THE REPRODUCTIVE CYCLE OF THE MALE INDIAN PALM SQUIRREL, *FUNAMBULUS PENNANTI* WROUGHTON

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Summary. The reproductive cycle of the male Indian palm squirrel was investigated from a collection of 365 animals during the period May 1963 to May 1965. It breeds from January to the end of July. This is followed by a period of regression (August–September) and the animals are quiescent during October and November. Redevelopment of the reproductive organs is initiated in December and results in the restoration of reproductive activity in late January. Sexual maturity in squirrels is attained by 8 to 9 months of age. The histological changes in the testis, epididymis and vas deferens with age and breeding season are described. The weights of the prostate gland and seminal vesicles show changes that parallel testicular weights and interstitial cell morphology. However, there is a time lag in the response of accessory glands both during the transition from puberal to the adult condition and in adults during the change from recrudescence to breeding condition. The role of exteroceptive factors in regulating the reproductive cycle of the palm squirrel is discussed.

INTRODUCTION

The rodents exhibit a variety of reproductive patterns; some show continuous reproductive activity while others show cyclical periodicity. The reproductive cycle in rodents belonging to the family Sciuridae has been studied by many investigators (Rasmussen, 1917; Allanson, 1933; Moore, Simmons, Wells, Zalesky & Nelson, 1934; Wells, 1935; Rowlands, 1938; Prasad, 1951; Layne, 1954; Kirkpatrick, 1955; McKeever, 1963, 1964, 1966). The majority of sciurid species investigated are hibernators in which the endocrine glands exhibit cyclical changes in response to hibernation and arousal. The mosaic of endocrine and other physiological factors which regulate the onset of hibernation and arousal precludes definite conclusions to be drawn about their role in the regulation of cyclical activity of gonads and other accessory glands. Prasad (1951) showed that the three-striped palm squirrel, *Funambulus palmarum* of South India does not hibernate and is spermatogenically active throughout the year. The present study deals with the reproductive cycle of a related species, *Funambulus pennanti*, occurring in Northern India.

MATERIAL AND METHODS

The five-striped Indian palm squirrel, *Funambulus pennanti*, is arboreal in habit. It abounds on trees close to human habitation and is a diurnal and non-hibernating species.

This investigation was based on a study of 365 male squirrels which were trapped alive in the vicinity of the University of Delhi. Weekly collections were made during the period May 1963 to May 1965 and the animals autopsied about 10 to 12 hr after capture when the stomach was nearly empty.

At autopsy the body weight and snout-vent length (length from the tip of the nostrils to the anus, also referred to as body length) were recorded. The testes, epididymides, prostate, seminal vesicles, adrenals, thyroid and spleen were dissected and weighed on a precision torsion balance to the nearest 0.2 mg and fixed in Bouin's fluid and Zenker-formol fixatives for histological studies. The combined weights of all paired organs were recorded. The os penis was dissected and cleaned of extraneous tissue by immersing it briefly in 20% KOH solution followed by washing in water. It was then dried to constant weight at 37° C for 1 week and weighed on a Mettler semi-micro balance. For histological studies sections of testis were cut at 5 to 7 μ and stained by the periodic acid-Schiff (PAS) and haematoxylin procedure and in haematoxylin-eosin. The sections of other accessory glands were stained in haematoxylin-eosin and R. A. Groat's tetrachrome stain (Dr H. W. Mossman, personal communication). For the measurement of diameter of seminiferous tubules, sections taken from the middle of the testis were used. Two diameters of each tubule were measured by means of an ocular micrometer at a magnification of 400. The average of fifty measurements from twenty-five tubules in each animal was taken as the diameter of the tubule.

The presence of spermatozoa in the epididymis and vas deferens was considered as a sign of sexual maturity and reproductive activity. In addition, the weight of the os penis was used in classifying animals according to the different age groups. This bone was heavier in the mature squirrels (11 to 17 mg) than in the immature squirrels (2.5 to 7.5 mg). The classification of each squirrel, by age and breeding season, based on weight of the os penis as well as weight and histology of the testes and accessory glands is shown below:

