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Reproduction in the Common Shrew (Sorex araneus Linnaeus). II. Seasonal Changes in the Reproductive Organs of the Male

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Phil. Trans. R. Soc. Lond. B 1935 **225**, 51-62
doi: 10.1098/rstb.1935.0006

Reproduction in the Common Shrew (*Sorex araneus* Linnæus) II—Seasonal Changes in the Reproductive Organs of the Male

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(Communicated by A. S. Parkes, F.R.S.—Received August 1—Read November 13, 1934.)

[Plate 9]

Contents

I—Introduction

The male Common Shrews obtained at the same time and in the same way as the females provide material which throws further light on the duration of life and of the breeding season in this species. This paper deals with the body-weights, weights of the reproductive organs and the occurrence of spermatozoa in the testes. The duration of fertility in the male and in the female are compared. The anatomy of the male reproductive organs is described by Ärnbäck-Christie-Linde (1907) and requires only brief consideration here.

II—Technique

The technique of obtaining material has been described already (p. 2). The reproductive organs were dissected out and fixed whole in the alcoholic modification of Bouin's fluid. They were transferred to 70% alcohol after 24 hours. The material, stored in 70%, was dissected subsequently and the testis, epididymis,

vas deferens, prostate and Cowper's gland of each side were weighed when these organs were sufficiently large to permit of this. The penis was weighed also. The combined weights of the two members of each pair were employed for purposes of analysis except where one was damaged, when double the weight of the other was taken as the weight of the pair.

Weighing was effected on a torsion-balance, accurate to 0·5 mg, after the superficial moisture had been dried off by gently rolling the organ on a pad of gauze. The weights of the organs in immature animals in which each testis was 3 mg or less in weight were not recorded as a rule, since the experimental error would have been as great as the individual variation. Transverse sections through the middle of one of the testes were cut whenever the two together weighed 20 mg or over. The sections were stained with Mayer's hæmalum and eosin.

III—Material

The material consisted of 577 males, the body-weights of 551 being recorded. Adults could be distinguished from immature animals in the majority of cases by body-weight alone since no immature animals weighed over 10 gm. Three adults, obtained in summer, weighing less than 10 gm, were easily identified by the size of the reproductive organs, the testes weighing over 65 mg, as compared with the minute organs of the immature animals with testes under 6 mg. One animal obtained in November weighing 9·25 gm could not be identified since the reproductive organs were not available. In spring, when the reproductive organs were exhibiting the rapid growth characteristic of the onset of the breeding season, all animals with testes under 20 mg were classified as immature. Animals with testes 20 mg and over were classed as mature or immature according to whether histological examination showed that mature sperms were or were not present in the testes.

IV—Structure of the Reproductive Organs

The anatomy of the reproductive organs has been described by Ärnbäck-Christie-Linde (1907). They are shown in their natural relations in fig. 3, Plate 9, and dissected out and displayed in fig. 4, Plate 9. It is unnecessary to describe them in detail here, but some points require mention for the proper understanding of this paper.

The vas deferens in the adult is narrow where it arises from the tail of the epididymis and gradually widens to form an upper swelling, which is limited distally by a clearly defined constriction situated about half way between the epididymis and the urethra. The distal part of the vas is enormously swollen and forms a conspicuous structure which is rounded proximally and gradually tapers distally to its junction with the urethra. Neither of these swellings are discernible in immature shrews in which the vas deferens is narrow throughout its length. The swellings are composed of alveolar pouches opening into the central duct and

surrounded by the common musculature of the vas deferens. Sperms can be observed in these pouches in sections. The large paired organs, called prostate glands by Ärnbäck-Christie-Linde (1907), are situated dorsally to the vasa deferentia and bladder. It appears equally probable, from their position and structure, that they should be regarded as seminal vesicles. Their homologies cannot be determined until more is known of the anatomy of the accessory organs of other Insectivora and, possibly, of their development. Since it is undesirable to change the name applied to them by Ärnbäck-Christie-Linde until their true nature is definitely determined they will be called prostate glands in this paper. The only other large glands associated with the reproductive tract of the shrew are the oval Cowper's glands situated on each side of the base of the tail. The penis, when retracted, is folded back upon itself as in fig. 3, Plate 9. When extended, it is very long considering the size of the animal. The prepucial glands are diffuse and, unlike those of many rodents, they are not conspicuous.

The total weight of the reproductive organs of a mature male sometimes exceeds 0·9 gm or 7·5% of the total body-weight.

V—Growth, Duration of Life and Breeding Season

The body-weights of 551 male shrews are plotted against the days of the year in fig. 1. The small dots represent immature animals and the large dots adults in which sperms are present in the testes. One adult (S. 1236) obtained on November 12 was too badly preserved to determine the presence or absence of sperms in the testes and is represented by a circle. During the first two months of the year almost all immature animals weigh between 5·5 and 7 gm and are thus comparable in weight to the females at this time. During the second half of March sperms are to be found in the testes of some of the animals and subsequently during April and May the body-weight increases rapidly. It can be seen from the second and third columns of Table I that all animals in spring weighing 8 gm and over have sperms in the testes. They increase in weight subsequently to the appearance of sperms in the testes, as can be seen from fig. 1 and by comparing columns 3 and 5 of Table I. The increase in body-weight of males begins about March 10, but in the females it cannot be detected until after March 20. The lightest male with sperms in the testes which was obtained weighed 6·75 gm and the heaviest 13·9 gm. Thus the range of body-weights of adult males corresponds to that of adult females (allowance being made for the weight of the embryos occasionally bringing the weight up to 15 gm). Barrett-Hamilton (1911), quoting Adams, records that 24 adult males taken in May, June, and July averaged 12 gm and ranged from 10 to 14 gm. The lightest young animal, presumably taken at weaning time, which was obtained in summer was 4·25 gm. During summer and autumn the majority of immature animals exceeds 7 gm, the heaviest obtained being 9·8 gm. During late autumn the weights of immature males fall

