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**Variation in Weight of the Internal Organs
of *Sorex araneus* Linnaeus, 1758.**

I. Salivary Glands

Zmienność wagowa narządów wewnętrznych

***Sorex araneus* Linnaeus, 1758**

I. Guczoły ślinowe

[With 4 tables and 3 figs.]

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I. INTRODUCTION

The present publication is based upon part of the material examined by a group of scientific workers in the Mammals Research Institute of the Polish Acad. Sci. at Białowieża. A general discussion will follow the conclusion of work on the material section as a whole. The order in which sections of work will be published will not be in accordance with a previously prepared plan, but will depend on the time by which work on the various parts of our researches is completed by the authors.

The aim of the work is to analyse variation in weight, according to season and age, of the submaxillary and parotid glands of the Common shrew, *Sorex araneus* Linnaeus, 1758.

I have assumed that variation in the weight of the fixed glands will follow a parallel course to the corresponding curve of the weight of „fresh” glands. In order to check the validity of the assumption 20 specimens were weighed before and after fixation.

The material was selected from one age group. When dealing with averages (for „submaxillary” glands from five specimens and for parotid glands from three) I obtained two parallel curves of weight — one for fresh glands, the other for fixed ones.

II. MATERIAL AND METHODS

The material was taken from the collection in the Mammals Research Institute. Shrews were captured in 1955 and 1956 in the Białowieża National Park, almost solely in deciduous forest, only 42 individuals being caught in a coniferous forest. The capture methods and description of the biotopes are given in the work by Borowski & Dehnel (1952).

Table 1.
Material examined.

Year	Age	sex	m o n t h s												n
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
1955	juv.	♀♀	2	2	1			62			3	12	30	2	114
		♂♂	1	1				52			4	8	21	3	90
	ad.	♀♀						15	20	39	45	11	2	132	
		♂♂						49	29	27	16	10	1	132	
1956	juv.	♀♀	16	1	12	16		4	8	15				72	
		♂♂	24		5	24	1	4	12			1		71	
	ad.	♀♀						2		3	3	2		10	
		♂♂						13	8	12	7	4	3	47	
Total			43	4	18	40	1	201	77	96	78	48	57	5	668

I drew up separate tables for the young specimens and adults from 1955, and supplemented the material with additional adults from corresponding months in 1956, providing me with a total of 668 individuals of *Sorex araneus*. All the specimens were fixed in toto in methyl alcohol. Before fixing, the abdomen was opened to facilitate complete fixation.

The material, segregated according to sex, and divided into young and adult animals for each month, is set out in table 1.

The sublingual gland (Clark, 1926) forms part of the „submaxillary” gland of the shrew. After preparation, the whole gland, composed of the submaxillary (*glandula submaxillaris*) and sublingual glands (*glandula sublingualis*) has a compact structure. For practical purposes these two glands cannot be separated in fixed material. As I found when using histological

microscopic sections, they consist of glandular elements only. In the rest of this text, therefore, the term „submaxillary” gland should be understood to refer to both glands together: submaxillary and sublingual.

The parotid glands (*glandulae parotis*) are relatively large. In addition to the two lobes, there are also small lobules grouped near the excretory ducts, and also closely-adhering lymph nodes. I removed the latter before weighing. I transferred the prepared glands to 85% methyl alcohol. Before weighing, in order to avoid too rapid evaporation, the material was placed in distilled water which was changed twice daily. The glands were dried on tissue before weighing which lasted 30 seconds. As the differences in weight between the paired glands was on the whole very slight, both parotid and, correspondingly, both „submaxillary” glands were treated jointly.

The whole material was divided into five groups for the analysis of variation in weight.

Young shrews caught during the period from June to December were placed in one group (group I). As sexual maturity is not attained in the first year of their lives by the great majority of the individuals, the population of young animals is fairly uniform. Beginning with the end of July, depressive processes start in shrews expressed in the first place by changes in the brain case (Dehnel, 1949; Pucek, 1955; 1957), and a decrease in the weight of the brain (Caboń, 1956; Bielak & Pucek, 1960). These processes in 1955, however, progressed slowly until December. The differences in monthly averages were small and division of the material into several smaller sub-groups would not seem to serve any useful purpose.

Group II includes young shrews caught during the period from January to April 1956. In the material obtained during the study year, the state of winter depression was maintained until as late as April, although part of the young males showed by the increase in the dimensions of their gonads that progressive changes had begun.

Distinct progressive changes in the whole population did not begin until the end of that month, and in May. In June-July the adults attained their maximum weight, both of body and of the glands examined. I have termed this material — group III.

In August-September the adults enter the stage of progressive depression (the beginning of which can be noticed as early as the end of July). This phenomenon, however, proceeds even more slowly at that time. I classed these individuals in group IV. Compared with the period of intensification of progressive changes (group III) the animals in group IV may be described as being in a phase of relative stabilisation.

Marked acceleration and intensification of depressive changes in the vanishing population of adults are not observed until October or November. For this reason I placed this material in a separate group V.

It would seem that the above divisions take into consideration, to a considerable degree, the character of the changes taking place in the material examined. It permits of a clearer and more accurate demonstration of the course followed by physiological processes and to a greater degree is con-

nected with the biology of the species than when material is merely grouped according to successive months¹).