BREEDING SEASON			
Mature			
Breeding (January–July)	Regressing (August–September)	Quiescent (October–November)	Recrudescence (December)
1. Spermatozoa are present in cauda epididymidis and vas deferens	Spermatozoa present in epididymis	Absence of spermatozoa in epididymis and vas deferens	Spermatozoa present mostly in epididymis
2. Active spermatogenesis	Early stages of degeneration of spermatocytes	Spermatogenesis arrested at spermatocyte stage	Early stages of restoration of spermatogenesis
3. Functional accessory glands with secretory epithelia	Regressing accessory glands with involuting epithelia	Accessory glands non-secretory; atrophy of epithelium and apparent increase in connective tissue	Redevelopment of accessory glands
4. Blood vessels on the tunica of testis with straight contour	Progressive convolution of the blood vessels on tunica	Fully convoluted blood vessels	Progressive changes leading to straight blood vessels

OBSERVATIONS AND DISCUSSION

GROWTH OF YOUNG AND AGE AT SEXUAL MATURITY

Squirrels are born from March to August. Immature males appear in the field for the first time in April and thereafter throughout the breeding period; however, two peaks of abundance are seen in July and September and are possibly a sequel to the peaks of pregnancies in March and July (Seth, 1966).

Body weight and length

The body weight and length of the early-born immature squirrels begin to increase from August–September, attaining adult size by October–November. This results in a considerable overlap in body weight and length making it difficult to distinguish, externally, growing immature animals from quiescent adults and recrudescing animals. In immature squirrels growth of the testes fails to keep pace with increase in body weight.

Testes and age at puberty

The testes descend into the scrotum at an early age and remain permanently scrotal thereafter.

The changes in weight of the testes in immature squirrels are shown in Table 1. The first set of young, born during the earliest part of the breeding season and which appears in the field in April, shows a gradual increase in the weight of the testes till July. This is followed by a decrease in August which is maintained till October; there is a marked increase in testes weight in November. Based on body weight, weight of the os penis and testicular weight and histology, two populations can be recognized in any collection of immature squirrels from July onwards; one set born early during the breeding season and the other representing those born at different intervals thereafter. The occurrence in

December of squirrels characterized by (a) body length of 14.5 to 15.0 cm, (b) os penis weight of 6 to 7.5 mg, (c) testes weight of 400 to 480 mg, and (d) the presence of spermatozoa in the testes, indicates that young born early during the breeding season (March) become sexually mature by December. Hence the period of sexual immaturity in such squirrels is 8 to 9 months. Irrespective of the time of birth in the breeding season, all the immature squirrels are sexually mature by March of the following year. Hence, it is likely that a squirrel born late in the breeding season, in August, has a period of sexual immaturity of 7 to 8 months. The period of immaturity in *Sciurus carolinensis* and *Tamias striatus* (Allanson, 1933; Mossman, Hoffman & Kirkpatrick, 1955) is about a year.

TABLE 1
SEASONAL CHANGES IN THE WEIGHTS OF THE REPRODUCTIVE ORGANS OF
IMMATURE MALE PALM SQUIRRELS (MEANS $\pm$ S.E.)

Month	No. of animals	Testes		Epididymides (mg)	Prostate (mg)	Seminal vesicles (mg)
		Absolute (mg)	Relative (mg/100 g)			
January	10	386 $\pm$ 31	430 $\pm$ 35	124 $\pm$ 8	35 $\pm$ 5.2	16 $\pm$ 3.5
February	5	482 $\pm$ 66	518 $\pm$ 79	167 $\pm$ 10	68 $\pm$ 20.6	30 $\pm$ 8.0
March	1	462	557	204	63	33
April	2	48	67	24	7	5
May	7	43 $\pm$ 5	71 $\pm$ 8	24 $\pm$ 4	11 $\pm$ 2.4	9 $\pm$ 2.2
June	10	75 $\pm$ 36	127 $\pm$ 48	40 $\pm$ 11	9 $\pm$ 0.9	5 $\pm$ 1.1
July	15	79 $\pm$ 39	90 $\pm$ 35	36 $\pm$ 8	9 $\pm$ 1.9	5 $\pm$ 1.0
August	12	59 $\pm$ 16	65 $\pm$ 16	28 $\pm$ 3	8 $\pm$ 1.1	5 $\pm$ 0.7
September	20	42 $\pm$ 3	53 $\pm$ 4	25 $\pm$ 2	8 $\pm$ 0.5	4 $\pm$ 0.2
October	17	62 $\pm$ 8	68 $\pm$ 7	34 $\pm$ 4	7 $\pm$ 0.7	4 $\pm$ 0.5
November	17	177 $\pm$ 36	181 $\pm$ 30	61 $\pm$ 9	9 $\pm$ 1.0	5 $\pm$ 0.7
December	14	177 $\pm$ 48	185 $\pm$ 43	73 $\pm$ 19	15 $\pm$ 3.4	7 $\pm$ 1.4

