DESCRIPTIVE ASPECTS OF TWO FAWN POPULATIONS AS DELINEATED BY REPRODUCTIVE DIFFERENCES

by

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INTRODUCTION

The white-tailed deer (Odocoileus virginianus) is the most common, adaptable, and widely hunted big game mammal in North America. Originally, as many as 40 million whitetails occurred on the continent, but were reduced to less than 500,000 at the turn of the century (Seton 1937: 244). By 1949 the estimated population was five million (Hosley 1961: 225), and during 1973 it was estimated that nearly one million individuals occurred on National Forest System lands alone (U.S.D.A., Forest Service 1973).

This recovery was due in part to the creation of prime deer habitat through logging and burning (Leopold 1950), and led to the recognition that the classic controls in game management; namely, restriction of hunting, predator control, refuges, and restocking, were not enough. Environmental management was also needed; food, cover, and water needed to be provided within the normal home range of the species. Historically then, deer management revolved around these concepts; provide the optimum food, cover, and water, protect the herd, and restock as necessary.

It soon became apparent, however, that another factor had to be dealt with, the ability of deer to overpopulate and destroy their range. The Kaibab herd has become a classic illustration of this phenomenon. During an 18 year period, a herd of approximately 4,000 individuals increased to nearly 100,000 before disease and starvation decimated the population (Young 1961: 4). From this and numerous other case histories documenting the innate ability of deer populations to increase (O'Roke and Hamerstrom 1948, Hesselton et al. 1965, and others) the concept of wildlife as a crop evolved; adequate harvest became an integral part of management.

Essentially, this is the status of present day deer management: to pro-

vide optimum habitat, furnish protection, and insure that an adequate harvest is obtained. Unfortunately, this may no longer be enough.

During the past two decades, deer habitat has diminished at an astonishing rate. Once prime habitat has been developed into sprawling urban complexes, rural farm land consolidated into vast agricultural workings devoid of cover, and millions of acres inundated for the production of hydroelectric and nuclear power. Concurrently, hunting pressure on big game species, particularly deer, has been increasing. During 1972, over 9 million man days of big game hunting occurred on National Forest lands (U.S.D.A., Forest Service 1973). In view of this, deer managers are faced with the problem of producing more deer and obtaining higher harvests.

Deer herds containing high proportions of breeding fawns have significantly higher reproductive attainments than those which do not. This is not only resultant because of fawn breeding, but may also be due to higher rates of production by that segment of the 1.5 year age-class which had successfully bred as fawns (Olmstead 1970).

Until recent years, most workers only suspected that fawns in the South contributed to total herd recruitment (McDowell 1965). However, data have accumulated which show that fawns are capable of high reproductive rates in this region. Fawn reproduction can also be an important parameter of overall population thrift since younger animals may tend to respond more rapidly to adverse environmental stimuli.

Fawn reproduction received little attention in the South for several reasons. As pointed out above, fawn breeding has been considered as insignificant and therefore, inconsequential to overall herd recruitment. Also, many herds in the South have been reintroduced only recently, and have therefore, been

managed under the "buck only" doctrine; meaningful samples of doe fawns have been unobtainable. Thirdly, doe fawns would tend to breed later than adult females; few, if any, pregnant individuals would be obtained during the November deer season which is common to much of the region. Furthermore, an ideal study would involve comparisons between breeding and non-breeding fawn populations from proximal areas, especially if both populations had the same genetic ancestry. It is unlikely that many such areas exist.

However, one such location, the Savannah River Plant, near Aiken, South Carolina, does afford such an area. The herd, believed to have desended from several dozen animals, had expanded to well over one individual per 13 ha in some areas (Payne et al. 1966). By 1967, it has been documented that doe fawn reproduction had virtually ceased in a river swamp area (Urbston 1967), and remained low through 1971 (Urbston 1972), while fawn reproductive rates remained high in a nearby upland habitat (Fig. 1, Table 1). It is thought that as opposed to being purely a local situation, these herd dynamics may typify those found elsewhere throughout the southeast, but due to the relatively short period of herd establishment, these changes were more apparent here.

Evaluating all factors which may affect fawn reproduction is well beyond the scope of this study. However, some insight into the dynamics of these reproductively different herds may be gained by investigating several variables which have been shown to interact with reproduction; these are nutrition, stress, and disease. Furthermore, during recent years, genetic diversity, or heterozygosity, and its interaction with population dynamics has been subject to much discussion. Inasmuch as the Savannah River Plant presents an ideal case history on deer expansion and niche exploitation, the ramifications of genetic structure of the two populations should not be omitted.

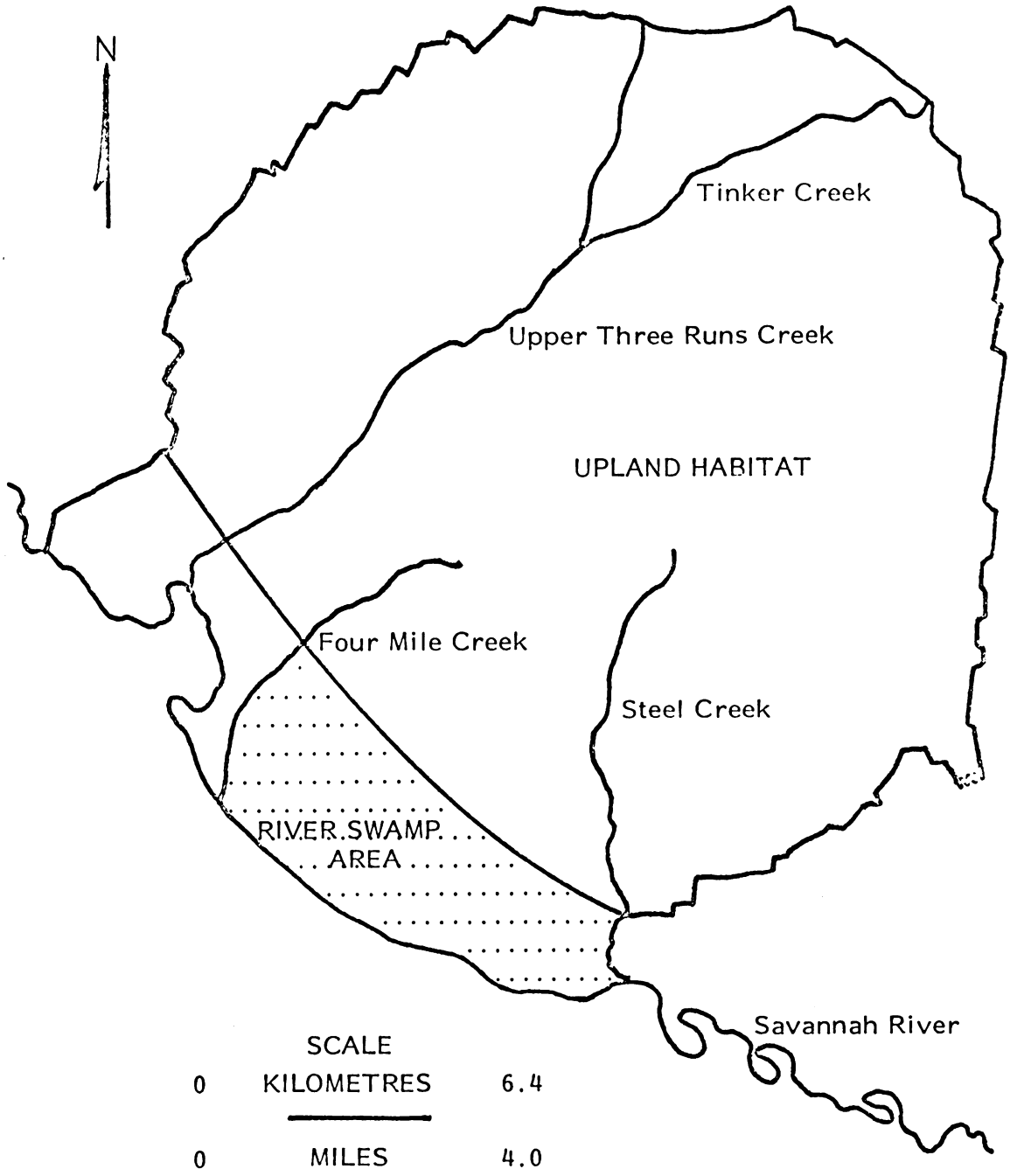

Fig. 1. Areas having different rates of doe fawn reproduction on the Savannah River Plant during the period 1966 through 1970.

Table 1. Doe fawn reproduction from two areas on the Savannah River Plant during the period 1965 through 1970 as determined by pregnancy rates of fawns and lactation rates of 1.5 year old does during following year.

Area	Year	Estimated by pregnancy: Fawns collected (Number)	Estimated by pregnancy: Fawns pregnant (Percent)	Estimated by lactation: Yearlings collected (Number)	Estimated by lactation: Yearlings lactating (Percent)
Swamp	1965	0	--	26	0.00
	1966	26	0.00	36	2.78
	1967	3	0.00	15	26.67
	1968	4	25.00	0	--
	1969	1	100.00	16	6.25
	1970	10	10.00	17	11.77
Upland	1965	0	--	44	45.46
	1966	1	100.00	93	32.26
	1967	8	62.50	71	57.75
	1968	8	75.00	108	46.30
	1969	10	70.00	82	43.90
	1970	5	40.00	57	45.61

This study attempted to describe two reproductively different populations of fawn deer on the Savannah River Plant in terms of nutritional levels, levels of stress, pathological factors, and genetic heterozygosity.

Furthermore, this investigation attempted to identify significant interactions between these factors and fawn reproduction.

LITERATURE REVIEW

Nutrition

Current deer management in the southeast is directed primarily toward managing the habitat for greater and more nutritious forage to produce and sustain more animals. Considerable work has been directed toward correlating deer reproduction with nutrition. Gerstel (1938) reported on diminished productivity on poorer Pennsylvania deer ranges. Cheatum and Severinghaus (1950) stated that fertility levels were closely correlated to range quality, which itself was a function of topography, climate, forest type, and land use patterns. According to Gill (1956) several other important aspects which determine range quality are soil parent material, precipitation, slope, and the presence of calcareous deposits. Sileo (1973) compared fertility rates by age of the dam, physiography, general forest regions, specific forest types, soil, use patterns, and percent of land farmed. He found that soil and forest type were the two most important environmental factors affecting deer fertility. Based on these, he was able to delineate six major fertility regions in the eastern United States, the highest occurring in the northern states and the lowest in the south.

Various investigators have found nutrition and reproductive attainment to be highly correlated. Verme (1965) found significant reductions in the number of embryos produced when pen raised deer were maintained on restricted diets. He also obtained similar reductions when animals were maintained on extremely high nutritive levels. In the latter case, a situation similar to that in cattle developed whereby fat infiltrated the ovaries and inhibited ovulation (Maynard and Loosli 1969: 501). The work of Verme (1965), as well as a similar study (Verme 1969), showed significant increases in the proportion of males

to females produced in does maintained on low planes of nutrition. Studying fertility in fawns on Crab Orchard National Refuge, Follmann and Klimstra (1969) found a 36.9 percent fertility rate. They concluded that fertility was related to age and possibly high nutritional intake. However, based on results from a subsequent study on the area, Roseberry and Klimstra (1970) found that the onset of puberty in fawns was most probably a function of body weight. The average weight of 94 unbred females was 28.4 kg, while average weight for 49 bred individuals was 31.2 kg. An additional 17 early breeders had a mean weight of 32.9 kg. In this study, they concluded that onset of breeding was related to body weight which probably reflected age. However, body weight may not necessarily reflect age. French et al. (1956), Verme (1963), and others have shown significant increases in growth rates in fawns on high nutritive diets. In both beef and dairy cattle breeds onset of puberty is dependent upon reaching a minimum body weight (Hafez 1968: 256). Factors such as age and nutrition affect onset of puberty only to the extent that they delay reaching this weight requirement.

Describing nutritional characteristics in wild deer populations is difficult. Such work has taken two directions in the past: evaluation of the habitat in reference to what the animal consumes, or direct assessment of the animal's physical condition. The former approach has been used extensively because sampling presented no special political or legal problems. Consequently, numerous habitat or "browse" surveys have been conducted throughout the southeast (Harlow 1959, Moore 1969, and others). In an attempt to circumvent the obvious problem of determining utilization by visual inspection of forage, biologists analyzed rumen contents from sampled deer, thereby obtaining direct information on forage consumed. Studies by Korschgen (1954), Harlow (1964),

Cushwa et al. (1970), and others demonstrated the inadequacies of the browse survey approach; rumen analysis provided reliable assessments of species composition of forage ingested and seasonal, regional, and local variation between diets whereas browse surveys often did not.

Biologists have also determined the nutritive value of forages "preferred" by deer. Using proximate analysis techniques, Short et al. (1966) determined nutritive values of forage. Various other workers have used detergent solutions (Van Soest 1967 and Whelan et al. 1973) and in vitro microdigestion trials (Oh et al. 1966, Johnson and Dehority 1968, and Pearson 1970).

Another approach involves direct physiological assessment of the animal itself. Lofgreen and Garrett (1954) found that density of 9th, 10th, and 11th ribs of beef cattle were correlated with water, protein, and fat content. Various other techniques have been used to assess nutritive condition of deer. French et al. (1956) correlated antler development with nutrition and Longhurst and Douglas (1953) suggested onset of antler development as an indicator of nutrition. Other indices which have been used are: femur fat (Cheatum 1949), weight and girth correlations (Hunter 1947), and fat deposition throughout the body (Hammond 1942, Harris 1945, Riney 1955, and Nichols and Pelton 1972). Riney (1955) summarized these indices and found kidney fat index to be of most value when assessing physiological condition of red deer (Cervus elaphus) in that it was applicable in all seasons, provided equitable comparisons between animals of different size, and was applicable over wide ranges of values. Ransom (1964) and Monson et al. (1974) also found this technique to be satisfactory for white-tailed deer.

Nutrient composition in terms of the entire animal has been studied. Kelly et al. (1968) evaluated carcass composition of beef cattle by lyophilizing

large quantities of meat for moisture assay and determined protein, ash, and ether extract by A.O.A.C. (1960) methods. Robbins et al. (1974) determined body composition (protein, fat, ash, and water) of 23 captive deer under controlled feeding conditions.