It may be objected that when making an analysis of the ratio of weight of glands to body weight, that the weight of fixed material has been related to individuals weighed in the fresh state. This is of no fundamental significance, however, as the purpose is not to present certain concrete relationships, but to discover the variations taking place from the time aspect.

In order to facilitate reading, the value of the relations in tables 2 and 3 was multiplied by 1000.

III. BODY WEIGHT

The general character of the curve of variations in body weight was much the same in 1955—56 as that several times described previously (Dehnel, 1949; Borowski & Dehnel, 1952, etc.).

Borowski & Dehnel (1952) showed that the average body weights

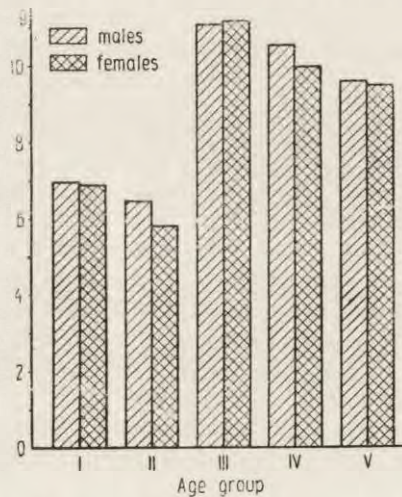


Fig. 1. Variation in the body weight of the common shrew.

of shrews in the various months over a period of several years may be subject to deviations. This variability of course depends on habitat conditions, that is, on climatic and food factors. This must exert an influence on the weight of the organs, but does not, however, mean that habitat conditions may decisively affect the general character of depressive or progressive processes (Pucek, 1957).

These two years (1955 and 1956) differ distinctly as to the character of the climatic elements. The winter of 1954/55 was mild, and the spring of 1955 early and warm. As shown by the captures made, the condition of the

¹) A somewhat similar treatment of the whole of the material was used by Schubarth (1959) when working on measurements of the skulls of *Sorex araneus araneus*.

shrews in the area in 1955 was good. The winter of 1955/56 was exceptionally hard. As a result of the formation of several layers of ice on the surface of the soil in the forest, the living conditions of mammals markedly deteriorated (Caboń, 1958). Only a relatively very small portion of the shrew population born in 1955 survived the winter, or rather the early spring period of 1956.

The climatic conditions exerted a certain influence on the general condition of the shrews. Body weight of young animals in 1955 was, for a shrew population, unusually even and did not exceed 8.4 g. This state was maintained until December. It was not until January that a fairly sudden decrease in body weight became evident, which was maintained at this level throughout the whole winter and early spring period (individuals in group II). The decrease in weight is more distinct and intensive in females. This phenomenon was observed in a large series of individuals.

The spring jump in growth began, as previously stated, very late. Despite the fact that maturation of the males began in April, the increase in their body weight was on an average only about 0.8 g. in relation to the winter mean.

In the spring and beginning of the summer the adults, after the difficult early spring period, were in an obviously poorer condition than in the same periods of the previous year. This was reflected even in the body weight of the young in the first spring litter, which were lighter than young from the first litter of the preceding year.

The adults did not attain large body weights until the second half of the summer of 1956.

The autumn depression in the adults began in 1956 with greater intensity than was the case in 1955. This suggests the earlier dying-out of adults in 1956.

IV. VARIATION IN THE WEIGHT OF THE „SUBMAXILLARY” GLANDS

The weight of the „submaxillary” glands in young shrews (group I) varies from 13.2 to 38.8 mg. No great differences occur between the mean weights per month. The difference in body weight observed between males and females is reflected in the weight of the „submaxillary” glands — their mean weight being slightly greater in females. This phenomenon would not appear to depend on the condition of the animals. A slight decrease in body weight apparent in the females in the later autumn months was not expressed by a decrease in the weight of „submaxillary” glands.

In individuals from group II (in the winter-early spring period) the weight of „submaxillary” glands decreases only very slightly.

These organs, therefore, are almost entirely independent of the winter weight depression. At this same time the body weight falls by about 8% in males and about 16% in females.

In April the „submaxillary” glands in males, in which progressive variations have begun, with an increase in body weight of about 11%, increase in weight by about 6%.

In June both males and females have the body weight normally encountered in adults during this period, i.e. 11—12 g. Simultaneously a marked increase in the weight of „submaxillary” glands takes place. While body weight increases by 38%, the weight of the „submaxillary” glands increases in males by 59%, and in females by 68%. In relation to the minimum values during the period of deepest winter depression, the figures are as much as 61% and 79%.

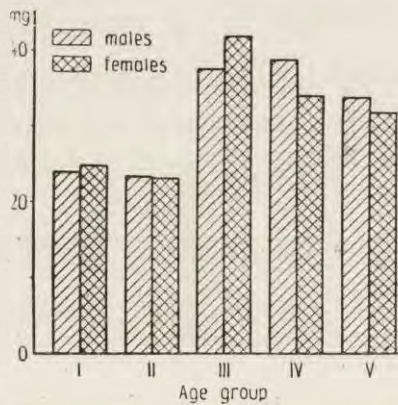


Fig. 2. Variation in the weight of the „submaxillary” glands.

