

A STUDY OF SPERMATOZOAN RESERVES OF MALE WHITE-TAILED
DEER AND OF THE REPRODUCTIVE PHYSIOLOGY OF
FAWNS

by

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Thesis submitted to the Graduate Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in

Wildlife Management

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May, 1973
Blacksburg, Virginia 24061

6.8-73 AM

ACKNOWLEDGEMENTS

I wish to express appreciation to my wife for patiently encouraging me during the writing of this thesis. Without her love and understanding this thesis would not have been possible.

Gratitude is expressed to my committee members; Dr. H. S. Mosby, Dr. P. F. Scanlon and Dr. J. B. Whelan, for their advice and help throughout this project. A special word of thanks goes to Dr. Scanlon, my supervisor for his personal direction throughout the project and especially as editor of my thesis.

The financial assistance (National Science Foundation grant) was made possible through Virginia Polytechnic Institute and State University in the Division of Forestry and Wildlife Resources due largely to the efforts of Dr. Whelan. I wish to acknowledge his effort on my behalf.

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INTRODUCTION

The white-tailed deer (Odocoileus virginianus) is one of America's most popular big game animals and as such is the subject of intensive management. Primarily, management efforts are focused around habitat manipulation which provides better food and cover for the deer and enables more to survive and produce greater numbers of offspring. Regulation of hunting seasons and setting of hunting limits are designed to allow optimum harvests of deer consistent with management strategies.

The productivity of any species is directly related to the ability of members of the species to reproduce. An understanding of the reproductive physiology of deer, as of any species, is necessary in planning approaches in management and to reliably predict the outcome of management strategies. As the intensity of management and harvesting increases, for example in a situation where the objective is to maximize hunter satisfaction, increased emphasis is placed on the ability of the individual animal to reproduce. Also reproduction by immature animals is of increasing importance in total herd reproduction. In the case of the polygamous deer, where maximization of hunter satisfaction might be achieved by harvesting maximum numbers of male animals, the ability of the individual male to reproduce would be of prime importance from the point of view of minimum and optimum ratios of males to females which would be required for normal herd reproduction.

In the case of domesticate farm animals, normal management

procedure involves manipulation of the male to female ratio.

Reproduction is not impaired but maximum numbers of surplus animals are available for meat production. The choice of optimum male to female ratios for the farm species has been made on the basis of the reproductive capacity, in terms of behavior and fertility, of individual male animals. In actual practice with some farm species artificial insemination is practiced which widens the ratio of males to females. In these circumstances, the limiting factor is the ability of the individual male to produce fertile spermatozoa. Management practices where this situation exists have evolved from knowledge of spermatogenic activity, of storage and maturation of spermatozoa in the epididymides and of the optimum number of ejaculates per unit of time. Considerable understanding of spermatogenesis and rate of spermatozoa production has been gained by determining the quantity of spermatozoa in the testes and in the epididymides of animals.

While information is available on many aspects of male reproduction of white-tailed deer, relatively little is available on the reproductive capacity of males. This information, though difficult to obtain is important in making decisions concerning intensive management of deer herds. Determination of testicular and extra-testicular spermatozoan numbers could provide quantitative indications of male reproductive capacity. This information may be attained from deer harvested during the hunting season or by removing one testis from a live animal without sacrificing the animal or

eliminating his capacity to reproduce.

This research was undertaken to determine testicular and epididymal spermatozoan reserves of deer harvested during November and December and also to examine aspects of reproductive activity of male and female deer in their first year of life.

LITERATURE REVIEW

Breeding Seasons in Male Animals

Successful reproduction occurs over a wide range of environmental conditions. During the reproductive cycle from late pregnancy through birth and lactation is a period when the mother and her offspring are susceptible to detrimental effects from environmental factors. Therefore, there is a tendency among species in temperate and frigid regions to produce their young when environmental conditions favor survival of mother and young. Baker (1938) described these conditions that favor survival as the ultimate cause of the timing of the breeding seasons (period during which breeding normally occurs). For most wild species which live in the latitudes where great annual variations in environmental conditions occur, the breeding season has been genetically established. Length of gestation periods is largely responsible for regulating the timing of the breeding season as time of birth is set by requirements for favorable environmental conditions for the young at birth.

Successful breeding requires coincident fertile periods in males and females. Among Cervidae in temperate regions the male has a breeding season during which gonad size reaches a maximum and spermatogenesis occurs. This season coincides with or extends longer than that of the female. This has been described for many Cervine species including the white-tailed deer (Odocoileus virginianus Severinghaus and Cheatum 1956), black-tailed deer (Odocoileus

hemionus columbianus, Dasmann and Taber 1956), reindeer (Rangifer tarandus, Meschaks and Nordkvist 1967), roe deer (Capreolus capreolus, Short and Mann 1966), and the red deer (Cervus elaphus, Lincoln 1971a).

Reproductive physiology of the male resembles that of the female in that the pituitary secretions (FSH and LH) influence gonadal development. Interstitial cell development is controlled by LH, spermatogenesis is controlled by FSH and the development of the accessory sex organs is controlled by testosterone produced by interstitial cells. Wislocki (1949) used a variety of histochemical and histological methods to examine in detail the effects of seasons on production by testes, epididymides and seminal vesicles of lipids, nucleoprotein, acid mucopolysaccharides, glycogen, and phosphatases. Four Virginia white-tailed deer and two Sika deer (Cervus nippon) were examined by Wislocki. Deer examined during the month of June were compared with others examined in October and November to compare differences in production of the various androgens. Short and Mann (1965, 1966) found through histochemical and histological studies that the peak of reproductive development in the male roe deer occurs in mid-July to mid-August. In a comprehensive study of the red deer stag, Lincoln (1971a) measured testes, accessory organs, secondary sexual characters, body weight and food intake for an annual cycle. All reproductive parameters reached maximum levels from mid-September through October and then tapered off to a minimum in May and June. Within the testes, the

interstitial cells reached maximum development and testosterone concentrations were at a peak in October (1000 times greater than their resting-level concentrations in May and June. Combined testis weight reached a maximum (165g) about the middle of September as did the epididymis (30g) and tubule diameter of the epididymis. Seminal vesicle, prostate, and pelvic urethra weight reached peak levels in the beginning of October.

Lambiase et al. (1972) collected semen from five male white-tailed deer per month throughout the year to determine volume and concentration of spermatozoa per ejaculate. Those authors concluded that white-tailed deer can ejaculate motile spermatozoa in sufficient quantities to enable successful breeding between early October and the end of February.

Seasonal effects also influence male domestic animals. A marked effect is evident in domestic sheep in temperate regions. In domestic sheep McKenzie and Berliner (1937) reported seasonal influences on the production and quality of semen. A definite seasonal pattern was noted in numbers of spermatozoa ejaculated and in the production of abnormal cells. Similar results were reported by Green (1940) and Comstock et al. (1945). Cupps et al. (1960) provided evidence of seasonal effects on several semen characteristics. Maqsood (1951) showed by histological examination that spermatogenesis was arrested in a majority of seminiferous tubules in the testis of sheep during the non-breeding season. During the breeding season most tubules were characterized by active spermatogenesis.

Experimental evidence by Yeates (1947) indicates that the non-breeding season decline in spermatogenesis and in semen quality of domestic sheep is linked to seasonal effects. He showed that reversal of the normal light regime could lead to modification in the non-breeding season pattern of semen quality deterioration and decline in libido. The nature of seasonal influences on spermatogenesis in sheep was shown by Ortavant (1954a, 1954b). His reports showed that the rate of division of primary spermatocytes and the time of their subsequent maturation was relatively unaffected by photo-period but that the number of spermatids which survive the complete maturation process was affected. Ortavant (1962) later showed that a photoperiod of 12 hours provided the maximum stimulus to spermatogenesis in the sheep. Pelletier and Ortavant (1964) subjected two groups of sheep to contrasting photoperiods. Testicular weight and numbers of spermatozoa produced were higher in sheep on an 8 hours light regime than in those on a 16 hour light regime.

Spermatozoan Reserves in White-Tailed Deer

There has been little research reported on quantitative spermatozoan production in the white-tailed deer. Bierschwal et al. (1968, 1970) were the first to report successful ejaculation of wild white-tailed deer. They reported ejaculate volumes from 12 deer collected in February of from 0.5 to 1.5 ml with a spermatozoa concentration of 1×10^9 per ml.

