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Health Assessment of White-Tailed Deer of the Cuyahoga Valley National Recreation Area, Ohio February 17, 1999

Principal Investigators: Terry E. Creekmore, M.S.
Lynn H. Creekmore, D.V.M., M.S.

U.S. Department of the Interior
U.S. Geological Survey

National Wildlife Health Center
Biological Resources Division
6006 Schroeder Road
Madison, WI 53711

Creekmore, T. E. and L. H. Creekmore. Health Assessment of White-tailed Deer of the Cuyahoga Valley National Recreation Area, Ohio, February 17, 1999.

Abstract: Data from 10 white-tailed deer (*Odocoileus virginianus*) collected on the Cuyahoga Valley National Recreation Area (CVNRA), Ohio, on February 17, 1999, were analyzed and compared to data from 10 deer collected on February 3, 1997, and 10 deer collected on March 3rd and 4th, 1998 by the National Wildlife Health Center as part of a deer herd health assessment program. In 1997 and 1998 low body fat indices in fawns, low fetal:doe ratios in prime age does, as well as abnormal physiologic indices including a hypothyroid state and low magnesium, copper, zinc and selenium levels were used to conclude that the white-tailed deer on the CVNRA have likely exceeded the carrying capacity of the habitat and were suffering from the effects of malnutrition. In 1999 moderate to high body fat indices indicated that the deer herd was in better nutritional condition than observed in 1997 or 1998; however, trace mineral levels and thyroid hormone levels are still low as observed in previous years. 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 Recreation Area (CVNRA), located near Brecksville, Ohio, is managed by the National Park Service (NPS). Resource managers of the CVNRA 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 CVNRA, 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 feeding. In February and March of 1996, excessive fawn deer mortality occurred on the CVNRA. Because of concern for a catastrophic crash in the population and the direct and indirect effect of high deer densities on other natural resources, as well as on park visitors, the CVNRA developed a Resource Management Plan in 1993 which proposed to monitor white-tailed deer herd health and mortality in addition to other environmental parameters potentially impacted by WTD. This health assessment is the third 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 disease 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 resource adaptive management, (4) provide information on some zoonotic diseases carried by the deer herd, and (5) store serum and tissues that may be used for later analysis.

METHODS

On Feburary 17, 1999, ten deer were euthanized using a .243 caliber rifle aiming for the neck region. Animals were aged by tooth wear and replacement (Severinghaus,1949). Blood was immediately collected from the heart and placed in tubes containing EDTA anticoagulant or into tubes to allow clotting to occur. Clotted blood was centrifuged and serum harvested within two hours of collection. Refrigerated serums were sent the morning following collection by overnight service to Columbus, OH, Veterinary Diagnostics Laboratory for serum chemistries, triiodothyronine (T3), and thyroxine (T4) measurements. The remaining serum was frozen and later sent to the Wisconsin Animal Health Laboratory for serology for bluetongue virus (BTV), epizootic hemorrhagic disease virus (EHDV), bovine virus diarrhea (BVD), parainfluenza 3 virus (PI3), bovine respiratory syncytial virus (BRSV), and *Leptospira canicola*, *L. grippotyphosa*, *L. hardjo*, *L. icterohaemorrhagiae*, *L. pomona*, and *L. bratislava* as well as to Michigan State University Animal Diagnostic Laboratory for analysis for Vitamin E and selenium and for other trace minerals. Additional frozen serum from each deer was banked. Blood smears were made from the EDTA blood within 2-4 hours of collection, air dried and fixed in methanol for later parasitologic examination. The EDTA blood was then refrigerated and shipped by overnight service the next morning to the Columbus, OH Veterinary Diagnostics Laboratory for a complete blood count (CBC). Deer were transported to a facility at the CVNRA where they were necropsied. Fat indicies including mean body fat % (BF%), visual kidney fat (VKFI)(Kistner, et al., 1980), kidney fat index (KFI)(Riney, 1955), and bone marrow fat (BMF)(Cheatum, 1949) were recorded at the time of necropsy. Body fat % was tabulated based on visual estimation of the relative amounts of fat in six body locations and the condition of the body musculature. The visual kidney fat is based on visual observation and estimation of the surface area of the kidney covered by fat and is ranked I(<25%), II (25-50%), III (50-75%), or IV (>75%). The kidney fat index is based on mean weights of perirenal fat divided by mean kidney weight x 100. Bone marrow fat (%) is ranked I through VII; 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, based on the color and consistancy of femar marrow. Fetal lengths were measured and fetal ages were calculated (Hamilton et al., 1985). In 1997 and 1998 deer weights were estimated by chest girth. In 1999, 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. Various tissues were collected by standard procedures for assessment by histology, microbiology, and parasitology as indicated by necropsy findings. Feces were collected for measurement of fecal diaminopimelic acid (DAPA) and nitrogen. These samples were refrigerated for 48 hours, then frozen and later submitted by overnight service to the Washington State University Wildlife Habitat Laboratory for analysis. Feces were collected for parasitologic assessment in 1997 and 1998 but not in 1999. In 1999, close visual exam for key parasites was performed during the gross necropsy. Selected physical condition indicies and trace mineral results from 1999 were compared to 1997 and 1998 data.