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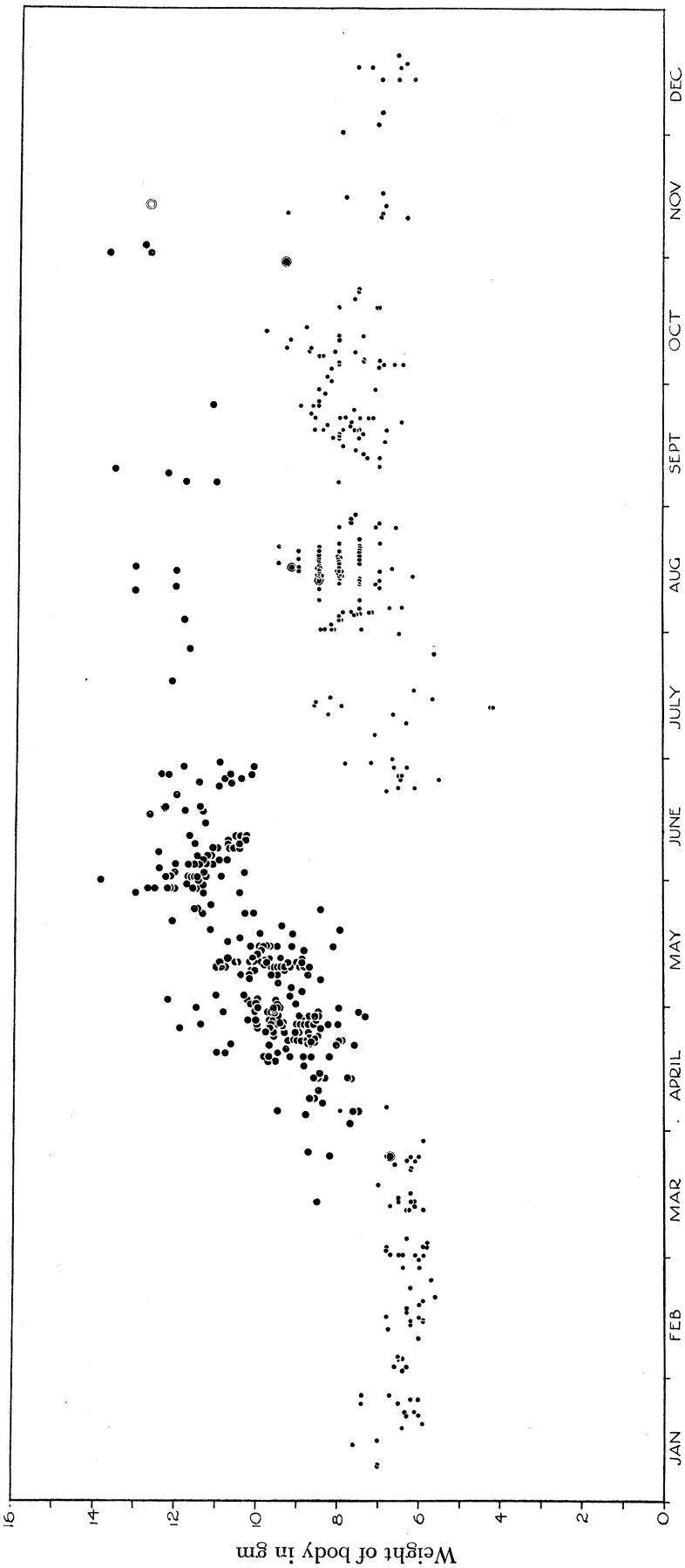

FIG. 1—Scatter diagram of the body-weights of males according to days of the year. • = immature male, ● = mature male with sperms in the testes (ringed in some cases for easier identification), O = adult male in which presence or absence of sperms in the testes could not be determined

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TABLE I

Body-weight gm	December to May		June to November	
	Without sperms	With sperms	Without sperms	With sperms
13–13·9	—	2	—	4
12–12·9	—	9	—	16
11–11·9	—	22	—	25
10–10·9	—	36	—	21
9– 9·9	—	71	10	2
8– 8·9	—	52	77	1
7– 7·9	11	11	71	—
6– 6·9	62	1	29	—
5– 5·9	12	—	4	—
4– 4·9	—	—	2	—

off gradually to the winter range, as was observed with the females. Thus immature males attain a greater body-weight during the season in which they are born than that which they have attained in the following spring at the time of the appearance of mature sperms in the testes. This is clearly seen by comparison of columns 2 and 4 of Table I. From July to November inclusive the adult males obtained, with three exceptions, weighed 11 gm and over and they were therefore more than 1 gm heavier than the heaviest of the immature animals. The three exceptional adults were 8·5, 9·2, and 9·3 gm weight respectively, but the weights of their reproductive organs clearly distinguished them from the immature animals. There is therefore no evidence that young males ever become mature during the season in which they are born.

The latest date on which an adult male was obtained in North Wales was October 29 and in Hertfordshire November 12. None was obtained between the latter date and the following March, thus providing even stronger evidence than do the females that adults die at the close of the breeding season.

It may be concluded that males, like females, do not breed during the year in which they are born and die in the late summer or autumn of the following year, when they are 15 to 18 months old, after one breeding season.

Fecundity, as defined by the occurrence of animals with sperms in the testes, extends from March 13 to November 2. No animals without sperms were obtained between April 5 and June 21. Thus, in spring, all males contained mature sperms in the testes for over one month before the first pregnant female was obtained and six weeks before the last non-pregnant non-parous female. It is clear, therefore, that the onset of the breeding season in the shrew is determined by the female and not by the male. It is probable that the end of the breeding season is also determined by the female, since males with sperms were obtained after the last pregnant female in autumn. The total number of adults obtained in autumn was, however, too small to be conclusive.

