STUDIES ON THE REPRODUCTIVE CYCLE OF THE POCKET GOPHER *GEOMYS BURSARIUS* (SHAW)

by

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INTRODUCTION

Literature dealing with the pocket gopher, Geomys bursarius (Shaw), is relatively scarce and is concerned principally with the economic importance. Therefore, it is of interest that further enlightenment be gained in other phases of investigation.

It is the present tendency of numerous workers to turn to the field of reproduction in correlation with endocrine activities. This field is being thoroughly investigated using numerous animals, but until the present very little has been found out about the pocket gopher. There are various ways of carrying out an investigation of this nature but the most feasible means is to use histological studies as the main basis of procedure because this overcomes the difficulty of keeping the animals alive in the laboratory. This plan of investigation is followed in order to study the various phases of the reproductive cycle of the pocket gopher and to attempt to correlate endocrine functions of the gonads, adrenals, thymus, thyroid, anterior hypophysis and pineal with this cycle.

REVIEW OF LITERATURE

The majority of rodents are polyoestrus with a breeding

season extending over several months according to Marshall (1922). However, Scheffer (1931) says that the pocket gopher, Geomys bursarius, probably has one litter a year born in the spring. English (1951) finds that the breeding season of the pocket gopher, Geomys breviceps breviceps begins in January or February and lasts until July with only one litter. This gives evidence that gophers of the genus Geomys are monoestrus but of three species of the genus Thomomys examined, two of them, Thomomys quadratus quadratus, according to Wight (1915), and Thomomys townsendi according to Horn (1908), have two litters a year; while the third, Thomomys bulbivorous, has one litter a year (Wight, 1918).

By way of comparison to other mammals living underground it might be stated that the starnosed mole, Condylura cristata, an insectivore, seems to have only one litter a year with young recorded from April 18 until the middle of June (Hamilton, 1931).

Various periods of the monoestrous female mammal are recognized by Marshall (1922). The non-breeding season (anoestrus) or period of rest is when the generative organs are quiescent and the uterus is normal and comparatively anaemic. The animal shows no disposition to seek out a mate. The first part of the breeding season (proestrus) is characterized by marked changes in the generative organs.

The height of the breeding season when coitus takes place is the period of oestrus. If this is successful there is a period of gestation followed by birth, lactation and nursing with final return to normal. If coitus does not take place or is not successful there is a short period (metoestrus) during which activity gradually subsides and returns to normal.

Another type of monoestrous rodent is the thirteen lined ground squirrel (Citellus tridecemlineatus). Studies on the ovary of this squirrel by Dripe (1919) show that ovulation occurs only once a year. This occurs during rut and is dependent on the stimulus of coitus.

Among the polyoestrous or dioestrous wild rodent on which work has been recently done is the gray squirrel. Deanesly and Parkes (1933) worked out the oestrus cycle of the female gray squirrel (Sciurus carolinensis). All animals obtained from August to the middle of January were prepubertal or anoestrus except five still lactating in autumn. Parous squirrels commonly breed in spring and may do so again in summer. Some of the first year ones breed in spring and others not until summer. There is no period of oestrus immediately after parturition or during lactation.

Allanson (1933) found male gray squirrels (Sciurus carolinensis) with fully functional testes throughout the

year with no regular period of quiescence. She also states that it is possible that individuals do not remain continuously in reproductive activity.

An interesting phase of reproductive phenomena is the relaxation or absorption of the pubic symphyses to facilitate birth of young. Hisaw (1924) found from examination of a thousand pocket gophers during a four year interval that when females are almost a year old the pubic bones start being resorbed first in the symphysis region then laterally almost to the obturator foramen. Absorption is correlated with the genital activities of the reproductive system preceding pregnancy and is usually complete before copulation.

Castrated males lose their symphyses if given intraperitoneal injections of desiccated ovarian substance.

Later Hisaw (1929) showed that extracts of sow corpora lutea caused relaxation of the pelvic ligaments.

The symphysial ligament is a wide band in the guinea-pig when young are born. It returns to the normal position but never gets firm as in the virgin (Bland-Sutton, 1911).

A characteristic of a great many wild rodents whether they be monoestrous or polyoestrous is a prolonged winter anoestrous period. Parkes and Brambell (1927) attribute this prolonged winter anoestrus of wild rodents to a dimin-

ished food supply under conditions of temperature which for the maintenance of normal function would require an increase of food.

Histology bears an important relation to any interpretation of physiological function with the result that most workers in that particular field include it as an essential feature. Histological studies of the reproductive tracts of both wild and laboratory rodents aid in revealing the nature of cyclic changes taking place. Rasmussen (1917) found that the testis of the woodchuck (Marmota monax) undergoes a marked annual change in size, position and histological structure. In spring during rutting the interstitial cells increase greatly in size due to the accumulation of lipoids in the cytoplasm. There is also apparently an increase in cells. In July and August they decrease in size again. In 1918 he found a marked annual periodicity in the interstitial cells of the ovary of the woodchuck consisting of a gradual enlargement during winter followed by a more rapid hypertrophy after hibernation.