RESULTS

The sample size of 10 deer collected for each year is adequate for estimating the health status of the entire herd. This sample size is based on results of over 30 years of herd health evaluations conducted by the Southeastern Cooperative Wildlife Disease Study (SCWDS) throughout the southeastern united States (SCWDS, unpub. Data)

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 BW of 2.5 year-old and older females (n=7) was 121.7 lbs. (55.3 kg.) (range, 112-140 lbs.). Mean body fat % and visual kidney fat index for all deer were 49.0 % and 3.2, respectively. The mean BF% in females (n=8) was 55 compared to a mean in males (n=2) of 25. The mean visual kidney fat for females versus males was 3.6 and 1.5 respectively. The mean kidney fat index for female and male deer were 52.7 and 7.0, respectively. Bone marrow fat results ranged from a rating of I (90%) to IV (55%) with a mean for all deer of 1.8 (86%). The mean BMF for females was 1.38 (88%) compared to a mean for males of 3.5 (62.5%).

Table 1. Body condition, sex, age, weight, and location of white-tailed deer collected on Cuyahoga Valley National Recreation Area, Ohio, February 17, 1999.

ID #	Sex	Age (yrs)	Body Fat (%)[1]	KFI[2/3]	Weight (lbs)	Bone Marrow Fat [4]	Pregnant
001	M	2.75	20	I / 1.89	105	IV	-
002	F	4.75	30	III / 21.32	125	I	Yes
003	F	5.75	40	IV / 40.46	115	I	Yes
004	F	6.75	80	IV / 112.79	140	I	Yes
005	F	3.75	65	IV / 48.02	115	II	Yes
006	M	0.75	30	II / 12.11	68	III	-
007	F	6.75	50	III / 33.12	115	I	Yes
008	F	1.75	35	III / 35.88	80	II	No
009	F	3.75	60	IV / 46.54	112	I	Yes
010	F	3.75	80	IV / 83.66	130	II	Yes

[1]Techniques developed by T.P. Kistner (Oregon State University, Corvallis), 1980, A Field Guide Technique for Evaluating Physical Condition in Deer, 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 (Kistner et al.,1980) based on visual observation and estimation of the surface area of the kidney covered by fat I(<25%), II (25-50%), III (50-75%), IV (>75%).

[3]KFI= Kidney Fat Index (Riney, 1955) based on mean weights of perirenal fat divided by mean kidney weight x 100.

[4]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.