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VI—Testes

The weights of the testes of all adult animals and some immature animals are given in the form of a scatter diagram against the days of the year in fig. 2. The presence or absence of sperms is denoted as in fig. 1. The weights of the testes of all animals taken between February 22 and June 20 are shown. The testes of immature animals at other times were so small, weighing 5 mg or under, that the margin of error in weighing was nearly as great as the variation. Therefore only a few are included for comparison with the adults. The 50 mg line serves to distinguish the testes containing sperms from those without. Only one animal with testes just over 50 mg did not contain sperms, and it was obtained at the beginning of the season. One adult animal obtained in November had testes under 50 mg in which, owing to bad preservation, the presence or absence of sperms could not be determined. The heaviest testes obtained weighed 290 mg.

Only four adult animals were obtained after April with testes weighing less than 70 mg and these differed from those with testes of similar weights obtained in March and April in that the other reproductive organs, especially the vasa deferentia, prostate and Cowper's glands, were much heavier. This is compatible with the assumption that the former are adults with unusually light, possibly retrogressing, testes. The weights of the testes of the adult and immature animals from June to November are not so sharply differentiated as those recorded by Middleton (1931) who obtained none between 30 and 200 mg (fresh weight) during these months.

The relation of the weight of the testes to the body-weight is clearly brought out in Table II in which the data for 327 animals are given in the form of a correlation table. It appears to approximate to a straight line regression.

Table II

Weight of testes in mg	5·5	6·0	6·5	7·0	7·5	8·0	8·5	9·0	9·5	10·0	10·5	11·0	11·5	12·0	12·5	13·0	13·5
279															1	1	
											1			1			1
															1		1
200							1	1	2	3	2	5	2	2		2	
199							1	2	6	5	3	4	5	5	1		
							4	5	10	11	5	7	5	7	1		1
							3	10	10	8	9	7	7	1			
					4	4	15	4	12	6	3	2	1	3	1		
100						5	8	5	2		1						
99				1	3	3	4	1	1			1					
			1		1	1	2	1									
				1	2		2		1				1				
20		4	2		1										1		
19	8	18	14	1	1	1	3										

Body-weight in gm

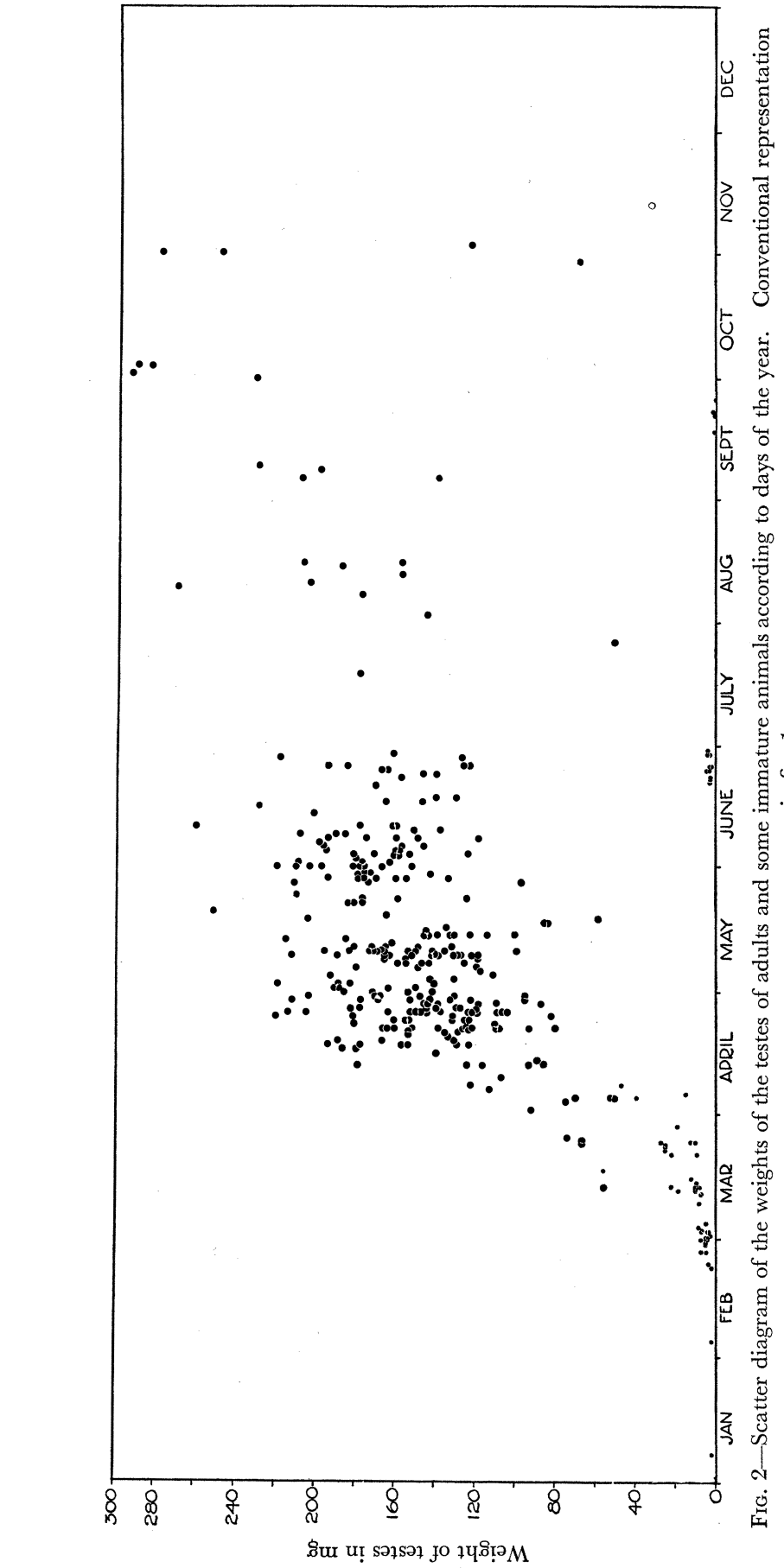

FIG. 2.—Scatter diagram of the weights of the testes of adults and some immature animals according to days of the year. Conventional representation as in fig. 1

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VII—Accessory Sexual Organs

The size changes of the various accessory organs were examined and it was found that all underwent enormous increase before the beginning of the breeding season. The swellings on the vasa deferentia, prostate and Cowper's glands were so small in immature animals that they were scarcely discernible macroscopically and could not be weighed. The data available are given in the form of correlation tables.

a. Epididymides

The weights of these organs exhibit a simpler relation to the weights of the testes than they do to the body-weights. It can be seen by inspection of Table III that the relation of weight of epididymides to weight of testes approximates to a straight line regression passing through or close to the origin. The spread is small in view of the nature of the data.