Unfortunately, a model which relates fawn productivity solely to nutrition and weight may be inadequate; there are some serious inconsistences. Olmstead (1970) found poorer reproductive rates in deer herds found on swamp and bottomland types of forest and alluvial soils as opposed to those found on oak-pine forest types in Georgia, Alabama, and Mississippi. This was surprising in that he regarded the former types to be more fertile than the latter. Similarly, he found that the more fertile grey-brown podzols in the southern loblolly-shortleaf pine types yielded lower deer fertility rates than the red and yellow podzols of the same type. Testing deer density, maternal age, forest type, and soil fertility on deer productivity, he found that maternal age and deer density overrode all other effects significantly. Unfortunately, weights were not evaluated since data were not available. Klein and Strandgaard (1972) studied growth rates and size of red deer in Denmark. They found that growth rates and size were greatest on areas of lower density, regardless of soil fertility. Although the more fertile areas produced a greater total biomass (deer), the largest and most rapidly growing individuals came from the areas of lower density. Urbston (1967) reported on significant differences in fawn reproduction between two areas near Aiken, South Carolina. In one area having virtually no fawn reproduction, density was estimated to be in excess of one deer per 5 ha. On the other area, fawn pregnancy exceeded 40 percent; in this area density was estimated at one individual per 13 ha. Although not significantly so, fawn weights were lower in the area of higher density.

In view of the above discussion, it appears likely that a model describing fawn productivity must be expanded to include density as a factor which may reduce growth and onset of puberty via stress.

Stress

It is well known that increased hormone secretions resulting from stress affect every metabolic process of an organism. Generally, such animals suffer decreased resistance to disease, lower utilization of food, higher levels of circulating lipids, less protein synthesis, and lower reproductive attainment. Since animals respond to stressors by increased secretions of adrenaline and noradrenaline from the adrenal medulla, increased hypertrophy and subsequent weight increase of the adrenal glands would be expected. Cognizant of these interactions, wildlife biologists have attempted to quantify stress in deer by removing and weighing adrenal glands.

Christian, Flyger, and Davis (1960) reported that adrenal glands from Sika deer (Cervus nippon) on James Island, Maryland, were larger during years of high population density. Welch (1962) reported similar data from deer in North Carolina. However, overall value of this work has been somewhat questionable. Welch (1965) spoke against using adrenal weights an an indicator of stress. He warned that hyperactivity of the gland does not always result in an increase of its weight. At other times, severe demand in hormone secretion may actually cause glandular failure and a subsequent decrease in its weight. Moreover, the time lag between stress and increased adrenal weight (should it occur) may be so great that it is nearly impossible to detect the time of stress. Similarly, an organism may be erroneously described as being in the stressed condition long after the stressor has been removed. Christian and Davis (1964: 1551) cautioned against cursory use of adrenal weights as

indicators of stress by stating "adrenal weights are not valid indices of function unless certain precautions are observed." Age, sex, presence of immature (X) zones within the gland, weight loss with excessive stimulation, lipid accumulations, and sex hormone interaction should be considered. Obviously, the average wildlife biologist has neither the time, equipment, nor experience to interpret these interactions; an alternate method for detecting stress is needed.

One such technique involves the quantification of catecholamines or their metabolites which are produced by an animal during times of physical or mental duress. Epinephrine and norepinephrine are two such catecholamines. Their oxidation product, 3-methoxy-4-hydroxymandelic acid (vanilmandelic acid) is a urinary metabolite. During recent years, considerable investigation has been conducted on the relationships between stress and vanilmandelic acid (VMA) levels in urine.

According to von Euler (1964), the release of epinephrine from the adrenal medulla may result from either metabolic stress or emotional stimuli. Norepinephrine appears as an excretion from nervous tissue. While much less a by-product of emotional stimuli, levels of this catecholamine increase significantly following periods of physical strain or adjustments by the animal to external temperature stimuli. Euler and Lundberg (1954) found significant epinephrine releases in military personnel transported by air, while norepinephrine values remained unchanged. However, similar tests involving pilots in prolonged supersonic flights indicated increased circulatory levels of both catecholamines. Bloom et al. (1963) found that rates of epinephrine excretion doubled in officers and trainees involved in daytime parachute jumps. Night jumping resulted in even higher levels.

Armstrong et al. (1957) identified vanilmandelic acid (VMA) as a major

urinary metabolite of epinephrine and norepinephrine. He detected increased urinary levels of VMA in patients with pheochromacytoma. Gitlow et al. (1961), Crout et al. (1963), and others have reported similar results. High levels of VMA have also been reported in patients with neuroblastoma and related neural tumors (Gjessing 1962 and Chaptal et al. 1963). Sunderman (1960) developed a specific colorimetric procedure for determining VMA in urine, and used this technique on approximately 1,600 patients, including 18 with pheochromacytoma and 4 with neuroblastoma and related tumors. He found increased levels of urinary VMA in patients exhibiting the above pathologic alterations. Trauma, parturition, burns, and stress were other disfunctions resulting in increased levels of this metabolite in the urine. Malnutrition, however, was evidenced by decreased urinary levels of VMA.

Stefanovic et al. (1970) used the technique described by Wybenga and Pileggi (1967) to evaluate the effects of heat, cold, and starvation on swine. They found marked increases in urinary VMA from pigs exposed to prolonged periods of heat and cold, but significant decreases in the metabolite when the animals were starved. The relationship between nutritional stress and VMA production apparently varies by species. Stefanovic's results agree with those of Sunderman (1960) and Goodman et al. (1967), who also found no increase in VMA among fasting human subjects. Le Duc (1961), however, found a three-fold increase in epinephrine in the fasting rat. To date, this relationship has not been established for deer.

Heterozygosity

Just as stress may interact to depress productivity, so may the genetic constitution of the individual. Animal breeders have long been cognizant of the advantages and dangers of inbreeding. Full or half sib matings are often

employed to produce individuals which in turn are cross bred with others to obtain hybrid vigor. Conversely, it is known that inbreeding results in an increase in the frequency of homozygous alleles, or otherwise stated, an increase in the probability that two alleles at a particular locus were derived from a common ancestor. The result is either an increased occurrence of deleterious recessive alleles, or the rendering of certain genes homozygous which are more advantageous in the heterozygous state, or both. More commonly, this situation is referred to as inbreeding degeneration (Lerner 1968: 263) and results in reduced fitness, impaired productivity, and in some cases extinction of populations, or even, eventually the species, since according to Yasuda (1969), random drift of gene frequency in a small population will lead to random extinction and fixation of alleles; consequently, genetic traits common in large populations may become absent in small populations.

Although this may be appropriate in controlled situations involving few individuals or relatively small populations from confined areas, biologists have been reluctant to apply these principals to large mobile populations, particularly those involving polygamous of promiscuous species. Previously, workers such as Dobzhanski (1941), Grant (1963), Mayr (1963), and others have argued that geographical isolation was a requisite for divergence. Consequently, deer biologists have generally disregarded genetic rammifications except those which were grossly obvious (piebaldness, albinism, etc.) rationalizing that distribution and mobility would obscure divergence.

Recent work now questions that rationale. Seaton and Antonovics (1967) showed niche divergency between two strains of fruit flies whereby both diverged into separate sub-habitats of what was believed to be a homogeneous environment. Similarly, Selander et al. (1971) found that intrapopulation genetic diversity

varied geographically in the old field mouse (Peromyscus polionotus). Generally, heterozygosity increased as the number of sub-habitats became more diverse. Antonovics (1971) refutes the dogma that geographical isolation is necessary for divergence and speciation.

However, for the deer manager, the question is more basic than divergence and speciation. One would hardly expect morphological changes resultant from sub-speciation to occur in relatively short time spans. As Nei (1971) suggested, it may have taken as long as 500,000 years to establish differences between sibling pairs of Drosophila. Rather, the question is, are fluctuations in animal populations random or are they controlled by internal as well as external factors?

Internal population control was suggested by Birch (1960). In his model, he hypothesized interaction between genetic composition and population fluctuation. The existance for such interaction has been demonstrated for a variety of small mammals (Semeonoff and Robertson 1968, Berry and Murphy 1970, Gaines and Krebs 1971, Ramsey 1973, and others). Chitty (1967) hypothesized that density dependent selection operated on different genotypes in vole populations so as to affect population decline. Chai (1959) and Roderick and Storer (1961) have shown that reproductive potential and survival have genetic bases. Smith et al. (1975) have discussed positive correlation between genic heterozygosity, environmental variability, and mean reproductive rate in small mammal populations. Furthermore, they state that heterozygosity appeared to decline in increasing populations due to inbreeding and, conversely, it (heterozygosity) appeared to increase in declining populations due to superior fitness of heterozygous individuals.

Interaction of greater heterozygosity and population dynamics have

been investigated for various species. Some of the rammifications as postulated by Smith et al. (1975) may also be applicable to deer:

1) Increased reproductive performance and increased density. Investigations have shown that reproduction and density are positively correlated with genetic variability. Hybrid fruit fly populations increase to greater numbers and exhibit greater productivity than their parental populations (Ayala 1968). Blue grouse (Dendragapus obscurus) density is positively correlated with heterozygosity (Redfield 1973). Percent of breeding males of meadow voles (Microtus pennsylvanicus) increases with increased genetic variability (Smith et al. 1975).
2) Increased survival resulting from increased heterozygosity. Mechanisims affecting survival may be behavioral, morphological, or physiological, and may be correlated with heterozygosity. For example, Avise and Smith (1974) have shown selection against homozygous bluegill sunfish (Lepomis machrochirus). Male prairie voles (Microtus ochrogaster) heterozygous at the transferrin locus survive better than homozygotes (Krebs et al. 1973). According to Frelinger (1972), a similar relationship exists for pigeons (Columba livia).
3) Increased dispersal resulting from greater heterozygosity. Old-field mice exhibit greater dispersion patterns with increased heterozygosity (Garten 1974). Ayala (1968) hypothesized that successful colonization was dependent on heterozygosity.

Early work on big game species has dealt with attempting to determine genic variability between species or subspecies over broad portions of their

range. Analyzing starch gel electrophoretic patterns in blood samples, Miller et al. (1965) found genetic variability in 200 white-tailed deer collected in Iowa. Braend (1962) found little or no variation in elk (Alces alces), but in a later study (1964), found transferrin variation in reindeer (Rangifer tarandus).

Unfortunately, blood protein analysis alone may be relatively insensitive for obtaining accurate scores of relative heterozygosity. The technique employed by Selander et al. (1971) whereby genetic heterozygosity in the old field mouse was determined by electrophoretic analysis of 30 polymorphic proteins to determine percent heterozygous loci would be more appropriate. Recently, such techniques have been applied to white-tailed deer (Harris et al. 1973 and Ramsey et al. in press), and it is now possible to identify local populations on the basis of their genetic make-up.

Work by Manlove et al. (1975) on the Savannah River Plant applied these techniques to deer, in relation to preparation, electrophoretic technique, and interpretation.

Pathogenic Implications

Brucellosis and leptospirosis are important reproductive diseases in cattle (Hafez 1968) and possibly in white-tailed deer. Baker et al. (1962) inoculated two does with the pathogen, Brucella abortus. One doe, bred to a fertile buck, did not produce a fawn the year following the innoculation, but bore a healthy fawn on the second year. The other doe bore non viable twins both years. Early survey work in the southeast (Shotts et al. 1958) indicated a low incidence of the disease in deer populations of 12 states. Only one individual of the 403 examined had significant serum titers. In a later survey conducted by Hayes et al. (1960), 6307 deer were examined; only 8 were

classified as "reactors", and an additional 15 "suspicious". Based on this work, they concluded that the incidence of brucellosis was insignificant in the southeast.

Leptospiral antibodies have been detected in significant numbers of deer in the southeast. Shotts and Hayes (1970) found a 19 percent occurrence of these antibodies from 1544 deer collected in 9 states. They concluded, however, that naturally occurring leptospirosis in white-tailed deer constituted a sub-clinical condition of little or no consequence.

However, the possibility of either brucellosis or leptospirosis interacting to depress reproduction should not be ignored. Little information is available on the effects of either of these diseases on expanding deer populations or the role of feral animals in transmission. Swine are known to be an important reservoir of leptospirosis, and conditions which permit intermingling of feral hogs, free ranging cattle, and wild deer would be optimum for exchange of the disease.

TECHNIQUES AND PROCEDURES

Collection of Animals

It was hoped that fawns could be obtained from the 2 areas by collecting with high powered rifles. However, it became apparent that an adequate sample size could not be obtained by this method alone. Therefore, samples were also obtained from dog drive hunts on both areas. A buffer zone of at least 6.4 km separated the 2 areas (Fig. 2). Both male and female animals were used in this study.

Physiological and Nutritional Status

A broad assessment of the physical condition of the animals was made by determining the kidney fat index, percent body fat, and growth rate for each individual. A fourth technique, the specific gravity of the 11th, 12th, and 13th ribs, was discontinued since too many of the samples were ruined by buckshot. Reproductive organs of both sexes were examined to determine puberal status. Whole body analysis was conducted to determine major mineral content of individual fawns. One liter rumen samples were analyzed for vegetative composition by species. Additional samples were to be analyzed for nutritive value by proximate analysis; unfortunately, these were lost due to a defective freezer. However, smaller samples were analyzed for crude protein by determining rumen nitrogen.

Kidney Fat Index

Both kidneys and the perirenal fat attached to them were removed from each deer. Fat was dissected from each kidney and it and the fat free kidney were weighed separately to the nearest 0.1 g. For the purpose of this study, only the fat attached directly to the kidney was weighed; mesentary and fat connected to it were omitted. The kidney fat index was obtained by dividing

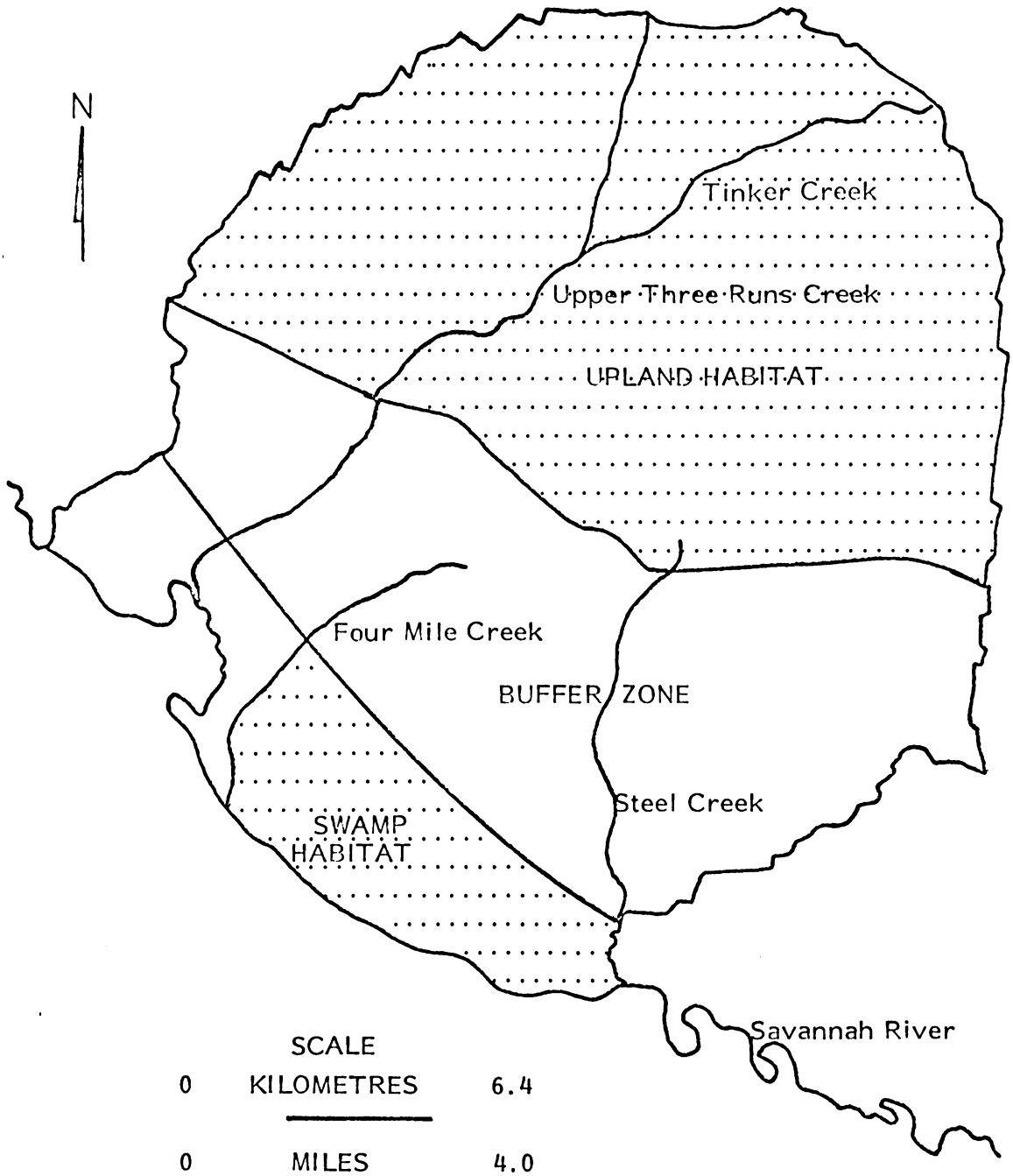

Fig. 2. Location of sampling areas. Savannah River Plant, 1971.

the total kidney weight (fat free) into the kidney fat. The procedural techniques are fully described in Monson et al. (1974) and Fuller et al. (1975).

