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Health Assessment of White-Tailed Deer of the Cuyahoga Valley National Park, Ohio February 27, 2001

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Abstract: Data from 10 white-tailed deer (*Odocoileus virginianus*) collected on the Cuyahoga Valley National Park (CVNP), Ohio, on February 27, 2001, were analyzed and compared to data from 10 deer collected in each of the preceding 4 years by the National Wildlife Health Center as part of a deer herd health assessment program. Results from 2001 show decreases in body weight compared to the first 3 years, and decreased fetal and twinning rates from 2000. The conception dates for fetuses were earlier than those from 2000. The kidney fat index was lower than in 2000 but the median body condition index was approximately the same. Serum copper and zinc values were lower than the reference values reported for cattle. As in previous years, physiological indices such as the fetal/doe ratio, fawn pregnancy rates, twinning rates, and thyroid hormone (T3 and T4) values remain below reference values for deer with adequate nutrition. The deer are presently causing damage to urban gardens and landscapes, to agricultural crops, and to motor vehicles as a result of collisions on roads and highways. The deer herd is considered potentially vulnerable to adverse environmental factors in years when they are nutritionally stressed and in the future may experience population declines due to malnutrition and density dependent disease.

INTRODUCTION

The Cuyahoga Valley National Park (CVNP), located near Brecksville, Ohio, is managed by the National Park Service (NPS). Resource managers of the CVNP have become concerned in recent years about the increase in number and density of white-tailed deer (WTD) (*Odocoileus virginianus*) on the area. During 1990-1994, deer-vehicle collisions within Summit and Cuyahoga Counties, in and near the CVNP, increased at an annual rate of 16 percent. Private landowners in the same general area have experienced increasing damage to gardens, landscaping, and agricultural crops due to deer foraging. In February and March of 1996, excessive fawn mortality occurred on the CVNP. Because of concern for a catastrophic crash in the population and the direct and indirect effect of high deer densities on other natural resources, the surrounding communities, and on park visitors, the CVNP developed a Resource Management Plan in 1993. The plan included monitoring white-tailed deer herd health and mortality in addition to other environmental parameters potentially affected by WTD. This health assessment is the fifth and final year of data collection and analysis for that plan.

The objectives of the deer herd health assessment are to: (1) provide information on the health of the deer herd by assessing body condition through external and internal gross examination and through physiological indicators obtained through testing of blood, tissue, and feces, (2) provide information on the deer herd's exposure to infectious disease by assessing serum antibody titers to selected pathogens, (3) provide baseline data that will be used to monitor changes in herd health over time and to measure the response of the deer herd to adaptive resource management, (4) provide information on some zoonotic diseases carried by the deer herd, and (5) store serum and tissues that could be used for later analyses.

METHODS

To accomplish the stated objectives, 50 deer (10 deer each in 1997, 1998, and 1999, 2000, and 2001) on the CVNP have been killed, using a .243 caliber rifle aiming for the neck region. Blood was immediately collected from the heart and placed in tubes containing EDTA anticoagulant or into serum collection tubes to allow clotting to occur. Blood smears were made from the EDTA blood within 2 - 4 hours of collection, air-dried and fixed for later parasitologic examination. The EDTA blood was then refrigerated overnight and shipped by an express service to Veterinary Diagnostics Laboratory, Columbus, Ohio, (VDL) for a complete blood count (CBC). Clotted blood was centrifuged and serum harvested within two hours of collection. Refrigerated sera were sent the morning following collection by overnight service to VDL for serum chemistries and triiodothyronine (T3) and thyroxine (T4) measurements. The remaining sera were frozen; portions were later sent to the Wisconsin Veterinary Diagnostic Laboratory, Madison, Wisconsin to test for antibodies against bluetongue virus (BTV), epizootic hemorrhagic disease virus (EHDV), bovine virus diarrhea virus (BVD), parainfluenza 3 virus (PI3), bovine respiratory syncytial virus (BRSV), and leptospirosis (6 serovars); and to Michigan State University Animal Health Diagnostic Laboratory, Lansing, Michigan for analysis of Vitamin E, selenium and trace minerals. Additional frozen serum from each deer was banked. Deer were transported to a facility at the CVNP where they were necropsied. In 1997 and 1998 deer weights were estimated by chest girth. In 1999, 2000, and 2001, animals were weighed using a hanging spring scale. Rectal swabs were collected from each deer to culture for *Salmonella* spp. and *Escherichia coli*, specifically *E. coli* O157:H7. Lung samples, and, when indicated by gross pathology observed at necropsy, additional tissues, were collected by standard procedures for assessment by histology, microbiology, and parasitology. Feces were collected for measurement of fecal diaminopimelic acid (DAPA) and fecal nitrogen (FN). These samples were refrigerated for 48 hours, frozen and later submitted by overnight service to the Washington State University Wildlife Habitat Laboratory for analysis as a pooled sample. Feces were collected for parasitologic assessment in 1997 and 1998 but not in 1999, 2000, or 2001. From 1999 to 2001 a close visual exam for key parasites was performed during the gross necropsy. In 2000 and 2001, retropharyngeal lymph nodes were collected for bovine tuberculosis testing.