Edgar Allen (1922) states that in the mouse histological changes in the uterus consist of periodic growth, degeneration and leucocytosis of the epithelial cells. The changes coincide with those in the vagina. There is

evidence that ovulation occurs only at the time of copulation and spontaneously only once after parturition.

Studies by Loeb (1923) reveal three types of mammalian ovary as represented by the guinea-pig, rat and rabbit. In the guinea-pig during oestrus before ovulation most follicles except very small ones degenerate. In the rat ovulation is not preceded by atresia of follicles and in the rabbit there is no atresia en masse. Spontaneous ovulation does not occur before maturation. If copulation does not occur atresia of large follicles takes place. Small follicles may also become atretic.

Corner (1923) states that the onset of oestrus is preceded or accompanied by changes (enlargement) in the graafian follicles.

The relation of certain of the endocrine or ductless glands to the reproductive cycle brings about another important relation of histological structure to physiological function.

Charipper and Haterius (1932) found that the anterior pituitary of the female albino rat undergoes a definite cyclic rhythm in predominant cell types as revealed histologically. The rhythm is correlated with the phase of sex cycle present when obtained. During oestrus they are mostly basophylic and during diocstrus they are mostly eosinophylic.

In the nulliparous rat, pregnancy changes manifest themselves on the third and fourth days following copulation, both through a marked hyperemia and the appearance of an eosinophil cell type characterized by a clear almost homogeneous cytoplasm and an eccentric besicular nucleus (Materius, 1932).

Rasmussen (1925) determined the relative number of different types of cells in the normal adult male human anterior pituitary.

Chromophobes - 37 to 65 per cent, average 57 per cent.

Acidophils - 23 to 45 per cent, average 31 per cent.

Basophils - 5 to 27 per cent, average 12 per cent.

Later (1929) he made a differentiated count of 10,000 to 30,000 cells from 100 to 350 microscopic fields taken systematically from three different regions using 100 supposedly normal glands.

Chromophobes - 34 to 66 per cent, average 50 per cent. Coefficient of variation is 15.

Acidophiles - 23 to 59 per cent, average 37 per cent. Coefficient of variation is 21.

Basophiles - 5 to 27 per cent, average 11 per cent. Coefficient of variation is 34.

Joffe and Marine (1923) basing experiments on the fact that hypertrophic change occurs both in the interstitial

tissue of the ovary and in the adrenal cortex in certain animals during pregnancy determined the effect of removal of the adrenal glands on the ovary in rabbits. A moderate or marked ovarian enlargement was observed in 76 per cent of rabbits which survived double suprarenalectomy over 30 days. This enlargement consisted essentially of hypertrophy of the interstitial cells which is a compensatory reaction. In another paper the authors found no effect on the cells of Leydig in the testes.

The interstitial cells of the ovary and testis are suspected of having endocrine function. Shaw (1926) states that interstitial cells are found in the human ovary from late intrauterine life to the menopause. They are derived from the theta interna cells of the follicles. The function is obscure.

METHODS AND MATERIAL

General Technic

The pocket gophers used in this study were taken from Riley County, Kansas, in the vicinity of Manhattan, and were of the species Geomys bursarius (Shaw). Most of the animals were taken in steel traps and brought in by trappers at fairly regular intervals since February, 1932. Some were dead and the majority of those alive had suffered some

degree of injury by the traps. An attempt was made to keep some of these alive in the laboratory but it failed principally because of the injuries they had received. Each animal was numbered and full data concerning it were recorded. All the animals were weighed and the live animals were killed with ether or by striking across the thoracic vertebrae with a stick. The testes in the males were measured in millimeters (length, width and thickness) and the ovaries and width of the uterine horn were measured in the females. The organs used in this study were then selected and prepared for histological examination.

The length, width and thickness of the right gonad were multiplied together in both male and female thus giving roughly the comparative volumes for the different animals. Since the measurements of the two gonads of an animal were almost identical the volume of the left was not computed.

A graph (Fig. 1) was then prepared from these volume measurements which showed the increase and decrease in the size of the gonads throughout the year.

Full data were recorded for all animals in regard to the appearance of the external genitalia. In the males if the testes were descended in a scrotum they were called "scrotal", otherwise they were called "non-scrotal". In the female the vagina was recorded as either "open" or

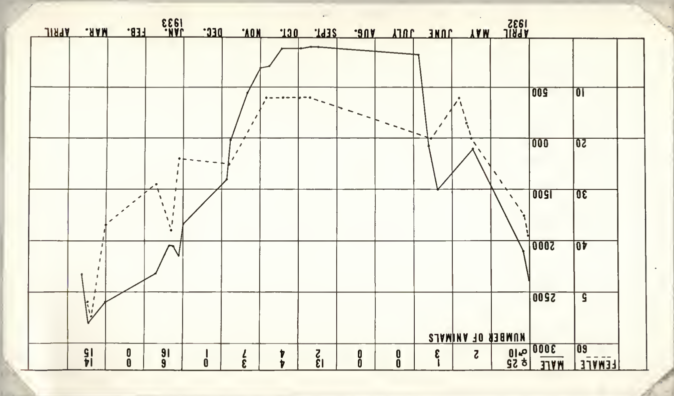

Fig. 1. A graph made from volume measurements in cubic millimeters of the right gonads of the male and female gophers showing changes throughout the year.