Percent Body Fat

Entire deer, including ingesta free gastro-intestinal organs, were frozen and sectioned with a Hobart meat saw. Sections were homogenized with a Hobart meat grinder using a 15 mm plate. Six 250 g samples of the homogenate were freeze dried and rehomogenized in a Wiley mill, using a 2 mm screen. Ether extractions were made from 1 g aliquots of each of the 6 subsamples by the Goldfisch ether extraction technique. (A.O.A.C. 1960). Total body fat content of each deer was determined from the average of the 6 subsamples.

Growth Rates

Carcass weights for field dressed fawns with heads removed at the first cervical vertebra were obtained to the nearest kg. Simple weight comparisons between sexes and areas were unsuitable in that there was a considerable spread in age distribution (10 weeks to 7 months). Various workers have shown linearity between age and eye lens weight in deer (Longhurst 1964, Hoffman and Robinson 1966, and Nellis 1966). Therefore, growth rates were determined from regressions of body weights on eye lens weights by sex and area. The techniques used were described by Urbston (1969).

Puberal Status of Reproductive Organs

Ovaries from female fawns were preserved in a standard AFA soultion prior to sectioning. Two mm sections were cut and each section examined for developing follicles and evidence of prior ovulation. The greatest surface area of each tertiary follicle was computed by obtaining the width-length measurements to the nearest 0.1 mm and applying the formula for an elipse. Total

follicular surface area for each animal was obtained by adding the above.

Testes and epididymides were preserved in Bouins solution. Standard histological techniques were employed to examine sections for the stage of spermatogenesis in the seminiferous tubules and the presence or absence of mature sperm in the cauda epididymides.

Major Mineral Content

Homogenates were prepared by the same techniques used in determining percent body fat. The six subsamples were ashed and analyzed for calcium, potassium, phosphorus, nitrogen, magnesium, and manganese by A.O.A.C. (1960) methods.

Rumina Species Composition

One liter samples were frozen and analyzed as described by Cushwa et al. (1967). Species composition was catagorized by 7 major food items; namely, hard mast, soft mast, honeysuckle, smilax, mushrooms, legumes and forbs, and others.

Crude Protein in Rumina

Crude protein was determined by analyzing for nitrogen (A.O.A.C. 1960) and multiplying by 6.25.

Evaluation of Stress

Weights of adrenal glands and concentration of vanlimandelic acid in both blood and urine were evaluated as possible stress indicators. Samples came from both sexes, collected and hunted.

Adrenal Glands

Adrenal glands were removed from kidneys, stripped of fat and mesentary, and weighed to the nearest 0.1 mg. As in body weight comparisons, the weight of the gland is dependent on animal size which in turn is partially a function

of age. Therefore, regressions of adrenal gland weights on eye lens weights were compared by sex and area.

Vanilmandelic Acid in Blood and Urine

Twenty cc samples of whole blood and urine were drawn in vacutainers by heart and bladder puncture, respectively. Both were acidified with 6 ml 6 N HCL and refrigerated in dark bottles until analysis. Laboratory analysis was contracted to the Savannah River Laboratory, E. I. du Pont de Nemours and Company. The procedural technique employed was as described by Sigma (1969).

Trial Analysis with Captive Deer

To determine if applied stress elevated VMA level, three deer were captured and confined in box traps. A stainless steel pan was provided under the floor of the trap to catch urine. Animals were harassed during confinement and urine voids monitored for elevated VMA levels.

Genetic Variability

Blood and tissue samples of heart, liver, and kidney were collected as soon as possible after death from collected and hunted animals.

Blood

Twenty ml of whole blood were collected in vacuum tubes containing the anti coagulant ethylene diamine tetraacetic acid. Immediately after collection, tubes were stored in ice water prior to processing in the laboratory.

Tissue Samples

One g samples of heart, liver, and kidney were collected and quick frozen in dry ice in the field. Samples were stored in a nitrogen freezer at -40 C.

Preparation of Extracts and Electrophoretic Procedure

Tissue and blood extracts from 98 fawns were prepared and examined for electrophoretic variation in the structural loci of 22 proteins (Table 2). As part of a larger study, proteins from 50 yearling and 64 adult deer were also examined (Ramsey et al. 1975). The laboratory procedure for preparing and analyzing the starch gel extracts is fully described by Manlove et al. (1975).

Individual heterozygosity was determined by comparing the number of heterozygous loci to the total (22) number examined. Average heterozygosity by age, sex, and area was calculated.

Brucellosis and Leptospirosis

Twenty cc vacutainers charged with EDTA were used to collect whole blood samples from deer. Sera were separated from formed elements by centrifugation and mailed directly to the State Livestock Disease Eradication Agency located in Columbia, South Carolina.

Standard tube agglutination techniques were used to determine the presence of Brucella abortus agglutins (Huddleson 1932), while leptospiral macroscopic slide agglutination tests were used to screen serum for leptospires. In this test, the following killed antigens were used: canicola, pomona, sejroe, harjo, autumalis, and ictro (Stoenner 1955).

Criteria for diagnosing brucellosis were titers of 1:100 or greater (Committee Report 1956). Due to the possibility of cross agglutination with other serotypes, only titers exceeding 1:100 were considered as diagnostic of leptospirosis. This was considered a conservative ratio approximately 30 percent less than commonly accepted (Shotts et al. 1958).

Table 2. Proteins and tissue sources analyzed for electrophoretic variation in the white-tailed deer on the Savannah River Plant during 1971.

Protein	Tissue Sources
Esterase - 5 (Es-5)	plasma
Esterase - 6 (ES-6)	hemolysate
Esterase - 2 (ES-2)	liver
Lactate dehydrogenase - 1 (LDH-1)	kidney
Lactate dehydrogenase - 2 (LDH-2)	kidney
Malate dehydrogenase - 1 (MDH-1)	kidney, liver
Malate dehydrogenase - 2 (MDH-2)	kidney, liver
Isocitrate dehydrogenase - 1 (IDH-1)	liver, heart
Isocitrate dehydrogenase - 2 (IDH-2)	liver, heart
α Glycerophosphate dehydrogenase (α GPD)	liver
6 - Phosphogluconata dehydrogenase (6PGD)	hemolysate, liver
Glutamate dehydrogenase (GDH)	liver
Phosphoglucose isomerase (PGI)	liver
Glutamate oxalate transaminase - 1 (GOT-1)	liver
Glutamate oxalate transaminase - 2 (GOT-2)	liver
Indophenol oxidase (IPO)	liver
Albumin (ALB)	liver, plasma
Transferrin (TRF)	plasma
Sorbitol dehydrogenase (SDH)	liver
Phosphoglucomutase (PGM)	liver
Hemoglobin $^{11}\alpha$ (Hb-$^{11}\alpha$)	hemolysate
Hemoglobin β (Hb-β)	hemolysate

Post Study Reproductive Analysis

During the period prior to this study (1965-1970), management was directed towards drastic population reductions in the swamp. It was anticipated that eventually such reductions in density would elicit a population response, possibly including increased reproduction. To determine if significant increases in fawn reproduction occurred during 1971 or any year thereafter as a result of these removals, fawn reproduction as evidenced by lactating 1.5 year old does was monitored during the period 1972-1974.

Seasonal Analysis

Many of the data are stratified by season. Samples collected during the months of August, September, and October are classified as fall data; those obtained during November, December, and January are handled as winter data.

Statistical Analysis

Data were analyzed on an IBM 370/155 Computer using the Statistical Analysis System (Barr and Goodnight 1971).

RESULTS

One hundred and seven fawns were obtained from collections and hunt returns. Distribution by sex, location, and method of collection are given in Table 3. Complete data were not obtained for all samples, therefore, sample sizes varied for given analyses. Tests for significance were at the $P \leq 0.05$ level.

Physiological and Nutritional Status

Results on kidney fat index, percent fat, growth rate, mineral content, rumen content, and reproductive organ development are presented in the following sections.

Kidney Fat Index and Percent Fat

Kidney fat index and percent body fat were obtained for 80 and 51 fawns, respectively. Distributions by sex, location, and season are given in Table 4. A factorial arrangement for kidney fat data indicated that only seasons differed significantly (Appendix Table I). Kidney fat indices for fawns collected during the winter were significantly greater than those for animals obtained during the fall months; differences between sexes, locations, or interactions were not significant.

As in kidney fat index, body fat was significantly greater during the winter. However, fat values were also significantly greater for individuals from the swamp. Fat values between males and females were not significantly different. There were no significant interactions between sex, season, or location.

Growth Rates

An analysis of the regression of dressed body weight (kg) on age, as estimated by oven dry eye lens weight (mg), was performed. These data are

Table 3. Sex, location, and method of collection of 107 fawns obtained on Savannah River Plant, 1971.

Location	Sex	Method of collection		Total
Swamp	Male			
		Rifle	2	
		Hunt	13	
				15
	Female			
		Rifle	9	
		Hunt	12	
				21
Upland	Male			
		Rifle	16	
		Hunt	18	
				34
	Female			
		Rifle	16	
		Hunt	21	
				37
Total				107

Table 4. Sample size, sex, location, and season for kidney fat index (KFI) and body fat (percent) of fawns collected on Savannah River Plant, 1971.

Location	Season	Sex	Sample size KFI (n)	Sample size Body fat (n)	Mean KFI ($\bar{x}$)	Mean Percent body fat ($\bar{x}$)
Swamp	Fall	Male	4	3	0.03	7.77
		Female	7	6	0.03	9.15
	Winter	Male	10	6	0.25	12.42
		Female	14	10	0.21	11.74
Upland	Fall	Male	13	10	0.05	6.51
		Female	12	12	0.05	9.15
	Winter	Male	5	0	0.30	---
		Female	15	4	0.22	9.25

shown in Appendix Table II. Correlation of these factors for males from both areas was high (r swamp and upland = 0.91), while that for females from the respective areas was lower (r swamp = 0.74, upland = 0.81). No significant differences were detected when slopes for both sexes combined were tested between the two areas. Growth rates were also tested by sex between areas. No significant differences were detected from either male or female fawns between the two habitats.

Intercepts were tested by sex and area. No significant difference was observed for male fawns. However, swamp females had a significantly higher value (0.97) than did does from the upland habitat (-2.35). These functions are shown in Figure 3.

Rumina Species Composition

Forage contents of rumina were analyzed for 78 fawns. Although a wide variety of species occurred, six groups occurred in nearly all rumina examined. These were hard mast, soft mast, honeysuckle (Lonicera japonica), fungi, Smilax (spp.), and legumes. A seventh group, designated as "other", included all other forage items. The average percent volume of each category was calculated and is shown in Table 5. Data were arranged factorially and F tests for significance calculated (Appendix Table III).