Prepuberal. The prepuberal testes weigh 30 to 300 mg and occur in squirrels collected between April and December. They consist of closely packed solid seminiferous cords with a diameter of 30 to 40 μ . The basement membrane enveloping the tubules is smooth. The cords contain only gonocytes or primordial germ cells with large spherical nuclei and supporting cells with oval nuclei (Pl. 1, Fig. 1). With increase in the testis weight, many of the gonocytes migrate towards the periphery of the cords and some degenerate as evidenced by enlargement of the nucleus resulting in fragmentation (Pl. 1, Fig. 2).

In testes weighing 50 to 70 mg the gonocytes divide to form Type A spermatogonia which are characterized by 'dusty' chromatin in the nuclei; the supporting cells give rise to Sertoli cells (Pl. 1, Fig. 3). The first primary spermatocytes and the earliest signs of lumen formation are seen in testes weighing between 100 and 150 mg (Pl. 1, Figs. 4 and 5). With the increase in testes weight to 230 to 300 mg the lumen widens and the diameter of the tubules increases to 80 to 100 μ (Pl. 1, Fig. 6). The migration of gonocytes and their division to form Type A spermatogonia in the palm squirrel are similar to the findings of Clermont & Perey (1957), Beaumont & Mandl (1963) and Huckins (1963) in the rat. The gonocytes are present in the palm squirrel testis for nearly 3 to 4 months after birth whereas in the rat most of them disappear by 4 to 6

days of age. Since these squirrels were caught in the wild, their age can only be approximately assessed, based on criteria already described.

The Leydig cells are in the form of fusiform mesenchymal cells located in the intertubular spaces. The cells have very little cytoplasm and do not show sudanophilia.

Puberal. This condition is reached during January or February when the testes weigh between 386 and 482 mg, and spermatozoa are first seen in the lumen of the tubules. The late puberal animals show spermatozoa only in the caput epididymidis and not in the vas deferens. The cytoplasm of the interstitial cells is sudanophilic and the cells appear secretory.

BREEDING SEASON

The palm squirrel is a seasonal breeder in which spermatogenic activity continues from January to July. The testicular weight begins to decrease in August reaching the lowest level in October. Following this period of regression, squirrels are quiescent in October and November (Table 2). Recrudescence of

TABLE 2
SEASONAL CHANGES IN THE WEIGHTS OF THE REPRODUCTIVE ORGANS OF
MATURE MALE PALM SQUIRRELS (MEANS $\pm$ S.E.)

Month	No. of animals	Testes		Epididymides (mg)	Prostate (mg)	Seminal vesicles (mg)
		Absolute (mg)	Relative (mg/100 g)			
January	22	1019 $\pm$ 53	908 $\pm$ 44	297 $\pm$ 21	302 $\pm$ 26	219 $\pm$ 19
February	24	992 $\pm$ 35	940 $\pm$ 29	297 $\pm$ 6	316 $\pm$ 19	259 $\pm$ 22
March	30	1004 $\pm$ 36	974 $\pm$ 52	298 $\pm$ 11	340 $\pm$ 16	287 $\pm$ 11
April	30	1082 $\pm$ 39	1021 $\pm$ 33	317 $\pm$ 13	368 $\pm$ 14	289 $\pm$ 12
May	28	1038 $\pm$ 43	958 $\pm$ 40	317 $\pm$ 8	324 $\pm$ 13	237 $\pm$ 16
June	15	1147 $\pm$ 49	1096 $\pm$ 47	393 $\pm$ 25	378 $\pm$ 25	338 $\pm$ 23
July	13	996 $\pm$ 30	916 $\pm$ 19	345 $\pm$ 9	281 $\pm$ 25	220 $\pm$ 22
August	15	863 $\pm$ 69	815 $\pm$ 64	334 $\pm$ 13	285 $\pm$ 27	134 $\pm$ 16
September	9	578 $\pm$ 112	546 $\pm$ 106	234 $\pm$ 34	158 $\pm$ 29	74 $\pm$ 15
October	14	419 $\pm$ 103	372 $\pm$ 90	173 $\pm$ 33	98 $\pm$ 14	43 $\pm$ 4
November	13	431 $\pm$ 77	338 $\pm$ 44	146 $\pm$ 13	63 $\pm$ 4	38 $\pm$ 3
December	13	1006 $\pm$ 59	843 $\pm$ 49	266 $\pm$ 16	176 $\pm$ 33	83 $\pm$ 17

the testes and other related organs is initiated in early December and results in the restoration of reproductive activity in January when weights of the testes attain the breeding condition.