"closed". The pelvic girdle was felt with the fingers to determine whether the bones of the pubic symphysis had been resorbed or not. The condition of these bones determined the degree of maturity of the female as they are completely absorbed by the time of full sexual maturity and never grow back. The degree of maturity of the males could only be roughly determined by the size and weight of the animals. The larger ones approaching a weight of two hundred grams or more were considered fully mature because the majority of the sexually active males examined when scrotal weighed at least that much.

Histological Technic

From animals received alive and from some which had very recently died were selected the reproductive organs and various endocrine organs. The gonads, accessory reproductive organs (which in the male consist of Cowper's and prostate glands and in the female of uterus and vagina), adrenal glands, thymus, thyroid, pineal and anterior hypophysis were taken out and the whole organ or a representative portion was fixed in Bouin's fluid for about twelve hours. In the case of the testes the Bouin's fluid was usually modified by warming and by adding a few urea crystals. After fixation the tissues were imbedded in

paraffin and cut 10 micra in thickness with the microtome. Hematin and eosin bluish according to Kornhauser's method were used for staining all tissue. Usually one slide was made of each organ but a few selected ovaries were sectioned completely.

THE SEXUAL CYCLE OF THE FEMALE

Gross measurements of the reproductive organs in millimeters accompanied by histological studies as previously explained reveal a yearly cyclic enlargement with characteristic changes. These observations and the fact that very young gophers are found only in spring and early summer give fairly conclusive evidence that this species has a monoestrous (anoestrous) cycle.

Ovaries

A graph (Fig. 1) made of the relative volume measurements of the ovaries of adult females show that enlargement of these organs begins in early November, reaches a maximum in February and March and then steadily declines until late May and early June. From this time until November again they remain fairly constant in size. Histological changes are closely correlated with the volume changes.

The typical ovary in the resting condition (Fig. 3) is characterized by atrophic condition of the interstitial and stromal tissue; the individual cells appear shrunken and the nuclei quite elongate. Three or four layers of small oogonial cells are in the outer cortex while in the center of the ovary there are a number of small follicles in various degrees of atresia and one or more small healthy follicles. These healthy follicles finally become atretic before reaching any great size. As the reproductive season advances beginning in late October and November there is a gradual increase in the number and size of the interstitial and stromal cells. When the reproductive season as shown by pregnancies reaches its height late in January until April the ovaries reach their maximum size (Fig. 4). The oogonial cells consist of a single irregular layer. The center of the ovary contains only a few small or large atretic follicles. One or more follicles to each ovary become mature and gradually approach the outer edge. When the follicles reach their maximum size there is a period of heat in which the female receives the male but it has not been determined whether copulation is necessary for ovulation to occur or whether it takes place after ovulation in this species. Corpora lutea formed after ovulation became large but never reach any striking size (Fig. 5).

After the sexual season has reached its climax there is a gradually regression from late April until late June when there is a complete return to the resting condition.

Uterus

The uterus of the virgin female is about 1 mm. in diameter during the period from the latter part of June to late October while that of the female that has had one or more litters is about 2 mm. in diameter (Fig. 6). A section of the uterus at this stage shows a rather general atrophic or inactive condition. The lumen is rather narrow and irregularly elongate while the lining is made up of low columnar epithelium with no indication of individual glands or goblet cells. Shallow uterine glands are infolded at intervals and there is no indication of secretion into the lumen. The mucosa is very compact with no marked vascularity or blood spaces. The muscularis and submucosa present a somewhat similar appearance. All cells appear rather depleted and shrunken.

As the reproductive season advances from late October until it reaches its height in January to April a marked hypertrophy takes place in all parts of the uterus (Fig. 7). The lumen becomes more open with a tendency to be rounded rather than elongate or slit-like. The lining is composed

of several layers of high columnar epithelium interspersed with goblet cell and there is a great deal of secretion. The uterine glands becoms deeper and some of them branched. The blood supply of the submucosa and mucosa shows a marked increase with numerous blood spaces. If fertilization takes place these changes become even more marked, especially in the region where the ovum becomes attached and the uterus increases in size as the embryos develop.

After the height of the reproductive season there is a gradual decline in size from April until late June when the uterus returns to the resting condition.