Hard mast. Hard mast was composed almost entirely of acorns, although the fruits of palmetto (Sabal minor) and sumac (Rhus spp.) were also included. No attempt was made to distinguish between the species of acorns. As shown in Appendix Table III, rumina from the swamp deer contained significantly greater percent volumes of hard mast than did those from upland deer. Significantly more hard mast was found in the winter as opposed to the fall in both areas. Although no differences were detected between sexes, a

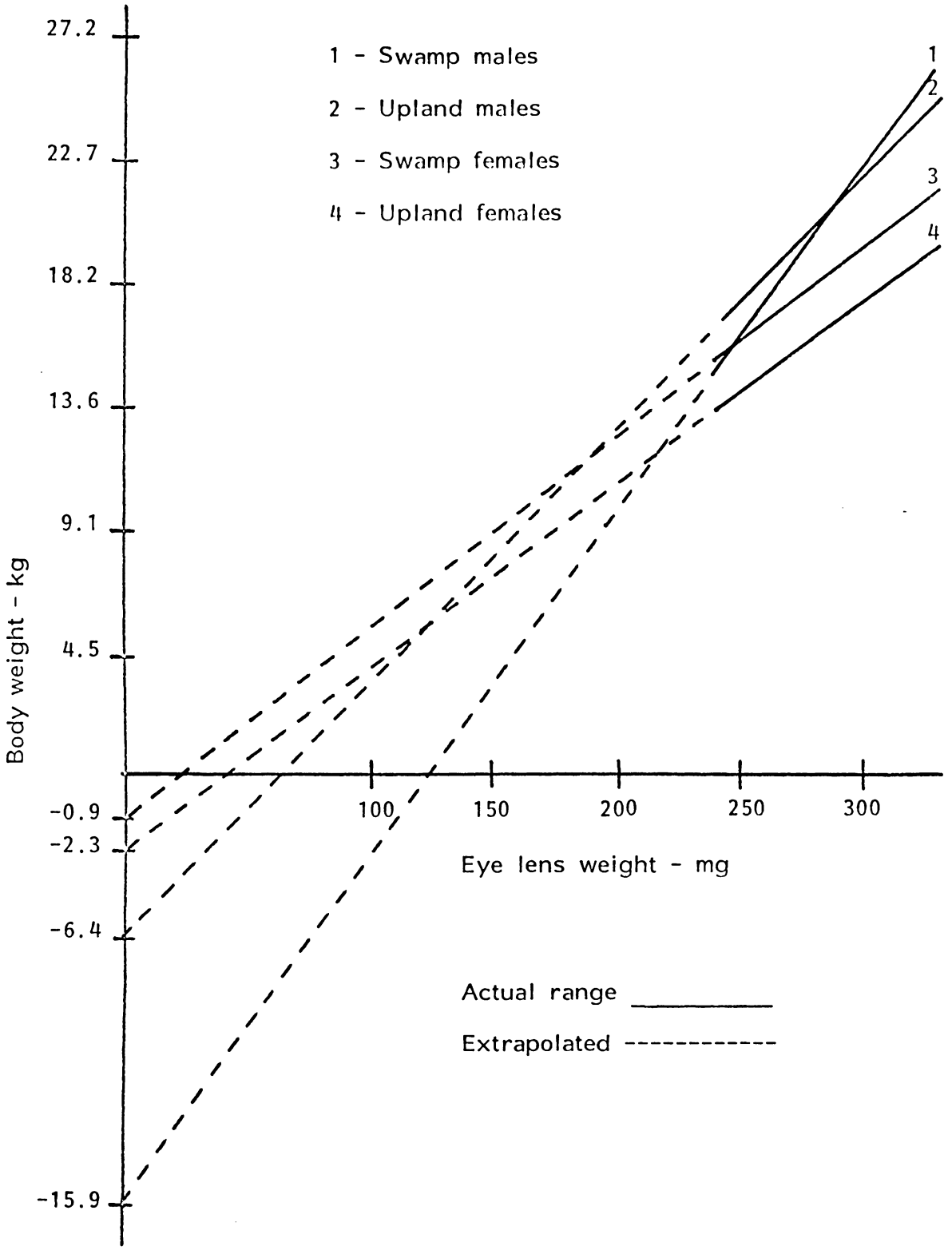

Fig. 3 Least squares fit of dressed body weight on age as expressed by eye lens weight. Savannah River Plant, 1971.

Table 5. Average percent volume of forage found in rumina of 78 fawns by location, sex, and season. Savannah River Plant, 1971.

Location	Season	Sex	Sample size (n)	Average percent volume by forage type						
				Hard mast	Honeysuckle	Soft mast	Fungi	Smilax	Legumes	Other
Swamp	Fall	Male	4	45.25	9.00	22.50	8.50	0.00	1.25	13.50
		Female	7	32.29	1.00	36.14	11.71	1.00	5.00	12.86
	Winter	Male	11	86.45	0.00	0.73	7.45	1.73	0.09	3.54
		Female	14	56.29	0.71	18.14	10.64	1.79	3.00	9.43
Upland	Fall	Male	11	19.09	31.91	12.82	6.18	5.27	7.18	17.55
		Female	12	12.00	25.50	13.58	7.83	6.58	6.75	27.92
	Winter	Male	5	13.80	53.20	0.00	21.80	0.60	0.60	10.00
		Female	14	43.15	35.14	0.00	6.93	0.43	0.71	13.64

significant sex-location interaction was detected. Males from the swamp and females from the uplands had significantly greater volumes of hard mast than did their counterparts.

Honeysuckle. Both males and females from the upland area had significantly more honeysuckle in their rumina than did individuals from the swamp. Unlike hard mast, there was no significant seasonal change nor were there any significant interactions. Although there are no definite data on habitat capability in terms of either mast or honeysuckle for the 2 areas, it is almost certain that the differences were due to availability and not preference. The uplands contain proportionately far less acreage of hardwood stands as compared to the swamp; conversely, it has been noted that much of the honeysuckle in the swamp had been overbrowsed during the late 1960's.

Soft mast. Soft mast in this study consisted primarily of grape (Vitis spp.), persimmon (Diospyros virginiana), and crab apple (Crataegus spp.). Winter samples from both habitats contained significantly less volumes than did fall samples. In addition, rumina from swamp fawns contained significantly more soft mast than did those from upland deer.

Fungi, Smilax, legumes and other. Fungi consisted primarily of mushrooms and various other foliose species. A wide variety of species were consolidated under the category other. Some of the prevelant items were prickley pear (Opuntia compressa), blueberry and huckleberry (Vaccinium spp.), trumpet creeper (Campsis radicans), yellow jessamine (Gelsemium sempervirens), and holly (Ilex spp.). No significant differences between location, season, or sex were detected.

Mineral Analysis

Fawns were assayed for calcium, potassium, phosphorus, magnesium,

and manganese content. Samples were also analyzed for body and rumen nitrogen as an index of crude protein content. Percentage composition of body protein and crude protein content of ingesta were estimated by multiplying by 6.25 (crude protein contains approximately 16 percent nitrogen). Mineral and protein values by location, sex, and season are given in Tables 6 and 7, respectively. F values were obtained by analysis of variance and are shown in Appendix Table IV.

Calcium. Average percent body calcium for all fawns approximated 4 percent. No significant differences between location, sex, or season were detected.

Potassium. Average values were slightly over one percent except for 3 upland females collected during the winter; the average of these was 3.33 percent. No differences between sexes or locations were detected. Significantly greater values were obtained for winter samples, and a significant interaction between location and season was detected. Potassium levels were highest in swamp deer during the fall yet highest in upland deer during the winter.

Phosphorus. Average percent phosphorus for all deer from the swamp ($\bar{x}$ = 2.79) was not significantly greater than for upland deer ($\bar{x}$ = 2.60). Main effects for season and sex were not significant, but a significant sex-season interaction was detected; males had a higher phosphorus content during the winter, whereas phosphorus content of females declined.

Magnesium. Percent body magnesium of upland deer ($\bar{x}$ = 0.09) was significantly greater than that from swamp deer ($\bar{x}$ = 0.08). Average values from fall samples were not significantly greater than those from the winter. Sex differences or interactions were not detected.

Manganese. Average body content for all fawns was 28.91 ppm. Main effects or interactions were not significant.

Table 6. Average calcium, potassium, phosphorus, magnesium, and manganese content (dry, fat free) of 46 fawns collected by location, sex, and season on the Savannah River Plant, 1971.

Location	Season	Sex	Sample size (n)	Composition (Percent) Ca	K	P	Mg	(Parts/million) Mn
Swamp	Fall	Male	3	3.53	1.17	2.47	0.09	20.67
		Female	6	4.17	1.13	2.85	0.09	30.83
	Winter	Male	6	4.37	1.10	2.97	0.07	27.00
		Female	7	4.37	1.06	2.71	0.07	28.57
Upland	Fall	Male	9	4.07	1.09	2.83	0.10	28.44
		Female	12	3.73	1.03	2.55	0.09	31.58
	Winter	Male	0	----	----	----	----	----
		Female	3	2.97	3.33	2.10	0.09	28.67

Table 7. Average values of body and rumen protein (dry, fat free) as determined by nitrogen analysis by location, sex, and season on the Savannah River Plant, 1971.

Location	Season	Sex	Body nitrogen (percent)	Protein equivalent (percent)	Sample size (n)	Rumen nitrogen (percent)	Protein equivalent (percent)	Sample size (n)
Swamp	Fall	Male	10.97	68.56	3	2.20	13.75	2
		Female	10.25	64.06	6	3.45	21.56	2
	Winter	Male	10.10	63.13	5	1.66	10.38	5
		Female	10.01	62.56	8	2.35	14.69	11
Upland	Fall	Male	10.55	65.94	10	3.44	21.50	9
		Female	10.12	63.25	12	3.18	19.88	11
	Winter	Male	----	----	0	2.45	15.31	2
		Female	10.30	64.38	3	3.33	20.81	10

Body protein. The crude, dry, fat free protein composition of all fawns averaged 64.2 percent. No significant differences were detected between areas, sexes, or locations.

Rumen protein. Crude protein percentages obtained from rumina differed by sex, location, and season. Rumina from upland fawns contained 19.7 percent crude protein while crude protein content from swamp deer was 14.2 percent. Protein content from fall deer averaged 19.2 percent while that from winter samples averaged 16.2 percent. Rumina from females contained significantly more crude protein than did those from males (18.6 percent vs. 15.6 percent). No significant interactions between location, season, or sex were detected.

Development of Reproductive Organs

Ovaries from 50 doe fawns and testes from 30 males were examined for sexual development.

Follicular development. Average surface area of developing follicles from 18 swamp fawns which had not previously ovulated was 9.83 mm^2 (range 0.0 - 18.0, s = 6.16). The mean from 24 unovulated upland does was 13.79 mm^2 (range 0.0 - 31.0, s = 7.08). Means and variances between the 2 areas were not significantly different.

Two females from the swamp and 6 from the uplands had previously ovulated. A chi-square test for independence between ovulation rate and area indicated that the two were not dependent.

Testicular development. Criterion of sexual maturity in males was histological evidence of complete spermatogenesis. Tissue sections, 7μ thick, were examined to determine the condition of the seminiferous tubules and the presence or absence of spermatozoa in the cauda epididymides. Based on this, indivi-

duals were assigned to one of the following catagories:

1) Spermatogenesis not initiated. Lumen of seminiferous tubule undeveloped; spermatocytes, spermatids, or sperm not found in tubule or cauda epididymis.
2) Spermatogenesis initiated. At least primary spermatocytes present in tubule, but spermatazoa absent; spermatazoa absent from cauda epididymis.
3.) Spermiogenesis. Spermatazoa released from Sertoli cytoplasm and present in lumen of tubule. Sperm not found in cauda epididymis.
4.) Spermatogenesis complete. Spermatazoa found in lumen of seminiferous tubule and cauda epididymis.

Four individuals (13 percent) were judged to be sexually mature in that spermatogenesis was complete. Two others were nearing maturity; sperm were present in the lumen of the seminiferous tubles, but not in the cauda epididymides. Twenty three (77 percent) individuals appeared to be in early stages of spermatogenesis; spermatocytes were present in the Sertoli cytoplasm, but absent from the lumen of the seminiferous tubules. Spermatogenesis was not initiated in one individual.

Complete spermatogenesis is apparently influenced by testis size; the 4 individuals judged sexually mature had testes considerably heavier than other fawns. Iniatation of spermatogenesis apparently begins regardless of testis size; similarities in sexual development were observed in testes ranging from 1.36 g to 10.74 g.

Histologically, sexual activity of the testes appeared quite similar between the 2 areas. Correlation analysis was performed for the regression of testis weight on body weight and total length. Body weight best described testis weight ($r = 0.79$); correlation was lower for total length ($r = 0.71$).

Scattergrams of the relationship between body weights and testes weights appeared to indicate differences between the 2 areas, and ratios of testicular tissue to body tissue (testis weight/dressed body weight) were significantly higher for swamp fawns.

Stress

Analysis of data obtained on adrenal weights and concentration of vanilmandelic in blood and urine are presented in the following sections.

Adrenal Weights By Sex, Location, and Age

Adrenal weights were obtained from 44 upland fawns and 33 swamp individuals. Age was grouped into two classes ("young", eye lens weight ≤ 280 mg; and "old", lens weight > 280 mg) and a 3X2 factorial analysis of adrenal weights by age, sex, and location was made (Appendix Table V). Age was the only significant effect observed; older animals, as a group, had heavier adrenal weights than did younger individuals. Effects due to sex or location were not detected.

Using actual lens weights as criteria of age, body weight, age, and age and body weight were analyzed by simple and multiple correlation. Resultant r values were so low that it was concluded that factors other than age and body weight were affecting adrenal weights. These data are given in the Appendix, Table VI.

Vanilmandelic Acid (VMA) Levels in Blood and Urine

Several difficulties were encountered with the laboratory technique as described by Sigma (1969). Overman (1972), who was primarily responsible for the analytical work, made the following observations and modifications:

1. Gross errors in the analyses resulted from large amounts of easily oxidized compounds present in the urine samples. The best indication

of the presence of these compounds was the formation of a zinc ferrocyanide precipitate during the oxidation step. High optical densities at the 580-600 and 420-450 millimicron regions also indicated the presence of these interfering compounds. The only sure method of minimizing errors caused by these compounds was to reduce the sample size to 10 ml or less. The method was valid for analyzing blood and urine from either humans or wild deer. Interfering compounds were present in some urine samples regardless of animal origin.

2. An impurity, present in some batches of ethyl acetate, was easily removed by extracting the impurity with potassium carbonate. After the carbonate extraction, samples and standards of ethyl acetate containing the same amounts of VMA yielded the same optical densities.
3. Measurement of the vanillin-indole color was improved by making all measurements of the peak versus air or water.
4. The amount of VMA found in deer blood, about 0.2 μg/ml blood, was close to the detection limit. The precision at this level was $\pm$ 50 percent, while the recovery of VMA added to the blood samples was from 50-70 percent.
5. The amount of VMA found in deer urine ranged from 1 to 15μg/ml urine, the standard deviation for urine samples (run in triplicate) being $\pm$ 20 percent for 1 to 10 ml urine samples.

In view of these results, it was concluded that while VMA could be detected with reasonable precision in urine, the technique was not applicable to blood. Therefore, only urine was analyzed in this study.

Influence of Applied Stress on VMA in Confined Deer.

Three adults, two males and one female, were caught and confined in

modified box traps for approximately 20 hours. Urine voided during this time was analyzed for VMA. Results are shown in Table 8.

Although sample size was very limited, several general trends were apparent. VMA levels were higher on second voids than for initial urinations. Although the time lag between epinephrine and norepinephrine release and increased urinary VMA was not known, it was assumed that first void levels approximated the normal and any increases resulted from "stress". VMA levels in both males leveled off or decreased thereafter; the female died shortly after the second void.

Relationships Between Age, Sex, Location, Method of Collection, and Season on Urinary Levels of VMA in Fawns.

Due to small sample sizes, experimental design was changed from a 5^2 factorial to three 3^2 factorials. Since location and method of collection were most pertinant to this study, these factors appeared in each of the three analyses; age, sex, and season were introduced as the third variable.

Location, method of collection, and sex. VMA levels were significantly greater for dog driven deer as opposed to those collected with rifles; location and sex had no significant effects on VMA levels. Furthermore, no significant interactions between location, method of collection, and sex were detected. Sample sizes, mean VMA levels and appropriate F ratios from analysis of variance are shown in the Appendix, Table VII.

Location, method of collection, and season. In this analysis, sexes were combined and data analyzed by location, method of collection, and season (Fall vs. Winter). As in the previous analysis, the only significant main effect was method of collection; VMA levels were significantly greater for dog driven deer. Unfortunately, lack of samples from swamp deer may have impaired any seasonal

Table 8. Urinary levels of VMA from three confined deer. Savannah River Plant, 1973.