Lambiase et al. (1972) electroejaculated five white-tailed deer bi-weekly from August through March. Sufficient quantities

of spermatozoa to enable successful breeding were collected between October and February. Maximal spermatozoan output was achieved in mid-November with an average of 3.4×10^9 spermatozoa per ejaculate. Testicular and epididymal spermatozoan reserves were determined for 10 adult deer in November and December using homogenization techniques. Testicular spermatid concentration was $7.6 \pm 0.5 \times 10^9$ for 1.5 year old deer and $8.6 \pm 1.9 \times 10^9$ for older deer. Epididymal spermatozoan reserves were $16.5 \pm 1.4 \times 10^9$ and $11.3 \pm 4.3 \times 10^9$ respectively for 1.5 year old deer and deer 2.5 years old or older.

Procedures Used to Study Spermatozoan Production

Spermatozoan production rate is the most important parameter for determining the breeding capabilities of individual males. Many early works estimating spermatozoan production were based on the number of cells in ejaculated semen. The time between each ejaculate and the number of ejaculates taken were not carefully regulated. Consequently these procedures did not satisfy the criteria for calculating spermatozoan production (Almquist and Amann 1961, Amann and Almquist 1961, Freund 1962, 1963). Chang (1943, 1945), in studying semen collection as a method of estimating spermatozoan production, reported that infrequent collection, or collection at irregular intervals between successive collections, produced incorrect estimates of spermatozoan production. The total number of spermatozoa obtained in a series of successive ejaculates was found to be highly correlated with the number of spermatozoa present in the caudae epididymides before the initial ejaculation.

Using this approach Van Demark et al. (1956), Boyd and Van Demark (1957), and Almquist and Amann (1961) estimated daily spermatozoan production of cattle (Bos taurus). Similar studies were conducted with sheep (Ovis aries) by Chang (1945), with horses (Equus caballus), cattle and sheep by Bielanski and Wierzbowski (1963), swine (Sus scrofa) by Swierstra (1968a), laboratory rabbits (Oryctolagus cuniculus) by Kirton et al. (1967) and Lambiase and Amann (1969).

Research indicates that there exists a high correlation between daily sperm production and testicular weight (Amann 1970). This was true for continuous breeding species and for seasonal breeding species during the breeding season. Willett and Ohms (1957) correlated scrotal circumference of cattle with spermatozoan production using exhaustion tests (multiple semen collections). Boyd and Van Demark (1957) and Amann and Almquist (1962) also found testes and epididymides weights to be highly correlated to total number of spermatozoa ejaculated by cattle.

Kennelly (1960) concluded differences in spermatozoan production among swine was largely a function of testicular weight and the proportion of semeniferous tubules within the testes. Swierstra (1968b) reported testicular weight and daily spermatozoan production of swine were highly correlated. Ortavant (1958) found a high correlation between the number of spermatids in a testis and testicular weight of sheep.

Quantitative testicular histology is a method of estimating daily spermatozoa production from relative germ cell volume. The technique

was described by Chalkley (1963). Five pointers are placed in the microscope ocular. By recording the tissue component at the end of each pointer in a large number of randomly selected fields, the percentage of each component in the tissue was determined.

Amann (1962) and Amann and Almquist (1962) used this technique to assess the relationship between daily spermatozoan production and daily spermatozoan output in cattle. Swierstra (1966) also determined spermatozoan production in cattle through quantitative testicular histology. Calculations were based on volume of round spermatid nuclei compared to the total volume examined. Similar studies were conducted on swine by Kennelly and Foote (1961, 1964). They found volumetric histologic methods could be used to estimate spermatozoan production. Swierstra (1968a) reported actual spermatozoan output to be 88 percent of daily spermatozoan production in swine using these same methods.

Testicular homogenization has been used successfully to estimate daily spermatozoan production. Ortavant (1952) demonstrated that there exists a point during spermiogenesis when the nucleus of the developing, mammalian spermatid becomes resistant to physical destruction. After this point, it is possible to prepare testicular homogenates in which the nuclei of spermatozoa can be counted by hemocytometric techniques.

Amann and Almquist (1961) developed a homogenization technique for direct measurement of gonadal and extra-gonadal spermatozoan reserves in cattle. Almquist and Amann (1961, 1962) determined gonadal

and extra-gonadal spermatozoan reserves by direct counts using the homogenization technique and compared this to depletion trials (multiple semen collections). Homogenization techniques have been used to determine spermatozoan reserves in sheep by Ortavant (1958), in the guinea pig by Verma et al. (1966), in laboratory rabbits by Orgebin Crist (1968) and Amann and Lambiase (1966, 1969), and in white-tailed deer by Lambiase et al. (1972). These workers demonstrated that this technique provides accurate estimates of spermatozoan production.

The homogenization technique offers several advantages over other methods in working with large numbers of animals. It is less time consuming than quantitative testicular histology and is equally as precise. The technique is less demanding in terms of equipment and material preparation. Since there have been no significant differences reported between quantitative testicular histology and homogenization numbers, it was decided to employ homogenization methods in this study.

Puberty in the Male Cervidae

Studies on the capacity of male white-tailed deer to reproduce during their first year of life are limited and to some extent contradictory. In New York, Cheatum and Morton (1946) concluded male fawns do not reach puberty during their first year. This observation was based on absence of spermatozoa in the convoluted tubules of the testes as determined by histological examination. Since that time, however, there have been reports of deer attaining puberty during their first year of life. Silver (1965) reported that a male fawn in New Hampshire successfully mated when he was 202 days old and

weighed 43 kg. Follman and Klimstra (1969) indicated 37 percent of the male fawns examined in southern Illinois during January were fertile based on presence of spermatozoa found in smears made of the testis and cauda epididymis and 98.5 percent had undergone some spermatogenic activity as determined by the presence of spermatocytes, spermatids, or spermatozoa in the testes. Lambiase et al. (1972), in Pennsylvania, attempted to collect semen by electro-ejaculation from fawns and quantify spermatozoan output. Eight of the ten fawns in the study were considered fertile at some time between December and March. Between 5×10^3 and 11×10^6 spermatozoa were obtained at least once from these fawns. Two female fawns became pregnant as a result of service by a male fawn (Lambiase et al. 1972).

Black-tailed deer have been observed to attain puberty during their first year of life (Cowan and Wood 1955, and Wood et al. 1962). Polished antler buttons and rut behavior were considered as indicative of puberty attainment. Fertile matings of male and female fawns substantiated their conclusion that puberty was attained.

Efforts to study the growth and development exhibited by other members of the Cervidae family as they approach puberty have also been undertaken. Chapman and Chapman (1970) used the diameter of the seminiferous tubules as a parameter of pubertal change in the male fallow deer. Based on weights and histological appearance of the testes and epididymides, it was suggested that puberty occurs at about 16 months of age in the fallow deer. Lincoln (1971) noted that the first reproductive cycle (development of testes to point where they were producing spermatids) of the red deer stag took two years, but no rutting

behavior was apparent. Puberty was defined as the period from nine to fifteen months of age. This period included the onset of androgen secretion to the completion of spermatogenesis. Techniques used in this study included measurement of testes and epididymides weights, development of secondary sex characteristics, and change in body growth rate. Histological (diameter of tubules and determination of the different stages of spermatogenesis) and histochemical (androgenic activity) studies have also been used to quantify pubertal development.

Reproduction in Female Fawns

Several studies of the female white-tailed deer fawn have indicated that under certain circumstances some animals are capable of breeding during their first year of life. Studies of female fawns from several deer herds indicate that up to 40 percent of the fawns examined were pregnant. Well documented evidence by Cheatum and Morton (1942), Morton and Cheatum (1946), and Roseberry and Klimstra (1970) indicate pregnancy rates of 40.1, 36.2, and 41.3 percent among fawns, respectively. These findings were based on examination of fawns from November through June. Teer et al. (1965) examined 160 fawns during the month of December in the Llana Basin in Texas. He reported no pregnancies but 3 percent of the animals had a single corpus luteum in the ovaries. Upon examination of 520 sets of ovaries collected from 1.5 year old deer, however, results indicated the fawns probably were examined before they had reached sexual maturity and began breeding activity. Sixteen percent of 1.5 year old deer had corpora albicantia in their ovaries when examined in December indicating that the fawns may have been examined prior to ovulation.