Vagina

The vagina when open resembles quite closely that of the common white rat. It remains completely closed during the period from April to January, with considerable variation among individuals, and remains open or partly so the rest of the year. Several open vaginae were found to be slightly plugged with a whitish mass but whether this plug served the purpose of preventing further copulation has not been determined.

There is little difference in the size of the vagina throughout the year but marked changes take place in the size and shape of the lumen and in the appearance of the

lining epithelium. Studies of sections of the vagina show that a typical oestrous cycle occurs. During the inactive period from late June to October the lumen is narrow, partly closed and the lining is composed of a thin layer of flat epithelial cells. As the reproductive season advances, beginning in the latter part of October, the epithelial layer gradually becomes thick and cells are sloughed off in the lumen (Fig. 2). Eventually the epithelial cells next to the lumen lose their nuclei and become cornified. This stage occurs sometime in the period from January until April and marks the height of the reproductive season when evidence from work done on other rodents indicates that breeding takes place. The external vaginal opening is large and swollen. The cornified epithelial stage only lasts a short while and then there is an invasion of leucocytes and a final return to the flat epithelial condition which in a monoestrous animal marks the close of the reproductive season.

SEXUAL CYCLE OF THE MALE

Gross measurements and observations of the male reproductive system show marked changes taking place throughout the year. The testes and accessory organs increase from a small size to relatively enormous proportions and the

testes move from a position in the abdomen into an external scrotum.

Testes

A graph (Fig. 1) made of the volume measurements of the right testis shows that the male reproductive cycle closely correlates that of the female. The testes begin enlarging in late November and reach their maximum in the period from January until March, with marked variation among individuals, and return to the small resting condition in May and early June. Apparently the testes descend into the temporarily enlarged scrotum only for a short period as few animals examined were scrotal. Spermatozoa, however, are found in the tubules from November until early June (Table I).

Microscopic examinations during the resting period from June to November show small tubules of varying diameter with the lumina closed or nearly so (Fig. 8). In the outermost portion of the tubule there is a single layer of spermatogonia and next there are two or more rather uniform layers of primary spermatocytes with somewhat elongate nuclei. These cells are slightly larger than the spermatogonia. There is relatively little meiosis taking place in these layers. Nearer the center of the tubule are a

Table I. Spermatozoa in Tubules.

Animal number	Date	Spermatozoa*	Animal number	Date	Spermatozoa*
	1932			1932	
1	Feb. 25	+	89	Sept. 16	-
16	Apr. 1	+	91	Sept. 20	-
19	Apr. 1	+	94	Sept. 22	-
34	Apr. 4	+	96	Sept. 27	-
42	Apr. 4	+	105	Oct. 22	-
61	May 14	+	112	Nov. 10	+
66	May 14	+	117	Nov. 23	-
70	May 24	-	118	Nov. 25	+
72	June 1	-	119	Nov. 25	-
73	June 11	+	122	Dec. 27	+
				1933	
81	Sept.14	-	137	Jan. 7	+
82	Sept.14	-	141	Jan. 10	+
85	Sept.14	-	142	Jan. 10	+
			144	Jan. 21	+
			153	Mar. 1	+

* Spermatozoa: presence indicated by +; absence by -.

great number of irregularly arranged cells some large and some small and the majority are in some stage of meiosis. The smaller ones are probably spermatids while the larger are spermatocytes. The very center of the tubule is made up of colloidal substance with some vacuoles and a few cells that appear to be degenerating. As the reproductive season approaches in November the testes begin enlarging and moving down toward the scrotum. The tubules begin enlarging and meiosis increases in all types of cells. The spermatogonia remain as a single layer and the two or three layers of spermatocytes become reduced to a single layer of large primary spermatocytes in various degrees of meiosis. The cells next in order are smaller spermatocytes and those nearest the center are spermatids which are the smallest cells in the tubule. These occur in considerable numbers and progressively increase. The colloidal substance in the lumen breaks down causing the latter to open and the degenerating cells almost completely disappear. The tubules continue enlarging until twice the size of those in the resting condition. The spermatids increase in numbers and then decrease to some extent as spermatozoa start forming in late November. The lumen becomes large and completely open (Fig. 9). The final climax is the descent of the testes into the scrotum sometime in the period from late January

to April and copulation with the female. After this period the testes gradually return to the resting nearly inactive condition that begins in May and June.

The volume of the testis is about 200 cu. mm. during the resting period and increases to a volume of 2900 cu. mm.

Prostate Glands

The prostate glands are situated anterior to the bladder, ventral to the intestine, and attached to the anterior end of the urethra. They are composed of two parts; one, an irregular glandular structure flattened dorso-ventrally and the other, a four-lobed structure situated ventral to and partly covering the rest of the glands. The latter is not glandular but is thin and sac-like and probably acts as a place of storage. During the inactive season from June until November the entire glands are small and shrunken (Fig. 10). Microscopical examination of sections of the gland shows that the ducts are small, their walls thick and the openings very irregular due to the folding of the walls. There is no indication of secretion. As the reproductive season advances from November on, however, the glands increase in size until the period from January to April when they become relatively enormous (Fig. 11). The walls become thin and the entire glands are filled with colloidal material

of a thick glue-like consistency. The lobed storage portion is distended until the walls are nearly transparent. As the reproductive season hears its close in the beginning of April the glands gradually decrease in size until they reach the inactive condition of June.