Table III

Weight of epididymides in mg	Weight of testes in mg														
	19	20			99	100			179	180			259	260	
89												1			
												1			
75							1								
74															1
									1						
											1			1	1
									1	3	1	1	1		1
50								1	2	1	5		1		
49							2	3	10	2	6			1	
							2	11	12	9	3		1		
					1		7	13	15	9	4				
						5	15	22	12	7	1				
25					3	8	16	8	4	2					
24		1	2	1	7	5	12								
			2	2	3	3									
		1	1	3											
5		1	1												
4	16														

b. Penis

The weights of the penis, like those of the epididymides, exhibit a simpler relation to the weights of the testes than they do to the body-weights. The spread is considerably greater than in the case of the epididymides, as can be seen from Table IV. It approximates to a straight line regression passing through or near to the origin.

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TABLE IV

Weight of penis in mg	19–20	99–100	179–180	259–260
259				1
				1
200			3	2	1	2		1	
199			3		6	1	7				
			8	13	12	11	4		2	1	1
	1	2		4	3	18	26	20	12	6	1	1		
				5	12	17	13	13	5	1				
100				1	3	9	3	4	1	1				
99				4	1				1	1				
		1	3		2									
		2	2											
20	1	1	1											
19	20 1													

Weight of testes in mg

c. Vasa deferentia, prostate and Cowper's glands

The relation of the weights of each of these organs to the weights of the testes is not obviously simpler than to the body-weights. They all differ in this respect as well as in the greater spread exhibited by the data, from the epididymides and penis. A more fundamental difference is that they do not appear to conform to a simple straight line relation to the weight of the testes, see Tables V, VI

TABLE V

Weight of vasa deferentia in mg	19–20	99–100	179–180	259–260
199				1				
			1					
				1				
150				1				
149		1		3	2					
			1		2	2	1				
			1	1	5	2	2				
			1	3	5	1	2		2		
100			1	3	2	3	5	3			1
99			2	4	4	3	1			1	
		1	2	4	2	3					
	1		1	6	4	4	3				
		1	7	11	8	5	4				2
50		1	10	10	9	6	3		1		
49	1	2	8	16	9	9	3			1	
		5	6	9	1	2	1				
	1	4	2	4	2						
10	1	3	1	2							
9	11 2	3	3								

Weight of testes in mg

and VII. None of these organs increases perceptibly in weight until the testes have attained a size of 60 to 80 mg. They exhibit a rapid increase in weight relative to the weight of the testes in animals in which the testes are more than

TABLE VI

Weight of prostate glands in mg	19|20	99|100	179|180	259|260
299			1	1
			2	
		1		
				2 1 1
200			1 4 1	1
199		1	1 5 3	2 1
		2	2 4 3	3 2
		2	8 5	5 6 1
	1	2	3 5 10	2 4 1 1
100		1	12 19 12	10 2 1
99	1	3	6 17 15	11 6 2 1 1
		3	3 8 4	4
		2	5 8 1	1 1
20	1	4	1 3	
19	9 2 4 5	1	2	

Weight of testes in mg

TABLE VII

Weight of Cowper's glands in mg	19|20	99|100	179|180	259|260
				1
75				
74			1	
			1	
			2 2	1
50		2	2 1 1	2 1
49		2	1 5 4	1 3
		2	9 8 13	6 8 1 1
	1	1	6 12 10	7 3 1 2
		1	2 9 13	16 7 1 1
25			4 11	10 4 7 1 1
24	1	3	4 8	5 3 1 1
		5	5 8	1 1 1
	1	2	1 1	1
5	1 2	1	2	
4	1 2 3			

Weight of testes in mg

60 to 80 mg in weight. It would appear, therefore, that when the reproductive organs hypertrophy, prior to the onset of the breeding season, there is a marked initial lag relative to the testes, epididymides, and penis before the vasa deferentia, prostate, and Cowper's glands begin to increase in weight.

These results show that the weights of the accessory organs of *Sorex* exhibit two different types of relationship to the weights of the testes. The first type of relationship, that exhibited by the epididymides and penis, is encountered also with the epididymides and penis of *Evotomys* (ROWLANDS, *in preparation*) and with the epididymides of *Erinaceus* (*see* ALLANSON, 1934). The second type of relationship, exhibited by the vasa deferentia, prostate, and Cowper's glands of the shrew, is found in both *Evotomys* and *Erinaceus* with the seminal vesicles, prostate, and Cowper's glands and in *Evotomys* with the prepucial glands as well. The grey squirrel (see ALLANSON, 1933) on the other hand does not appear to exhibit these two types of relationship, since the weights of the epididymides, seminal vesicles, prostate, and Cowper's glands against the weights of the testes approximate to straight line regressions passing near the origin. The weight of the penis against testes weight in this species exhibits an initial rapid rise followed by a period in which increase in the weight of the testes does not appear to be correlated with any increase in the weight of the penis. The relation of weight of penis to weight of testes in the squirrel therefore differs from that observed in the shrew, the bank-vole and the hedgehog.

The weights of the vasa deferentia and prostate glands are very closely correlated with each other, as can be seen from Table VIII. The relation obviously approximates to a straight line regression passing through or close to the origin.

The expenses of this research were defrayed in part by grants from the Government Grant Committee of the Royal Society for which we wish to express our thanks.