Illige (1951) found no pregnant female fawns in south Texas. The number of fawns he examined during a year long study was not reported.

Roseberry and Klimstra (1970) reported that breeding activity in individual fawns appeared to be related to body weight and that body weight difference probably reflected age differences. They also noted a positive correlation between age and corpora luteal counts. These studies were conducted in the Crab Orchard National Wildlife Refuge in southern Illinois where range conditions were considered good by the authors. Several authors, including Morton and Cheatum (1946), Cheatum and Severinghaus (1950), Pimlott (1959), and Allen (1968) have related body size to the attainment of puberty in Cervidae. Range conditions were considered to influence body size. It was observed that animals in poor habitats were smaller and a greater percentage did not attain puberty during their first year of life.

Wood et al. (1962) reported ovulations in six month old black-tailed deer when reared on a high nutritional plane while deer raised on a plane of nutrition equivalent of 70 percent of this high nutrition diet did not reach puberty during their first year. A sudden reduction in growth rate was associated with attainment of puberty. Observations cited in a review by Joubert (1963) indicate levels of bodily development depend upon nutrition. In seasonal breeders the attainment of a minimum body size and development during their first breeding season is essential if animals are to attain puberty during their first year of life (Joubert 1963). All reports on female fawn development indicate that ovarian activity in fawns is directly related to body weight. If the fawn does not attain the necessary level of bodily development

during the first fall breeding season, it will not ovulate that year. As the animal continues to grow this level of bodily development is attained before the following breeding season and the animal then undergoes its first estrus.

MATERIALS AND METHODS

Experiment I

Reproductive organs were recovered from 73 male deer killed during legal hunts on the Savannah River Project of the Atomic Energy Commission located in Aiken and Barnwell counties in South Carolina. Collection dates were November 3-6, 1971, and December 8-11, 1971. Body weight of all animals was recorded and age was determined by evaluation of dental characteristics (Severinghaus 1949). Deer ranged in age from fawns (0.5 year old) to 6.5 years old. Testes and epididymides were removed from animals and frozen until laboratory analysis could be conducted.

Testes and epididymides were identified as the left and right organs. The epididymis was removed from each testis and the testis weight recorded. Epididymides were divided into two parts representing the caput plus corpus epididymis and the cauda epididymis. Weight of each portion of the epididymis and of the total organ was recorded.

Spermatozoan numbers were determined in each individual testis and in each portion of the epididymis. The procedure used was based on that of Almquist and Amann (1961) and Amann and Lambiase (1969). Testes were homogenized in 0.9 percent NaCl (containing 0.05 percent Triton X-100 as a surfactant) in a Waring blender. Homogenization was allowed to continue for one minute. Aliquots of the homogenate were removed for counting of spermatozoa. Counting

was done using hemocytometer slides (A. O. Spencer Brightline: double improved Neubauer ruling). The counting procedure was that described by Herrick and Self (1962:99). Both chambers were counted on each of three slides and the means of these counts was used in calculating the number of spermatozoa. Numbers of spermatozoa were calculated in terms of number per organ and number per gram of tissue.

The separate portions of the epididymides were homogenized in similar quantities of the same medium as used for testis homogenization. Homogenization was continued for two periods of 2.5 minutes separated by an interval of one minute. Determination of numbers of spermatozoa was by counting spermatozoan numbers in an aliquot of homogenate using hemocytometer slides as previously described for the testis.

Experiment II

Fawns studied in this experiment were from a confined deer herd at the Radford Army Ammunition Plant, Dublin, Virginia. The fall population in the confined area (440 ha.) was approximately 450 animals. The experimental design called for a study of five male and five female fawns per month over the period January, 1972, to May, 1972. Various aspects of gonadal activity of the fawns, to be detailed later, were studied.

Deer were approached in a truck and attempts were made at immobilization by remote injection of succinylcholine chloride. The technique used was that described by Liscinsky et al. (1969).

When the fawn selected was within range (generally 50 m or less) a dart loaded with powdered succinylcholine chloride (Pneu-darts: Pneu-dart Inc. Williamsport, Pa.) was discharged at the animal. When the fawns were immobilized the heart-girth was measured as a means of estimating the live weight of the animal (Smart et al. 1972).

Examination of Male Animals

One testis (the left) was removed following ligation of the internal spermatic artery supplying the organ. The testis was weighed and a portion removed and preserved in 10 percent formalin for future histological analysis. The remainder of the testis was frozen for later homogenization and determination of spermatozoan numbers. The procedures followed were those described in Experiment I. Epididymides were divided into portions representing caput plus corpus epididymis and cauda epididymis. These were weighed and frozen for later homogenization and determination of spermatozoan numbers. Procedures followed were those described in Experiment I. The content of the portion of the vas deferens removed with each testis was expressed onto a slide and examined for presence of spermatozoa.

Examination of Female Fawns

Laparotomy examinations were conducted on female fawns to determine ovarian activity. Research with sheep has shown that the technique of laparotomy may be greatly facilitated by the use of a suitable restraining and support apparatus (Lamond and

Urquhart 1961, Hulet and Foote 1968). A support apparatus for field use with deer was designed.

Laparotomy Support Apparatus

Dimensions of a support apparatus for field laparotomy of deer are given in Figure 1. The apparatus was designed to be portable, collapsible, and suitable for field use. Since the supporting device was intended for field use, it has to be strong yet portable and easy to use. The device consisted of two wooden frames hinged together so that it could be folded for carrying. The front frame was partly covered with burlap. For use, the device was laid flat on the ground and the immobilized animal was placed on top in a supine position. The hindlegs were strapped to the upper portion of the front frame. The upper portion was then elevated and the back frame was used to prop the device in its standing position. The animal was predominantly suspended by the hindlegs; its back was supported by the burlap and its shoulders rested on the ground. In this position, a clear view of the animal's inguinal region (the incision site for laparotomy) was presented.

The Laparotomy Technique

After the deer was in position, a local anesthetic (procaine: 10cc) was injected subcutaneously. The appropriate site was cleaned and the hairs plucked to provide maximum sterility.

An incision (approximately 5 cm long) was made 2 cm to the left of the midline and 5 cm anterior to the mammary gland. This

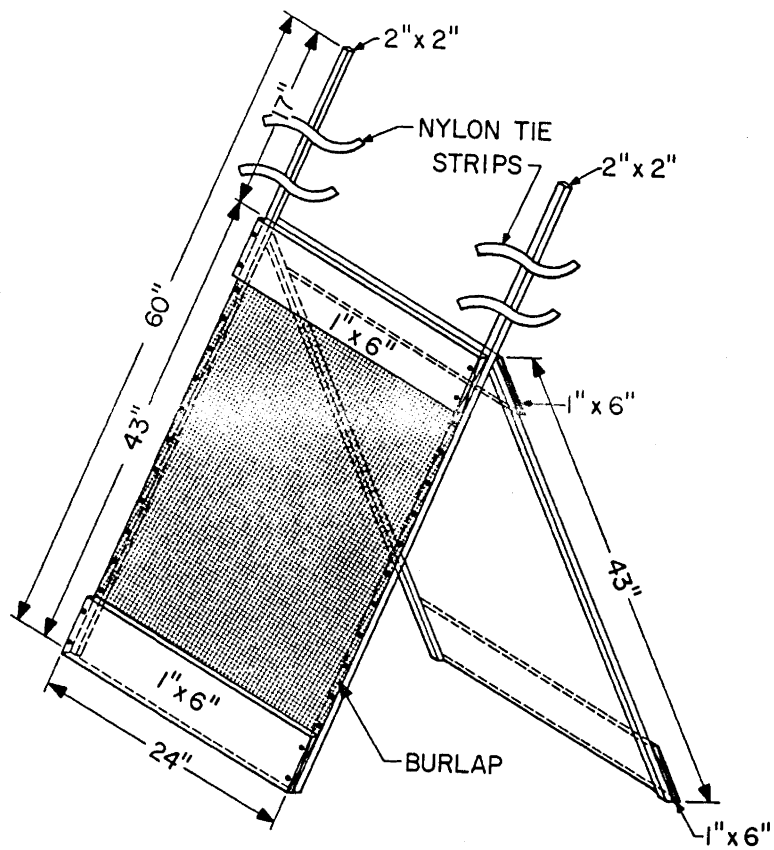


Fig. 1. Laparotomy Support Apparatus.

allowed access to the reproductive organs within the body cavity of the animal. By inserting two gloved fingers through the incision and into the body cavity, the ovaries and uterine horns were identified. The tip of one uterine horn was grasped between two fingers and the reproductive organs drawn toward the incision. Each ovary was drawn through the incision in turn and examined for details of follicular activity which were recorded. After examination, the reproductive organs were replaced in the body cavity. The incision was then closed by first suturing the peritoneum with Vetafil. The skin incision was closed with three interrupted sutures. An antibiotic (Combiotic, Chas. Pfizer and Co. Inc. New York 17, New York) was injected and the animal was disengaged from the support apparatus. Each animal was marked with eartags and streamers for future identification and left to recover.