Sex	Time caught (hours)	Time of voids (hours)	VMA level (μg VMA/ml urine)
Male	2200	0030,0730,0930	4.2, 5.5, 5.5
Male	2230	0100, 0200-1000, 1100	2.7, 6.3, 2.4
Female	1200	2350, 0030	7.7, 10.1

tests; however, the relative similarity of mean VMA levels in the uplands suggests that seasonal differences did not exist. These data are summarized in Table VIII of the Appendix.

Location, method of collection, and age. Age groups were stratified into 2 levels according to eye lens weight. Fawns having mean lens weights equal to or less than 280 mg were classified as young, while individuals having lens weights greater than 280 mg were ranked as old. In the factorial analysis, age was a significant main effect; older fawns had higher VMA levels than did younger individuals. Neither method of collection nor location significantly influenced VMA levels, possibly due to limited sample size. No significant location, method, or age interactions were detected. These data are summarized in the Appendix, Table IX.

Relationship Between Adrenal Size and VMA Level

Correlation (r) values were obtained for the regression of VMA level on adrenal weight for collected animals only. These values were so low (upland = 0.03, swamp = 0.13) that it was concluded that, in this sample, the size of the adrenal gland had no effect on VMA concentration in urine.

Heterozygosity

Two hundred and twelve deer were analyzed for genetic variability; 98 were fawns and the remaining 114 were older individuals. Data are presented on all deer. Eight proteins, including the alpha and beta chains of hemoglobin, exhibited polymorphism; the remaining 14 were considered monomorphic (Table 9). Average heterozygosity for all deer was 12.7 percent.

Differences Between Areas by Age and Sex

Following angular transformation for binomial data, F ratios were obtained to compare variances by age and sex between locations. Genetic variability

Table 9. Electrophoretic analysis of 22 proteins from deer on the Savannah River Plant, 1971.

I Proteins considered monomorphic

1. Lactate dehydrogenase - 1 (LDH-1)
2. Lactate dehydrogenase - 2 (LDH-2)
3. Malate dehydrogenase - 2 (MDH-2)
4. Isocitrate dehydrogenase - 1 (IDH-1)
5. Isocitrate dehydrogenase - 2 (IDH-2)
6. 6 - Phosphogluconata dehydrogenase (6PGD)
7. α - Glycerophosphate dehydrogenase (α GPD)
8. Glutamate dehydrogenase (GHD)
9. Phosphoglucose isomerase (PGI)
10. Glutamate oxalate transaminase - 1 (GOT-1)
11. Indophenol oxidase (IPO)
12. Albumin (ALB)
13. Esterase - 5 (Es-5)
14. Esterase - 6 (Es-6)

II Proteins considered polymorphic

1. Malate dehydrogenase - 1 (MDH-1)
2. Glutamate oxalate transaminase - 2 (GOT-2)
3. Esterase - 2 (Es-2)
4. Transferrin (TRF)
5. Sorbitol dehydrogenase (SDH)
6. Phosphoglucomutase (PGM)
7. Hemoglobin - $^{II}\alpha$ (Hb-$^{II}\alpha$)
8. Hemoglobin - β (Hb-β)

was greater for both sexes and all age-classes of swamp deer except female fawns. However, only the swamp male fawns were significantly more variable than their upland counterparts.

Mean heterozygosity was greater for upland males, but not significantly so. Upland adult females had significantly greater mean heterozygosity than did swamp adults; no differences were observed in fawns and subadults between the two habitats. These data are summarized in Table 10.

Differences Between Age And Sex Within Areas

Although variability was greater in males from the swamp than for females, F ratios were significant only for the 1.5 year old class. Upland female fawns were significantly more variable than yearling does. No other significant differences were detected between age-classes or sexes in the upland.

Overall, it appeared that average heterozygosity was increasing slightly in the swamp in that fawns were slightly more heterozygous than adults. Conversely, the upland herd exhibited a slight trend towards a more homozygous state. Mean heterozygosity was significantly greater for female fawns from the swamp than for adult females, and subadult females were more heterozygous than adult females. Significant differences for mean heterozygosity were not detected in upland deer. These data are shown in the Appendix, Table X.

Heterozygous Frequencies of Individual Loci.

Heterozygous frequency was examined for each of the eight polymorphic proteins by sex and area. It appeared that individuals from the swamp exhibited greater heterozygosity at the MDH-1 and TRF loci, while upland fawns had proportionately more heterozygotes at the PGM and both hemoglobin loci.

Male fawns had more heterozygous loci in the TRF, PGM, and SDH systems and fewer in the Es-2, Hb^{II}_{α}, and Hbβ proteins than did females.

Table 10. Average percent heterozygosity for swamp and upland deer, and F and t' values after angular transformation for binomial data. Savannah River Plant, 1971.

Sex	Area	Age (years)	Sample size (n)	Percent heterozygosity: Mean ($\bar{x}$)	Percent heterozygosity: Standard deviation (SD)	F and t' after transformation: (F)	F and t' after transformation: (t')
Male	Swamp	0.5	15	11.50	6.41		
	Upland	0.5	28	12.48	5.05	2.53*	0.89
	Swamp	1.5	12	10.58	7.06		
	Upland	1.5	9	13.11	6.21	1.93	0.99
	Swamp	2.5+	13	13.22	9.64		
	Upland	2.5+	6	14.38	5.31	2.87	0.69
Female	Swamp	0.5	20	14.54	6.86		
	Upland	0.5	35	12.32	5.58	0.99	1.24
	Swamp	1.5	12	14.38	5.43		
	Upland	1.5	17	13.62	4.55	1.38	0.33
	Swamp	2.5+	25	10.72	4.12		
	Upland	2.5+	20	14.09	5.88	1.08	2.09*

* Significant at 0.05 level or greater.

Chi square contingency tests were used to determine if these differences were dependent on sex and area. None were at the P = 0.05 level, although hemoglobin β was significant at the P = 0.10 level. These data are shown in the Appendix, Table XI.

Relationships Between Heterozygosity and Body Mineral Composition

Factorial arrangements of body minerals by sex and allele form for each of the 8 polymorphic proteins were analyzed. These data are summarized in the Appendix, Tables XII through XIX.

Sex was a significant main effect for manganese level in 5 of the 8 proteins examined. In these, females had significantly higher levels of this mineral. Sex was also significant for nitrogen at the PGM and SDH loci; males contained greater amounts of body nitrogen than females.

Locus was found to be a main effect for SDH in relation to percent body fat; heterozygotes had higher levels than homozygotes. However, at the beta chain of hemoglobin, homozygotes had greater levels of manganese than did heterozygotes.

Significant sex interactions for calcium at the PGM and for magnesium at the alpha chain of hemoglobin loci were also observed. Heterozygous males had greater amounts of both minerals than did homozygotes. Females, however, exhibited the opposite; homozygotes had higher calcium and magnesium levels than did heterozygotes. These results were interesting, but inconclusive. Although sample sizes were small, it appeared that there was little correlation between heterozygosity and body mineral content. Manganese content was apparently correlated with sex; females had higher concentrations than males.

Relationships Between Heterozygosity and VMA Levels

Data were analyzed factorially to determine if heterozygosity, sex, and

method of collection were correlated with VMA levels. Method of collection was a significant main effect in every analysis; individuals collected with dogs exhibited higher VMA levels regardless of sex or allele form. The only significant interaction found was at the Hb^{II}_{α} locus; males heterozygous at this locus had higher VMA levels while homozygous females exhibited higher VMA levels. These data are summarized in the Appendix, Tables XX through XXVII.

Brucellosis and Leptospirosis

Blood samples from 49 fawns were analyzed for brucellosis and leptospirosis. Fourteen of these came from the swamp habitat and the remaining 35 from the uplands.

Brucellosis

All specimens tested negative for the Brucella antigen (Brucella abortus); no reactor or suspect titers were observed.

Leptospirosis

Only one animal, a doe fawn from the uplands, showed a significant titer for a leptospire antigen. This titer, + 100 for sejroe, would not have been considered significant by clinical standards.

Based on these data, it was concluded that neither brucellosis nor leptospirosis occurred to any significant degree in either of these populations.

Post Study Evaluation

Animals from the two study areas were examined during the period 1972 through 1974. Since this investigator was transferred during 1971, it was possible to obtain data only from fall hunt returns. The 1.5 year old females were examined for lactation, and dressed body weights were obtained. It was thought that had any significant shifts in herd quality occurred, these

indices would have detected them.

Reproductive Analysis

One hundred and seventy five 1.5 year old does were classified as either lactating or not. Questionable individuals were not included in the analysis. Using this as criterion of successful fawn breeding during the previous year, it appeared that reproduction in swamp fawns increased substantially during the period. Data were subjected to a Chi-square evaluation using Yate's correction for continuity. Significant interactions between area and reproduction could not be detected for any of the 3 years. These data are given in Table 11.

Dressed Body Weights

Dressed weights of 95 male and 85 female fawns were compared between the 2 areas for the years 1973 and 1974. Only November and December weights were used since this is the period when fawns approach puberal weights. Unfortunately, sample size for swamp females was limited and no data were available for 1972. A one-tailed t-test failed to detect any weight differences between the 2 areas. When weights for all years were compared, it was observed that upland fawns of both sexes had generally significantly greater weights until 1971. No differences were detected during 1973 and 1974. These data are given in Table 12.

Table 11. Reproductive history of doe fawns from swamp and upland habitats during the period 1971 through 1973 as evidenced by percent lactation in 1.5 year old does collected on the Savannah River Plant during 1972 through 1974.

Year	Lactation rates				Chi-square
	Swamp		Upland		
	Lactating (percent)	Sample size (n)	Lactating (percent)	Sample size (n)	(x^2)
1972	33.33	12	40.00	25	0.00 ns
1973	33.33	12	44.64	56	0.16 ns
1974	37.50	16	27.78	54	0.99 ns

Table 12. Dressed body weights of fawns by sex and habitat. Savannah River Plant, 1966-1974.

Year	Sex	Swamp Habitat			Upland Habitat			t'
		Mean (kg)	Variance (kg)	Sample size (n)	Mean (kg)	Variance (kg)	Sample size (n)	
1966	Male	19.05	15.17	17	23.25	14.07	38	-3.79*
	Female	17.44	8.48	16	20.48	7.12	43	-3.81*
1967	Male	21.88	17.40	44	25.80	13.37	84	-5.49*
	Female	19.49	13.07	28	21.49	14.03	65	-2.39*
1968	Male	20.35	16.93	28	22.44	24.72	64	-1.96*
	Female	18.52	6.66	19	18.30	17.37	78	0.22 ns
1969	Male	21.99	11.26	15	22.73	16.66	115	-0.67 ns
	Female	19.75	15.56	14	19.99	11.59	97	-0.24 ns
1970	Male	20.79	11.73	13	23.54	10.85	97	-2.81*
	Female	18.92	11.90	19	20.84	11.86	77	-2.18*
1971	Male	22.47	11.58	15	22.10	11.20	26	-0.33 ns
	Female	19.05	15.70	15	19.34	13.52	36	-0.25 ns
1972	Male	--	--	--	23.05	6.33	11	--
	Female	--	--	--	18.11	8.52	13	--
1973	Male	23.14	22.71	11	22.38	12.03	29	0.56 ns
	Female	22.36	17.73	6	20.17	17.35	28	1.17 ns
1974	Male	18.08	20.03	23	21.23	19.12	32	-2.62*
	Female	18.27	17.50	17	19.17	6.39	34	-0.96 ns

* Significant at 0.05 level or greater.

DISCUSSION AND CONCLUSIONS

There is little doubt that significant reproductive differences existed between doe fawns of the 2 areas during the period 1966 through 1970. Data obtained during 1971 through 1974 indicate that fawn reproduction increased substantially in the swamp herd after 1971 and, consequently, significant differences between the two populations may not have existed during the base year of this study. Therefore, the discussion which follows represents a retrospective approach to possible differences during earlier years.

Physiological and Nutritional Status

Kidney Fat Index and Percent Fat

Kidney fat indices were highly correlated with percent body fat as determined by ether extraction. Although Dauphine (1975) found some serious inconsistencies in the technique due to fluctuating kidney weights, this variation was due primarily to season. His work was done in Canada where seasonal effects are more pronounced than in the southern states. Furthermore, he worked with several age-classes; this work was concerned with fawns only. Therefore, in this study, it was concluded that the kidney fat index was a reliable indicator of body fat and probably general physiological condition. Assessment of fawn condition by these techniques indicated that fat content was highest during early winter, and individuals from the swamp had significantly greater body fat deposition than did their upland counterparts. These results were not unexpected when rumina contents were examined; significantly greater percentages of hard mast, a high energy forage item, occurred in early winter samples from both habitats, and individuals from the swamp consumed more acorns than did upland deer. Also, fat deposition is more a function of body weight than age (Maynard and Loosli 1969: 488); consequently, higher

levels would be expected in late fall and early winter when animals were larger.

Growth Rates

Caution should be exercised when interpreting growth rate data between the 2 areas. Although no significant differences were detected between growth rates of either sexes or both sexes combined, it should be remembered that eye lens weight was used as criterion of age. Lord (1962) observed that lens weights tended to be heavier for animals whose nutritional intake was high. Nutritional variability could have biased age estimation; nutritional effects on lens weights and body weights would have tended to mask each other in the derivation of a growth equation. There is some suggestion that this may have occurred in the swamp population; intercepts from swamp females were significantly higher than those from upland doe fawns, and fat content was slightly greater. However, these data were inconclusive and the hypothesis of no significant difference between growth rates appears reasonable at this time.

Rumina Species Composition

Differences occurred in 3 of the 7 food catagories; hard mast, soft mast, and honeysuckle. As discussed previously, area and seasonal differences were observed in the rumina contents of hard mast. The interaction between sex and location is difficult to explain. Females from the uplands and males from the swamp ate more mast than their counterparts. Aside from possible sampling error, a possible explanation would be disproportionate fawn dispersal during periods of rutting and hunting. Mast producing hardwoods were more abundant and uniformly distributed in the swamp as opposed to the upland habitat, and generally deer were concentrated around these mast sources during the fall when rutting and hunting, especially with dogs, were continual

sources of harassment. Sweeney et al. (1971) demonstrated considerable movement out of home range when deer were subjected to intense harassment. Although most of this movement was temporary, if male fawns are more active and more prone to wander, as Jackson et al. (1971) suggested, males from the uplands would chance to encounter less mast in their wanderings than would females which returned to their original range much quicker. Feral hog populations have continually competed with deer for mast in the swamp habitat. Here, wandering males might have an advantage over females by finding fresh sources of mast before the hogs.

Differences between soft mast content by season and area are easily explained. More of this type forage was available during the fall as opposed to winter, and silvicultural and industrial management have eliminated much of the crabapple, wild plum, persimmon, and grape in the upland habitat.

Honeysuckle was much more abundant in the upland habitat than in the swamp, where obvious evidence of overuse was apparent. Rumina from upland fawns almost always contained substantial amounts of this species, whereas those from the swamp habitat contained relatively little.