Testes

Active spermatogenesis is observed throughout the breeding season (Pl. 2, Fig. 7). In January, squirrels with functional testes include puberal males approaching their first breeding season and adults about to breed for the second or third season. The distinction between the two groups becomes increasingly difficult as the breeding season advances. The squirrels showing spermatozoa both in the epididymis and vas deferens and having functional accessory glands

are designated as adults. The presence of spermatozoa in epididymis and vas deferens cannot be the sole criterion for classifying an animal as adult, since there is a time lag between the spermatogenic activity of the testes and that of the secretory activity of the accessory glands (Reddi, 1966). When fully functional the testes weigh between 900 and 1500 mg and the seminiferous tubules have an average diameter of about 150 μ . The interstitial cells are large and polyhedral and possess spherical vesicular nuclei containing prominent nucleoli (Pl. 3, Fig. 11). The cytoplasm exhibits intense sudanophilia indicative of secretory activity (Pl. 3, Fig. 15).

During August the majority of testes show early signs of regression in the form of a disorganization of the spermatids and spermatocytes which are desquamated into the lumen of the tubules (Pl. 2, Fig. 8). A few of these cells are observed in the epididymis. The diameter of the tubules becomes gradually reduced and ranges between 110 and 120 μ (Pl. 2, Fig. 9). The testicular regression is not synchronous in all the squirrels of a population. The interstitial cells decrease in size and secretory activity (Pl. 3, Fig. 12); the sudanophilic material and PAS-positive granules are decreased considerably. Later in regression the seminiferous tubules become irregular in outline and there is an apparent increase in the intertubular space.

Squirrels are sexually inactive during October and November. The weight of the testes varies between 130 and 250 mg, representing a six- to seven-fold decrease compared to the condition in adults during the breeding season. During this period there is an overlap in the testicular weights of quiescent animals and those in different stages of growth and maturity. While the quiescent testis has a wrinkled tunica and blood vessels with wavy outline, the puberal testis has a smooth tunica traversed by blood vessels with straight contours. In addition to the weight of the os penis (see Material and Methods), the nature of blood vessels on the tunica is yet another diagnostic feature in distinguishing the puberal from quiescent animals. The majority of seminiferous tubules in the quiescent animals show primary spermatocytes as the terminal stage in development, while a few show regression to a condition in which only spermatogonia and Sertoli cells are present (Pl. 2, Fig. 10). The diameter of the tubules in these quiescent squirrels ranges between 60 and 80 μ and the lumen is obliterated. There is an apparent increase in the number of Sertoli cells per cross-section of the tubule. In the absence of any mitoses in the Sertoli cells, this increase in their number is probably due to the shortening of seminiferous tubules. The interstitial cells appear non-secretory; the nuclei are oval and small. The sudanophilia and PAS-positive granules, so characteristic of the active testis, are absent in the quiescent state (Pl. 3, Figs. 13 and 16). The interstitial cells are indistinguishable from the intertubular connective tissue cells.

The first signs of recrudescence of the testes are observed in the last week of November and early December when their weights begin to increase. There is a parallel increase in the diameter of seminiferous tubules. The rapid recrudescence of the gonads is marked by quick and successive appearance of primary spermatocytes, secondary spermatocytes, spermatids and spermatozoa within a month's duration. By the end of December the majority of animals have spermatozoa in the testes. The interstitial cells again become secretory as

evidenced by their vesicular nuclei (Pl. 3, Fig. 14), increased sudanophilia and PAS-positive reaction.

The cyclical changes in the seminiferous tubules during different periods of the year observed in the palm squirrel are similar to those in the fox squirrel, *Sciurus niger* (Kirkpatrick, 1955).

Epididymis and vas deferens

The weight of the epididymis closely parallels testicular growth in immature squirrels (Table 1). The prepuberal epididymis is characterized by a narrow lumen with a low cuboidal epithelium (Pl. 4, Fig. 17); the cellular connective tissue is in the form of a dense network surrounding the epididymal tubules. With increasing testis weights the epithelium differentiates to the adult secretory type with tall columnar cells (Pl. 4, Fig. 18). Spermatozoa reach the epididymis only in late puberal animals. As the epididymal tubules become packed with spermatozoa (Pl. 4, Fig. 19), the tubules are distended accompanied by a reduction in the intertubular connective tissue. In the adult animals the epididymis weighs between 280 and 380 mg during the breeding season.