TABLE VIII

Weight of vasa deferentia in mg	Weight of prostate glands in mg														
	19|20				99|100					199|200				299
199											1				
								1							
															1
150										1					
149								1		1	1		1	2	
									1	2	2				1
						1		3	2	4		1			
					1		3	1	5	1	2	1			
100						1	5	3	3	3	1	2			
99					1	2	3	8	1						
					1	5	2	2	1	1					
					5	5	5	4	1						
					9	16	7	4	2						
50				1	18	19	2								
49			4	12	24	7	2								
		1	10	8	4	1									
		8	4	1											
10	6	1													
9	17														

VIII—Summary

The material consisted of 577 male Common Shrews. The localities in which they were obtained and their distribution throughout the year have been dealt with in the previous paper. The anatomy of the reproductive organs is summarized.

The distribution of body-weights throughout the year is described. The smallest immature animal trapped in summer was 4·25 gm. During late summer the majority of immature animals weigh 7 to 9 gm but none exceeds 9·8 gm. The weight falls off gradually in autumn, and in winter the majority weigh only 5·5 to 7 gm.

The body-weight rises rapidly before the onset of the breeding season and, by June, the majority of adult animals weigh 10 to 13 gm, the heaviest obtained being 13·9 gm. Only three adults obtained in summer had body-weights less than 10 gm and these were easily distinguished from immature animals by the size of the reproductive organs.

The earliest date on which mature sperms were present in the testis was March 13 and the latest November 2. All adult animals obtained between April 5 and November 2 contained sperms. No adult animals were obtained between November 13 and the following March. It is concluded that young males do not breed in the season in which they are born and that adult males do not live over a second winter.

It is clear, from the results recorded in this and the preceding paper, that the onset of the breeding season in the Common Shrew is determined by the female and not by the male. It is probable that the end of the breeding season is determined also by the female.

Testes weighing 50 mg and over were found to contain mature sperms almost invariably. The heaviest testes obtained weighed 290 mg. The relation of the weights of the testes to the body-weights is given in tabular form.

The relations of the weights of the epididymides, vasa deferentia, prostate glands, Cowper's glands, and penis to the weights of the testes were examined. It was found that the weights of the epididymides and of the penis on the weights of the testes approximate to straight line regressions passing near the origin. The other organs exhibit an initial phase during which there is no perceptible increase in weight followed by a second phase, beginning when the testes are 60 to 80 mg, in which there is rapid increase in weight correlated with increase in the weights of the testes.

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Rowlands. (*In preparation.*)

X—Description of Plate 9

Abbreviations :—*B* = bladder, *C* = Cowper's gland, *CP* = crus of penis, *DV* = lower or distal swelling on vas deferens, *HE* = head of epididymis, *K* = kidneys, *L* = ligament uniting ventral ends of pubes, *P* = body of penis, *PG* = prostate gland, *PR* = prepuce, *PV* = upper or proximal swelling on vas deferens, *R* = rectum, *SV* = spermatic vein, *T* = testis, *TE* = tail of epididymis, *U* = ureter.

Fig. 3—Photograph of ventral aspect of adult male reproductive organs dissected so as to show them *in situ* in their natural relations (S. 1244). × 2·7. An outline key is provided at 3a.

Fig. 4—Photograph of ventral aspect of adult male reproductive organs dissected out and displayed (S. 1247). × 2·5. An outline key is provided at 4a.

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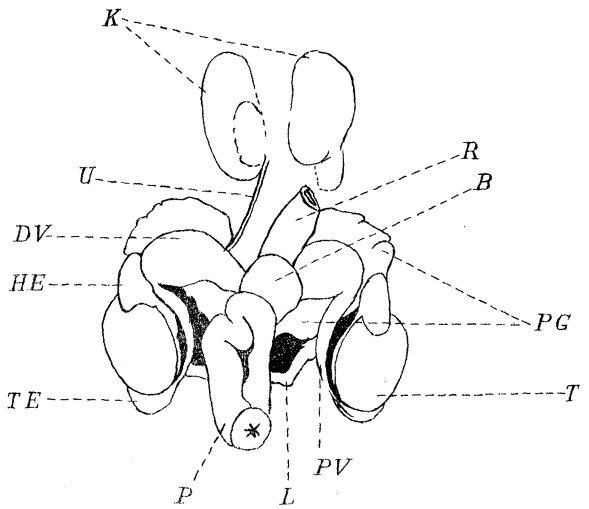

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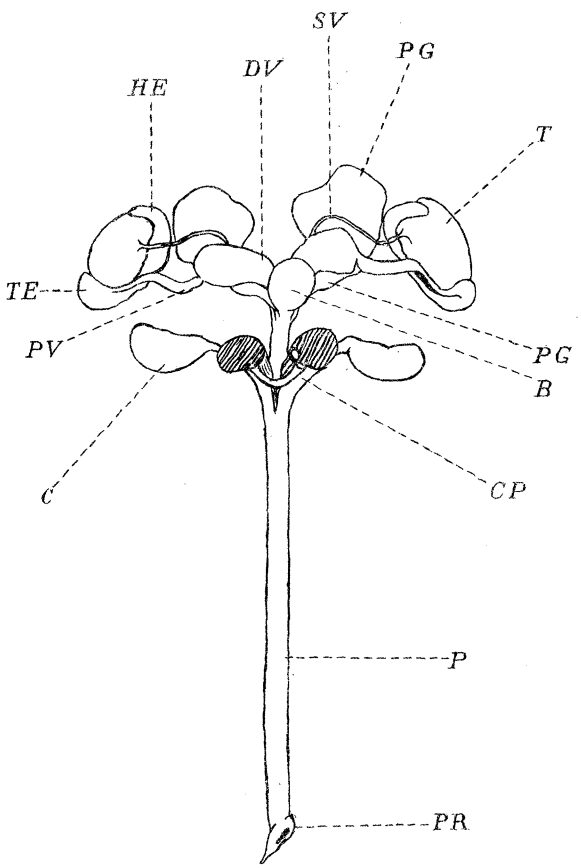