RESULTS

General Body Condition

General body condition was assessed and the animals were sexed, aged, and weighed as part of the necropsy examination (Table 1). Mean body weight (BW) of adult (1.75 year-old and older) females (n = 7) was 48.7 kg (107.4 lbs); range 20.4 kg (45 lbs); min – max: 37.2 – 57.6 kg (82 – 127 lbs). The mean kidney fat index (KFI; Riney, 1955) for all females (n = 8) was 26.6 (range 60.8; min – max: 0.43 - 61.3) and for males (n = 2) was 23.1 (range 1.6; min – max: 22.3 - 23.9). Bone marrow fat classes (BMF; Cheatum, 1949) ranged from a rating of I (90%) to III (70%) with a mode of II (85%). The modal BMF classes for females and males were II and III, respectively.

Table 1. Body condition, sex, age, weight, and location of white-tailed deer collected on Cuyahoga Valley National Park, Ohio, February 27, 2001.

ID #	Sex	Age (yrs)	BC[1]	KFI[2]	Weight (lbs)	BMF[3]	Pregnant
001	F	0.75	20	16.2	74	II	No
002	F	1.75	45	25.4[4]	82	II	No
003	F	8+	15	7.3	102	II	Yes
004	M	1.75	30	23.9	95	III	-
005	F	2.75	65	48.9	127	I	Yes
006	F	1.75	60	61.3	115	II	Yes
007	F	2.75	20	0.43	100	II	Yes
008	F	2.75	35	11.4	112	II	Yes
009	F	3.75	45	31.8	114	II	Yes
010	M	3.75	40	22.3	145	III	-

[1]BC = Body condition. Techniques developed by Kistner *et al.* (1980), based on visual estimation of the relative amounts of fat in six body locations and the condition of the body musculature.
[2]KFI= Kidney Fat Index (Riney, 1955) based on weight of perirenal fat divided by weight of kidneys x 100.
[3]Bone Marrow Fat (Cheatum, 1949): I - 90%, White Solid; II - 85%, Spotted Pink Solid; III - 70%, Dark Pink Solid; IV - 55%, Yellow Solid; V - 50% Red Solid; VI - 1.5%, Red Gelatinous; VII - 1.5%, Yellow Gelatinous.
[4]Based on one kidney.

Table 2. Reproductive parameters of white-tailed deer on the Cuyahoga Valley National Park, Ohio, February 27, 2001.

ID #	Age (yr)	Fetuses per Doe	Fetal Sex/Size[1] (cm)
001	0.75	0	-
002	1.75	0	-
003	8+	1	M/28.0
005	2.75	2	M/20.25 F/20.0
006	1.75	1	.F/25.75
007	2.75	1	F/24.25
008	2.75	1	F/24.75
009	3.75	2	F/20.0, M/21.25

[1]Crown to rump length

Sex, Age, and Reproduction

Mean age of adult females examined in 2001 (n = 7) was 3.54 years (min. – max.: 1.75 - 8+). Sex ratio of fetuses (n = 8) near mid-gestation was 38% male and 62% female (Table 2). Six of the 7 does of breeding age examined were pregnant. The female fawn examined was not pregnant. Crown to rump lengths for fetuses ranged from 20.0 to 28.0 cm. The twinning rate for pregnant does was 33.3%.