At the end of the breeding season the epididymis undergoes sequential changes that parallel those in the testis, and its weight decreases gradually during this period to quiescent levels in October and November (Table 2). In the regressing animals spermatozoa occur in the epididymis in spite of a marked reduction in spermatogenic activity. During the later stages of regression, spermatocytes desquamated from the testes are seen in the epididymal tubules. The epididymal tubules are empty during quiescence and the height of the epithelium is considerably reduced (Pl. 4, Fig. 20). During recrudescence, in December, the epididymal epithelium becomes functional before the migration of spermatozoa in a manner similar to that seen in puberal animals.

The vas deferens is canalized in early prepuberal animals (Pl. 4, Fig. 21). The moderately tall columnar epithelium of prepuberal animals changes to the pseudo-stratified tall columnar type in puberal animals (Pl. 4, Fig. 22). In the adult breeding animals the lumen of the vas deferens is packed with spermatozoa (Pl. 4, Fig. 23). The vas deferens is devoid of spermatozoa and the epithelium is reduced during quiescence (Pl. 4, Fig. 24). The changes in the vas deferens are similar to those observed in the epididymis.

Accessory glands

In immature animals examined between April and December the weights of the prostate and seminal vesicles range from 7 to 14 mg and 5 to 9 mg respectively and during January they enlarge in response to increasing testicular activity. However, there is a time lag of about 3 to 4 weeks between the appearance of spermatozoa in the testis and the onset of secretory activity in the accessory glands.

In the adults a similar correlation between the growth of the accessory organs and testes was seen throughout the reproductive cycle (Table 2). The weights of the seminal vesicles decrease sharply during the regressing period while that of the prostate is gradual. During recrudescence, the recovery of testicular activity precedes the onset of secretory activity in the accessory glands. The prostate is

more responsive than the seminal vesicles to changes in testis weight in early January, following the onset of spermatogenic activity. The seminal vesicles become secretory only by the end of January. The changes in the testes and accessory glands during recrudescence are similar to those observed during the transition from the puberal to the adult condition. The weights of the Cowper's glands could not be determined as they are enclosed in the musculature of the bulb.

The changes in the morphology of the Leydig cells of the squirrel are correlated with functional activity of the accessory glands. The present findings are similar to the observations of Hooker (1944, 1948) and Hay, Lindner & Mann (1961) in the bull; Baillie (1961, 1964) in the mouse; Clegg (1966) in the rat; Wislocki (1949) in the deer; and Short & Mann (1966) in the roebuck. The changes in the interstitial cell sudanophilia with age and breeding season in the palm squirrel are similar to the observations of Clegg (1966) and Lofts (1960). These results are further confirmed by changes in the histology of the accessory glands and the variations in the accessory gland fructose and citric acid during the different seasons of the year which will be published elsewhere.

The weights of adrenals, thyroid and spleen do not show any marked changes with age and reproductive cycle of the squirrel.

EXTEROCEPTIVE FACTORS AND THE REPRODUCTIVE CYCLE

The Indian palm squirrel, *Funambulus pennanti*, occurring in and around Delhi (28° 12' N latitude) is a seasonal breeder from January to July. It differs from a related species of the same genus *F. palmarum* occurring in the latitude of Bangalore (12° 58' N) in South India, which breeds throughout the year (Prasad, 1951) and is an example of the influence of latitude on breeding season in related species of mammals. Environmental factors have been correlated with the initiation, maintenance and regression of reproductive activity in the palm squirrel.

Food

The palm squirrels feed on nuts, seeds, tender leaves and insect larvae depending upon their availability in the different months of the year (Prasad, Dhaliwal, Seth, Reddi, Sivashankar & Uberoi, 1966). In view of this wide range of food habits it appears unlikely that food can be a factor in regulating the reproductive cycle of the palm squirrel.

Light

The palm squirrels are diurnal in habit and it is important to consider day length as a probable factor in the control of reproductive activity. There is a progressive decline in the weight and spermatogenic activity of the testis in August when day length begins to decrease (Text-fig. 1). This presumably is a factor responsible for the regression of the reproductive organs; on the other hand, the testes begin to redevelop in December when day length is still decreasing; they are spermatogenically active in January before the gradual increase in day length. These observations indicate that recrudescence of reproductive activity may be independent of changes in day length.