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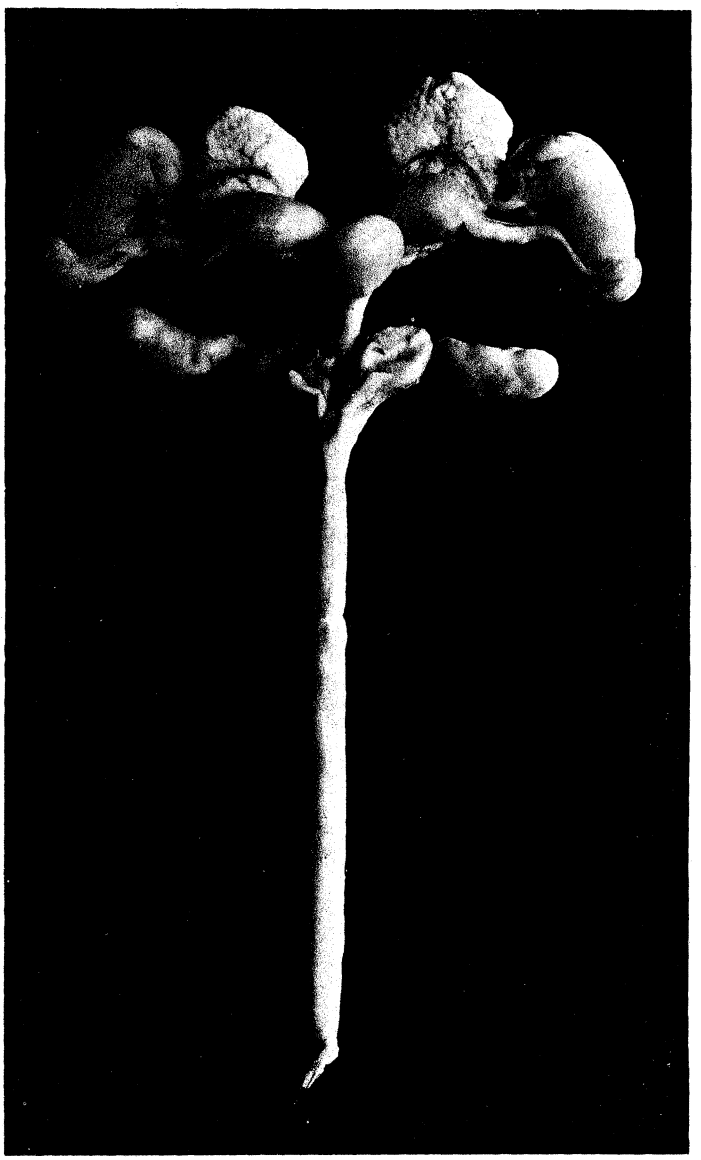

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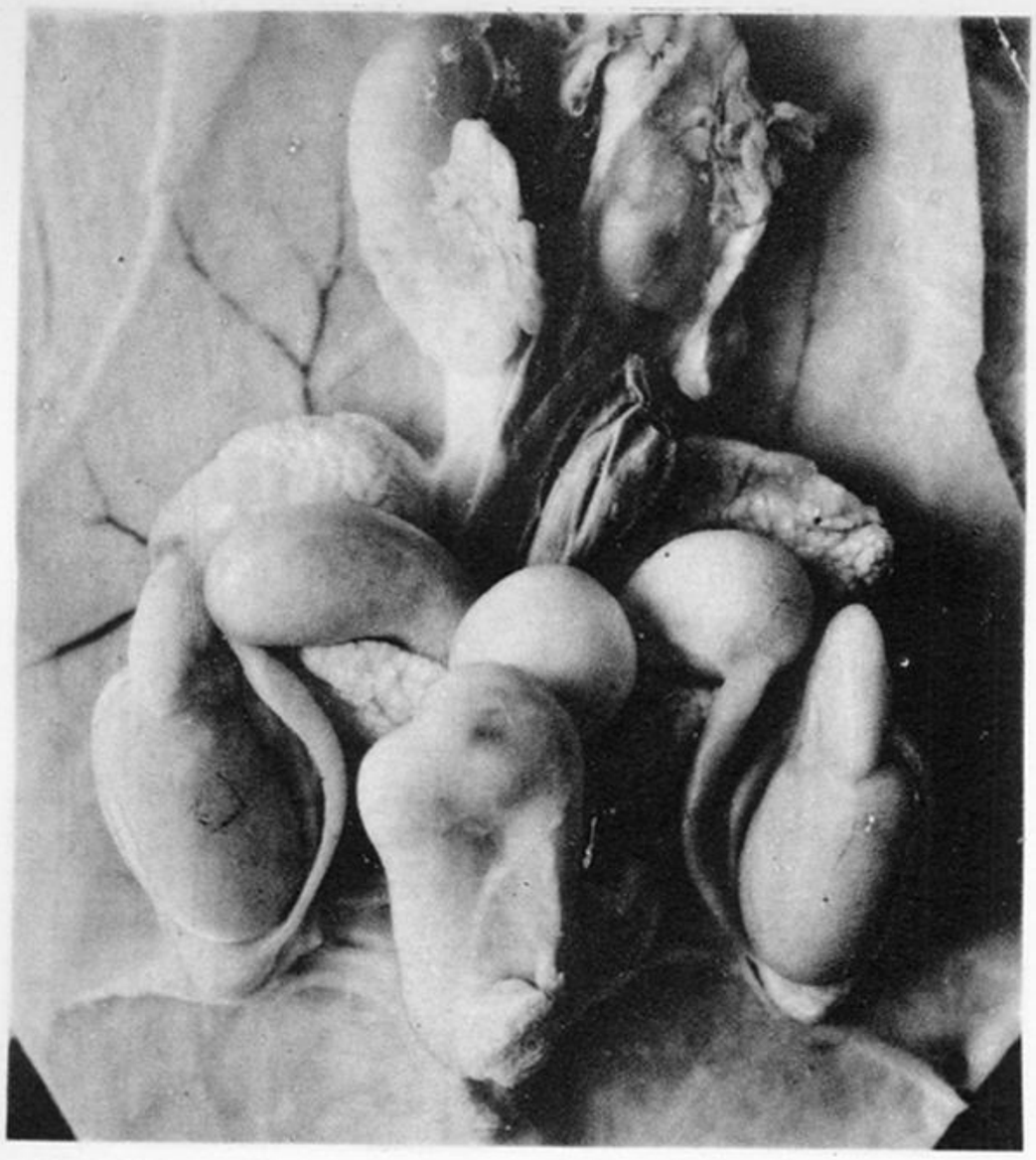