Analysis of Data

An analysis of variance was used to determine differences among the age classes for the parameters measured and differences between months of collection for each age class. When significant differences were found, Duncan's multiple range test was used to determine the location of these differences. The t-test was used when two means were compared and the t-test for paired comparisons was used to determine differences between the parameters measured in the left and right portions of the reproductive tract.

RESULTS

Experiment I

Body Weight

Data on live weights of deer in different age classes killed in November and December are given in Table 1. Live weights of the 0.5 age class were significantly ($p < 0.05$) lower than those of the older classes of deer in November and in December. The 1.5 year old deer were significantly ($p < 0.01$) lighter than the 1.5 plus age-class in November and in December. There were no significant increases in body weight from November to December although the mean body weight of deer in each age class was heavier in December than in November.

Paired Testis Weights

The mean paired testis weight of the 0.5 year old deer was significantly ($P < 0.05$) lower than those of the other age classes (Table 1) in November and in December. Yearling deer (1.5 years of age) had significantly ($p < 0.05$) lighter paired testis weights than the 1.5 + age class in November and in December. There were no significant differences between November and December in the testis weights of the 0.5 year old deer. The 1.5 year old and older deer collected in November had significantly ($p < 0.05$) higher paired testis weights than those collected in December.

Paired Epididymis Weight

The mean paired epididymis weight (Table 1) of fawns (0.5 years) was significantly ($p < 0.05$) lower than that of the older deer

Table 1. Testis weights, epididymis weights, and body weights of male deer collected in November and December, 1972, from South Carolina.

Age Class	Number of Deer	November			Number of Deer	December		
		Paired ^f Testis Weights (g)	Paired ^f Epididymis Weights (g)	Live ^f Weights (kg)		Paired ^f Testis Weights (g)	Paired ^f Epididymis Weights (g)	Live ^f Weight (kg)
0.5	7	15.12 ^a ± 8.03	3.31 ^a ± 0.78	26.7 ^a ± 3.6	10	14.81 ^a ± 5.34	3.36 ^a ± 1.02	28.6 ^a ± 2.2
1.5	11	61.53 ^b ± 17.16	9.61 ^b ± 1.99	47.9 ^b ± 9.4	17	43.66 ^{b,e} ± 8.91	8.92 ^b ± 1.31	51.5 ^b ± 5.3
2.5	8	77.88 ^c ± 16.93	11.88 ^c ± 1.61	61.8 ^c ± 14.2	2	63.67 ^{c,e} ± 8.92	11.61 ^c ± 0.51	69.1 ^c ± 14.1
3.5	4	71.82 ^{b,c} ± 7.86	11.05 ^c ± 1.56	72.6 ^d ± 5.1	6	60.39 ^{b,c,e} ± 6.64	10.64 ^b ± 1.30	78.0 ^d ± 11.1
3.5+	4	75.18 ^c ± 13.27	15.31 ^d ± 1.91	75.7 ^d ± 8.5	4	62.44 ^{c,e} ± 22.31	9.74 ^b ± 3.34	75.2 ^d ± 3.8
1.5+	16	75.69 ^c ± 13.71	12.53 ^c ± 2.30	70.45 ^d ± 14.74	12	61.62 ^{c,e} ± 12.91	10.50 ^b ± 2.07	75.61 ^d ± 9.42

(a,b,c,d) Means with different superscripts in the same column are significantly (p<.05) different.

(e) Indicates significant (p<.05) difference from corresponding value for November.

(f) Mean ± standard deviation.

in November and in December. Yearling deer (1.5 years old) had significantly ($p < 0.01$) lower paired epididymis weight in November than the 2.5 years old and older deer. There was no significant difference between the mean paired epididymis weight of the 1.5 year old deer and the 2.5 year old and older deer in December. There were no significant differences in mean paired epididymis weights between months for 0.5 year old deer. The mean epididymis weights of 1.5 year old and of older deer tended to be lighter in December than in November but were not significantly different.

Spermatozoan Numbers in Paired Testes

Mean spermatozoan numbers in paired testes of deer of all age classes killed in November and December are presented in Table 2. Fawns had significantly ($p < 0.05$) fewer spermatozoa in their testes than all of the older age classes in November and in December.

Mean spermatozoan numbers in the testes of 1.5 year old deer were not significantly different from the 1.5 plus age class of deer in November and in December. All age classes except fawns and the 3.5 plus age class had a significant ($p < 0.05$) reduction in numbers of spermatozoa in the testes in December. Mean numbers of spermatozoa in the testes of fawns were lower in December but the difference was not significant.

Table 2. Spermatozoan numbers ($\times 10^9$) in paired testis and paired epididymis of male deer collected in November and in December, 1972, from South Carolina.

Class	November				December			
	Number of Deer	Testis ^f	Epididymis ^f	Testis plus ^f Epididymis	Number of Deer	Testis ^f	Epididymis ^f	Testis plus ^f Epididymis
0.5	7	.182 ^a ± .314	.087 ^a ± .174	.269 ^a ± .462	10	.108 ^a ± .213	.094 ^a ± .173	.202 ^a ± .375
1.5	11	6.59 ^b ± 2.96	9.43 ^b ± 2.85	16.02 ^b ± 5.48	17	5.05 ^{be} ± 1.05	8.73 ^b ± 2.44	13.78 ^b ± 3.00
2.5	8	9.29 ^c ± 3.59	11.45 ^b ± 4.15	20.75 ^b ± 7.57	2	5.50 ^{be} ± 0.82	11.08 ^b ± 2.79	16.58 ^b ± 3.61
3.5	4	9.49 ^c ± 0.88	13.52 ^c ± 5.09	23.01 ^c ± 5.15	6	4.92 ^{be} ± 2.13	9.43 ^b ± 4.79	14.35 ^b ± 6.63
3.5+	4	5.78 ^b ± 2.09	11.11 ^b ± 3.88	16.89 ^b ± 5.07	4	4.45 ^b ± 3.16	7.34 ^b ± 4.04	11.79 ^b ± 7.15
1.5+	16	8.46 ^b ± 3.10	11.89 ^b ± 4.15	20.35 ^b ± 6.51	12	4.86 ^{be} ± 2.23	9.01 ^b ± 4.18	13.87 ^b ± 6.18

(a,b,c) Means with different superscripts in the same column are significantly (p<.05) different.

(e) Indicates significant (p<.05) difference from corresponding value for November.

Spermatozoan Numbers in Paired Epididymides of Deer

Table 2 illustrates mean spermatozoan numbers in the paired epididymides of deer of all age classes killed in November and in December. Fawns (0.5 year old deer) had significantly ($p < 0.01$) fewer spermatozoa in their epididymides than the older deer in November and in December. Mean spermatozoan numbers in the paired epididymides of the 1.5 year old deer were not significantly different from mean spermatozoan numbers in the epididymides of the 2.5 year old and older deer in November or in December. There were no significant differences between mean numbers of spermatozoa in paired epididymides between November and December in any age class.

Less than half the fawns examined had testicular spermatozoa (Table 3). This resulted in a reduction in the mean numbers of spermatozoa in paired testes and paired epididymides as presented in Table 2. Table 3 compares paired organ weights and spermatozoan numbers in paired testes and paired epididymides of those fawns with testicular spermatozoa with the mean values presented in Tables 1 and 2. Among those fawns with any spermatozoa in their testes, the mean number of spermatozoa in the testes were significantly ($p < 0.05$) lower than those of the older age classes. The mean numbers of spermatozoa in epididymides of fawns producing spermatozoa were significantly ($p < 0.05$) less than in all older deer. Testes and epididymides weights of fawns with spermatozoa were heavier than in fawns without spermatozoa.