Pathology

Observations of pathology from gross and microscopic examination of 10 deer were unremarkable. Histologically, 7 of the 10 deer had mild to severe granulomatous pneumonia due to embryonated eggs and larvae of meningeal worms (*Parelaphostrongylus tenuis*), but no gross lesions were noted. One adult female (008) had a healed fracture of the left rear metatarsus and a number of 2 to 5 mm ulcerated nodules on the surface of the tongue. Histologically, this deer had a severe multifocal chronic granulomatous stomatitis associated with embedded plant material. No evidence of bovine TB was seen in the 10 animals tested. Swab cultures for *Salmonella* spp. and *E. coli* 0157:H7 were negative for all 10 deer.

Parasitology

No significant external parasites were observed. Second and third instars of nasal bots (*Cephenemyia* spp.) were found in six deer. Adult meningeal worms were found in three deer, and larvae or eggs in seven. No liver flukes (*Fascioloides magna*) were observed on gross examination of the liver, although minor lesions on the surface of the liver of one deer indicated larval parasite migration. Sarcocystosis was diagnosed by histologic examination of muscle tissue in two deer (002 and 008). No large stomach worms (*Haemonchus contortus)* were seen on close gross examination of abomasal contents. No lungworms (*Dictyocaulus viviparous*) were found on lung wash examination of airways and no parasites were seen on the blood smears examined. Neither the parasite prevalences nor species found are unusual or an obvious health issue.

Serology

Serum from each of the 10 deer was analyzed for antibody titers to six pathogens; bluetongue virus (BTV), epizootic hemorrhagic disease virus (EHD), bovine viral diarrhea virus types I and II (BVD), parainfluenza virus type 3 (PI-3), respiratory syncytial virus (RSV), and *Leptospira interrogans* (6 serotypes). Deer 003 had a weak positive PI-3 titer. No additional antibodies were reported in any of the 10 deer tested.

Clinical Pathology

Basic statistical descriptions of hematological and biochemical variables for 10 animals (7 adult females, 2 adult males, and one 9-month old female) are presented in Tables 3 and 4. Data were compared with reference values for white-tailed deer when possible (Seal et al. 1981, Bubenik and Brownlee 1987, Tumbleson et al. 1968); otherwise reference values for domestic animals were used (Smith, 1996).

Hematology

Packed cell volumes (PCV) were all within the range of the reference values; however, the hemoglobin concentrations were low in 9 of 10 deer when compared to reference values from killed white-tailed deer (Table 3). The overall leukocyte counts were within the reference range for all of the deer examined, but the differentials were not. Lymphopenia (a decrease in lymphocytes) was observed in one deer and monocytosis (an increase in monocytes) was found in six deer. Seven animals had eosinophilia (increase in eosinophils); in three it was marked.

Table 3. Mean (s.d.), minimum and maximum values for hematologic parameters of 10 free-ranging white-tailed deer from Cuyahoga Valley National Park, Ohio, February 27, 2001.

Parameter	Mean (s.d.)	Min.-Max.	Reference Values[1]
PCV (%)	46.9 (5.6)	40.0-55.0	39 - 58
Hemoglobin (g/dl)	16.9 (1.9)	13.9-19.6	18.3 -19.3
MCHC (g/dl)	36.1 (1.0)	34.6-37.6	34.7 - 36.1
MCV (fl)	35.2 (3.8)	31.1-43.2	23.8 - 33.0
Leukocytes ($x10^3/\mu l$)	2.47 (1.0)	1.0-3.8	1 - 4.2
Segmented Neutrophils (%)	55.8 (14.0)	20-70	57 - 72[2]
Seg. Neutrophils ($x\ 10^3/\mu l$)	1.45 (0.72)	0.19-2.52	0.6 - 2.8
Lymphocytes (%)	36.3 (13.5)	20-68	24 - 35[2]
Lymphocytes ($x10^3/\mu l$)	0.84 (0.33)	0.34-1.28	0.6-1.8
Eosinophils (%)	7.1 (5.6)	1-20	2 - 7[2]
Eosinophils ($x10^3/\mu l$)	0.16 (0.09)	0.02-0.34	< 0.10
Monocytes (%)	0.7 (0.67)	0-2	1 - 3[2]
Monocytes ($x10^3/\mu l$)	0.019 (0.017)	0-0.04	< 0.01

[1]Reference values were adopted from Seal *et al.*, 1981 except when other source is indicated.
[2]Bubenik and Brownlee, 1987.