Sex, Age, and Reproduction

The mean age of adult females examined in 1999 (n=8) was 4.62 years (range 1.75-6.75). Sex ratio of fetuses (n=13) at near mid-gestation was 54% male and 46% female. Table 2 depicts the reproductive performance of deer on the CVNRA. Of the 8 does of breeding age (1.75-6.75 years old) examined, 87.5% were pregnant. The 1.75 year old female examined was not pregnant. Crown to rump lengths for fetuses ranged from 15.5 to 23.0 cm. The twinning rate for those does that were pregnant was 71.4%.

Table 2. Reproductive performance of white-tailed deer on the Cuyahoga Valley National Recreation Area, Ohio, February 17, 1999.

ID #	Age (yr)	Fetuses per Doe	Fetal Sex/Size[1] (cm)
002	4.75	I	M/20.0
003	5.75	2	M/15.5, F/16.0
004	6.75	2	M/20.5, M/20.75
005	3.75	2	M/20.75, F/20.5
007	6.75	2	M/17.0, F/16.75
008	1.75	0	-
009	3.75	2	M/22.0, F/21.75
010	3.75	1	F/23.0

[1]Crown to rump length

Pathology

Observations of pathology from gross and microscopic examination of 10 deer were predominantly unremarkable. Deer 008 had a 10 cm partially healed laceration on the medial surface of the left leg in the inguinal area . Minor lesions on the surface of the livers of two of the deer indicated larval parasite migration. Meningeal nematodes (*Parelaphostrongylus tenuis*) were found in seven of the 10 deer examined. No liver flukes (*Fascioloides magna*) were observed on gross examination of the liver. The adult male (001) had a 1 mm non-inflammatory fistulous tract visible on the capsular surface of the left kidney and extending into the parenchyma and a larval tapeworm cyst was found on the surface of the liver of deer 002. Two deer (003,008) each had a larval tapeworm cyst loosely adherent to the intestinal serosa. Four deer had areas of diffuse congestion in the lungs.

Parasitology

No significant external parasites were observed. Second and third instars of nasal bots (*Cephenemyia spp.*) were found in one deer. Meningeal worms were found in seven deer and larval tapeworm cysts were found in three deer. *Parelaphostrongylus sp.* larvae and eggs were seen in all 10 deer during histologic examination of lung sections. No large stomach worms (*Haemonchus contortus*) were seen on close gross examination of abomasal content or microscopic examination of an aliquot of abomasal content. No *Dictyocaulus viviparus* lungworms 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 considered a health issue.

Serology

Serum from each of the 10 deer was analyzed for antibody titers to six disease pathogens. With the exception of PI-3, no antibodies were reported in any of the 10 deer tested. Four of 10 deer tested had PI-3 titers of 1:8 (n=2), 1:32 (n=1), and 1:64 (n=1). Results are shown in Table 3.

Table 3. Results of serologic tests used to detect antibodies against selected disease agents in white-tailed deer collected on Cuyahoga Valley National Recreation Area, Ohio, February 17, 1999.

Agent	No. Samples	Test	Result
Bluetongue	10	competitive ELISA	negative
Epizootic Hemorrhagic Disease	10	agar gel immunodiffusion	negative
Bovine Viral Diarrhea I & II	10	serum neutralization	negative
Parainfluenza-3	10	serum neutralization	1:8-1:64
Respiratory Syncytial Virus	10	micro agglutination	negative
Leptospira canicola	10	micro agglutination	negative
L. grippotyphosa	10	micro agglutination	negative
L. hardjo	10	micro agglutination	negative
L. icterohaemorrhagiae	10	micro agglutination	negative
L. pomona	10	micro agglutination	negative
L. bratislava	10	micro	negative

Clinical Pathology

Basic statistical descriptions of hematological and biochemical variables for 10 animals, 8 adult females, 1 adult male and 1 nine month old male are presented in Tables 4 and 5. Data were compared with reference values provided by Seal et al. (1981), Bubenik and Brownlee (1987) and Tumbleson et al. (1968), for white-tailed deer when possible, otherwise reference values for domestic animals were used (Smith, 1996).