Table 3. Differences in reproductive organ weights and spermatozoan numbers of male fawns with and without testicular spermatozoa that were collected in November and in December in South Carolina.

	November			December		
	All Fawns	Fawns with Spermatozoa	Fawns without Spermatozoa	All Fawns	Fawns with Spermatozoa	Fawns without Spermatozoa
Number of Deer	7	2	5	10	4	6
Live ^c Weight (kg)	26.7 ± 3.6	30.23 ± 4.17	25.27 ± 2.56	28.6 ± 2.2	30.79 ± 1.72	27.12 ± 0.84
Paired Testis ^c Weight (g)	15.12 ± 8.03	25.04 ^a ± 3.16	11.15 ^b ± 5.04	14.81 ± 5.34	18.26 ^a ± 3.96	12.50 ^b ± 5.10
Paired ^c Epididymis Weight (g)	3.31 ± 0.78	4.25 ^a ± 0.02	2.94 ^b ± 0.53	3.36 ± 1.02	4.11 ^a ± 0.76	2.86 ^b ± 0.88
Mean Testis ^c Spermatozoan Numbers (x10 ⁹)	.182 ± .314	.636 ± .119	0	.108 ± .213	.270 ± .278	0
Mean ^c Epididymis Spermatozoan Numbers (x10 ⁹)	.087 ± .174	.307 ± .215	0	.094 ± .173	.234 ± .173	0

(a,b) Means with different superscripts in the same row are significantly ($p < .05$) different.

(c) Mean ± standard deviation.

Spermatozoan Concentration per Gram of Testis Tissue

Data on spermatozoan concentration per gram of tissue in paired testes of deer killed in November and December are presented in Table 4. A comparison of the concentration of spermatozoa on a per gram of tissue basis may provide a more accurate picture of individual differences in spermatogenic activity. The 0.5 year old deer had significantly ($p < 0.05$) lower concentrations of spermatozoa per gram of testis tissue than all older deer. There were no significant differences between spermatozoan concentrations per gram of testis tissue between 1.5 year old deer and 2.5 year old and older deer in November or in December. There was no significant difference between November and December among all age classes of deer in spermatozoan concentrations per gram of testis tissue.

Spermatozoan Concentration per gram of Epididymal Tissue

Fawns had significantly ($p < 0.05$) lower concentrations of spermatozoa per gram of epididymal tissue than all older deer in November and in December (Table 4). There were no significant differences in spermatozoan concentrations per gram of epididymal tissue between 1.5 year old deer and older deer in November and in December. There were no significant differences between November and December among all age classes of deer in spermatozoan concentrations per gram of

Table 4. Spermatozoan concentration ($\times 10^9$) per gram of tissue in paired testis and paired epididymis of male deer collected in November and in December in South Carolina.

Age Class	November			December		
	Number of Deer	Testis ^c	Epididymis ^c	Number of Deer	Testis ^c	Epididymis ^c
0.5	7	0.008 ^a ± 0.015	0.021 ^a ± 0.041	10	0.008 ^a ± 0.013	0.022 ^a ± 0.038
1.5	11	0.115 ^b ± 0.05	0.80 ^b ± 0.273	17	0.14 ^b ± 0.04	0.990 ^b ± 0.29
2.5	8	0.130 ^b ± 0.041	0.981 ^b ± 0.340	2	0.10 ^b ± 0.01	0.96 ^b ± 0.29
3.5	4	0.140 ^b ± 0.012	1.23 ^b ± 0.45	6	0.09 ^b ± 0.04	0.92 ^b ± 0.54
3.5+	4	0.082 ^b ± 0.034	0.97 ^b ± 0.19	4	0.07 ^b ± 0.04	0.72 ^b ± 0.28
1.5+	16	0.12 ^b ± 0.04	0.97 ^b ± 0.37	12	0.09 ^b ± 0.04	0.86 ^b ± 0.41

(a,b) Means with different superscripts in the same column are significantly ($p < .05$) different.

(c) Mean $\pm$ standard deviation.

epididymal tissue.

Spermatozoan Concentration in Portions of the Epididymis of Deer

Epididymides were divided into two portions, the caput plus corpus segment and the cauda segment. In discussing spermatozoan concentrations below, the concentrations refer to those in the paired segments from individual animals (i.e. paired caput plus corpus and paired cauda epididymides). Mean spermatozoan numbers in the caput plus corpus epididymis, cauda epididymis, and the total epididymis of deer killed in November and December are presented in Table 5. Fawns (0.5 year old deer) had significantly ($p < 0.05$) fewer spermatozoa in both portions of the epididymis in November and in December than the older deer. The yearlings (1.5 years old) had significantly ($p < 0.05$) less spermatozoa in the caput plus corpus epididymis than the older deer in November. There were no significant differences in spermatozoan numbers found in the epididymis between yearlings and older deer in December.

Among yearlings and older deer there was a significant ($p < .05$) reduction in spermatozoan concentrations in caput plus corpus epididymis in December compared to November values. There was not a significant reduction in spermatozoan concentration in the cauda epididymis. This was true for yearlings and older deer.

Relative Proportions of Spermatozoan Numbers

A comparison of the relative proportion of spermatozoan numbers in the different portions of the epididymis is presented in Table 6. The total number of spermatozoa present in the

Table 5. Spermatozoan numbers ($\times 10^9$) in caput plus corpus epididymis, cauda epididymis, and total epididymis of male deer collected in November and in December in South Carolina.

Age Class	November				December			
	Number of Deer	Caput-Corpus ^f Epididymis	Cauda ^f Epididymis	Total ^f Epididymis	Number of Deer	Caput-Corpus ^f Epididymis	Cauda ^f Epididymis	Total ^f Epididymis
0.5	7	0.037 ^a <u>+0.79</u>	0.044 ^a <u>+0.088</u>	0.87 ^a <u>+ 0.174</u>	10	0.027 ^a <u>+0.064</u>	0.066 ^a <u>+0.120</u>	0.094 ^a <u>+ 0.173</u>
1.5	11	3.00 ^b <u>+0.94</u>	6.43 ^b <u>+0.95</u>	9.43 ^b <u>+ 2.85</u>	17	2.33 ^{be} <u>+0.68</u>	6.40 ^b <u>+2.12</u>	8.73 ^b <u>+ 2.44</u>
2.5	8	3.82 ^c <u>+1.18</u>	7.64 ^b <u>+3.21</u>	11.45 ^b <u>+ 4.15</u>	2	2.78 ^{be} <u>+0.57</u>	8.30 ^b <u>+2.22</u>	11.08 ^b <u>+ 2.79</u>
3.5	4	3.71 ^c <u>+0.45</u>	9.82 <u>+4.87</u>	13.52 ^b <u>+ 5.09</u>	6	2.61 ^{be} <u>+1.05</u>	6.82 ^b <u>3.89</u>	9.43 ^b <u>+ 4.79</u>
3.5+	4	3.68 ^c <u>+0.81</u>	7.43 ^b <u>+3.24</u>	11.11 ^b <u>+ 3.88</u>	4	2.52 ^{be} <u>+1.37</u>	4.81 ^b <u>+2.72</u>	7.34 ^b <u>+ 4.04</u>
1.5+	16	3.75 ^c <u>+0.91</u>	8.13 ^b <u>+3.56</u>	11.89 ^b <u>+ 4.15</u>	12	2.61 ^{be} <u>+1.03</u>	6.40 ^b <u>+3.32</u>	9.01 ^b <u>+ 4.18</u>

(a,b,c) Means with different superscripts in the same column are significantly different ($p < .05$).

(e) Indicates significant ($p < 0.05$) difference from corresponding value for November.

(f) Mean ± standard deviation.

Table 6. Comparison of relative proportion of spermatozoan numbers in the segments of epididymides of male deer collected in November and in December in South Carolina.

Age Class	November				December			
	Number of Deer	Caput-Corpus	Epididymis Cauda	Combined	Number of Deer	Caput-Corpus	Epididymis Cauda	Combined
0.5	7	.450	.550	1	10	.299	.711	1
1.5	11	.288	.712	1	17	.267	.733	1
2.5	8	.333	.667	1	2	.251	.749	1
3.5	4	.274	.726	1	6	.276	.724	1
3.5+	4	.473	.527	1	4	.344	.656	1
1.5+	16	.315	.685	1	12	.266	.734	1

epididymis was equated to one for each age class. The ratios of spermatozoan numbers in the caput plus corpus epididymis and the cauda epididymis were calculated. This presentation provides a ready comparison of spermatozoan concentrations in the different portions of the epididymis. The cauda epididymis contain from two to three fold more spermatozoa than the caput plus corpus epididymis in all deer except fawns in November.