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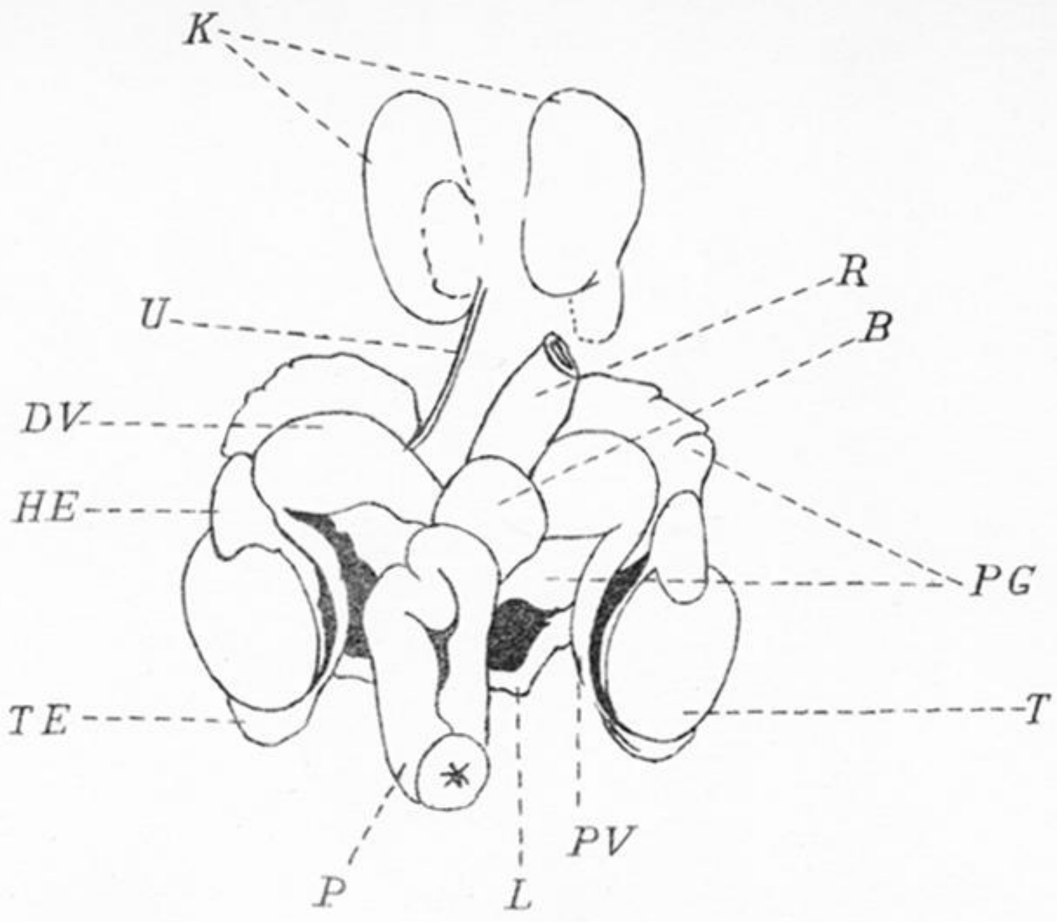

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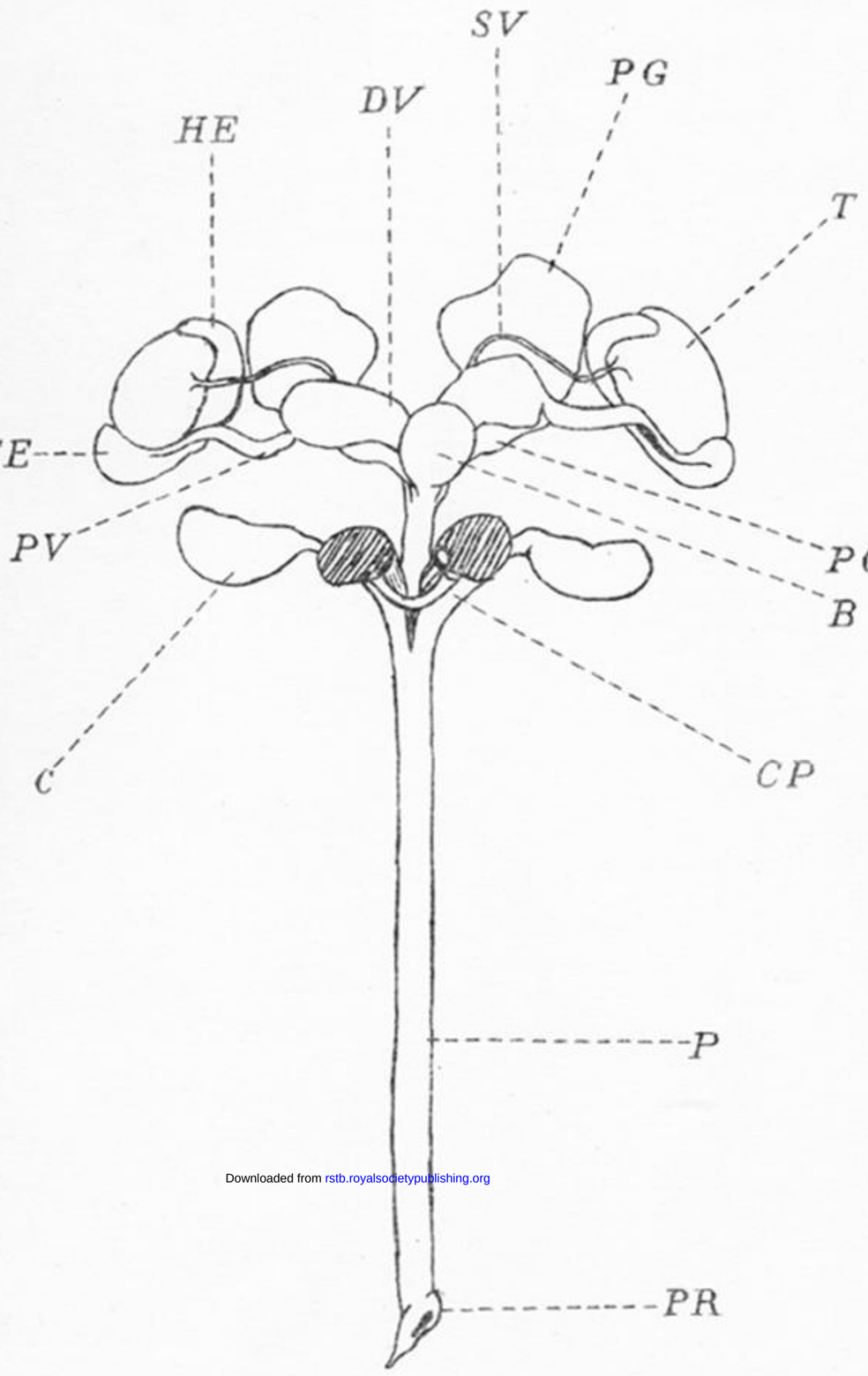