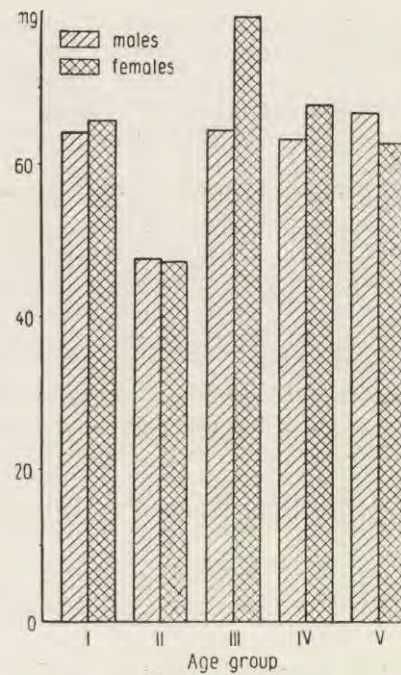


Fig. 3. Variation in the weight of the parotid glands.

The heavy weight of the „submaxillary” glands is maintained until the autumn. In females from group III (In June and July) the average weight of these glands is always higher than in males. The average for females is 41.5 mg., for males about 37 mg. (Fig. 2).

Beginning with August, a sharp decrease in the weight of the „submaxillary” glands can be observed in females. Their average weight falls in August and September (in the case of specimens from group IV) by about 19%. This is accompanied by a decrease in body weight of about 10%.

With males both the weight of the glands and the body weight is maintained on an almost unvarying level.

In 1956 the decrease in weight of the „submaxillary” glands was far more strongly accented than in the corresponding months of 1955, although the course followed by these processes was similar. In the autumn the decrease in body weight and the weight of the

Table 2.

The ratio of weight of „submaxillary” glands to body weight.

	g · 10 ⁻³		3.5	4.7	5.9	7.1	8.3	9.5	10.7	11.9	13.1	14.3	15.5	n	x̄
	age group	sex													
young	I	♀♀			5	14	27	24	17	12	2	3	1	105	9.53
	/VI-XII/	♂♂	1	6	11	23	19	11		8	4	2		85	9.31
	II	♀♀		5	3	10	14	9	5	1	1			48	8.27
	/I - IV/	♂♂		5	10	17	13	5	2					52	7.40
adult	III	♀♀		4	10	14	5	1	1					35	6.92
	/VI-VII/	♂♂	3	28	42	17	5		1					96	5.96
	IV	♀♀	3	6	24	32	20	1	1					87	6.92
	/VIII-IX/	♂♂	1	18	27	8	6	1		1				62	6.15
	V	♀♀		3	2	4		1						10	6.47
	/X - XI/	♂♂		1	4	4	3	1						13	7.10
Total			7	71	133	131	116	62	38	22	7	5	1	593	

„submaxillary” glands in females reached as much as 30%. The scanty material from 1956 did not permit, however, of drawing completely objective conclusions.

The ratio of weight of „submaxillary” glands to body weight exhibits relatively slight fluctuations over the life span of the shrews (Table 2). This ratio varies in the case of males within limits of 3.4 to 3.8; with females — 3.4 to 4.0. The greatest increase in this ratio is observed in the winter with individuals from group II, during the weight depression. A certain increase in the ratio during the early autumn period (with males from group IV) is caused (or so it would seem) by the slight decrease in body weight

which is not accompanied by a decrease in the weight of the glands.

In the late autumn (with specimens from group V) the decrease in the ratio figure for weight of the „submaxillary” glands to body weight is caused in adults rather by the reduction in weight of the glands. This phenomenon is observed only in adults during this period. With young animals both the weight of the glands and the body weight is maintained on almost the same level. In the case of the adults, therefore, this phenomenon is connected with their growing old.

Fluctuations in the value of the ratio for different years are random in character (Neumann test).

To sum up the results obtained it may be said that:

1. The trend in the variation in weight of the „submaxillary” glands is in general outline in agreement with the course followed by variation in body weight. With individuals from group II (winter depression period) the decrease in body weight is not, however, accompanied by a decrease in the weight of the „submaxillary” glands on a similar scale. These glands are hardly at all subject to depressive variations revealing themselves in a decrease in weight.

2. The ratio of weight of the „submaxillary” glands to the body weight exhibits fluctuations of a random character. The greatest value of the ratio falls within the winter depression period (individuals of group II).

3. The largest and heaviest „submaxillary” glands are encountered in adult females during the period of their greatest sexual activity (females from group III).

V. VARIATION IN WEIGHT OF PAROTID GLANDS

Variations according to season or age in the parotid glands take a different form to those in the „submaxillary” glands. These relations are illustrated by fig. 3.

The weight of parotid glands is not subject to great fluctuation. An exception to this is formed by the individuals from the winter depression period (group II) and the females during the period of their great sexual activity (groups III and IV).

In June the parotid glands in young females are about 5% heavier than those of the males.

In the case of sexually active adult females, which will be discussed later on, the parotid glands are very heavy. Young females from the first litter, as Pucek showed (1959) nearly all have a transitory tendency to sexual maturation. It is therefore possible that the slight increase in weight of the parotid glands in young females indicates the connection between these glands and the sex organs.