Cowper's Glands

The Cowper's glands are a pair of pear-shaped organs covered with a tough glistening muscular sheath. They are situated beneath the pubic symphysis, one on each side of the rectum and a thread-like duct leads from each gland to the urethra. Internally the Cowper's glands are made up of greatly coiled tubules interspersed with connective tissue and lined with columnar epithelium.

During the inactive period from June to November the tubules are small, the epithelium low columnar and the cells closely crowded together (Fig. 12). There is little or no secretion in the lumina of the tubules. During the active season beginning in November and reaching its height from January to April, the tubules enlarge markedly, the columnar epithelium becomes high and the cells are evenly arranged rather than being irregularly crowded (Fig. 13). The lumens are well filled with colloid material. After April there is gradual return to the inactive condition of June.

THE ENDOCRINE GLANDS AT DIFFERENT TIMES OF THE YEAR

Histological examination of the endocrine glands reveals that some of these undergo typical cyclic changes closely correlating that of the reproductive cycle or slightly preceding it. Others show little or no change.

Anterior Hypophysis

Studies of the anterior hypophysis show that this gland is made up almost entirely of three types of cells. A large cell with pale, almost colorless cytoplasm and a pale vesicular nucleus (chromophobe); a small irregular cell with eosin staining cytoplasm and a dark compact eccentric nucleus (eosinophile); and a rather large cell with a bluish cytoplasm and a compact nucleus (basophile).

In the female during the inactive sexual season from June until October there is a rather loose arrangement of cells. The chromophobes are in the majority, eosinophiles next, and basophiles least in number. A change in this picture beginning in the latter part of October appears to initiate the reproductive season at that time. The chromophobes decrease in number and the basophiles and eosinophiles increase. The gland loses its loose appearance and becomes quite compact. This condition remains until the

reproductive organs approach their maximum size in January and then there is a return to the typical picture of the inactive season.

The period of pregnancy shows the appearance in considerable numbers of a smaller type of eosinophile with a very dark staining nucleus. These are the so-called pregnancy cells. The gland also has a tendency to remain more compact with a less amount of chromophobes during this period.

The anterior hypophysis of the male undergoes changes similar to those described for the non-pregnant female but the gland does not return to the inactive appearance so soon. The changes more closely correspond to those in the testes, in other words.

Adrenals

The adrenal glands undergo a cyclic increase in size that correlates with the increase in the reproductive organs. This is probably in the cortex but evidence from data accumulated is not conclusive. Another indication of change in activity is the occurrence of giant cells (Fig.14). These cells are characterized by enormous size and round nuclei with dark material clumped in the middle giving them a "bull's eye" appearance. The cells almost entirely

disappear during most of the year but increase markedly during the approach of the reproductive season, beginning in October. As the reproductive season reaches its height in January to April they again decrease and practically disappear.

Thymus

The tremendous variation between the ages of the animals examined and the difficulty of determining this factor made it impractical to find anything definite concerning seasonal changes in this gland.

Thyroid

The thyroid gland showed no cyclic changes in appearance. There was a marked variation in the size, shape and number of follicles at all seasons of the year. Some glands showed large and small evenly distributed follicles well filled with colloid while others had only a few scattered shrunken follicles. The majority were intermediate between these two extremes. The age factor is again important in the case of this gland as in the thymus but this could not be determined in animals taken in the field.

Pineal

The pineal shows variation in size and amount of pigment which is scattered in the gland or more concentrated toward the dorsal portion. Some glands are compact and others appear spongy. These variations are apparently due to age because they are not cyclic and have no definite rhythm. The cells present the same picture the year around. The gland is made up of rather pale cells with a round or slightly oblong nucleus and dark chromatin material clumped in the middle. Typical connective tissue cells are interspersed at intervals throughout.

DISCUSSION

In a study of the reproductive cycle of a wild mammal many factors arise which would not do so in the case of domesticated mammals under controlled laboratory conditions. Some of these factors can be overcome with ease while others are extremely difficult or practically impossible to overcome. One of the chief difficulties encountered centered around keeping the animals captive in the laboratory. This was of course overcome by killing the animal as soon as received but at the same time this procedure eliminated many interesting phases that would have been of value to the

problem. The most important of these is the age factor which influences the appearance of many of the ductless glands. Had this been controlled much more could have been found out regarding the functions of the glands. However, the anterior hypophysis and adrenal glands which have been proved by numbers of workers to bear the most important relation to sex were not influenced by this age factor to any great extent.