Hematology

Packed cell volumes were all within the range of the reference values; however, the hemoglobin concentrations were consistently low as compared to reference values from killed white-tailed deer (Table 4). The leukocyte values are within the reference range for all of the deer examined. Lymphopenia was observed in 70% of the deer and monocytosis was observed in 20%. All of the deer sampled had eosinophilia; in four animals the increase was marked.

Table 4. Mean (S.D.), minimum and maximum values for hematologic parameters of 10 free-ranging white-tailed deer from Cuyahoga Valley National Recreation Area, Ohio, February 17, 1999.

Parameter	Mean (S.D)	Min.-Max.	Reference Values[1]
PCV (%)	46.5 (5.5)	39.8-60.0	39 - 58
Hemoglobin (g/dl)	17.2 (1.8)	15.7-22.0	18.3 -19.3
MCHC (g/dl)	37.1 (1.2)	35.7-39.4	34.7 - 36.1
MCV (fl)	36.8 (1.9)	34.6-40.0	23.8 - 33.0
Nucleated RBC (/100 WBC)	0	0	0
Leucocytes ($x10^3/\mu l$)	2.28	1.1-4.4	1 - 4.2
Seg. Neutrophils (%)	67.6	43-91	57 - 72[2]
Seg. Neutr. ($x\ 10^3/\mu l$)	1.50	0.64-2.55	0.6 - 2.8
Neutrophilic Bands (%)	0.7	2-5	
Neutr. Bands ($x10^3/\mu l$)	0.01	0.04-0.06	
Lymphocytes (%)	19.8	2-36	24 - 35[2]
Lymphocytes ($x10^3/\mu l$)	0.50	0.03-1.58	0.6-1.8
Monocytes (%)	0.90	0-2	1 - 3[2]
Monocytes ($x10^3/\mu l$)	0.07	0.05-0.09	< 0.010
Eosinophils (%)	11.0	5-21	2 - 7[2]
Eosinophils ($x10^3/\mu l$)	0.26	0.14-0.82	< 0.10
Platelet Estimate	Adequate	Adequate	< 0.10

[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. AST was elevated in three deer and CPK was above the reference range for all 10 deer tested. Creatinine values were above the reference value for three deer.

Slightly depressed chloride levels were apparent in 50% of the animals examined. The calcium phosphorus ratio is well balanced and the magnesium values of the deer examined are within the normal range.

One deer had a glucose value greater than the reference range. Hypoalbuminemia (<2.5 g/dl) was detected in six of the deer sampled. However, four of the deer with hypoalbuminemia had values that were only slightly below the reference value, and comparison of albumin values with body fat results indicates that only two deer (001,008) had depressed albumin results as well as reduced fat stores. The T3 and T4 levels for all of the deer collected in 1999 were below the normal reference values.

Table 5. Mean (S.D.), minimum and maximum values for serum biochemical values for 10 free-ranging white-tailed deer from Cuyahoga Valley National Recreation Area, Ohio, February 17, 1999.

Parameter	Mean (S.D.)	Min.-Max.	Reference Value[1]
Sodium (mmol/L)	136.0 (4.1)	131-142	132 - 156
Potassium (mmol/L)	8.6 (1.2)	6.2-10.5	3.4 - 5.0
Chloride (mmol/L)	99.7 (3.7)	92-105	100 - 110
Calcium (mg/dl)	9.7 (0.3)	9.1-10.2	8.1 - 10.8
Phosphorus (mg/dl)	7.7 (1.1)	6.1-9.0	4.5 - 8.5
Magnesium (mg/dl)	2.4 (0.1)	2.3-2.5	2.2-2.6[2]
Glucose (mg/dl)	265.7 (70.2)	154-408	60 - 320
BUN (mg/dl)	24.1 (6.0)	14-35	15 - 45
Creatinine (mg/dl)	1.9 (0.3)	1.4-2.3	0.4 - 2
Total Protein (g/dl)	6.3 (0.4)	5.8-6.9	5.0 - 7.8
Albumin (g/dl)	2.4 (0.2)	1.9-2.6	2.5 - 4.2
ALKP (U/L)	33.5 (10.8)	15-47	27 - 107[3]
CPK (U/L)	722.5 (281.4)	659-1192	20 - 400
AST (U/L)	129.5 (37.0)	91-177	40 - 150
GGT (U/L)	43.2 (10.5)	29-51	40 - 100
Total Bilirubin (mg/dl)	0.3 (0.1)	0.2-0.4	0.1- 1
T3 (ng/ml)	0.81(0.21)	0.52-1.18	1.25 - 3.05
T4 (ng/ml)	77.7 (1.59)	51.8-103.4	150 - 300