Also, species diversity was greater in rumina from the uplands than from the swamp. Thirty two species occurred regularly in rumina from this habitat, while 24 were found from those in the swamp. If, as Harlow (1974) and Harlow et al. (1975) suggested, periodic mast failures adversely affect reproduction, the swamp population would be more apt to have reproductive fluctuations. Unfortunately, comparative data for most other years were lacking. However, during the fall and winter of 1965, rumina from 25 swamp deer were analyzed. Acorns appeared in only 16.0 percent of the samples, and average percent volume was 7.4 percent. Doe fawn breeding for that year apparently

was very low since none of the 26 individuals collected were pregnant nor were any of the 1.5 year old does obtained from 1966 fall hunt returns found to be in a lactating condition. Conversely, during the fall of 1971 acorns occurred in 89.2 percent of all swamp rumina examined, and average volume was 58.0 percent. Fawn reproductive attainment for this year was estimated to be 33.3 percent.

Mineral Analysis

Values for 5 major mineral elements were obtained as part of a larger study by Wiener et al. (1975). Although magnesium content was significantly greater for upland deer, values obtained for swamp individuals appeared adequate to meet physiological needs. However, calcium and potassium values appeared quite high in both areas, and since dietary increases in these elements also increases minimum magnesium requirements, the lower values of magnesium observed in swamp deer may have actually been marginal.

Although potassium increase during the winter was significant, most of this was due to one fawn collected in the uplands with an unusually high content (8.0 percent) of the mineral. This individual was collected near an industrial site where various wastes are commonly found; therefore, the estimate or the analysis may have been biased.

Seasonally, it appeared that male fawns increased in phosphorus content during the winter while females declined. Since the rumina which were to be subjected to proximate analysis were lost, it was impossible to determine dietary interaction.

Although no differences were detected in manganese content in the location, sex, and season factorial analyses, differences were found when mineral content was evaluated in reference to heterozygosity. Manganese content of females

was significantly greater than that of males in 5 of the 8 polymorphic proteins. However, heterozygosity apparently had no effect on manganese level, and overall, it was concluded that neither area exhibited deficiency symtoms.

Protein

Body protein between areas, sexes, and seasons was quite uniform. On a dry, fat free basis, the range was between 62.6 and 68.6 percent protein for all deer. These figures are consistent with those for other vertebrates (Boyd 1971). Since nearly all individuals appeared to be in excellent physical condition, these were accepted as normal values for deer.

Crude protein in the rumina differed by area, sex, and season. Declines were observed during the winter for both sexes and areas, no doubt due to a dietary shift from herbaceous forage to acorns. Rumen protein remained higher in the uplands than in the swamp for both males and females during the fall and winter periods. This was not surprising in that rumina from the upland contained significantly more honeysuckle than did those from the swamp, which contained predominantly acorns. Females had significantly more rumen protein than did males. Although differences between rumen contents of honeysuckle and acorns were not significant between the sexes, females always contained more honeysuckle. Perhaps this, as well as possible differential digestibility between forage species and sexes (Short 1975), accounted for the greater rumina protein content in females.

Overall, it appeared that the crude protein content observed was adequate to meet maintenance requirements in both habitats, but not necessarily adequate for optimum growth in the swamp. Dietz (1965) gave minimum crude protein levels in deer forage at approximately 7 percent. French et al. (1955) have suggested dietary protein levels of 13 to 16 percent for optimum growth, and

6 to 7 percent for maintenance. Ullrey et al. (1967) found that males require more crude protein (20.2 percent) than females (12.7 percent) for optimum growth. Smith et al. (1965) estimated that 19 g digestible crude protein per kg of metabolic body weight was required daily for optimum fawn growth; this was equivalent to a concentrate diet containing 25.2 percent crude protein (dry matter basis).

The average protein content found in the rumina of swamp males was 11.3 percent. This was less than optimum for growth and development. Average value for females was 15.7 percent, adequate by the standards of French et al. (1955) and Ullrey et al. (1967), but marginal according to Smith et al. (1975). Crude protein level in upland rumina was higher for both sexes (males = 20.4 percent, females = 20.3 percent); these were near optimum values for maximum growth.

It is reasonable to conclude that swamp fawns may have existed on protein deficient diets during the period 1966 through 1970, since much of the honeysuckle was overbrowsed and deer density was much higher. Even during years when mast was in abundance, it is doubtful that nutritive requirements for optimum growth and sexual development were met.

Reproductive Development

Gonadal development in both males and females appeared quite similar between the two areas. While various workers have shown relationships between follicular size and nutritional condition in sheep (Howland et al. 1966; and Bellows 1963) and cottontail rabbits, (Kirkpatrick and Kibbe 1971), little work has been done pertaining to follicular development in deer. Teer (1965) described sexually inactive does as those whose ovaries had follicles 1 mm or less in diameter; sexually active individuals had ovarian follicles over 4 mm

in diameter. Kirkpatrick (1974), however, examined follicular measurements in ovaries obtained from 6 areas in the southeast and questioned the use of this technique as a predictor of potential fecundity.

Although the use of follicular development as a predictor of either nutrition or reproductive potential in deer remains somewhat confusing, its application in this study infers that no differences between the 2 areas existed. Furthermore, the similarity in ovulation rates reinforces this conclusion.

Male fawns were once thought to be incapable of reaching puberty during the first year of their life (Cheatum and Morton 1946). However, Silver (1965) reported on the fertility of a buck fawn, and Wood et al. (1962) attributed puberty in a black-tailed deer fawn (Odocoileus hemionus) to high nutritional intake. Follmann and Klimstra (1969) found that fertility in male fawns was common on Crab Orchard National Refuge, near Carbondale, Illinois. They found that 36.9 percent of the male fawns collected during January 1966 had spermatozoa in the cauda epididymides. Results obtained in this study were similar; 33.3 percent of the buck fawns collected after November 15th had spermatazoa in the cauda epididymides.

Although testes development between the two populations appeared similar, the fawns from the swamp habitat had significantly heavier testes in relation to body size. The reasons for this are undetermined. However, male fawns from the swamp were significantly more heterozygous than upland males and consumed significantly more acorns, a high energy forage, than did upland fawns. Since reproductive development is related to heredity and nutritional plane, further research on these aspects is required.

For the purpose of this study, it was concluded that there were no significant differences in puberal status of males between the 2 areas.

Stress

Adrenal Weights

Adrenal weights, in this study, were correlated with age, and to some extent with body weight. This was not unexpected in that older animals would generally weigh more and, up to a certain point, have heavier organ and glandular weights. No differences between sexes or areas were observed. Since it was not known if stress actually existed in either population, the validity of adrenal weights as indicators of stress was not investigated. However, several fawns, in poor condition, had adrenal weights within the range of all other deer collected; hence, the technique was considered suspect.

Vanilmandelic Acid

Although reasonable estimates of VMA could not be made from blood samples, excellent results were obtained from urine analyses once several modifications to Sigma's (1969) technique were made. Several deer captured and put under mental and physical duress exhibited elevated urinary levels of VMA. Deer driven by dogs had significantly higher urinary levels of the metabolite than did those which were collected with rifles in an "unstressed" condition. Since VMA is a metabolite of both epinephrine and norepinephrine, there was no way, in this study, of differentiating between the two amines. Euler (1964) pointed out this major disadvantage in his disucssion on quantification of stress by catecholamine analysis. Furthermore, excretion of the two amines is affected by different physiological mechanisms. Epinephrine release from the adrenal medulla is associated with mental duress, pain, or general discomfort. Norepinephrine, excreted from nervous tissue, is associated with metabolic stress, such as exposure to cold, physical strain, and other factors which act to induce blood pressure or temperature homostasis.

Quite probably then, comparisons between collected animals and those run by dogs involved differential response to stress. Higher VMA levels found in deer run by dogs could have resulted from physical strain, mental duress, or both. The problem may have been further compounded by differences in time of collection. Collected deer were obtained at night whereas dog chased deer were obtained during daylight hours. Sunderman et al. (1960) have shown that nocturnal levels of VMA in humans are generally lower than those obtained diurnally. However, this relationship may not be true for animals such as deer which are most active nocturnally.

No significant differences in VMA levels were observed between locations or sexes, and it was concluded that there was probably little if any stress differential between the 2 areas.

Urine from older (and larger) animals contained significantly more VMA than urine from younger individuals. While data were limited, these results were not contrary to those of Sunderman et al. (1960), Sunderman (1964), and Stefanovic et al. (1970), as these investigators reported that younger individuals generally had lower VMA levels.

Since the origin of the VMA in the urine was not known, it was impossible to draw any valid conclusions pertaining to adrenal size and metabolite output. However, in this study, no relationship between adrenal size and VMA output could be found.

Overall, it was concluded that vanilmandelic acid content in the urine could be determined with reasonable precision, and elevated levels were correlated with some form of stress.

Heterozygosity

Twenty two proteins were examined by electrophoresis; of these, 8

were found to be polymorphic, although later work by Manlove et al. (1975) demonstrated polymorphism in a 9th (LDH) protein. Estimated average heterozygosity was obtained from direct counts of heterozygous loci for each of 212 deer examined. Mean heterozygosity for all deer was 12.7 percent; according to Ramsey et al. (1976) this is the highest yet reported for a vertebrate species.

Variability between individuals was greater for swamp deer than for those from the uplands. However, F ratios were significant only for male fawns. Only the adult does from the uplands were significantly higher in average heterozygosity than swamp individuals. No differences were detected between fawns, subadults, and adult males of the 2 habitats. The large variability in average heterozygosity between individuals from the swamp was not expected. However, during the period 1965 through 1970, 1260 deer were removed from the 10 square mile study area. Although there is no direct evidence of ingress into the area from across the Savannah River, it is almost certain that some did occur; this may have contributed alien genotypes.

Upland adult females had significantly greater average heterozygosity than did adult does from the swamp. Whether or not this lower heterozygosity from swamp deer contributed to their lower reproductive performance as fawns is unknown. However, as Chai (1959), Smith et al. (1965), Lerner (1968: 264), and others have pointed out, genotype may affect reproductive potential. Therefore, although it would be premature to conclude that the lower heterozygosity in these swamp adults resulted in reduced heterosis and poor reproductive performance as fawns, this possibility should not be disregarded. Wegge (1975) postulated that reproductive differences between island and mainland populations of red deer in Norway may have had a genetic basis in that insular isolation led to reduced heterosis, lower growth rates, and delayed

puberty. In this study, upland deer of both sexes exhibited a very slight decline in heterozygosity during the period 1965 through 1970; fawns collected during 1970 were, on the average, less heterozygous than the yearlings (fawns of 1969) which in turn were less heterozygous than adults. During this same period, fawn reproduction (Table 1) and body weight (Table 12) declined slightly. Swamp deer, however, experienced shifts in the opposite direction; average heterozygosity and dressed body weights were increasing during the period, and as Table 1 indicates, fawn breeding may have been increasing.

Heterozygous Frequencies at Individual Loci

Although no significant differences were observed, the frequency of heterozygous alleles varied by sex and area. Chi-square values for sex and area dependence on gene form of the beta chain of hemoglobin approached significance at the 0.05 level. Additional work is being conducted to determine the existence and significance of this.

Relationships Between Heterozygosity, Body Mineral Composition, Percent Fat, and VMA Levels

These analyses attempted to ascertain whether heterozygosity at individual loci was correlated with body mineral content, percent body fat, or stress as measured by vanilmandelic acid content in urine. As discussed previously, sex was a significant main effect for manganese; regardless of allele form, in 5 out of the 8 polymorphic proteins evaluated, females were significantly higher in body manganese than males. Similarly, at 2 loci, PGM and SDH, sex was significant for nitrogen. Males contained greater amounts of nitrogen than did females.

Locus, however, was a significant main effect for several polymorphic proteins. Heterozygotes had the greatest fat values at the SDH locus, while

homozygotes had greater levels of manganese at the Hb β locus. Sex and locus were correlated for calcium at PGM and for magnesium at $Hb^{II}{}_{\alpha}$. Heterozygous males had greater amounts of calcium and magnesium although homozygous females had greater amounts of these minerals than heterozygotes of the same sex.

At the Hb α locus, heterozygous males had significantly greater VMA levels; females homozygous at this locus had greater VMA levels than heterozygous does. Regardless of allelic variation, deer driven with dogs had significantly greater VMA levels than those collected.

Although these analyses infer causal relations between genic variability and physiological parameters, chromosomal mapping is virtually unexploited in deer and consequently, little is known about the genetic composition of the species. It would be naive, at this point in time, to suggest that an individual heterozygous at the SDH locus will have greater amounts of body fat than a homozygote. Similarly, there is no assurance that heterozygous males at the alpha locus of hemoglobin will have higher VMA levels than their homozygous counterparts. However, these data suggest that allelic variation of polypeptides may have predictive values. Does the male heterozygous at the Hb β locus have a genetic advantage for metabolizing calcium and magnesium? Is a female homozygous at the $Hb^{II}{}_{\alpha}$ locus more successful in combating stress than one which is heterozygous? Considerably more work is required to clarify these relationships. Equating overall population heterozygosity to reproduction is subject to the same restrictions. Little is known concerning white-tailed genomes. The 22 polypeptides analyzed in this study most probably did not include all of the total controlling loci in the 2 populations. Extrapolating these sets to the entire genome is, as Selander and Johnson (1973) stated, a

risky proposition. When these limitations are compounded by other variables which are known to interact with reproduction, the task becomes exceedingly difficult.

Perhaps, at this time, the use of allelic variation is most useful as an index for describing overall genetical differences between populations (Manlove et al. 1975). Since the genetic constitution of an individual is fixed at fertilization, comparisons of cohorts between and within populations would provide valuable information as to temporal and spatial changes.

Brucellosis and Leptospirosis

Forty nine animals were examined for brucellosis and leptospirosis. No animals tested were positive for brucellosis, and only one individual exhibited a significant titer for the leptospire antigen sejroe.

These results were not surprising in that Shotts et al. (1958) and Hayes et al. (1960) found low incidences of these pathogens throughout the southeast. Furthermore, during 1966, several dozen individuals were collected from both habitats and necropsies conducted; no evidence of either pathogen was found at that time. Based on these results, it was concluded that neither brucellosis nor leptospirosis have been significant pathogens on the Savannah River Plant.

Population Density and Fawn Weights

It is apparent that the deleterious effects of high deer density reviewed earlier were interacting with deer from the swamp habitat by as early as 1966 (Urbston 1967). During that year, fawn reproduction was not observed and dressed weights and antler development of 1.5 year males were significantly lower than from upland deer. Population density was estimated at one deer per 4 ha in the swamp and one individual per 13 ha in the upland habitat.

During the next four years, the swamp herd was reduced by hunting to approximately one deer per 9 ha, while the upland population increased slightly to one individual per 10 ha. Gradual increases in body weight and antler development were observed in swamp deer; by the fall of 1971, fawn weights between the 2 habitats were not significantly different (Table 12).