Biochemistry

All 10 deer sampled had elevated levels of potassium (Table 4). Chloride values were slightly below the reference values for two deer and phosphorus levels were elevated in six. The calcium/phosphorus ratios were normal. Five deer had slightly elevated magnesium values. Aspartate aminotransferase (AST) level was slightly elevated in one deer and markedly elevated in another. Creatine phosphokinase (CPK) was above the reference range for 3 of the 10 deer tested, including one animal with a CPK 130 times the upper value for the normal range. Creatinine values were above the reference range for eight deer, and three had glucose values greater than the reference range. Hypoalbuminemia (<2.5 g/dl) was detected in five of the deer sampled. However, two of the deer with hypoalbuminemia had values that were only slightly below the reference range, and only two (003, 009) had depressed albumin results as well as reduced fat stores. Nine animals had depressed gamma-glutamyl transferase (GGT) results, and T3 and T4 levels were below the reference range for all 10 animals in 2001.

Table 4. Mean (s.d.), minimum and maximum values for serum biochemical values for 10 free-ranging white-tailed deer from Cuyahoga Valley National Park, Ohio, February 27, 2001.

Parameter	**Mean (s.d.)**	**Min. - Max.**	**Reference Value**[1]
Sodium (mmol/L)	146.0 (4.2)	141-152	132 - 156
Potassium (mmol/L)	8.3 (1.5)	6.7-10.9	3.4 - 5.0
Chloride (mmol/L)	102.3 (3.6)	97-108	100 - 110
Calcium (mg/dl)	10.0 (0.7)	9.2-10.9	8.1 - 10.8
Phosphorus (mg/dl)	9.2 (1.5)	7.0-11.0	4.5 - 8.5
Magnesium (mg/dl)	2.6 (0.2)	2.2-2.9	2.2-2.6[2]
Glucose (mg/dl)	236.9 (119.2)	91-402	60 - 320
BUN[3] (mg/dl)	28.3 (4.7)	21-35	15 - 45
Creatinine (mg/dl)	2.3 (0.3)	1.6-2.7	0.4 - 2
Total Protein (g/dl)	6.5 (0.4)	6.2-7.1	5.0 - 7.8
Albumin (g/dl)	2.4 (0.4)	1.7-3.0	2.5 - 4.2
ALKP (U/L)	46.8 (36.4)	13-125	27 - 107[4]
CPK (U/L)[5]	306.2 (160.50)[5]	125-628[5]	20 - 400
AST (U/L)	301.3 (525.4)	94-1792	40 - 150
GGT (U/L)	33.8 (7.4)	25-51	40 - 100
Total Bilirubin (mg/dl)	0.2 (0.1)	0.1-0.4	0.1- 1
T3 (ng/ml)	0.57 (0.2)	<0.4-0.9	1.25 - 3.05
T4 (ng/ml)	93.0 (28.0)	55.0-139.0	150 - 300

[1]Reference values were adopted from Seal *et al.*, 1981 except where indicated.
[2]Smith, 1996 (bovine values).
[3]Abbreviations: BUN – blood urea nitrogen, ALKP - Alkaline Phosphatase, others in text.
[4]Tumbleson *et al.*, 1968.
[5]Outlier removed, n = 9; deer 004 CPK was 52,060 U/L.

Nutrition

Trace minerals and vitamin E

Basic statistical descriptions for serum vitamin E, copper, zinc and iron, and whole blood selenium concentrations are presented in Table 5. Serum copper values (range 0.4 - 0.8 ppm) were below the reference value for cattle (Smith, 1996) for 7 of the10 deer tested, as were serum zinc results for 9 of the 10. Whole blood analysis for selenium (ng/ml) was below the reference range of 100-180 (Puls, 1994) for five deer. Six deer had low vitamin E values. Fecal samples from 10 deer were pooled into one composite sample for analysis of fecal 2,6 diaminopimelic acid (FDAPA) and fecal nitrogen (FN). The composite results for FDAPA and FN were 0.364 mg/gm and 2.71% respectively.

Table 5. Mean (s.d.), minimum, and maximum values for selected trace minerals and vitamin E for 10 free-ranging white-tailed deer [adult female (n = 7), adult males (n = 2), and young of the year (n = 1) female] from Cuyahoga Valley National Park, Ohio, February 27, 2001. Whole blood was used for selenium assay; all other assays were done on serum.