With individuals from group II (winter and early spring period) the reduction in weight of the parotid glands is relatively great and deepens up to the end of April inclusively. The percentage is 28 for females and 26 for males, and therefore relatively considerably greater than the total loss in body weight.

With adult males, after the jump in growth, the parotid glands „return” in principle only to the weight attained during the summer-autumn period in young animals (included in group I), i.e. to about 63—65 mg. on an average. With adult males from 1956 (group III) the weight of the parotid glands is less than in males of group III from 1955, the difference being, on an average, about 8 mg, i. e. about 13%. With adult males (group V) during the late autumn period, the weight of the parotid glands increases slightly in relation to their weight during the early autumn period (group IV). These fluctuations are, however, small.

Variation in the weight of parotid glands in adult females take a completely different form. With females from group III, during the period of greatest sexual activity, the average weight of the parotid glands is as much as 80 mg. In relation to young females from June the increase in weight is about 17%, and in relation to inactive females from group V, 21%. Nevertheless the average weight of the parotid glands in females was high in September — 70 mg. It must, however, be emphasised that there was an only slightly smaller percentage of pregnant and nursing animals in the material studied than in June and July.

The material included nine females which matured in the first calendar year of their lives. They were caught in June, July and August. The weight of the parotid glands of these females was (as a rule) higher (75 mg.) than the average weight of the same glands in young shrews. The range of variation in the weight of the glands varied from 65 to 115 mg., and was therefore a similar weight to that encountered in pregnant adults.

Table 3.
The ratio of weight of parotid glands to body weight.

	g · 10 ⁻³												n	xi	
	age group	sex	1.9	2.3	2.7	3.1	3.5	3.9	4.3	4.7	5.1	5.5			5.9
young	I	♀♀	1	1	11	31	28	14	10	6	1	1	1	105	3.6
	/VI-XII/	♂♂	1	5	8	25	30	9	4	1				83	3.4
	II	♀♀			4	8	10	6	6	3	1	5		43	4
	/I - IV/	♂♂	2	1	7	10	10	9	6	4				49	3.6
adult	III	♀♀	3	2	3	6	8	8	3		1			34	3.4
	/VI-VII/	♂♂	1	4	15	36	12	10	5	5	1		1	90	3.4
	IV	♀♀			7	15	17	20	20	4	1	2		86	3.4
	/VIII-IX/	♂♂				4	18	19	5	5	6	1	2	60	3.7
	V	♀♀				2	2	4	2					10	3.4
	/X - XI/	♂♂				1	3	5	2	1				12	3.6
Total			8	20	70	156	146	85	44	26	7	8	2	572	

Table 4.
The ratio of weight of „submaxillary” glands to weight of parotid glands.

	g · 10 ⁻³												n	xi		
	age group	sex	0.17	0.25	0.33	0.41	0.49	0.57	0.65	0.73	0.81	0.89			0.97	1.05
young	I	♀♀	1	19	29	32	14	4	2						101	0.39
	/VI-XII/	♂♂		9	29	31	10	1							80	0.38
	II	♀♀			5	9	10	8	6						38	0.50
	/I - IV/	♂♂			6	14	16	11	1						48	0.48
adult	III	♀♀			1	10	9	12	1	1					34	0.51
	/VI-VII/	♂♂				12	22	29	13	11	2				89	0.57
	IV	♀♀				7	14	36	23	6	1				87	0.51
	/VIII-IX/	♂♂					2	15	18	9	10	4	2	1	61	0.63
	V	♀♀				1	2	3	3		1				10	0.51
	/X - XI/	♂♂					4	3	4	1	1				13	0.53
Total			1	28	78	130	138	113	39	25	6	2	1	561		

The „submaxillary” glands of these females (in four out of the six examined) were also large and the weight corresponded to the „submaxillary” glands of adults. In any case the weight of even the lightest „submaxillary” gland of these females was greater than the average for the weight of „submaxillary” glands in young animals from the same month.

The ratio of weight of parotid glands to body weight (Table 3) changes considerably with age. In young individuals from group I, it is maintained more or less on a uniform level. In young females, for the reasons discussed above, the ratio is slightly greater (females — 9.5, males — 9.3). In specimens from group II, as a result of the great decrease in weight of the parotid glands, the ratio decreases. It is the lowest for males from April, and is over 7.0. For the whole period, for the males, the average is 7.4, and for females 8.3. It therefore continues to be slightly higher for the females, which is partly accounted for by the relatively greater decrease in their body weight.

After the rapid increase in size, the ratio of weight of the parotid glands to body weight continues to decrease. In the case of females it is higher and does not vary in groups III and IV, while with males it is lower.

The ratio of weight of parotid glands to body weight increases with adult males from the spring until late autumn. This phenomenon can be observed on different scales, but the percentages are similar in both years. For example — the ratio for males from group III (June-July) — 5.96 (for both years), from group IV (August-September) — 6.15, from group V (October-November) — 7.10. The fall in body weight is only partly responsible for this. Depressive variations are not always accompanied by corresponding decreases in the weight of the glands, as is the case during the winter depression. On the contrary, in the late autumn, with males from group V, with the fall in body weight, an increase can be observed in the weight of the parotid glands (the average in percentage increases in 1955 by about 11%). It is, however, possible that the cause of these „variations” is the inadequacy of the material coming from that period.