The study on the reproductive cycle of the pocket gopher brought out several things of outstanding interest. One of these was the fact that spermatozoa were found in the tubules from November to June but the animals were scrotal only for a very short period within this time. This seems to be somewhat contrary to Moore's theory (1924) that the body heat prevents formation of spermatozoa and therefore the testes move down into a scrotal sac where this body heat will have little influence.

Another interesting fact is that the anterior hypophysis begins to function before the reproductive organs in order to initiate their activity and when these organs begin to increase there is a decrease in hypophyseal activity.

The problem as a whole brought out clearly the importance of histology as a means of attempting to interpret physiological function. Changes in structure are valuable

indicators of changes in function.

This study was not an attempt to study any particular organ in detail but it was rather a survey of the cycle as a whole trying to unravel some of the complicated relations that arise between the sex organs and ductless glands and between the sex organs themselves.

SUMMARY AND CONCLUSIONS

Pocket gophers have been brought in at fairly regular intervals since February, 1932, in order to make studies on the reproductive cycle.

Gross measurements of the gonads accompanied by histological studies reveal a yearly cyclic enlargement with characteristic changes beginning in November, reaching its height from January to April and returning to a normal resting condition again in June. Corresponding changes take place in the uterus, vagina, prostate glands and Cowper's glands.

Evidence from these studies show that the pocket gopher has a monoestrous (anoestrous) cycle.

Histological studies of the anterior hypophysis, adrenals, thymus, thyroid and pineal show that some of these undergo cyclic changes in correlation with those of the reproductive organs while others show little or no change.

The anterior hypophysis appears to initiate activity of the reproductive organs while the adrenals undergo changes corresponding to these organs. The thymus, thyroid and pineal showed marked variations but no cyclic changes.

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EXPLANATION OF FIGURES

Fig. 2. A section of the vagina from an animal taken in March showing epithelial cells sloughed off in the lumen. X14.

Figure 2.

Fig. 3. A section of the ovary from an animal taken in September. X25.

Fig. 4. A section of the ovary from an animal taken in January showing large follicles in various degrees of atresia. X25.

Fig. 5. A section of the ovary from an animal taken in March showing corpus luteum. X25.

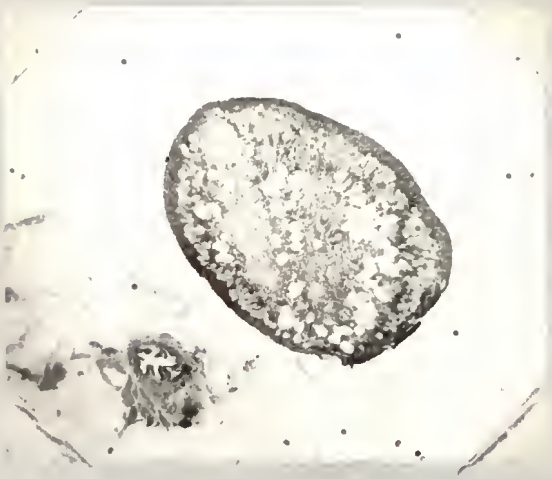

Figure 3.

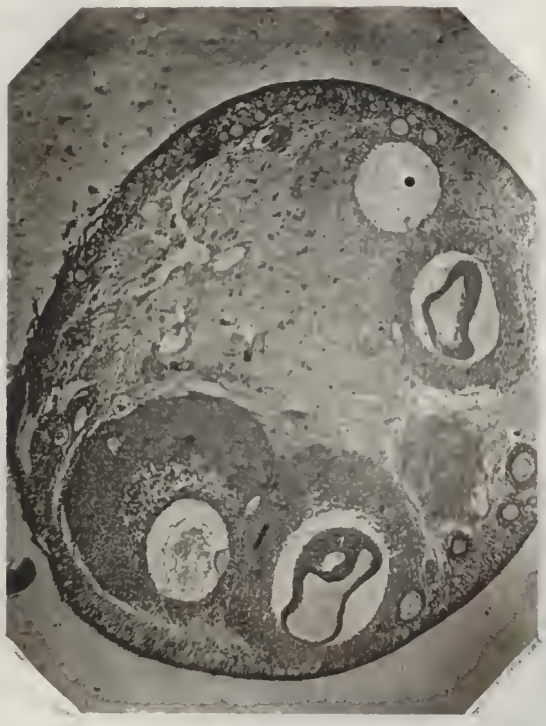

Figure 4.