Parameter	n	Mean (s.d.)	Min.-Max.	Reference Values[1]
Copper (ppm)	10	0.57 (0.11)	0.4-0.8	0.7 - 1.2
Zinc (ppm)	10	0.47 (0.14)	0.3-0.8	0.7 - 1.0
Iron (ppm)	10	2.12 (0.42)	1.57-2.74	0.7 - 2.3
Selenium (ng/ml)	10	101.1 (23.68)	60-129	100 - 180[2]
Vitamin E (µg/ml)	10	2.01 (0.41)	1.39-2.55	2.09 - 3.05[3]

[1]Smith, 1996 (bovine)
[2]Puls, 1994
[3]Ullrey, 1981

DISCUSSION

The small sample size precludes meaningful statistical analysis. However, useful comparisons can be made between years and among other deer populations, and over time assumptions can be made about the general trend of the population.

The general body condition for deer examined in 2001 was in most cases adequate, and one adult doe was in excellent condition considering the time of year. This discrepancy in physical conditions among animals may reflect variations in habitat quality or may be an indication of supplemental feeding of deer in some locations. However, no food types that would indicate supplemental feeding were noted in the rumen contents of the animals examined. The mean age and BW for adult does (> 1.5 years) was 3.5 years and 107.4 pounds, respectively, and the mean BW for does > 2.5 years (n = 5) was 111 pounds, as it was in 2000. This was the lowest average weight for adult does recorded during the study. The median body condition index for all deer, 37.5, was about the same as that in 2000 (35), while the mean KFI (24.7) was lower than in 2000 (34.6).

Six of the seven does (86%) greater than 1.5 years of age were pregnant. One 1.75 year old doe and one 0.75 year old doe were not pregnant. The mean number of fetuses per doe for those deer that were pregnant was 1.3. Reproduction among fawns and yearlings is more variable than among adult does as a result of sensitivity to nutritional factors (Verme, 1969). Normally, 97% of the female population breeds at 1.5 years of age, and pregnancy rates in fawns from Ohio range up to 60% (Gladfelter, 1984). Does in the 1.75 age class usually have one fetus and females 2.75 and older have two fetuses. Doe number 003 (1 fetus) was 8+ years old, had low kidney and body fat scores, and was probably beyond her peak breeding age. The relatively low reproductive rate in adult does may indicate an inadequate diet. The fetal sex ratio in 2001 was 62.5% female and 37.5% male. Theoretically, the sex ratio of fetuses should be even, but wide variations have been reported, with males usually predominating. Verme (1969) observed that adult does on a low nutritional plane prior to breeding produced 72% males, compared to well-fed does, which produced 43% males.

The fetal size for pregnant does in 2001 ranged from 20.0 cm to 28.0 cm, indicating a breeding season from October 26 to November 20. In comparison, the fetal size for pregnant does necropsied in 2000 ranged from 12.5 to 24.0 cm, indicating a breeding season from November 2 to December 9. The breeding season normally peaks around mid-November. The later breeding dates seen in 2000 might have been an indication of poor physical condition. In contrast, the breeding dates for 2001 are actually a little earlier than the expected peak.

Histologic examination of lung samples collected from CVNP deer revealed mild to severe granulomatous pneumonia in seven of the animals. These histologic lesions are most likely associated with larval *Parelaphostrongylus tenuis* migration, and while histologically significant, there were no overt lung lesions or obvious morbidity attributable to these findings.

Parainfluenza virus type 3 (PI-3) titers were found in one deer tested in 2001. PI-3 is primarily a viral disease of cattle, and limited studies of this agent in deer suggest that only nonfatal infections occur (Richards, 1981).

None of the animals sampled were anemic; however, anemia induced by undernutrition during winter may be concealed by the hemoconcentration that accompanies seasonal dehydration and decreased plasma volume (DelGiudice *et al.*, 1992). In addition, deer species have a large muscular spleen that undergoes contraction secondary to acute stressful events, causing transitory increases in packed cell volume. As a result, antemortem stress may mask any anemic states in the animals sampled. The hemoglobin concentrations were below the reference range for killed white-tailed deer in eight of the 10 animals tested. Seal *et al.* (1981) found variations in hemoglobin results of gunshot deer that were attributed to differences in the elapsed time of death of the animal.