VI. RATIO OF WEIGHT OF „SUBMAXILLARY” GLANDS TO WEIGHT OF PAROTID GLANDS

With young shrews (group I) in which the parotid glands are equivalent in weight to those of the adult males, and the weight of the „submaxillary” glands is less than that of the latter, the ratio is somewhat low, i.e. 0.38 for males and 0.39 for females. This may be simply expressed by stating that salivary glands in young

animals from group I are characterised by the „domination” of parotid glands (Table 4).

In individuals from group II (winter depression period) when the weight of the „submaxillary” glands remains almost unchanged and the weight of the parotid glands falls considerably, the ratio rises in favour of the „submaxillary” glands and reaches about 0.50. We therefore have, as it were, a „domination” in weight of the „submaxillary” glands during this period.

After the jump in growth the ratio of the weight of „submaxillary” glands to the weight of the parotid glands takes a slightly different form with the two sexes. With males (group III) the weight of the parotid glands rises only very slightly. The „submaxillary” glands during this period increase by about 59% in weight. An even more significant shift therefore takes place in the direction of dominance of the „submaxillary” glands. The ratio with adult males then rises to 0.57, and may even reach as much as 0.63. In the late autumn (group V) when the males are distinguished by an increase in the weight of the parotid glands, the ratio changes correspondingly to the disadvantage of the „submaxillary” glands.

With females the value of the ratio is established as early as in group II and remains unchanged. This of course results from the fact that in the case of sexually active females beginning with the end of the winter depression period, both the glands discussed increase in weight. In the late autumn (group V) the ratio is not subject to much variation as both glands simultaneously lose weight to more or less the same degree.

VII. DISCUSSION

For the reasons given in the introduction, the interpretation of the results obtained must be confined to the necessary minimum, until the publication of the materials as a whole.

The character of the variation in weight of the salivary glands, the variation in the ratio of their weight to body weight and the mutual ratio of both glands examined may be the result of very different causes.

These may be: 1) variations of a conditional type (change in feeding conditions); 2) seasonal variations in diet evoking excessive growth of one and reduction of another function and in consequence, of the mass of the second gland; 3) increase in the mass of food

consumed (e. g. in the case of females during a period of intensive reproduction), and therefore of the mass of the glands engaged in „breaking down and transforming” the food; 4) periodical variations in the glands caused by the action of factors of a hormonal character, leading to variations of a dimorphic character in the weight of the glands.

It would seem that all these factors exert an influence in different periods of the animal's life, and the curves obtained of seasonal variations in weight are to a certain degree their vectors. Of course the force of action of one or another factor may be non-uniform, and not all of them must act simultaneously.

1. **Conditional changes.** When investigating the influence of starvation on the organisms it was found that the salivary glands belong to that group of organs, decrease in the weight of which is parallel with reduction in the weight of the animal (J a c k s o n, 1929). As can be seen from the material which I have presented, in many cases the decrease in weight or increases in weight of the glands cannot be connected with the corresponding changes in the general body weight resulting from the improvement or deterioration of their living conditions. During the summer period it even seemed that on account of the high metabolic rate of shrews (M o r r i s o n & P e a r s o n, 1946; T u p i k o v a, 1949) temporary and frequent changes in the condition of the animals do not affect the weight of the glands.

Only distinctly marked depressive changes in the winter and early spring period (in individuals of group II) can be explained by hunger. This would be the simplest hypothesis to accept. As early as 1938 Stein assumed that the decrease in the body weight of shrews observed during the winter period is caused by hunger. It would not, however, seem that hunger was a regulator, or at least not the sole regulator, of depressive changes. Numerous authors (D e h n e l, 1949; 1950; B o r o w s k i & D e h n e l, 1952; P u c e k, 1956); and in particular P u c e k (1957) showed that the depressive phenomena begin far earlier than the start of the period during which feeding conditions might deteriorate. Progressive changes also occur considerably earlier than an improvement in living conditions can take place.

Intermittent collections made in 1961 of invertebrates hibernating under litter and in rotten tree stumps showed that it is com-

paratively easy to find large numbers of insects, *Myriapoda* and *Mollusca*. The shrew feeding in the winter below the surface of the litter, or digging tunnels in the rotten part of trees probably finds, without undue difficulty, numerous animals spending the winter there²). Finally, in the winter, the body weight in the material examined drops by about 8% in males and 16% in females. The great decrease in weight of the parotid glands considerably exceeds the limit to which it might reach in reference to the parallel variation in body weight, in the case of variations caused by hunger. The „submaxillary” glands on the other hand, exhibit practically no reaction to the decrease in body weight. We can therefore see that in both cases, some factors of a physiological character, clearly dominate over conditional phenomena.

On the other hand, an example of the effect of habitat conditions, both climatic and food, taken as a whole, on the salivary glands are the variations observed in the shrew population in 1956. The adults and young individuals from the first spring litter were lighter in weight when compared with such specimens from 1955.

2. Seasonal variation in diet. It is known that seasonal variation in diet may significantly affect the growth of the salivary glands, and may even alter their mutual size ratio. It is also known, for instance, that animals adhering to a mainly meat diet, have relatively well-developed submaxillary glands, and less extensively developed parotid glands.