Comparisons Between Left and Right Components of the Reproductive Tract

The following parameters were compared for left and right components of the reproductive tract of all males examined: testis weight, epididymis weight, spermatozoan numbers in the testis and spermatozoan numbers in the epididymis. All deer killed in November and in December were used in the comparisons and the results are presented in Tables 7 and 8. A t-test for paired comparisons was used to test for differences. No significant differences ($p < 0.01$) between the weight of left and right testes and left and right epididymides were observed (Table 7). Likewise there were no significant differences ($p < .01$) between left and right testes and epididymides in numbers of spermatozoa (Table 8).

Experiment II

Male Fawns

Data on individual fawns are presented in Table 9. Three of 19 fawns examined during the interval January through May had evidence of spermatogenesis. All animals with evidence of

Table 7. Weights of left and right portions of the reproductive tract in male deer collected in November and in December, 1972, in South Carolina.

Age Class	November					December				
	Number of Deer	Testis ^a		Epididymis ^a		Number of Deer	Testis ^a		Epididymis ^a	
		Left	Right	Left	Right		Left	Right	Left	Right
0.5	7	7.53 + 3.92	7.58 + 4.12	1.66 + 0.34	1.65 + 0.45	10	7.27 + 2.65	7.56 + 2.71	1.83 +0.55	1.53 +0.48
1.5	11	30.93 + 8.85	30.59 + 8.44	5.07 + 1.07	4.54 + 1.00	17	22.06 + 4.76	21.66 + 4.23	4.37 +0.66	4.55 +0.84
2.5	8	38.90 + 8.47	38.98 + 8.52	6.04 + 0.72	5.84 + 0.91	2	32.13 + 5.81	31.54 + 4.11	5.63 +0.24	5.98 +0.81
3.5	4	35.91 + 3.37	35.91 + 4.95	5.85 + 0.81	5.21 + 1.12	6	30.14 + 3.40	30.25 + 3.25	5.39 +0.75	5.25 +0.59
3.5+	4	37.53 + 6.58	37.65 + 6.75	7.54 + 0.64	7.77 + 1.53	4	31.19 +11.70	31.25 +10.87	4.88 +1.59	4.87 +1.84

(a) Mean $\pm$ standard deviation.

Table 8. Spermatozoan numbers of left and right portions of the reproductive tract in male deer collected in November and in December, 1972, from South Carolina.

Age Class	Number of Deer	November				December				
		Testes ^a		Epididymis ^a		Number of Deer	Testes ^a		Epididymis ^a	
		Left	Right	Left	Right		Left	Right	Left	Right
0.5	7	.091 ± .15	.091 ± .15	.043 ± .086	.044 ± .088	10	.055 ± .109	.053 ± .103	.045 ± .087	.048 ± .087
1.5	11	3.33 ±1.55	3.26 ±1.43	4.68 ±1.44	4.75 ±1.44	17	2.51 ± .51	2.54 ± .59	4.46 ±1.27	4.33 ±1.23
2.5	8	4.74 ±1.82	4.55 ±1.77	5.86 ±2.16	5.59 ±2.01	2	2.78 ± .25	2.72 ± .57	5.59 ±1.37	5.49 ±1.42
3.5	4	4.96 ± .42	4.53 ± .58	7.03 ±2.51	6.49 ±2.62	6	2.58 ±1.11	2.34 ±1.04	4.63 ±2.34	2.47 ±2.47
3.5+	4	2.93 ±1.09	2.85 ±1.16	5.63 ±1.93	5.48 ±2.06	4	2.05 ±1.51	2.40 ±1.66	3.47 ±1.95	3.86 ±2.11

(a) Mean ± standard deviation.

Table 9. Data obtained through examination of male fawns in Virginia.

Deer Number	Date 1972	Estimated Body Weight (kg)	Testis Weight (g)	Epididymis Weight (g)	Histological Evidence of Spermatozoa [±]	No. Spermato- zoa in Testis (x10 ⁹)	No. Spermato- zoa in Epi- didymis (x10 ⁹)
1	1-11	34.55	8.07	1.68	-- [#]	1.32	4.64
2	1-11	22.73	1.75	0.53	--	0	0
3	1-11	30.91	6.27	1.40	--	1.54	4.703
4	1-17	27.83	2.86	1.21	--	0	0
5	1-22	28.64	3.07	0.75	--	0	0
18	2- 9	30.45	5.84	1.12	-	0	0
19	2- 9	20.00	1.62	0.52	-	0	0
28	2-21	28.64	1.59	0.75	-	0	0
33	3- 7	32.27	5.46	1.65	+	0.829	2.56
39	3-22	25.91	2.10	0.98	-	0	0
40	3-28	31.36	5.70	1.13	-	0	0
41	3-30	29.55	2.64	1.06	-	0	0
42	3-31	25.91	2.21	0.74	-	0	0
48	4-26	30.45	3.99	1.36	-	0	0
44	4-18	25.45	3.28	1.34	-	0	0
59	5-25	33.18	3.27	1.45	-	0	0
60	5-26	34.09	3.27	1.33	-	0	0
63	5-31	36.82	7.73	1.70	-	0	0
64	5-31	35.00	7.66	1.82	-	0	0

[#] Data not reported.

spermatogenesis had bodyweight in excess of 30 kg and were above the mean in bodyweight of animals examined. Testis weights and epididymis weights of fawns studied during January through May at the Radford Army Ammunition Plant were lower than those of South Carolina fawns examined in November and in December (Table 10). The percentage, by month of examination, of fawns that had initiated spermatogenesis is recorded. Table 10 summarizes the results of the study on all male fawns.

Female Fawns

Data on individual female fawns examined January through May are presented in Table 11. Due to the small number of animals involved no statistical analyses were attempted. Of the 21 fawns examined only one was pregnant. Bodyweight of this animal which had a single fetus was estimated to be 30.4 kg.

Evidence of some gonadal development was apparent in six of the 13 fawns examined by laparotomy. These six fawns had 1 to 4 follicles greater than 5 mm diameter present on their ovaries yet none appeared to have ovulated prior to the time of examination. Seven fawns were without recognizable follicular development. Seven were not examined by laparotomy so no information is available on follicular growth. These fawns that were not examined by laparotomy were palpated through the abdominal wall to determine the presence of a fetus and all were considered non-pregnant.

Table 10. Comparison of reproductive data on male fawns from two study areas.

Variables	Dublin, Virginia					Aiken, S. Carolina	
	Jan.	Feb.	March	April	May	Nov.	Dec.
Number of Deer	5	3	5	2	4	7	10
Live Weight (kg) ^a	28.91 <u>+4.34</u>	26.36 <u>+5.59</u>	29.0 <u>+2.99</u>	27.95 <u>+3.53</u>	34.77 <u>+1.55</u>	26.69 <u>+3.62</u>	28.59 <u>+2.23</u>
Testis Weight (g) ^a	4.40 <u>+2.65</u>	3.02 <u>+2.45</u>	3.62 <u>+1.80</u>	3.63 <u>+0.50</u>	5.49 <u>+2.55</u>	7.53 <u>+3.92</u>	7.25 <u>+2.65</u>
Epididymis Weight (g) ^a	1.11 <u>± .47</u>	0.79 <u>± .30</u>	1.11 <u>± .34</u>	1.35 <u>± .02</u>	1.57 <u>.22</u>	1.66 <u>± .34</u>	1.83 <u>± .55</u>
Number (percent) of Fertile Fawns	2(40)	0	1(20)	0	0	2(28.6)	4(40)
Testis spermatozoa (x10 ⁹) ^a	.57 <u>± .79</u>	0.0	.166 <u>± .31</u>	0.0	0.0	.182 <u>± .314</u>	.108 <u>± .213</u>
Epididymis spermatozoa (x10 ⁹) ^a	.187 <u>+2.56</u>	0.0	.511 <u>+1.14</u>	0.0	0.0	.089 <u>± .174</u>	.094 <u>± .173</u>

(a) Mean ± standard deviation.