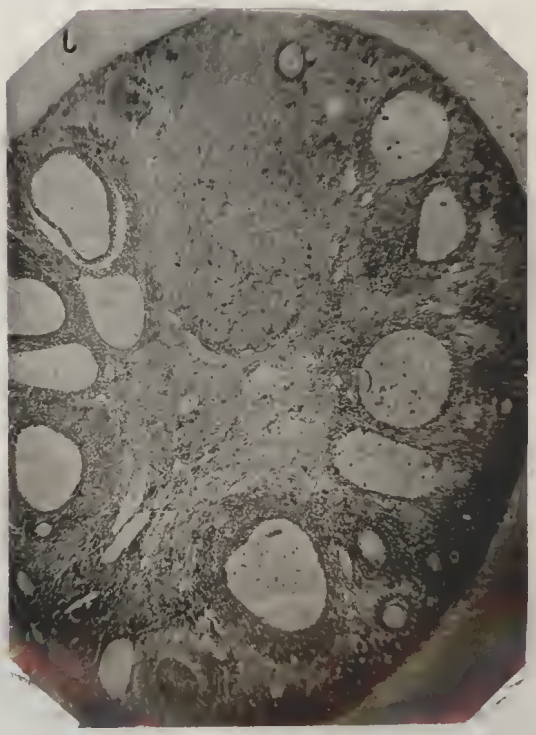

Figure 5.

Fig. 6. A section of the uterus of an animal taken in September. X25.

Fig. 7. A section of the uterus of an animal taken in March. X14.

Figure 6.

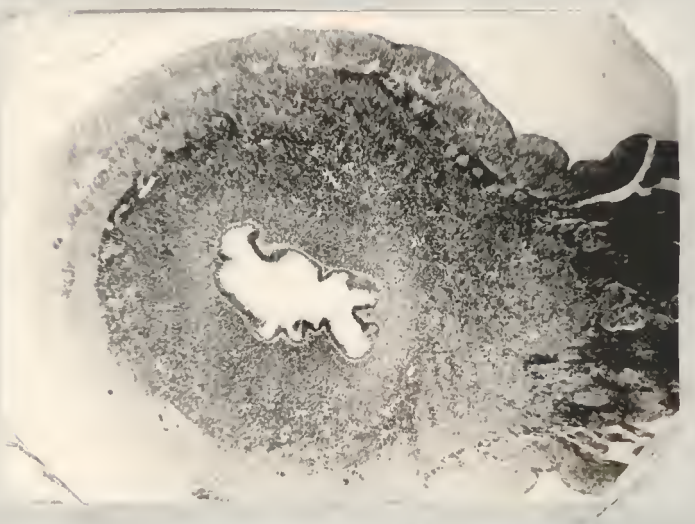

Figure 7.

Fig. 8. A section of a tubule in the testis of an animal taken in September. X1100

Fig. 9. A section of a tubule in the testis of an animal taken in March showing spermatozoa. X1100.

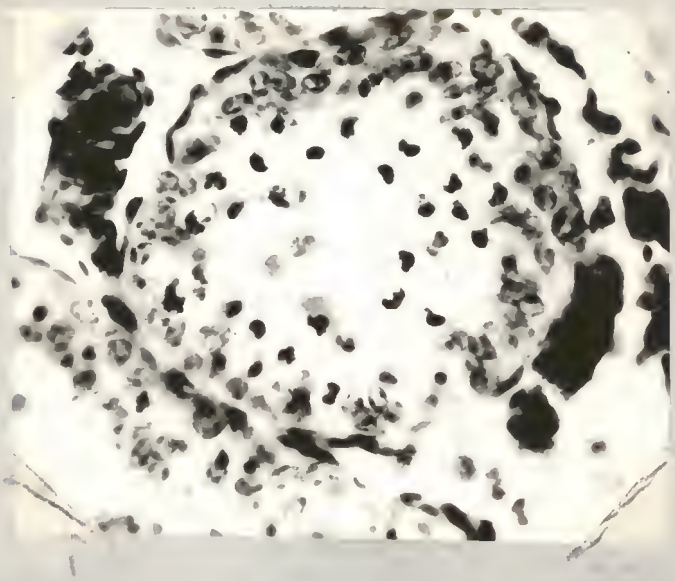

Figure 8.

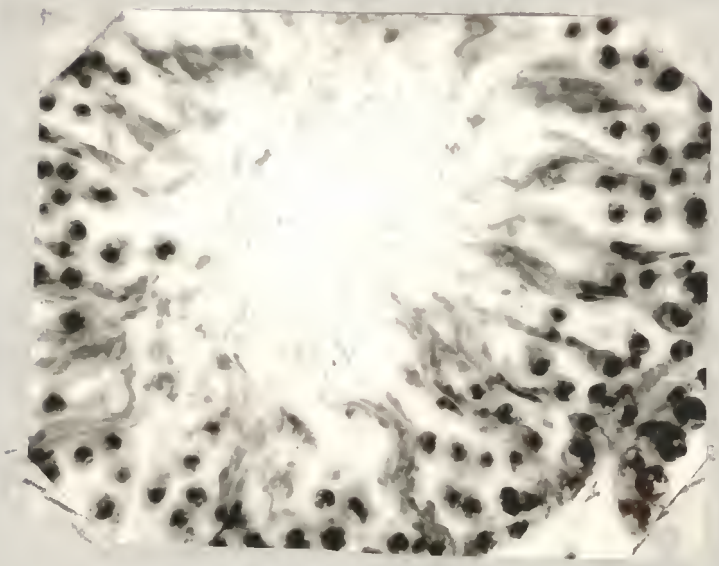

Figure 9.