Variations in the ratio of weight of these glands in ruminants are, for example, characteristic. Wilkus (1957) showed that in the case of European bison calves, on transition from a milk to a vegetable diet, changes take place in the character of the salivary glands and their weight. With calves up to 15 days old, the submandibular glands are heavier than the parotid ones. In individuals from 1 to 2 years old, the weight ratio of the submandibular to parotid gland is 100:157.7, and in adult animals — 100:185.4. The considerable growth of the parotid gland in goats upon transfer to vegetable diet was established by Geshinskaya (1957). Changes in weight of the salivary glands of rats reared on a varied diet are also known (Brieger, 1939).

²) In favour of the above supposition is the fact that under winter conditions the shrews are as a rule caught near stumps or in the hollows left by overturned trees or stumps.

The shrew is basically „carnivorous”, but it can consume relatively large amounts of vegetable food (Tupikova, 1949). This authoress even supposes that vegetable food is a normal addition to the natural food of shrews and under natural conditions is always included in its diet. The fact is also well known that *Soricidae* can be caught by means of a cereal bait (bread) in relatively large numbers (Reinwaldt, 1955).

The investigations of many authors showed that under field conditions shrews readily eat the seeds of coniferous trees (Moore, 1942; Kangur, 1954; Zablockaya, 1957; Pelikan, 1955; Dehnel, 1961). Kangur, in his observations of shrews kept in cages, found that over a period of 24 hours they consumed an amount in weight of seeds equal to half of their whole body weight. Under field conditions they ate from 50 to 100% of the seeds put out for them. The amount of seeds consumed varied according to the season of the year, being greatest in the winter and early spring, when natural food was scarce. Zablockaya (1957) in her experiments, however, showed that consumption of the seeds of coniferous trees by the shrews was highest in the autumn, and lowest in the winter. This latter would explain the decrease in weight of the parotid glands (and therefore probably the reduction of their function as a result of the smaller participation of the vegetable component in the shrews' food) especially in the winter (in individuals from group II).

Under the conditions in the Białowieża Forest numerous trees, e.g. hornbeam, ash, and alder, shed their seeds the whole winter, whereas the coniferous trees, the seeds of which form the chief vegetable food of shrews, shed mainly in the very early spring. Until the disappearance of the thick covering of snow, however, these seeds are in any case difficult for the shrews to find, especially during frosts. I am of the opinion, like Zablockaya (1957), that consumption of seeds takes place only to a very slight extent in the winter.

It may therefore be that the decisive factor in variations in weight of the salivary glands during the winter period (in individuals of group II) is the change in the composition of the animals' food, or the differences in the amount of vegetable food eaten in relation to food of animal origin. The maintenance of the weight of the „submaxillary” glands during the period under discussion

would seem to indicate that the shrews changed over during this time to an almost entirely meat diet. The increase in weight of the salivary glands in the early spring would be accounted for by the general increase in body weight. When the shrews become „carnivorous”, the „submaxillary” glands of course develop far more strongly, and the parotid glands remain in principle, after regaining the weight lost during the winter period, on a level similar to that in young individuals.

It is also possible that the „domination” of parotid glands in young specimens from group I could be accounted for by the fact that the young, and as yet somewhat clumsy animals make greater use than the adults of vegetable food.

3. Increase in the mass of food consumed. This undoubtedly contributes to the excessive growth of the salivary glands (with sexually active females). The increase in the weight of parotid and „submaxillary” glands can be observed in group III during the period of the greatest intensity of reproduction. These are increases incomparably greater than those occurring during this period in males. It would seem probable that the mother shrews may be far less fastidious in their choice of food and supplement animal food by large quantities of vegetable food.

4. Hormonal factors. Without entering into a discussion here of the changes taking place in the internal structure of glands it must be stated that a certain external expression of the so-called „sexual dimorphism” of the salivary glands are changes in dimensions. During a period of sexual maturation an increase in weight of the salivary glands can be observed in many species in the one sex only.

This phenomenon was discovered by Hammett (1923) in the white rat. It was not fully investigated until 1940, by Lacasagne, in the mouse and also in the rat (in fact for a long time doubts were felt as to the existence of dimorphism in the salivary glands of the rat).

In the males of white mice, during sexual maturation, the tubular part of the submaxillary gland expands. This causes the submaxillary glands of the males to become heavier than those of the females. Castration causes atrophy of the glands in males, and in females an increase in the weight of the glands and change in structure tending to „masculinisation”. Pregnancy also causes a certain „masculinisation” (Deschmann, 1930; Thompson,

1933; Lacassagne, 1940; Raynaud, 1944; 1949; Junqueira et al., 1949; Harvey, 1952; Mostachfi, 1955; Desclin, 1958; Atkinson et al., 1959).

In other species of rodent studied, Raynaud J. & A. (1944) found that sexual dimorphism in *Apodemus sylvaticus* (Linnaeus, 1758) was „almost imperceptible” (with an absence of distinct differences in weight). Raynaud (1949) found similar relations as in the case of mice, in three species of voles: *Microtus arvalis* (Pallas, 1779), *Microtus agrestis* (Linnaeus, 1761) and *Clethrionomys glareolus* (Schreber, 1780).