Temperature

Delhi is subject to maximum temperatures of 40 to 43° C in May and June. The temperature begins to decrease in October reaching the lowest in December and January. The reproductive cycle does not correlate with changes in temperature (Text-fig. 1) and this is not surprising since these squirrels are non-hibernating and are active throughout the year.

Rainfall

Maximum rainfall is recorded in Delhi during July to September and it appears to have no relation to the reproductive cycle.

TEXT-FIG. 1. Relationship between the seasonal changes in environmental factors (light and temperature) and the reproductive cycle.

From the foregoing consideration of the role of exteroceptive factors in the regulation of the reproductive cycle, it appears that decreasing day lengths may have a role in the onset of regression. However, the initiation of recrudescence cannot be related either to day length or any other environmental factor. It is possible that an annual internal rhythm initiates the onset of reproductive activity. The nature of the internal rhythm and the intrinsic factors regulating it are not clear at present.

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PLATE 1

(Facing p. 244)

PLATE 2

PLATE 3

PLATE 4

EXPLANATION OF PLATES

PLATE 1

Figs. 1 to 6. Photomicrographs of histological sections of testes at different stages during transition from early prepuberal to puberal squirrels. $\times 495$.

FIG. 1. Section through testis of an early prepuberal animal showing gonocytes and supporting cells in the seminiferous cords. Interstitial cells are in the form of mesenchymal cells.

FIG. 2. The arrows point to degenerating gonocytes as evidenced by nuclear fragmentation.

FIG. 3. The seminiferous cords are lined by spermatogonia and Sertoli cells.

FIG. 4. A late prepuberal animal showing primary spermatocytes. The earliest signs of lumen formation are seen.

FIG. 5. The lumen of seminiferous tubules is lined by pachytene spermatocytes.

FIG. 6. The diameter of the seminiferous tubules is considerably increased and the spermatids are observed.

PLATE 2

Figs. 7 to 10. Histological sections showing the changes in the testes of mature squirrels during different periods of the reproductive cycle. $\times 550$.

FIG. 7. Section showing active spermatogenesis during the breeding season.

FIG. 8. The desquamation of spermatocytes into the lumen during the regressing period.

FIG. 9. At a later stage during regression pachytene spermatocytes line the lumen of the seminiferous tubules.

FIG. 10. Section through the testis of a squirrel during the quiescent period showing spermatocytes, spermatogonia and Sertoli cells. Note the obliteration of the lumen of seminiferous tubules.

PLATE 3

Figs. 11 to 14. Morphology of the interstitial cells during the different periods of the reproductive cycle. $\times 1080$.

FIG. 11. The interstitial cells are well developed and appear secretory during the breeding season.

FIG. 12. There is a marked reduction in the interstitial cell cytoplasm during the regressing period.

FIG. 13. The interstitial cells appear atrophic and non-secretory in the quiescent testis.

FIG. 14. The interstitial cells increase in size following the onset of recrudescence.

Figs. 15 and 16. Histological sections through the testis stained with Sudan Black B to demonstrate sudanophilia. $\times 1080$.

FIG. 15. The interstitial cells exhibit characteristic sudanophilia during the breeding season.

FIG. 16. Note the absence of sudanophilia in the interstitial cells of a quiescent squirrel.

PLATE 4

Figs. 17 to 20. Sections through the corpus epididymidis (mid-epididymis) showing changes with age and reproductive cycle. $\times 256$.

FIG. 17. The epididymal lumen is narrow with a low cuboidal epithelium in a prepuberal squirrel.

FIG. 18. In the puberal animal the epididymal epithelium is tall columnar and is secretory. Spermatozoa have not yet migrated into the epididymis.

FIG. 19. The epididymal tubules are distended with spermatozoa in an adult squirrel during the breeding season.

FIG. 20. The epididymal tubules lack spermatozoa and are considerably reduced in diameter in an adult squirrel during the quiescent period.

Figs. 21 to 24. Sections through the vas deferens showing changes with age and reproductive cycle.

FIG. 21. The epithelium is cuboidal in the vas deferens of a prepuberal squirrel. $\times 96$.

FIG. 22. The vas deferens has a pseudostratified tall columnar epithelium in a puberal squirrel. $\times 56$.

FIG. 23. The lumen of the vas deferens is packed with spermatozoa in an adult squirrel during the breeding season. $\times 56$.

FIG. 24. The epithelium of the vas deferens is considerably reduced and the lumen is empty in an adult squirrel during the quiescent period. $\times 56$.