Table 11. Data obtained through examination of female fawns in Virginia.

Deer Number	Date 1972	Estimated Body Weight (kg)	Pregnant/ Non-pregnant	Corpora lutea present	No. of Follicles 5 mm.
101	1-7	29.5	NP	0	0
102	1-11	27.3	NP	0	1
103	1-17	30.4	NP	0	3
119	2-11	27.7	NP	0	2
120	2-14	32.3	NP	0	0
122	2-14	20.4	NP	0	0
127	2-18	24.5	NP	0	0
130	2-25	27.7	NP	0	1
132	2-25	30.4	NP	0	0
134	3-7	23.6	NP	0	0
135	3-10	27.0	NP	0	0
138	3-18	28.8	NP	0	4
146	4-18	32.3	NP	--#	--
147	4-24	30.4	P	--	--
152	4-28	31.4	NP	0	1
154	4-30	32.7	NP	--	--
155	4-6	27.0	NP	--	--
156	5-21	32.3	NP	--	--
157	5-23	31.4	NP	--	--
158	5-23	34.9	NP	--	--
162	5-30	34.9	NP	--	--

Data not reported.

DISCUSSION

Available studies of seasonal changes in reproduction in deer have utilized volumes or weights of testes and it is not always clear whether epididymides were included. Consequently, comparison of data available is difficult. The total weight of the paired testes and epididymides of six adult deer killed in Massachusetts in October and December averaged 91 g (Wislocki 1943). In New York Cheatum and Morton (1946) found maximal testicular size occurred in October and November. Average volume of each testis was 53 ml and 56 ml in each month respectively. Illige (1951) in south Texas, reported the volume for 12 testes averaged 32 ml each when examined from October through December. Robinson et al. (1965) studied the reproductive cycle of male deer in central Texas. Mean testicular weights reported were 24 g and 33 g for two yearlings and 12 older deer collected from October through December. In Pennsylvania Lambiase et al. (1972) reported paired testis weights for 1.5 year old deer were 67.3 g while older deer were 80.8 g. These results were based on 23 deer and 9 deer respectively collected in November and December. Comparison of results in this report with those of other reports are difficult because of variation in methods of measurement used in other reports, and because of variations in time of year and regions in which collections were made. Also other reports are limited by small numbers and limited segregation of animals into age classes. The data presented in this report in terms of paired testis weight are somewhat comparable to data reported for Pennsylvania deer

collected in November and December (Lambiase et al. 1972).

There was a significant ($P < 0.05$) drop in testicular weights from November to December for deer of all age classes except fawns examined in this study. Most other reports have examined too small a sample to find significant reductions for the period from October through December. Failure to differentiate between each month probably masks a development and regression pattern of testicular growth during the interval October to December. Results of this study indicate that regression of reproductive characteristics of the adult white-tailed deer in South Carolina had progressed substantially by mid-December. It also appears that not all parameters measured regressed at the same rate. Testis weights were significantly reduced in December, however, epididymis weights were not significantly reduced. Numbers of spermatozoa in the testis were significantly reduced in December indicating at least a slow down if not cessation of spermatogenesis. The number of spermatozoa in the epididymis were not significantly reduced indicating continued storage of the products of earlier spermatogenesis. Examination of the spermatozoan numbers in the caput plus corpus and the cauda epididymis revealed that the December figures for caput plus corpus spermatozoan concentrations indicated a significant reduction as compared to November figures. This was also indicative of interruption in the production of spermatozoa and that this interruption had already continued for a period of time. There was no significant reduction in the spermatozoan numbers in the cauda epididymis in December.

The indication from this may have been that the interruption in spermatogenesis had not happened sufficiently early to have yet affected spermatozoan numbers in this storage organ. On the other hand the data could have indicated that the opportunity for disposal of stored spermatozoa in December was different from those in November. Examination of female deer indicated that the vast majority were already pregnant at this stage, hence there was only limited breeding opportunities for males at this stage. Alternate means of spermatozoan disposal (e.g. resorption) possibly were not operating at fast rates. In summary, it appears that the pattern of testicular regression is somewhat as follows; loss of weight in testes associated with a reduction in the rate of spermatogenesis. These latter phenomena have taken place by mid-December in South Carolina. Numbers of spermatozoa passing through the caput plus corpus epididymis are significantly ($P < 0.05$) reduced at this time but essentially there is not yet a real reduction in numbers of spermatozoa in the main storage area of the epididymis (the cauda region). This latter could be a result of either of two phenomena viz. lack of breeding activity or relatively slow resorption of stored spermatozoa.

Lambiase et al. (1972) provides the only data for comparison of spermatozoan reserves in deer. Numbers of testicular spermatozoa reported in the 1.5 year old deer were 7.6×10^9 and in the older deer 8.7×10^9 for November and December. This compares to a value of 6.6×10^9 in yearlings and 8.5×10^9 in older deer examined in November in this study. Epididymal spermatozoan reserves reported

by Lambiase et al. (1972) were 16.5×10^9 spermatozoa in 1.5 year old deer and 11.3×10^9 spermatozoa in older deer examined in November and December. Spermatozoan numbers in the epididymides of 1.5 year old deer were 9.4×10^9 and in older deer were 11.9×10^9 as reported in this study for the month of November. The lower value of epididymis spermatozoa found in the 1.5 year old deer in this study could indicate a more active role being taken by yearling deer in the breeding process, thereby lowering the number of spermatozoa in the epididymis.

A knowledge of epididymal spermatozoan reserves and the number of spermatozoa per ejaculate are essential if estimation of daily spermatozoan output is to be made. Few studies of spermatozoan numbers in ejaculates are available. Bierschwal et al. (1968, 1970) reported 1.38×10^9 spermatozoa per ejaculate for deer ejaculated in February which is a relatively late stage of the breeding season in Missouri. Lambiase et al. (1972) reported a maximum spermatozoan output per ejaculate in November to be 4.8×10^9 . They reported however that successful breeding can occur with much fewer spermatozoa per ejaculate in the white-tailed deer. The capacity to ejaculate sufficient spermatozoa for fertile matings was present during the interval between early October and the end of February. Therefore, they considered that a spermatozoan concentration of 1.0×10^9 per ejaculate was sufficient for fertile mating. The number of spermatozoa in the cauda epididymis will limit the males reproductive potential (Hale and Almquist 1960). The ratio between cauda epididy-

mal and ejaculated spermatozoa has been reported for some domestic species. Ortavant (1958) reported a ratio of 28:1 for the ram, Almquist and Amann (1961) reported a 5:1 ratio in the dairy bull and Lambiase and Amann (1969) found a ratio of 4:1 in rabbits. The mean spermatozoan numbers reported in this study in 1.5 year old deer in November were 6.4×10^9 and in older deer 8.1×10^9 in the cauda epididymis. In domestic species it has been reported that depletion can remove approximately 50 percent of caudal spermatozoan reserves. Approximately 53 percent of the extra-gonadal (i.e. epididymal) reserves were removed from dairy bulls (Almquist and Amann 1961), 56 percent in rabbits (Edwards 1940) and 40 to 45 percent in golden hamsters (Mesocricetus auratus, Chang and Sheaffer 1957). Therefore if deer ejaculate daily during the breeding season, their daily spermatozoan output may approach 50 percent of their caudal epididymal reserves. Assuming the ejaculate concentration would be reduced by 50 percent in deer as it is in dairy bulls ejaculated six or seven times each week (Hafs et al. 1959), the output per ejaculate during the peak of the breeding season should approach 2×10^9 spermatozoa. The ratio between the caudal spermatozoan reserves and the spermatozoa per ejaculate would be about 3:1 in 1.5 year old deer and 4:1 in older deer. This means the white-

tailed deer could probably produce two fertile matings per day at the peak of the breeding season.

Sexual activity of a male is reflected by the ratio between the number of spermatozoa in the cauda epididymis to that in the caput plus corpus epididymis (Ortavant 1958, rams in the breeding season; Almquist and Amann 1961, dairy bulls; Lambiase and Amann 1969, rabbits). The ratio is narrower in frequently mated males than in sexually rested males. In this study the ratio was 2.2:1 for the older males and 2.5:1 for the yearling males. Therefore it appears the older deer had been mating more frequently than the 1.5 year old males. This sexual behavior pattern is not uncommon among Cervidae. Dominance by older males has been observed by Altmann (1960) in elk (Cervus canadenses nelsoni) and Lincoln (1971b) in red deer.