With insectivores, Nedelea (1953) did not find either sexual dimorphism or seasonal difference in the structure of the salivary glands of the mole, while Godet (1956), who investigated the parotid glands in moles also, showed that these glands are larger in the males and exhibit variation to a certain degree corresponding to the variation of the accessory sexual glands.

Variations of this type may therefore affect both salivary glands. As shown in the material examined, with young shrews from group I, with the exception of individuals caught in June, the glands in both sexes reveal no significant differences in weight. This can easily be explained by the fact that the young shrews do not mature sexually, with few exceptions, until the second calendar year of their lives.

The weight of the corresponding glands remains more or less the same in both sexes during the winter period (in specimens from group II).

It is not until the spring, during the maturation period and after the jump in growth that marked increase in the weight of both glands in females (group III) can be observed. In males during this time there is only a slight increase in the weight of the parotid glands and a lesser increase than with females in the weight of „submaxillary” glands.

During the early autumn period the weight of the „submaxillary” glands in females falls below the weight of these glands in males, while the parotid glands continue heavier (group IV).

In individuals from group V, in the late autumn after the reproduction period, the females have lighter parotid and „submaxillary” glands than the males.

It would seem that the great development in the parotid glands of sexually active females is caused by hormonal factors. This is

indicated by the young pregnant females from June, in which the weight of the parotid glands is about 75 mg. As is well known (Pucek, 1960) their maturation is not accompanied by the jump in growth proper to adults. Variations of this type could perhaps be „drawn into” the category of variation of a dimorphic character — in fact it would be a specific „ecological” dimorphism — closely connected with defined living conditions of the young animals in a given year.

On the other hand it is difficult to speak of dimorphic variations in the „submaxillary” glands of shrews. These glands are only heavier in females than in males during the two spring months (group III), later on the reverse occurs (in specimens from group IV).

In any case it would seem that we have here rather a case of the effect of intensification of the physiological function of glands on the variations in weight connected with it, than with the possible effect of factors of a hormonal-dimorphic character.

In the light of the most recent research work on the production of parotin by the salivary glands, it might be possible to connect the changes taking place in the parotid glands (functional, and therefore weight changes) with the seasonal variations in the height of the brain case of the shrew (these variations could in fact be connected with the submaxillary glands also). These connections have not so far been investigated in shrews. It is the more likely, because the variations in the weight of parotid glands (and therefore the possibility of intensification of activity in the presumed periods of production of a greater amount of hormones) are in general in accordance with the course followed by variations in the height of the brain case of shrews.

VIII. RESULTS.

1. The curve of variation in weight of „submaxillary” glands is in general in accordance with the course followed by variations in body weight. On the other hand variations in weight of the parotid glands do not in every age group keep pace with variation in body weight.

2. The phenomenon of winter depression is almost completely unreflected in the variations in weight of the „submaxillary”

glands. These organs are almost entirely independent of depressional variations which would be reflected in reduced weight. The weight of parotid glands during the winter depression period exhibits a relatively great decrease. Its reduction deepens until April inclusively, and is comparatively far greater than the general loss of body weight during this period.

3. The largest and heaviest „submaxillary” glands are those in adult females from group III (during the phase of most intensive reproduction). After this period the weight of these glands decreases. The weight of parotid glands in adult females (groups III and IV) which are sexually active is also considerably higher than in males. It does not decrease until the end of the reproduction period.

4. The weight of „submaxillary” glands in adult males from group III is relatively great (in comparison with individuals from group I — increase in weight is 59%), and the autumn decrease is fairly slow.

The weight of the parotid glands in these animals, in comparison with the weight of glands in males from group I, hardly increases at all. It „returns” only to the level of the summer-autumn period in young shrews. The weight of parotid glands in adult males from group V is higher in the late autumn than in that in individuals from group IV (during the early autumn period).

5. With young females which attained sexual maturity in the first calendar year of their lives, the weight of „submaxillary” glands and parotid glands is higher than the average weight of these glands in corresponding months in young immature females.

6. The ratio of weight of the „submaxillary” glands to body weight reveals fluctuations of a random character.

The ratio of weight of the parotid glands to body weight varies distinctly with age, and its fluctuations are of a non-random character (in both cases a check was made by means of the Neumann test).

7. The ratio of weight of „submaxillary” glands to the weight of parotid glands varies over the life span of the shrews. In general it may be noticed that salivary glands in young, immature animals are characterised by the „domination” of the parotid glands (specimens from group I). In individuals from group II (winter depression period) the domination in weight of the „submaxillary” glands is marked. With adults in the case of females from groups III, IV and V — the ratio, on account of the simulta-

neous increase or decrease in weight of both glands — does not alter. With males, except for the short late autumn period including animals from group V, the value of the ratio shifts in the direction of „domination” in weight of the „submaxillary” glands.

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STRESZCZENIE

Celem pracy jest przeanalizowanie wagowej zmienności sezonowej i wiekowej gruczołów ślinowych ryjówki aksamitnej, *Sorex araneus* Linnaeus, 1758. Materiał (Tabela 1) pochodził z odłowów w Białowieskim Parku Narodowym, w latach 1955—1956. Ślinianki (*glandulae submaxillares* i *glandulae parotis*) preparowano z materiału utrwalonego uprzednio i przechowywanego w alkoholu metylowym. Gruczoły podszczękowe (*gl. submaxillares*) traktowano łącznie z gruczołami podjęzykowymi (*gl. sublinguales*) ze względu na niemożność dokładnego rozpreparowania utrwalonego materiału. Na gruczołach „świeżych” przeprowadzone zostały tylko ważenia kontrolne. Materiał został podzielony na pięć grup i w takim układzie przedstawiony na tabelach (2—4) i diagramach (Ryc. 1—3). Układ ten pozwala na jaśniejsze i dokładniejsze pokazanie przebiegu zmian zachodzących w badanym materiale.