There is little doubt that a growth response was elicited by the reduction of population density in the swamp, thereby enabling fawns to reach puberal weights during the breeding season. Ransom (1967: 120) questioned the validity of minimum weight requirements for sexual development in that he found non pregnant fawns in a study area in Manitoba which were larger than pregnant individuals from 2 other areas and, concluded that "the nutrient requirements for growth were available but the additional requirements for sexual development were not available to fawns---." It is assumed that Ransom meant optimum growth, as most workers agree that factors which interfere with growth also inhibit sexual development (Hafez 1968: 256, Maynard and Loosli 1969: 502, and others). Furthermore, Ransom's study areas were several hundred km apart, isolated geographically, and were environmentally different. It is possible that puberal weights, either genetically or environmentally fixed, might be different. It is this writer's opinion that the use of puberal weight is valid on a local basis.

Roseberry and Klimstra (1970) found that fawns which bred weighed, on the average, 2.8 kg more than those which did not. Similar results were observed in this study; every year (1966, 1967, and 1970) swamp fawns bred at significantly lower rates than upland deer, their average weights were 1.8 to 3.2 kg lighter than those from the upland. After 1970, the average weight of swamp fawns apparently increased; there were no weight differences

between the 2 habitats during 1971 through 1973. During these years, fawn breeding rates between the 2 areas appeared quite similar.

Overall, the following conclusions were made:

1.) Fawn reproduction was significantly lower in the swamp habitat prior to 1971; after that there were no significant differences in breeding rates between the two habitats.

2.) Although differences existed between the 2 populations during the fall of 1971, none exerted sufficient impact to depress fawn breeding in the swamp habitat during that year.

3.) Differences which impaired fawn reproductive efficiency in the swamp prior to 1971 were most probably high animal density, low energy flow, fluctuating mast crops, and marginal available protein. The removal of over 1200 individuals during this period significantly reduced the impact of these factors on fawn reproduction.

4.) Brucellosis and leptospirosis were not significant factors.

5.) Stress, as determined by the level of vanilmandelic acid in the urine, was not a factor during 1971. Although stress resulting from high animal density may have interacted to depress reproduction before 1971, the use of VMA to determine stress levels is valid only for existing conditions; hence, there was no way of determining past effects.

6.) Genetical changes have taken place in the swamp population during the past 10 years. These probably resulted from ingress into the area. The effect of these changes on reproduction is not known.

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APPENDIX

Table 1. Analysis of variance for kidney fat index and percent body fat of fawns collected on the Savannah River Plant during 1971.

	Kidney fat index		Percent fat	
Source	F	Probability > F	F	Probability > F
Sex	0.00	0.96	1.22	0.28
Location	0.85	0.36	5.76*	0.02
Season	31.14*	0.00	9.69*	0.00
Sex-Location	0.00	0.98	1.94	0.17
Sex-Season	0.65	0.42	0.64	0.43
Location-Season	0.01	0.94	3.29	0.08
Sex-Location-Season	0.04	0.84	----	----

* Significant at 0.05 level or greater.

Table II. Analysis of regression of body weight (kg) on eye lens weight (mg) by sex and area for fawns collected on the Savannah River Plant during 1971.

Location	Sex	Sample size (n)	Correlation coefficient (r)	Intercept (a)	Slope (b)	Hypothesis B=0 (t)	Hypothesis $a_s=a_u$ (F)	Hypothesis $b_s=b_u$ (F)
Swamp	Male	15	0.91	-16.10	0.28	7.96*	3.22 ns	1.21 ns
Upland	Male	25	0.91	- 6.40	0.21	10.18*		
Swamp	Female	20	0.74	- 0.97	0.13	4.70*	<1 ns	8.08*
Upland	Female	34	0.81	- 2.35	0.16	7.69*		
Swamp	Both	35	0.70	- 4.38	0.17	5.71*	<1 ns	3.65 ns
Upland	Both	59	0.82	- 3.20	0.17	10.92*		

* Significant at 0.05 level or greater.

Table III. F values from analysis of variance for seven forage categories by location, sex, and season for fawns collected on the Savannah River Plant during 1971.

	F value						
	Hard mast	Honeysuckle	Soft mast	Fungi	Smilax	Legume	Other
Sex	0.43	1.21	1.86	0.17	0.07	0.32	0.75
Location	17.16*	21.87*	4.79*	0.07	1.00	0.28	1.81
Season	8.14*	0.56	8.02*	0.57	0.98	2.01	2.52
Sex-Location	4.19*	0.35	1.68	1.38	0.00	0.39	0.16
Sex-Season	0.36	0.01	0.02	0.98	0.08	0.00	0.00
Location-Season	1.52	1.94	0.33	1.01	2.53	0.72	0.14
Sex-Location-Season	2.82	0.50	0.04	0.97	0.00	0.02	0.36

* Significant at 0.05 level or greater.

Table IV. F values from analysis of variance for six body minerals and rumen nitrogen by location, sex, and season for fawns collected on the Savannah River Plant during 1971.

Source	F value						
	Ca	K	P	Mg	Mn	N	Rumen nitrogen
Sex	0.48	0.50	2.41	0.49	1.33	3.31	9.68*
Location	3.02	0.68	1.85	10.89*	0.51	0.14	6.05*
Season	0.01	4.52*	0.44	3.74	0.01	1.24	4.78*
Sex-Location	1.80	0.13	1.42	2.81	0.10	0.00	0.95
Sex-Season	2.20	1.74	4.37*	0.89	1.03	2.10	0.04
Location-Season	1.77	9.13*	0.68	2.05	0.01	0.58	1.56
Sex-Location-Season	0.00	0.00	0.00	0.00	0.00	0.00	1.86

* Significant at 0.05 level or greater.

Table V. F values from analysis of variance for adrenal weights as a function of sex, age, and location, for fawns collected on the Savannah River Plant during 1971.

Source	F
Sex	0.01
Location	0.00
Age	19.87 *
Sex-Location	3.25
Sex-Age	0.30
Location-Age	0.37
Sex-Location-Age	1.21

* Significant at 0.05 level or greater.

Table VI. Correlation coefficients (r) for the regression of adrenal weight on body weight, eye lens weight, and body and eye lens weight, by sex and area for fawns collected on the Savannah River Plant during 1971.

		Correlation coefficient (r)		
Location	Sex	Body weight	Eye lens weight	Body weight and eye lens weight
Swamp	Male	0.64	0.58	0.64
	Female	0.41	0.71	0.44
Upland	Male	0.72	0.75	0.75
	Female	0.26	0.47	0.47

Table VII. Sample size, mean VMA levels, and analysis of variance for location, method of collection, and sex for fawns collected on the Savannah River Plant during 1971.

Location	Method	Sample size		μg VMA/ml urine	
		Male (n)	Female (n)	Male ($\bar{x}$)	Female ($\bar{x}$)
Swamp	Rifle	2	8	3.75	4.06
	Dog	9	4	6.84	5.68
Upland	Rifle	11	12	2.90	4.23
	Dog	9	10	5.34	5.49

ANALYSIS OF VARIANCE

Source	F
Location	0.45
Method	5.72*
Sex	0.03
Location-Method	0.08
Location-Sex	0.44
Method-Sex	0.58
Location-Method-Sex	0.01

* Significant at 0.05 level or greater.

Table VIII. Sample size, mean VMA levels, and analysis of variance for location, method of collection, and season for fawns collected on the Savannah River Plant during 1971.

Location	Method	Sample size		μg VMA/ml urine	
		Fall (n)	Winter (n)	Fall ($\bar{x}$)	Winter ($\bar{x}$)
Swamp	Rifle	6	4	2.25	6.63
	Dog	0	13	---	6.48
Upland	Rifle	16	7	3.38	4.10
	Dog	11	8	5.70	5.04

ANALYSIS OF VARIANCE

Source	F
Location	1.01
Method	9.00*
Season	1.40
Location-Method	0.02
Location-Season	2.60
Method-Season	2.31
Location-Method-Season	0.00

* Significant at 0.05 level or greater.

Table IX. Sample size, mean VMA levels, and analysis of variance for location, method of collection, and age for fawns collected on the Savannah River Plant during 1971.

Location	Method	Sample size Young (n)	Sample size Old (n)	μg VMA/ml urine Young ($\bar{x}$)	μg VMA/ml urine Old ($\bar{x}$)
Swamp	Rifle	8	2	3.00	8.00
	Dog	3	10	4.50	7.08
Upland	Rifle	16	7	3.65	3.47
	Dog	16	3	5.21	6.57

ANALYSIS OF VARIANCE

Source	F
Location	1.00
Method	2.01
Age	5.64*
Location-Method	1.22
Location-Age	3.01
Method-Age	0.06
Location-Method-Age	1.15

* Significant at 0.05 level or greater.

Table X. F, t', and degrees of freedom (df) for heterozygosity by sex and age for swamp and upland deer. Savannah River Plant, 1971.

Age - Sex	Swamp F	Swamp t'	Swamp df	Upland F	Upland t'	Upland df
0.5 female - 1.5 female	1.52	0.03	30	2.12*	0.98	50
0.5 female - 2.5+ female	1.30	2.07*	43	1.42	1.17	53
0.5 male - 1.5 male	1.18	0.37	25	1.54	0.20	35
0.5 male - 2.5+ male	1.00	0.40	26	1.13	0.85	32
1.5 female - 2.5+ female	1.17	1.96*	35	1.49	0.18	35
1.5 male - 2.5+ male	1.17	0.72	23	1.75	0.50	13
0.5 female - 0.5 male	1.60	1.39	33	1.60	0.33	61
1.5 female - 1.5 male	2.84*	1.63	22	2.04	0.38	24
2.5+ female - 2.5+ male	2.08	0.63	36	1.28	0.17	24

* Significant at 0.05 level or greater.

Table XI. Percent heterozygosity and Chi-square values for eight proteins in 93 fawns, by sex and area. Savannah River Plant, 1971.

Protein	Percent heterozygosity				Chi-square
	Swamp	Upland	Male	Female	χ^2
GOT-2	25.7	24.1	23.8	25.5	1.37 ns
MDH-1	20.0	12.1	16.7	13.7	1.71 ns
TRF	42.9	29.3	38.1	31.4	3.53 ns
PGM	20.0	31.0	31.0	23.5	2.31 ns
Es-2	51.4	50.0	42.9	56.9	1.17 ns
SDH	37.1	41.4	42.9	37.3	2.28 ns
$Hb^{II}{}_{\alpha}$	42.9	39.7	33.3	47.1	3.08 ns
$Hb\,\beta$	40.0	53.4	35.7	58.8	6.72 *

* Significant at 0.10 level.

Table XII. Means and analysis of variance for six body minerals and body fat for GOT-2 by sex and allele form for fawns collected on the Savannah River Plant during 1971.

Sex	Sample size (n)	Allele form	Mean (Ppm)	Mean (Percent)					
			Mn	P	Ca	K	Mg	N	Body fat
Male	4	Heterozygous	21.50	2.60	3.78	1.05	0.08	10.43	10.50
Male	11	Homozygous	25.73	2.85	4.17	1.15	0.09	10.65	7.59
Female	5	Heterozygous	32.60	2.48	3.72	2.50	0.08	10.54	9.40
Female	20	Homozygous	30.80	2.65	3.89	1.06	0.09	10.13	9.33

ANALYSIS OF VARIANCE

Source	F ratio Mn	P	Ca	K	Mg	N	Body fat
Sex	4.85*	0.79	0.21	2.92	0.04	0.73	0.82
GOT-2	0.11	1.29	0.60	2.88	1.56	0.15	0.30
Sex - GOT-2	0.67	0.06	0.10	3.75	0.52	1.76	0.32

* Significant at 0.05 level or greater.

Table XIII. Means and analysis of variance for six body minerals and body fat for MDH-1 by sex and allele form for fawns collected on the Savannah River Plant during 1971.

Sex	Sample size (n)	Allele form	Mean (Ppm)	Mean (Percent)					
			Mn	P	Ca	K	Mg	N	Body fat
Male	4	Heterozygous	23.25	2.60	3.80	1.08	0.08	10.70	7.33
Male	11	Homozygous	25.09	2.85	4.16	1.14	0.09	10.55	8.75
Female	4	Heterozygous	22.00	2.53	3.63	1.15	0.08	10.28	8.85
Female	21	Homozygous	32.90	2.63	3.90	1.38	0.09	10.19	9.44

ANALYSIS OF VARIANCE

Source	F ratio Mn	P	Ca	K	Mg	N	Body fat
Sex	0.83	0.61	0.33	0.73	0.01	2.29	0.46
MDH-1	3.11	0.86	0.71	0.75	0.86	0.19	0.51
Sex - MDH-1	1.57	0.15	0.01	0.85	0.28	0.02	0.78

* Significant at 0.05 level or greater.

Table XIV. Means and analysis of variance for six body minerals and body fat for TRF by sex and allele form for fawns collected on the Savannah River Plant during 1971.

Sex	Sample size (n)	Allele form	Mean (Ppm) Mn	(Percent) P	Ca	K	Mg	N	Body fat
Male	4	Heterozygous	24.75	2.83	4.28	1.17	0.08	10.65	8.10
Male	11	Homozygous	24.55	2.77	3.99	1.11	0.09	10.57	8.46
Female	7	Heterozygous	37.57	2.81	4.14	1.09	0.09	10.39	7.19
Female	18	Homozygous	28.67	2.53	3.74	1.44	0.08	10.14	10.18

ANALYSIS OF VARIANCE

Source	F ratio Mn	P	Ca	K	Mg	N	Body fat
Sex	6.49*	0.51	0.30	0.09	0.23	2.18	0.09
TRF	1.88	0.91	0.97	0.11	0.03	0.47	1.63
Sex - TRF	1.71	0.42	0.03	0.27	1.69	0.13	1.00

* Significant at 0.05 level or greater.

Table XV. Means and analysis of variance for six body minerals and body fat for PGM by sex and allele form for fawns collected on the Savannah River Plant during 1971.

Sex	Sample size (n)	Allele form	Mean (Ppm) Mn	(Percent) P	Ca	K	Mg	N	Body fat
Male	5	Heterozygous	25.40	2.92	4.46	1.16	0.09	10.66	8.72
Male	10	Homozygous	24.20	2.72	3.87	1.10	0.09	10.56	8.19
Female	6	Heterozygous	23.83	2.30	3.27	2.17	0.08	9.98	11.77
Female	19	Homozygous	32.47	2.71	4.04	1.08	0.09	10.28	8.58

ANALYSIS OF VARIANCE

Source	F ratio Mn	P	Ca	K	Mg	N	Body fat
Sex	1.41	3.55	2.46	1.64	0.18	4.29*	1.77
PGM	1.69	0.40	0.08	2.18	0.07	0.18	2.08
Sex - PGM	2.79	3.34	4.40*	1.74	0.46	0.73	1.06

* Significant at 0.05 level or greater.