Although the cauda to caput plus corpus epididymis ratio of spermatozoan numbers in fawns was only 1.2:1, this probably represents the lack of ability of the testes to produce spermatozoa in sufficient quantities to build up extra gonadal spermatozoan reserves. The concentration of spermatozoan reserves in the epididymis is a function of spermatozoan production, resorption, and spermatozoan output (Almquist and Amann 1961). The fawn may be resorbing some spermatozoa but there is little likelihood that male fawns contribute substantially to breeding of the adult population. Buckland et al. (1973) provides evidence that male fawns are physically incapable of breeding older does despite

presence of libido.

The contribution of fawns to the productivity of the Radford Arsenal deer herd is probably minimal. One female of 21 examined January through May was pregnant. No evidence of ovulation and lack of successful mating was found. Female fawns have been known to breed successfully in the wild (Cheatum and Morton 1942, in New York and Roseberry and Klimstra 1970, in Illinois). Teer et al. 1965, reported no pregnancies in female fawns in December but found the fawns were examined too early in the breeding season. This is not the situation reported in this study. The body weight of the animals studied was small and may have been the most important factor limiting reproduction by fawns. Nutrition affects the onset of puberty by limiting the body size of animals (Joubert 1963).

A greater percentage of male fawns were fertile (25%: South Carolina and Virginia data combined). Lambiase et al. (1972) collected up to 11×10^6 spermatozoa from male fawns through electroejaculation. The fawns in this study averaged from four to six times this number of spermatozoa in their cauda epididymides, therefore they should be able to ejaculate sufficient spermatozoa for a fertile mating, though physical size would be a limiting factor in breeding adult deer (Buckland et al. 1973). The minimum size of male deer fawns in which spermatogenesis activity was seen was 30 kg.

Almquist and Amann (1961) have shown that differences exist between the left and right testis in terms of weight of organ in cattle. It would be advantageous to know whether such

differences exist in deer in any of the characteristics studies. If none exists the evaluation of these characteristics could be confined to parts of the reproductive tract and also accurate sampling from the live animal could be greatly facilitated. No differences were observed in any parameter measured (testis weight, epididymis weight, numbers of spermatozoa in testis and in epididymis). This allows accurate sampling for determination of male characteristics by removal of one testis as was done in Experiment II. The potential fertility of the male from which a sample is collected is thus not impaired.

SUMMARY AND CONCLUSIONS

Live weights, testes weights, and epididymides weights were examined in white-tailed deer collected from South Carolina in November and December. They were analyzed by age class and for variations between months. Adults (2.5 years old and older deer) were heavier, had greater testes weights, and epididymides weights than yearlings (1.5 year old deer) in November. Testis weights and body weights were significantly ($p < 0.05$) heavier in December in adults than in yearlings. Testes weights (g) in November were 15.12 ± 8.03 , 61.53 ± 17.16 , and 75.69 ± 13.71 for 0.5, 1.5, and older deer, and 14.81 ± 5.34 , 46.66 ± 8.91 , and 61.62 ± 12.91 in December, respectively. Epididymides weights (g) were 3.31 ± 0.78 , 9.61 ± 1.99 , and 12.53 ± 2.30 in November and 3.36 ± 1.02 , 8.92 ± 1.31 , and 10.50 ± 2.07 in December for 0.5, 1.5, and older deer, respectively. Spermatozoan numbers ($\times 10^9$) in the testes were 0.182 ± 2.23 , 6.59 ± 2.96 , and 8.46 ± 3.10 for 0.5, 1.5, and older deer in November and 0.108 ± 0.213 , 5.05 ± 1.05 , and 4.86 ± 2.23 , respectively in December. Epididymal spermatozoan numbers ($\times 10^9$) in November were $0.087 \pm .174$, 9.43 ± 2.85 , and 11.89 ± 4.15 in 0.5, 1.5, and older deer, respectively, and 0.094 ± 0.173 , 8.73 ± 2.44 , and 9.01 ± 4.18 , respectively, in December. Adult deer had more spermatozoa in their testes and epididymides than yearlings in November. This was not the case, however, in December. Fawns had significantly ($p < 0.05$) lighter testes, epididymides, and body weights and significantly ($p < 0.05$) fewer spermatozoa than 1.5 year old deer.

A pattern of regression between November and December was observed in the parameters measured in all deer except fawns. The pattern was as follows; loss of weight in the testes associated with a reduction in the rate of spermatogenesis. There is a loss in the numbers of spermatozoa in the testes. Numbers of spermatozoa passing through the caput plus corpus epididymides are significantly ($p < 0.05$) reduced at this time, but essentially there is no real reduction in numbers of spermatozoa in the cauda epididymis indicating its function as a storage organ.

Spermatozoan numbers in the cauda epididymis are useful in determining mating activity and breeding potential in a male. The ratio of spermatozoan numbers in the cauda epididymis to the caput plus corpus epididymis is indicative of mating activity. The greater ratio indicates a lack of mating by the male. In this study the 1.5 year old deer had a ratio of 2.5:1 compared to 2.2:1 in the older deer in November. Consequently the 1.5 year old deer were probably mating less frequently than older deer. The ratio of spermatozoa in the cauda epididymis to the spermatozoa in an ejaculate is useful in determining spermatozoan output. In this study it was determined that approximately two fertile matings a day could be accomplished during November.

Comparison of the left side of the male reproductive tract with the right provided no significant ($p < 0.01$) differences between testes and epididymides weights and testes and epididymides spermatozoan numbers. This means in future studies only one side of the reproduc-

tive tract need be examined for valid estimates concerning the animals reproductive capacity.

Examination of male and female fawns from the Radford Army Ammunition Plant indicated their limited influence on herd productivity. One female of 21 examined was pregnant. No other female fawns had ovulated. Three of 19 male fawns examined were fertile based on presence of spermatozoa in their testes and epididymides. When male fawns from South Carolina were examined, it was found that fawns which had spermatozoa in their testes and epididymides had heavier testes and epididymides weights than fawns with no spermatozoa in their testes or epididymides.

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A STUDY OF SPERMATOZOAN RESERVES
OF MALE WHITE-TAILED DEER AND
OF THE REPRODUCTIVE PHYSIOLOGY
OF FAWNS

by

David K. Lenker

(ABSTRACT)

Reproductive organs from 73 male white-tailed deer (Odocoileus virginianus) were collected in November and in December in South Carolina. Organ weights and spermatozoan reserves were analyzed by age class and for variation between months. Testes weights (g) in November were 15.12 ± 8.03 , 61.53 ± 17.16 , and 75.69 ± 13.71 for 0.5, 1.5, and older deer, and 14.81 ± 5.34 , 46.66 ± 8.91 , and 61.62 ± 12.91 in December, respectively. Epididymides weights (g) were 3.31 ± 0.78 , 9.61 ± 1.99 , and 12.53 ± 2.30 in November and 3.36 ± 1.02 , 8.92 ± 1.31 , and 10.50 ± 2.07 in December for 0.5, 1.5, and older deer, respectively. Spermatozoan numbers ($\times 10^9$) in the testes were 0.182 ± 2.23 , 6.59 ± 2.96 , and 8.46 ± 3.10 for 0.5, 1.5, and older deer in November and 0.108 ± 0.213 , 5.05 ± 1.05 , and 4.86 ± 2.23 , respectively, in December. Epididymal spermatozoan numbers ($\times 10^9$) in November were $0.087 \pm .174$, 9.43 ± 2.85 , and 11.89 ± 4.15 in 0.5, 1.5, and older deer, respectively, and 0.094 ± 0.173 , 8.73 ± 2.44 , and 9.01

± 4.18 , respectively, in December. The 1.5 year old deer had significant ($P < 0.05$) lighter testes weights than 2.5 years old and older deer in November and December. There was a significant ($P < 0.05$) reduction in testes weights and testicular spermatozoan numbers between November and December in adult deer. Fawn testes and epididymides weights, and testes and epididymides spermatozoan reserves were significantly ($P < 0.05$) lower than older deer in November and in December. Nineteen male and 21 female fawns collected from the Radford Army Ammunition Plant were examined to ascertain attainment of puberty. One female was pregnant and three males had evidence of spermatogenesis.