An elevated monocyte count (monocytosis) was seen in six animals. Monocytosis occurs most commonly due to chronic infections or as a physiologic response to fear, excitement, or handling (Kirk and Bristner, 1985). The absence of any discernable chronic infections in these animals implicates stress as the cause of these elevated white blood cells. However, it is unclear from the literature exactly how quickly this adrenal related response occurs, or if gunshot stress is a factor. As a result, the exact cause of the monocyte levels is undetermined. High eosinophil counts, seen in seven of the sampled deer, are rare in ruminants but may be caused by parasitic infection. Six of the seven animals with eosinophilia did have at least two species of parasites detected; the seventh had none. There did not appear to be a correlation between the parasite burdens and eosinophil counts.

Potassium values were elevated in six deer, creatinine values were above the reference range for eight deer, and CPK levels were elevated in three animals. The high levels of potassium and CPK found may in part be caused by postmortem collection of blood from the heart (Seal *et al.*, 1981; White and Cook, 1974). High potassium levels may also result from *in vitro* hemolysis (Smith, 1996). Prolonged storage can similarly cause an increase in potassium but the serum was separated within 3 hours of collection. High concentrations of CPK may also be attributed to general trauma and tissue damage caused by shooting or extreme muscle exertion. Deer 004 had a CPK value of 52,060 U/L, over 130 times the upper value for the normal range. This same animal had an AST value of 1,792 U/L, well above the normal range of 40-150 U/L. AST is a muscle leakage enzyme and elevations can be caused by trauma and tissue damage. Elevated potassium and creatinine levels were observed in a study by DelGiudice *et al.* (1992) in early and late winter as a result of decreased plasma volume and glomerular filtration rate due to reduced water intake.

In 1997, low protein concentrations with normal BUN values suggested energy deprivation and catabolism of body protein for energy (DelGiudice and Seal, 1988). In 1998, 1999, 2000, and 2001 both the total protein and BUN values were within the normal ranges, indicating a better plane of nutrition and energy balance.

Hypoalbuminemia was seen in six of the animals tested in 2001. However, only two animals had albumin levels that were significantly below the normal range. The primary cause of hypoalbuminemia is inadequate intake of dietary protein (Smith, 1996).

A hypothyroid state in the winter is normal for white-tailed deer, but can be intensified by decreased food intake (Seal *et al.*, 1972). The adaptive significance of diminished thyroid function in malnourished deer may be to reduce energy requirements when caloric intake is inadequate; a vital consideration in over-winter survival and neonatal mortality. The T3 values in 2001 (0.57 ng/ml) are lower than 1998 (0.93 ng/ml), 1999 (0.81 ng/ml), and 2000 (0.69 ng/ml) results, but are similar to 1997 values (0.60 ng/ml). The mean T4 values for 2001 (93.0) are the highest found during the 5 years of the study. The mean serum T4 concentration in these deer was lower than values for undernourished female white-tailed deer (T4 = 97 ng/ml) reported by DelGiudice *et al.*, (1987) suggesting a compromised nutritional situation. The T3 and T4 levels in CVNP deer from all years remain consistently below the reference values; decreased concentrations may reflect the diminished dietary energy available.

Fecal DAPA and FN results provide an indication of the quality of forage ingested within the previous 48 hours and can be compared to longer-term indices such as fetal rates and fat indices. Fecal DAPA increases in the rumen as a function of increased bacterial mass, and FN tends to increase as dietary protein and nitrogen increases (Leslie *et al.*, 1989). The DAPA and FN results from 2001 indicate that 24-48 hours prior to being euthanized the animals ingested forage with relatively low digestibility but moderate protein content. These methodologies were developed for western deer species (Hodgman *et al.*, 1996), but because the results indicate changes in forage quality these techniques are applicable to Ohio deer. Fecal DAPA and FN results for deer collected at CVNP could provide an indication of forage quality changes when compared between years. Fecal DAPA and FN results show a slight decline in winter nutritional quality between 1997 and 1998 and a slight increase in 1999, but results are greatly influenced by differences in collection dates and short-term changes in weather patterns. The FDAPA result (0.364 mg/gm) for 2001 was the lowest reported during the five years of this study. In contrast, the 2001 FN value (2.71%) was comparable to results from 1997, 1998, and 1999. Both results are within the DAPA and FN normal ranges of .25-1.3 mg/gm and 1-3 %, respectively (B. Davitt, Washington State University, Pullman, personal communication).