Table XVI. Means and analysis of variance for six body minerals and body fat for ES-2 by sex and allele form for fawns collected on the Savannah River Plant during 1971.

Sex	Sample size (n)	Allele form	Mean (Ppm)	Mean (Percent)					
			Mn	P	Ca	K	Mg	N	Body fat
Male	6	Heterozygous	22.17	2.87	4.12	1.15	0.08	10.65	7.75
Male	9	Homozygous	26.22	2.73	4.03	1.10	0.09	10.56	8.78
Female	14	Heterozygous	28.71	2.48	3.58	1.03	0.08	10.23	9.19
Female	11	Homozygous	34.27	2.78	4.21	1.75	0.09	10.18	9.55

ANALYSIS OF VARIANCE

Source	F ratio Mn	P	Ca	K	Mg	N	Body fat
Sex	5.62*	1.18	0.35	0.51	0.01	3.40	0.79
ES-2	2.44	0.29	0.80	0.83	2.42	0.11	0.31
Sex - ES-2	0.06	1.95	1.35	1.10	0.00	0.01	0.07

* Significant at 0.05 level or greater.

Table XVII. Means and analysis of variance for six body minerals and body fat for SDH by sex and allele form for fawns collected on the Savannah River Plant during 1971.

Sex	Sample size (n)	Allele form	Mean (Ppm) Mn	(Percent) P	Ca	K	Mg	N	Body fat
Male	7	Heterozygous	26.29	2.81	4.07	1.11	0.09	10.47	9.31
Male	8	Homozygous	23.13	2.76	4.06	1.13	0.08	10.70	7.54
Female	10	Heterozygous	29.70	2.46	3.63	1.72	0.08	9.89	11.31
Female	15	Homozygous	32.13	2.71	4.01	1.09	0.09	10.42	8.03

ANALYSIS OF VARIANCE

Source	F ratio Mn	P	Ca	K	Mg	N	Body fat
Sex	3.90*	1.63	0.63	0.61	0.09	4.60*	1.19
SDH	0.01	0.41	0.35	0.71	0.18	3.57	4.89*
Sex - SDH	0.79	0.94	0.38	0.76	1.35	0.56	0.43

* Significant at 0.05 level or greater.

Table XVIII. Means and analysis of variance for six body minerals and body fat for Hb$^{II}_{a}$ by sex and allele form for fawns collected on the Savannah River Plant during 1971.

Sex	Sample size (n)	Allele form	Mean (Ppm)	Mean (Percent)					
			Mn	P	Ca	K	Mg	N	Body fat
Male	4	Heterozygous	29.50	2.73	3.75	1.15	0.10	10.60	6.15
Male	11	Homozygous	22.81	2.81	4.18	1.11	0.08	10.59	9.17
Female	15	Heterozygous	32.27	2.60	3.88	1.04	0.08	10.22	9.87
Female	10	Homozygous	29.50	2.63	3.82	1.80	0.09	10.19	8.56

ANALYSIS OF VARIANCE

Source	F ratio Mn	P	Ca	K	Mg	N	Body fat
Sex	1.99	0.76	0.12	0.55	0.61	2.84	1.45
Hb$^{II}_{a}$	1.99	0.11	0.30	0.84	1.15	0.01	0.44
Sex - Hb$^{II}_{a}$	0.34	0.02	0.52	1.05	5.11*	0.00	2.82

* Significant at 0.05 level or greater.

Table XIX. Means and analysis of variance for six body minerals and body fat for Hb β by sex and allele form for fawns collected on the Savannah River Plant during 1971.

Sex	Sample size (n)	Allele form	Mean (Ppm)	Mean (Percent)					
			Mn	P	Ca	K	Mg	N	Body fat
Male	4	Heterozygous	20.00	2.83	4.25	1.10	0.07	10.73	10.15
Male	11	Homozygous	26.27	2.77	4.00	1.13	0.09	10.55	7.72
Female	14	Heterozygous	28.14	2.57	3.71	1.04	0.09	10.16	9.77
Female	11	Homozygous	35.00	2.66	4.04	1.73	0.08	10.26	8.80

ANALYSIS OF VARIANCE

Source	F ratio						
	Mn	P	Ca	K	Mg	N	Body fat
Sex	6.91*	1.10	0.55	0.48	0.24	3.36	0.07
Hb β	4.18*	0.01	0.01	0.82	1.54	0.03	1.71
Sex - Hb β	0.93	0.17	0.72	0.70	1.99	0.37	0.31

* Significant at 0.05 level or greater.

Table XX. Means and analysis of variance for VMA levels for GOT-2 by sex, method of collection, and allele form for fawns collected on the Savannah River Plant during 1971.

Sex	Method	Allele form	Sample size (n)	μg VMA/ml urine ($\bar{x}$)
Male	Rifle	Heterozygous	1	2.60
Male	Rifle	Homozygous	11	3.20
Male	Dogs	Heterozygous	6	7.03
Male	Dogs	Homozygous	10	5.53
Female	Rifle	Heterozygous	4	3.58
Female	Rifle	Homozygous	15	4.35
Female	Dogs	Heterozygous	4	6.03
Female	Dogs	Homozygous	9	5.49

ANALYSIS OF VARIANCE

Source	F
Sex	0.06
Method	5.44*
GOT-2	0.02
Sex - Method	0.51
Sex - GOT-2	0.07
Method - GOT-2	0.59
Sex - Method - GOT-2	0.31

* Significant at 0.05 level or greater.

Table XXI. Means and analysis of variance for VMA levels for MDH-1 by sex, method of collection, and allele form for fawns collected on the Savannah River Plant during 1971.

Sex	Method	Allele form	Sample size (n)	μg VMA/ml urine ($\bar{x}$)
Male	Rifle	Heterozygous	2	4.10
Male	Rifle	Homozygous	10	2.96
Male	Dogs	Heterozygous	3	7.13
Male	Dogs	Homozygous	13	5.85
Female	Rifle	Heterozygous	2	1.95
Female	Rifle	Homozygous	17	4.45
Female	Dogs	Heterozygous	3	4.23
Female	Dogs	Homozygous	10	6.08

ANALYSIS OF VARIANCE

Source	F
Sex	0.59
Method	5.13*
MDH-1	0.20
Sex - Method	0.22
Sex - MDH-1	2.43
Method - MDH-1	0.03
Sex - Method - MDH-1	0.01

* Significant at 0.05 level or greater.

Table XXII. Means and analysis of variance for VMA levels for TRF by sex, method of collection, and allele form for fawns collected on the Savannah River Plant during 1971.

Sex	Method	Allele form	Sample size (n)	μg VMA/ml urine ($\bar{x}$)
Male	Rifle	Heterozygous	5	3.96
Male	Rifle	Homozygous	7	2.57
Male	Dogs	Heterozygous	7	7.07
Male	Dogs	Homozygous	9	5.33
Female	Rifle	Heterozygous	3	1.70
Female	Rifle	Homozygous	16	4.66
Female	Dogs	Heterozygous	7	5.66
Female	Dogs	Homozygous	6	5.65

ANALYSIS OF VARIANCE

Source	F
Sex	0.14
Method	9.85*
TRF	0.00
Sex - Method	0.07
Sex - TRF	3.10
Method - TRF	0.92
Sex - Method - TRF	0.57

* Significant at 0.05 level or greater.

Table XXIII. Means and analysis of variance for VMA levels for PGM by sex, method of collection, and allele form for fawns collected on the Savannah River Plant during 1971.

Sex	Method	Allele form	Sample size (n)	μg VMA/ml urine ($\bar{x}$)
Male	Rifle	Heterozygous	6	2.15
Male	Rifle	Homozygous	6	4.15
Male	Dogs	Heterozygous	3	7.40
Male	Dogs	Homozygous	13	5.79
Female	Rifle	Heterozygous	2	4.15
Female	Rifle	Homozygous	17	4.19
Female	Dogs	Heterozygous	4	7.88
Female	Dogs	Homozygous	9	4.67

ANALYSIS OF VARIANCE

Source	F
Sex	0.13
Method	8.21*
PGM	0.51
Sex - Method	0.49
Sex - PGM	0.84
Method - PGM	3.14
Sex - Method - PGM	0.01

* Significant at 0.05 level or greater.

Table XXIV. Means and analysis of variance for VMA levels for ES-2 by sex, method of collection, and allele form for fawns collected on the Savannah River Plant during 1971.

Sex	Method	Allele form	Sample size (n)	μg VMA/ml urine ($\bar{x}$)
Male	Rifle	Heterozygous	6	2.88
Male	Rifle	Homozygous	6	3.42
Male	Dogs	Heterozygous	6	5.98
Male	Dogs	Homozygous	10	6.16
Female	Rifle	Heterozygous	13	4.20
Female	Rifle	Homozygous	6	4.17
Female	Dogs	Heterozygous	8	5.86
Female	Dogs	Homozygous	5	5.32

ANALYSIS OF VARIANCE

Source	F
Sex	0.11
Method	6.50*
ES-2	0.00
Sex - Method	0.80
Sex - ES-2	0.14
Method - ES-2	0.07
Sex - Method - ES-2	0.00

* Significant at 0.05 level or greater.

Table XXV. Means and analysis of variance for VMA levels for SDH by sex, method of collection, and allele form for fawns collected on the Savannah River Plant during 1971.

Sex	Method	Allele form	Sample size (n)	μg VMA/ml urine ($\bar{x}$)
Male	Rifle	Heterozygous	4	3.60
Male	Rifle	Homozygous	8	2.93
Male	Dogs	Heterozygous	6	7.37
Male	Dogs	Homozygous	10	5.33
Female	Rifle	Heterozygous	8	5.10
Female	Rifle	Homozygous	11	3.53
Female	Dogs	Heterozygous	4	4.83
Female	Dogs	Homozygous	9	6.02

ANALYSIS OF VARIANCE

Source	F
Sex	0.01
Method	6.23*
SDH	0.84
Sex - Method	1.38
Sex - SDH	0.48
Method - SDH	0.18
Sex - Method - SDH	1.51

* Significant at 0.05 level or greater.

Table XXVI. Means and analysis of variance for VMA levels for Hb^{II}_{α} by sex, method of collection, and allele form for fawns collected on the Savannah River Plant during 1971.

Sex	Method	Allele form	Sample size (n)	μg VMA/ml urine ($\bar{x}$)
Male	Rifle	Heterozygous	4	4.00
Male	Rifle	Homozygous	8	2.73
Male	Dogs	Heterozygous	3	8.77
Male	Dogs	Homozygous	13	5.48
Female	Rifle	Heterozygous	10	3.32
Female	Rifle	Homozygous	9	5.16
Female	Dogs	Heterozygous	13	5.65
Female	Dogs	Homozygous	0	--

ANALYSIS OF VARIANCE

Source	F
Sex	0.00
Method	7.70*
Hb^{II}_{α}	0.00
Sex - Method	0.98
Sex - Hb^{II}_{α}	4.61*
Method - Hb^{II}_{α}	0.59
Sex - Method - Hb^{II}_{α}	--

* Significant at 0.05 level or greater.

Table XXVII. Means and analysis of variance for VMA levels for Hb β by sex, method of collection, and allele form for fawns collected on the Savannah River Plant during 1971.

Sex	Method	Allele form	Sample size (n)	μg VMA/ml urine ($\bar{x}$)
Male	Rifle	Heterozygous	3	3.77
Male	Rifle	Homozygous	9	2.94
Male	Dogs	Heterozygous	5	6.38
Male	Dogs	Homozygous	11	5.96
Female	Rifle	Heterozygous	12	3.54
Female	Rifle	Homozygous	7	5.30
Female	Dogs	Heterozygous	4	5.33
Female	Dogs	Homozygous	9	5.80

ANALYSIS OF VARIANCE

Source	F
Sex	0.07
Method	4.94*
Hb β	0.08
Sex - Method	0.88
Sex - Hb β	0.95
Method - Hb β	0.06
Sex - Method - Hb β	0.23

* Significant at 0.05 level or greater.

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DESCRIPTIVE ASPECTS OF TWO FAWN POPULATIONS AS DELINEATED BY REPRODUCTIVE DIFFERENCES

by

David F. Urbston

ABSTRACT

Prior to 1971, doe fawns from a river swamp portion of the Energy Research Development Agency's Savannah River Plant near Aiken, South Carolina, bred at significantly lower rates than did fawns from a proximal upland habitat. During the fall and early winter of 1971, nutritional, stress, genetic, and pathological aspects of male and female fawns from these habitats were evaluated in an attempt to delineate possible factors affecting their past reproductive performance.

Kidney fat index was correlated with percent body fat as determined by whole body analysis. Although KFI was not significantly different between sexes or areas, swamp fawns had significantly more body fat than did individuals from the uplands.

No differences in growth rates between individuals from both areas were detected.

Upland fawns contained significantly more body magnesium than did swamp individuals. Although calcium, nitrogen, manganese, and phosphorus values were similar between the 2 areas, seasonal and sex differences were observed. Rumen protein was significantly greater in upland fawns; crude protein levels from swamp rumina were marginal for optimum growth and development.

Swamp rumina contained significantly more acorns than did those from the uplands. However, significantly greater amounts of honeysuckle were

observed in upland rumina, and species diversity was greater.

Adrenal weights were similar between the 2 areas and both sexes. Larger animals had heavier adrenal glands. Several animals judged to be in poor condition had adrenal weights within the range of those which appeared to be in excellent physical condition. Increased levels of vanilmandelic acid were indicative of increased stress levels. Although the technique was not applicable to blood, increased urinary levels of the catecholamine were observed in confined deer and those run by dogs. Significant differences between areas and sexes were not detected. Older animals had significantly greater VMA levels than younger individuals.

Ninty eight fawns and 114 older deer were evaluated for genetic heterozygosity by electrophoretic analysis of 22 proteins. Average heterozygosity for all deer was 12.7 percent. No significant differences in average heterozygosity between fawns or yearlings of the 2 areas was observed, but upland adult females were significantly more heterozygous than adult swamp females. Changes occurred in average heterozygosity in swamp females during 1970 and 1971; fawns and yearlings were significantly more heterozygous than adult deer. Significant relationships were observed between VMA level, mineral content, and sex for several loci.

Brucellosis and leptospirosis were not significant factors in either population.

Neither follicle sizes nor ovulation rates were significantly different between doe fawns of the 2 habitats. Onset and development of spermatogenesis was similar in males of the 2 habitats, although individuals from the swamp had significantly greater testes weights in relation to body sizes.

Reproductive rates were evaluated during the period 1971 through 1973;

no significant differences between the 2 populations were observed.

It was concluded that factors which inhibited doe fawn breeding in the swamp prior to 1971 were high animal density, fluctuating mast crops, and low protein availability. By 1971, animal density in the swamp had been reduced to the extent that these were no longer factors.