Fig. 10. A section of the prostate of an animal taken in September showing a shrunken appearance and small size of the lumens. X25.

Fig. 11. A section of the prostate of an animal taken in March showing the enormous size of the lumens and the presence of colloidal material. X25.

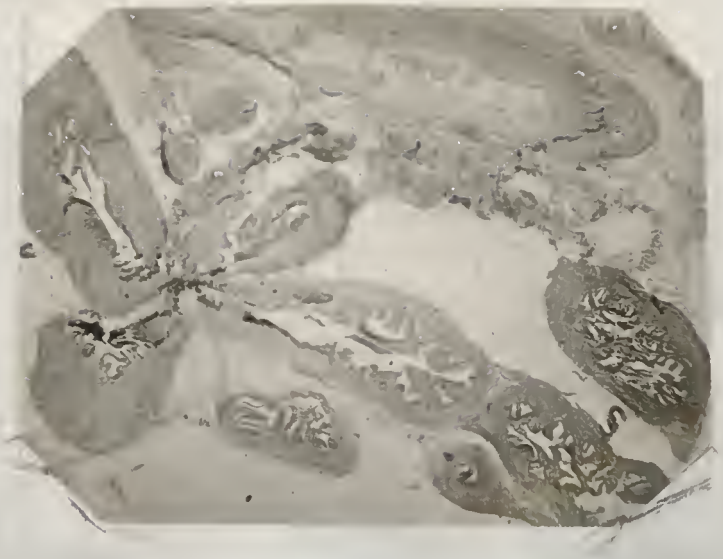

Figure 10.

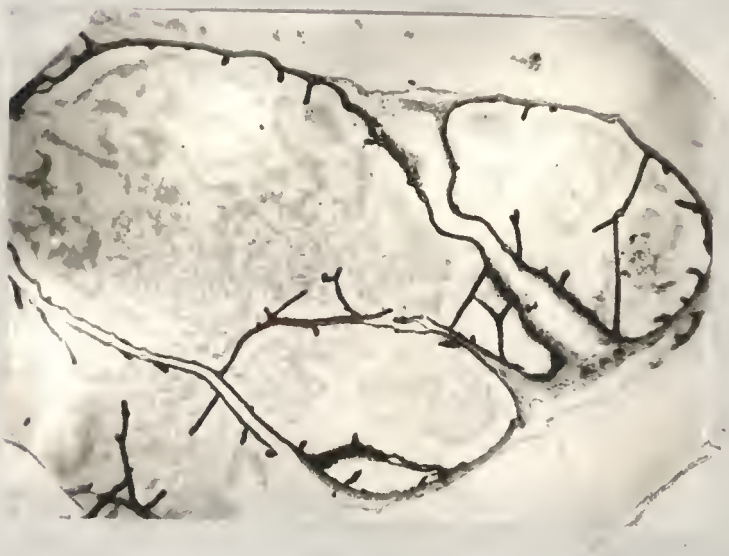

Figure 11.

Fig. 12. A section of the Cowper's gland from an animal taken in March. X25.

Fig. 13. A section of the Cowper's gland from an animal taken in September. X25.

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Fig. 14. A section of the medulla of the adrenal gland from an animal taken in December showing the presence of giant cells. X220.

Figure 12.

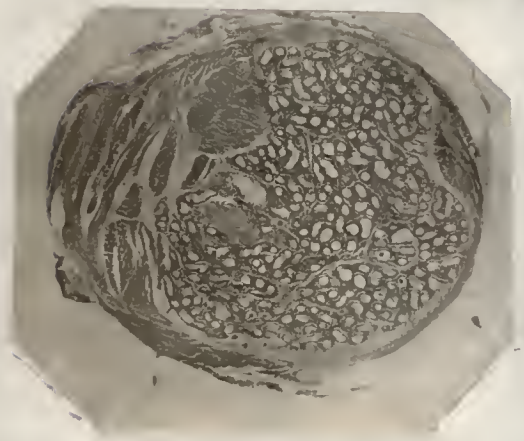

Figure 13.

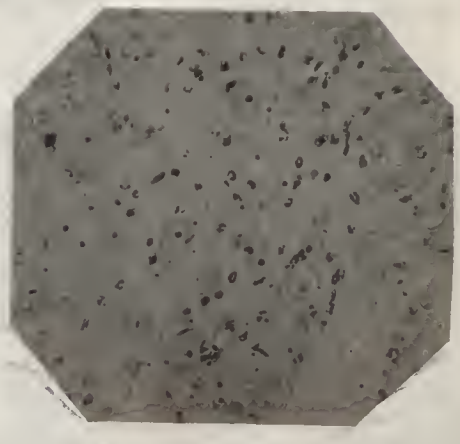

Figure 14.