Mean serum copper values (ppm) in 2001 (0.57) are higher than 1997, 1998 and 2000 values (0.50), (0.45), and (0.48), respectively, and comparable to those noted in 1999 (0.61). Serum copper values continue to be below the reference range of 0.7-1.2 for cattle. Copper deficiencies in wild ruminants have occurred worldwide with symptoms including pale, faded, brittle hair, osteoporosis, abnormal hoof and antler growth, weight loss and reduced reproduction (Robbins, 1993). Absorption of copper tends to be low and is affected by the copper status of the animal, chemical form, and levels of other metal ions which may interfere with absorption such as calcium, cadmium, zinc, iron, lead, silver, molybdenum and sulfur (Robbins, 1993). No clinical signs or lesions were seen that could be directly attributed to copper deficiency. In sheep, cattle and red deer, copper concentrations below 0.5 ppm are considered diagnostic for copper deficiency (MacKintosh *et al.*, 1986; Mertz, 1986). In cattle, no clinical signs are observed until levels are <0.2 ppm, but animals with serum copper levels < 0.4 ppm show positive growth response to supplementation (Wikse *et al.*, 1992). None of the deer had serum copper levels below 0.4 ppm.

Mean zinc results in 2001 (0.47 ppm) were below the normal range for cattle of 0.7 to 1.0 ppm for 9 of the 10 deer sampled. Mean zinc values dropped from 1.1 ppm in 1997 to 0.45 ppm in 1999 and increased slightly in 2000 (0.49). Slightly depressed levels of zinc were noted in 90% of the animals tested in 1998 as compared to 1997 when none of the animals examined had low levels of zinc. Zinc deficiency is characterized in calves by poor growth, rough scaly skin and dull listless appearance (Swenson, 1982), and deficiencies have been reported in grazing cattle (Dynna and Havre, 1963). The zinc content of liver and bone samples varies seasonally in free-ranging wild herbivores (Anke *et al.*, 1980), but zinc deficiency has not been reported in wild animals (Robbins, 1993). No clinical signs of zinc deficiency were noted in the deer examined in 2001.

Five of the10 deer sampled in 2001 had selenium values below the normal range. In 1999, all 10 deer had selenium values below the reference range. Selenium deficiency primarily affects juveniles, resulting in increased mortality during neonatal and pre-weaning periods (Keen and Graham, 1989) and may also cause low fertility in older animals (Robbins, 1993). Ohio is included in the area where the selenium concentration in plants is low (80% of all forage and grain contain <0.05 ppm of selenium) relative to domestic animal needs (Robbins, 1993). No clinical signs of selenium deficiency were apparent, probably because the vitamin E levels were only slightly below normal values. Adequate dietary levels of vitamin E can reduce the selenium requirement (Ullrey, 1981).

CONCLUSIONS

Decreases were seen in fetal rate and twinning rate from values noted in 2000. The body condition index was about the same, but the KFI was lower. As in previous years, physiological indices such as the fetal/doe ratio, fawn pregnancy rates, twinning rates, and T3 and T4 values remain below reference values for deer with adequate nutrition. However, these studies are timed to evaluate the deer herd during the season of year when they are expected to be in their worst physical condition and no animals were seen that were totally devoid of fat reserves.

During years without adverse weather conditions or food source failures the only population impact of this lower nutritional plane will be a reduced rate of productivity. However, in years when the herd is stressed by nutritional deprivation or other environmental factors the population may experience increased mortality due to malnutrition and density dependent disease.

LITERATURE CITED

ANKE, M., E. RIEDEL, E. BRUCKNER, and G. DITTRICH. 1980. The supply of wild ruminants with major trace elements. III. The zinc content of winter grazing and zinc status of red deer, fallow deer, roes and mouflons. Arch. Anim. Nutr. 30:479-490.

BUBENIK, G. A. and L. BROWNLEE. 1987. Assessing health of male white-tailed deer by white blood cell counts. J. Wildl. Manage. 51:945-949.

CHEATUM, E. L. 1949. Bone marrow as an index of malnutrition in deer. N.Y. State Conservation 3:19-22.

DelGIUDICE, G. E., L. D. MECH, K. E. KUNKLE, E. M. GESE, and U. S. SEAL. 1992. Seasonal patterns of weight, hematology, and serum characteristics of free-ranging female white-tailed deer in Minnesota. Can. J. Zool., 70:974-983.

DelGIUDICE, G. E. and U. S. SEAL. 1988. Classification of winter undernutrition in white-tailed deer via serum and urinary urea nitrogen. Wildl. Soc. Bull., 16:27-32.