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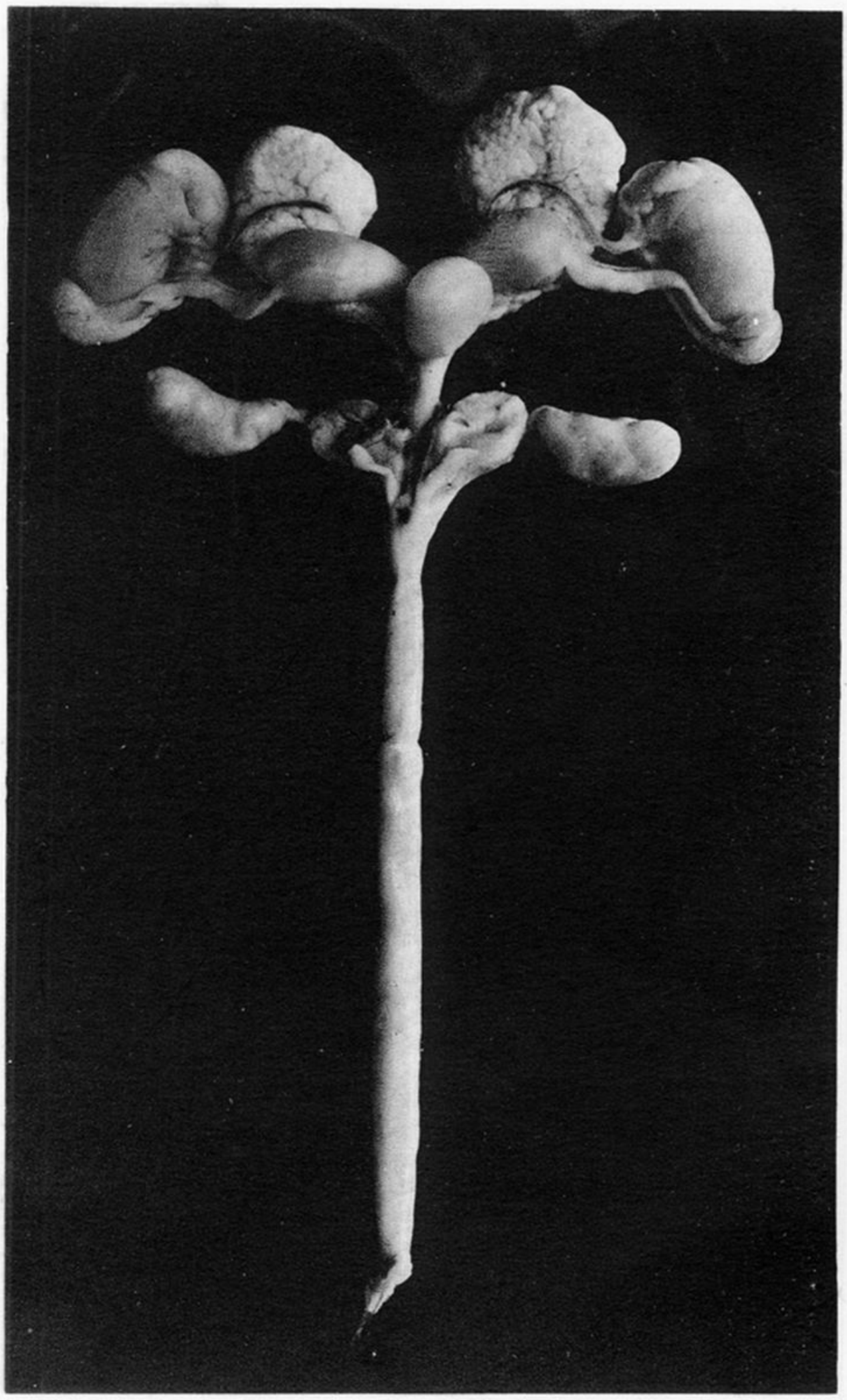

4

X—Description of Plate 9

Abbreviations :—*B* = bladder, *C* = Cowper's gland, *CP* = crus of penis, *DV* = lower or distal swelling on vas deferens, *HE* = head of epididymis, *K* = kidneys, *L* = ligament uniting ventral ends of pubes, *P* = body of penis, *PG* = prostate gland, *PR* = prepuce, *PV* = upper or proximal swelling on vas deferens, *R* = rectum, *SV* = spermatic vein, *T* = testis, *TE* = tail of epididymis, *U* = ureter.

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