[1]Reference values were adopted from Seal et al., 1981 except where indicated.
[2]Tumbleson et al., 1968.
[3]Smith, 1996 (bovine values).

Nutrition

Trace minerals and vitamin E

Basic statistical descriptions for serum copper, zinc and iron, and whole blood selenium and serum vitamin E concentrations are presented in Table 6. Serum copper values (range 0.449-0.679) were below the reference value for eight of the 10 deer tested, based on data from domestic animals (Smith, 1996). Serum zinc results were below the reference value for all 10 deer tested. One deer (010) had a slightly elevated serum iron value. The remainder of the deer had results within the reference value.

Whole blood analysis for selenium (ng/ml) was below the reference range of 100-180 (Puls, 1994) in all 10 deer examined. Four deer had vitamin E values that were depressed and one animal had a value slightly above the reference range; the remaining 5 deer had vitamin E levels within the normal reference range.

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 from 1999 for FDAPA and FN were 0.517 mg/gm and 2.80% respectively.

Table 6. Mean (S.D.), minimum and maximum values for selected trace minerals and vitamin A for 10 free-ranging combined adult female (n=8), adult male (n=1), and young of the year (n=1) white-tailed deer from Cuyahoga Valley National Recreation Area, Ohio, February 17, 1999.

Parameter	n	Mean (S.D.)	Min.-Max.	Reference Values[1]
Copper (ppm)	10	0.61 (0.10)	0.499-0.775	0.7 - 1.2
Zinc (ppm)	10	0.45 (0.06)	0.350-0.522	0.7 - 1.0
Iron (ppm)	10	1.9 (0.38)	1.49-2.47	0.7 - 2.3
Selenium (ng/ml)	10	44.1 (11.84)	20-58	100 - 180[2]
Vitamin E (µg/ml)	10	2.18 (0.57)	1.37-3.11	2.09 - 3.05[3]

[1]Smith, 1996.
[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 1999 was markedly better than those animals tested in 1997 and slightly improved over 1998 results (Table 7). Increases in mean % body fat (49.0%) and mean KFI (3.2) were seen in 1999 when compared to 1998 BF% and KFI results of 35.6% and 2.8, and 1997 values of 27.1% and 2.4 respectively. However, the 1999 mean body weight for adult does was slightly less than 1998 results. The apparent decrease in mean weight of adult does is possibly an artifact of the difference in methods of weight determination coupled with the small sample size. Weights were estimated by chest girth measurements in 1997 and 1998, while animals were weighed using a hanging scale in 1999. The mean age of adult does sampled in 1999 was 4.63. In 1998, and 1997, the mean ages of adult does were 5.4 years and 4.5 years respectively. The age structure of the population is difficult to determine due to the small sample size. However, based on this limited sample, no abnormalities were noted in the sex ratio and age structure.

Body fat, KF, and bone marrow fat indices were higher for adult does than for the adult male. In general, adult does enter the winter in better body condition than adult bucks, and fawns of both sexes. Adult bucks feed little and are very active during the late fall breeding season and consequently enter the winter in poor physical condition. Fawns initially invest the majority of their energy in body growth, but photoperiod changes cause a physiologic shift to fat deposition in the fall. Consequently, the fat reserves available to deer in the late winter are a crucial factor in survival during periods of stressful weather conditions. Winter mortality usually involves fawns and adult males, with adult doe mortality restricted to extreme conditions of weather and/or habitat quality.