DelGIUDICE, G. E.; L. D. MECH, and U. S. SEAL, and P. D. KARNS. 1987. Effects of winter fasting and refeeding on white-tailed deer blood profiles. J. Wildl. Manage., 51:865-873.

DYNNA, O., and G. N. HAVRE. 1963. Interrelationship of zinc and copper in the nutrition of cattle. A complex zinc-copper deficiency. Acta. Vet. Scand. 4: 197-208.

GLADFELTER, H. L. 1984. Midwest Agricultural Region. Pp. 427-440 *in:* L. K. Halls (ed.). White-tailed deer: Ecology and management. Stackpole Books, Harrisburg, PA. .

HODGMAN, T. P., B. B. DAVITT, and J. R. NELSON. 1996. Monitoring mule deer diet quality and intake with fecal indices. J. Range Manage. 49:215-222.

KEEN, C. L. and T. W. GRAHAM. 1989. Trace elements. Pp. 753-795 *in:* Kaneko, J.J. (ed.), Clinical Biochemistry of Domestic Animals. Academic Press, Inc., San Diego, California.

KIRK, R. W., and S. I. BRISTNER. 1985. Veterinary Procedures & Emergency Treatment. 4th edition. W.B. Saunders Co., Philadelphia, PA.

KISTNER, T. P., TRAINER, C. E. and N. A. HARTMANN. 1980. A field technique for evaluating physical condition of deer. Wildl. Soc. Bull. 8:11-17.

LESLIE, D. M., J. A. JENKS, M. CHILELLI and G. R. LAVIVNE. 1989. Nitrogen and diaminopimelic acid in deer and moose feces. J. Wildl. Manage. 53:216-218.

MACKINTOSH, C. G.; P. R. WILSON, N. S. BEATSON, K. TURNER and P. J. JOHNSTON. 1986. Preliminary report of the liver: serum copper relationship in red deer. Deer Veterinary Course Proc. Deer Branch, New Zeal. Vet. Assoc. 3:156-164.

MERTZ, W. 1986. Trace Elements in Human and Animal Nutrition. 5th ed. Academic Press, Inc., Orlando, Florida.

PLOTKA, E. D., U. S. SEAL, G. C. SCHMOLLER, P. D. KARNS, and K. D. KEENLYN. 1977. Reproductive steroids in the white-tailed deer (*Odocoileus virginianus borealis*). I. Seasonal changes in the female. Biological Reproduction 16:340-343.

PULS, R. 1994. Mineral levels animal health: Diagnostic data. 2nd ed. Sherpa International, Clearbrook, Canada, 356 pp.

RICHARDS, S. H. 1981. Miscellaneous viral diseases. *In:* Davidson, W. R., F. A. Hayes, V. F. Nettles, and F. E. Kellogg (eds.). Diseases and Parasites of White-tailed Deer. Miscellaneous Publication 7. Tall Timbers Research Station, Tallahassee, FL, pp 108-125.

RINEY, T. 1955. Evaluating condition of free-ranging red deer (*Cervus elaphus*) with special reference to New Zealand. N. Z. J. Sci. Technol. 36:429-463.

ROBBINS, C. T. 1993. Wildlife Feeding and Nutrition. Animal Feeding and Nutrition, A Series of Monographs, Cunha, T. J. (ed.). Academic Press, Inc., Orlando, Florida.

SEAL, U. S.; L. J. VERME, and J. J. OZOGA. 1981. Physiologic values. Diseases and parasites of white-tailed deer. *In:* Davidson, W. R., F. A. Hayes, V. F. Nettles, and F. E. Kellogg (eds.). Diseases and Parasites of White-tailed Deer. Miscellaneous Publication 7. Tall Timbers Research Station, Tallahassee, FL, pp 108-125.

SEAL, U. S.; L. J. VERME, J. J. OZOGA, and A. W. ERICKSON. 1972. Nutritional effects on thyroid activity and blood of white-tailed deer. J. Wildl. Manage. 36:1041-1052.

SHORT, C. 1970. Morphological development and aging of mule deer and white-tailed deer fetuses. J. Wildl. Manage. 34:383-388.

SMITH, B. P. 1996. Large Animal Internal Medicine. 2nd ed. Mosby. St. Louis, Missouri.

SWENSON, M. J. 1982. Duke's Physiology of Domestic Animals. 9th ed. Cornell University Press. London, UK.