Obliczono stosunek ciężaru badanych gruczołów do ciężaru ciała, przyjmując, że strata na wadze w wyniku utrwalania ma charakter stały a uzyskana krzywa zmienności jednakowo różni się od rzeczywistej relacji. Krzywa zmienności obrazuje zatem tylko przebieg procesów w aspekcie sezonowym.

W wyniku badań stwierdzono, że:

1. Krzywa zmienności ciężaru gruczołów „podszczękowych” jest w zasa-

dzie zgodna z przebiegiem zmienności ciężaru ciała (Ryc. 2). Ślinianki „podszczękowe”, jednak, prawie nie podlegają wagowym zmianom depresyjnym w okresie zimy (spadek ciężaru ich dla samic wynosi 6,2%, dla samców — 1,32%). U przezimków, po skoku wzrostowym, największe i najcięższe gruczoły „podszczękowe” mają samice w fazie intensywnego rozrodu (grupa III — czerwiec i lipiec). Po tym okresie ciężar tych gruczołów spada. U samców — przezimków, w czerwcu i lipcu, ciężar gruczołów „podszczękowych” jest również stosunkowo wysoki (w porównaniu do osobników młodych przyrost wynosi 59%), spadek jesienny jest dość powolny.

2. Zmiany ciężaru gruczołów przyuszných nie we wszystkich okresach cyklu życiowego ryjówek są skorelowane z ciężarem ciała. W okresie depresji zimowej ciężar ich zmniejsza się stosunkowo znacznie (dla samic o 27,8%, dla samców o 25,6%). Redukcja jego pogłębia się aż do kwietnia włącznie i jest większa niż ogólne straty ciężaru ciała w odpowiednim okresie (Ryc. 3). U samic-przezimków w ciągu całego okresu aktywności płciowej t. j. w grupach III i IV — ciężar gruczołów przyuszných jest znacznie wyższy niż u samców. U tych ostatnich, w porównaniu z młodymi, ciężar gruczołów przyuszných prawie nie wzrasta (przyrost 0,34% w czerwcu—lipcu). U samców z grupy V ciężar tych ślinianek jest wyższy niż u osobników z IV grupy (sierpień—wrzesień).

3. U młodych samic, które osiągnęły dojrzałość płciową w pierwszym kalendarzowym roku życia, ciężar zarówno gruczołów „podszczękowych” jak i przyuszných jest wyższy niż średni ciężar tych gruczołów w odpowiednich miesiącach u młodych samic płciowo nieaktywných.

4. Stosunek ciężaru gruczołów „podszczękowych” do ciężaru ciała (Tabela 2) wykazuje wahania o charakterze losowym, zaś gruczołów przyuszných zmienia się wyraźnie z wiekiem ryjówek (Tabela 3) i wahania jego mają charakter nielosowy (w obu przypadkach stosowano test Neuman'n'a).

5. Wzajemny stosunek ciężaru gruczołów „podszczękowych” do ciężaru gruczołów przyuszných (Tabela 4) zmienia się w ciągu życia ryjówek. Ślinianki młodych, niedojrzałych płciowo zwierząt, charakteryzuje „dominacja” gruczołów przyuszných (okazy grupy I). W okresie depresji zimowej zaznacza się „dominacja” wagowa gruczołów „podszczękowych”. U samic przezimków — ze względu na równoczesne zwiększanie lub zmniejszanie się ciężarów obu gruczołów — stosunek ten nie zmienia swej wartości. U samców, z wyjątkiem krótkiego okresu późno-jesiennego wartość relacji przesuwa się w kierunku ciężaru gruczołów „podszczękowych”.

6. Analizując zmienność przebadanych gruczołów ślinowych można stwierdzić, że: a) różnice wagowe występujące między materiałem z roku 1955 a 1956 mają charakter kondycyjny; b) zmiany zachodzące w okresie depresji zimowej nie wydają się mieć charakteru kondycyjnego; a raczej czynniki fizjologiczne dominują nad zjawiskami kondycyjnymi. Decydującą rolę może odgrywać tutaj zmiana składu pożywienia lub różnice w stosunku ilościowym spożywanego pokarmu roślinnego do zwierzęcego; c) można

przypuszczać, że „dominacja” wagowa gruczołów przyuszných u młodych zwierząt wynika z większego udziału łatwiej dostępnej karmy roślinnej w pożywieniu. To samo zjawisko u samic-przezimków w okresie najintensywniejszego rozrodu, poza wpływem pobierania większych ilości pożywienia wskazywać mogłoby na znacznie mniejszą wybiórczość niż u samców z tego samego okresu; d) wpływ czynników hormonalnych wydaje się odzwierciedlać tylko w przebiegu zmienności ciężaru gruczołów przyuszných.

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