In general, reproductive performance of the deer herd of the CVNRA appears similar to 1998 results and improved when compared to 1997 data. Reproductive performance of the CVNRA deer herd in 1999 is considered low based on the number of fetuses per doe (1.7:1) and the lack of pregnancy in the 1.75 year old female. These results are below the mean number of fetuses per doe (1.8:1) for deer in the same age group recorded for northern Ohio (Gladfelter, 1984). The mean number of fetuses per doe (>2.5 years) (1.7:1) increased from 1997 levels (1.3:1), and was about the same as 1998 results (1.6:1). 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). However, one 1.75 year old doe was not pregnant in 1999, the one female fawn was not pregnant in 1998, and in 1997 neither of two female fawns were pregnant. The twinning rate has also shown a steady increase from 1997 levels. The twinning rate in 1999 was 71.4% as compared to 62.5% in 1998 and 28.0% in 1997. Fetal sex ratios in 1999 were 54% male and 46% female while 1998 results were reversed at 46% male and 54% female. The fetal sex ratio for 1997 was 43% male and 57% female.

The fetal size (crown-rump length) varied significantly from 1.0-19.0 cm in 1997, and this fetal length indicates a breeding season from about November 1 to January 1. However, malnutrition can cause retarded growth of fetuses and thus preclude any accurate determination of their age by measurement (Short, 1970). As a result, the variation in fetal size seen in 1997 is most likely due to the malnourished state of individual does and not a reflection of an extended breeding season. The fetal size in 1998 was tightly clumped, ranging from 22-28 cm indicating a breeding season ranging from October 25 to November 16, 1997. Fetal size in 1999 ranged from 15.5-23.0 cm which places the breeding season between October 30 and November 22. The fetal size results from 1998 and 1999 are an indication of improved physical condition when compared to 1997 values.

PI-3 titers were found in four deer tested in 1999, one animal in 1998, and five deer in 1997. Parainfluenza virus type 3 is primarily a viral disease of cattle, and limited studies of this agent in deer suggest that only nonfatal clinical manifestations 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 splenic 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.

Lymphopenia was observed in seven deer and elevated monocyte counts were seen in 2 animals. Elevated lymphocyte and monocyte counts occur 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 elevated lymphocyte and monocyte levels is undetermined. High eosinophil counts are rare in ruminants but may be caused by parasite infection. However, the parasite burden was low in the animals examined making parasite infection less likely as the cause for the eosinophilia.

Potassium and CPK values were elevated in all 10 deer and AST values were above the reference range for three deer. The high levels of potassium, CPK and AST 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 AST and CPK may also be attributed to general trauma and tissue damage caused by shooting. 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 reduce water intake. The slightly low chloride levels seen in half of the deer from this study are a change likely due to dehydration. The validity of serum glucose for evaluating nutritional status is questionable as excessive depletion of gluconeogenic precursors can be masked by abnormally high glucose levels caused by handling stress (DelGiudice et al., 1987). The glucose values do not fall below the normal limits and the high values may be explained by capture stress indicating that glucose is likely within normal range in a non-stressed state.

In 1997, low protein concentrations and BUN values in the normal range suggested energy deprivation and catabolism of body protein for energy (DelGiudice and Seal, 1988). In 1998 and 1999, the total protein and BUN values are within the normal range indicating a better plane of nutrition and energy balance.

Hypoalbuminemia was seen in six of the animals tested. However , only two animals had albumin levels that were significantly out of 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 T4 values for 1999 (77.7 ng/ml) are about the same as those observed in 1998 (72.7 ng/ml) and are lower than the 1997 values (85.6 ng/ml). The T3 values in 1999 (0.81 ng/ml) are slightly lower than last year's value (0.93 ng/ml) but are still slightly higher than the 1997 values (0.6 ng/ml). The T4 and T3 levels in CVNRA deer from all years remain consistently below the reference values, and these decreased concentrations may reflect the diminished dietary energy available. The mean serum T4 concentration in these deer was lower than values for undernourished female white-tailed deer (T4=97 ng/ml) (DelGiudice et al., 1987) suggesting a compromised nutritional situation.

