der Widerristhöhe, Schalenbreite und im Brustumfang. Die Wachstumsraten der meisten Maße waren bei den Männchen höher als bei den Weibchen. Die meisten Maßkombinationen änderten sich allometrisch, nur der Brustumfang nahm im Verhältnis zur Kopfrumpflänge isometrisch zu. Jahreszeitliche Unterschiede zwischen dem Anteil vom Wildpret- am Lebendgewicht waren nur bei den Weibchen signifikant, nicht aber bei den Männchen. Letztere wogen im Durchschnitt aufgebrochen 72 % vom Lebendgewicht. Im Alter von 1,5 Jahren trugen die meisten Hirsche ein Spießgeweih. Die Endenzahl betrug auch bei älteren Hirschen nie mehr als 6. Die morphologischen Besonderheiten des Sikawildes in Maryland werden im Hinblick auf den "founder effect" diskutiert.

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