Fecal DAPA and Fecal nitrogen results provide an indication of forage quality. Fecal DAPA increases in the rumen as a function of increased bacterial mass, and FN tends to increase as dietary nitrogen increases (Leslie et al., 1989). 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 CVNRA should 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. However, the minor fluctuations in fecal DAPA and FN seen between years may in part be attributable to variations in sampling dates and the corresponding variation in forage quality.

Mean serum copper values (ppm) in 1999 (0.61) are higher than those seen in 1997 (0.50) and 1998 (0.45) but are still below the reference range of 0.7-1.2. 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). The 1999 results reverse somewhat the trend of lower copper values between 1998 and 1997 and no clinical signs or lesions were seen that can be directly attributed to copper deficiency. In sheep, cattle and red deer, copper concentrations below 0.5 ppm are considered diagnostic for copper deficiency (Mertz, 1986; MacKintosh et al., 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).

Zinc results were below the normal range for all 10 deer sampled. Mean zinc values dropped from 1.1 ppm in 1997 to 0.45 ppm in 1999. Slightly depressed levels of zinc were noted in 90% of the animals tested in 1998 as compared to data from 1997 where 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 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 (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 likely 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

Increases in fat indices, fetal rate, and the twinning rate reveal that the physical condition of the deer has improved from 1997 levels. However, these results are still below reference values for deer with adequate nutrition and continue to indicate that the deer population on the CVNRA is in excess of the carrying capacity of the habitat. If habitat quality and deer populations remain at current levels, fawn mortality can be expected during periods of extreme winter stress.

Table 7. Comparison of Mean Results 1997-1999

Parameter	1997	1998	1999	Ref. Value
Body Weight[1,2]	134.6 (n=7)	131.3 (n=8)	121.7 (n=7)	
Body Fat	33.0 (n=10)	35.6 (n=10)	49.0 (n=10)	
KFI (visual)	3.0 (n=10)	2.8 (n=10)	3.2 (n=10)	
Fetuses/Doe[1]	1.3 (n=7)	1.6 (n=8)	1.7 (n=7)	1.8 [3]
Twinning Rate	28.0 (n=7)	62.5 (n=8)	71.4 (n=7)	

[1] Does (>2.5 yrs.).

[2] Body weight was estimated in 1997-98 using chest girth measurements. Deer were weighed with a hanging scale in 1999.

[3] Gladfelter, 1984

Table 8. Comparison of Mean Results *1997-1999.*

Parameter	1997 (n=10	1998 (n=10)	1999 (n=10)	Ref. Value[1]
Copper (ppm)	0.5	0.45	0.61	0.7-1.2
Zinc (ppm)	1.1	0.54	0.45	0.7-1.0
Iron (ppm)	1.7	1.83	1.9	0.7-2.3
Vitamin E (ug/ml)	NT	1.96	2.18	2.09-3.05[2]
Selenium (ng/ml)	92.7	112	44.1	>100[3]

[1]Smith, 1996.
[2]Ullrey, 1981
[3]Puls, 1994
NT=Not Tested

Recommendations for Research

Baseline data on deer herd health is essential in understanding current herd status and trends. With such information, predictions on population dynamics and responses to resource management actions can be made. It is recommended that (1) an annual herd health assessment, similar to the ones conducted from 1997 to 1999, be continued for an additional two years. After completion of this 5-year data base, assessments at three year intervals should be sufficient, (2) if large scale habitat or population changes are initiated, annual herd health assessments should be implemented for a period time to measure the effects of management changes.

Armed with this information resource management personnel of the Cuyahoga Valley national Recreation Area should be able to make scientifically based and sound decisions to properly manage the white-tailed deer herd and associated natural resources.

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