17.

X-Ray Observations on the Passage of Food in Orthoptera.

By

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In a previous paper (Bergh, Funder & Nielsen 1943) the X-ray set-up used has already been described. In that paper it was also mentioned that the purpose of the investigation was to form a basis for a biochemical investigation of the metabolism of grasshoppers.

The material on which the present paper is based was collected for the purpose of getting an idea of the time required for the food to pass the different parts of the gut of a grasshopper. In 1941 27 exposures were made, 16 of which constitutes a series of a food passage in a *Tettigonia (Locusta) viridissima* L. and 11 of that in other animals. In 1942 33 series of food passages in *Tettigonia* were observed by means of 553 exposures, 2 series of *Decticus verrucivorus* L. (13 exposures), and of *Bryodema tuberculata* and *Aeschna cyanea* a series of each with 8 and 9 exposures respectively. The last two animals were included in the investigation at an early stage in the hope that it would be possible to obtain a comparison between a marked herbivorous, an omnivorous, and a marked carnivorous insect. Further experiments with *Tettigonia,* however, showed that the problem was much more complicated than originally supposed and all the following experiments therefore aimed only at solving the problem regarding the long-horned grasshopper *Tettigonia.* Only the experiments with males of this animal will be dealt with on the following pages.

1. Anatomy of the alimentary canal.

The anatomy of the digestive system of *Tettigonia* and (especially) the related genera was carefully described in 1898 by Bordas. It consists of the three usual parts: Fore-intestine, mid-intestine,

and hind-intestine (Fig. 1). The fore-intestine runs as an oesophagus from the mouth through the head and the anterior part of the thorax. It is not possible to distinguish any special part as the pharynx. In the foremost part of the thorax the tube-like oesophagus is dilated into the very well developed crop, the caudal termination of which is situated in the first segment of the abdomen. The small but very well developed gizzard is situated just behind the crop and constitutes the last part of the fore-intestine.

The mid-intestine in *Tettigonia* is developed as a tube-like mid-gut curled up in one single turn in the manner shown in fig. 1. In the foremost part of the mid-gut two enteric coeca arise.

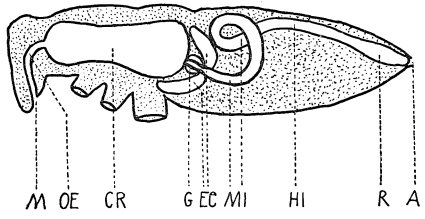

Fig. 1. Diagram showing the intestines of a *Tettigonia*.
M mouth, OE oesophagus, CR crop, G gizzard, EC enteric coeca, MI mid-gut, HI colon, R rectum, and A anus.

The hind-intestine continues the mid-gut just at the point where the Malpighian tubes arise in the gut. Two parts of it are clearly separable, viz. a colon and a rectum. The colon is tube-like, and the rectum is ovoid and somewhat larger than the preceding parts of the intestine. In the walls of the rectum the so-called rectal glands, six in number, are situated.

2. Technique.

As the technique used has already been described in the paper mentioned above (Bergh, Funder & Nielsen 1943), only a few words will be necessary here. In order to get a picture of the food during the digestion in the intestine, a contrast medium had to be mixed with the food. As a contrast medium uran oxide (U_3O_8) was found to give satisfactory results. The finely ground uran oxide was mixed with water, and the food soaked with this mixture before it was given to the animal. Immediately after the meal the grasshopper was fixed to a wrapper of black paper by means of plastilin or strips of gummed paper. The wrapper was of such a shape and size that it just fitted the negative material; it was stiffened by a bit of cardboard. On the top side was

a lap which could be turned round in order to protect the negative from the light.

Exposures were made at irregular intervals. Every negative was developed immediately after the exposure and the interval to the next picture estimated. During this estimation it was found very useful to distinguish between some phases in the advance of the contents of the gut. The same phases will be used in the following, and I shall therefore give a brief description of the phases shown in fig. 2, and plate I figs. 1—6.

Stage I, immediately after the meal. There is still some food in the oesophagus, nothing is seen behind the crop, which is more or less charged, corresponding to the amount of food received by the animal.

Stage II. After a rather long period — ½—2 hours — some of the contents of the crop are seen coming out into the gizzard. This stage is very short, and therefore only shown in a few of the pictures.

Stage III. The food now advances quickly in the mid-gut. In some cases the enteric coeca are charged in this and the following stages (shown in this but not in the following figures). In such cases an "e.c." is later on added to the number indicating the stage (IIIe.c.).

Stage IV. When the food has filled the ascending part of the mid-gut, I indicate the stage as IV. The advancing food-mass may be delayed here for some time, about one hour or more.

Stage V. The cranial-going part of the curl is now charged with food. At this moment more food is generally coming out of the crop into the mid-intestine. This stage lasts for one or two hours.

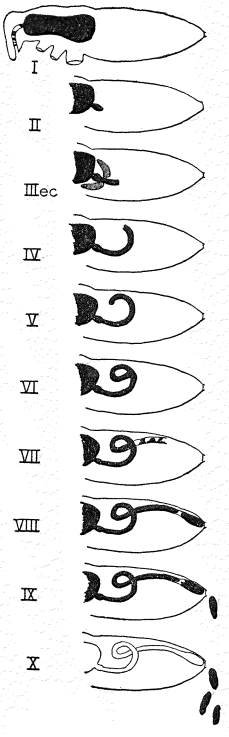

Fig. 2. Diagram of the ten stages in the progress of the food in the alimentary canal. See the text.

Stage VI is of very short duration. The curl is now totally filled and almost instantaneously part of the food proceeds into the hind-gut, very often in lumps (Stage VII). These lumps are then pressed together, and when a sufficient amount has gathered there, it is pressed into the rectum where it assumes the characteristic

form of the feces (Stage VIII). When the excrements have left the animal, the next portion is forced into the rectum (Stage IX). The last stage (X). The total draining of the entire food system has only been observed in a few experiments.

3. Relation of the temperature to the food passage.

In the first experiments in 1942 a very marked influence of the temperature was observed, and the following series aimed at the further elucidation of this problem.

In all these experiments the food was the same, viz. a house fly, presented to the grasshopper by means of a forceps after it had been moistened with the uran oxide mixture. Generally the grasshopper started by dividing the fly and first devoured the abdomen, later on picking up the rest of the prey. Wings, legs, and various other parts were left. During the process of chewing I smeared some of the uran oxide mixture on the food and the mouth-parts by means of a fine hair-pencil.

After fixation on the wrapper the animals were kept in a thermostat room at the temperature termed in the following the temperature of the experiment. But it is worth while to mention that during the exposure the heat from the X-ray tube radiated on the animal and raised the temperature in a manner somewhat difficult to control. A mercury bulb thermometer placed close beside the animal during the exposure showed a rise of about 2—4 degrees centigrade. This difficulty was coped with by regulating the temperature of the room in which the exposures took place to a temperature about 3^0 lower than the temperature of the thermostat room. Unfortunately, it was in these first experiments that a very slow negative material was used (Agfa Cine Positive Film) and the time of exposure was accordingly long. Later on, when Dentist's films were used, the time

was so short that the heating during exposure was without any importance.

The results of the experiments are given in the tables 1 and 2.

Table 1. Time in hours required for attaining Stages II—IX at different temperatures.

Temperature °C	Experiment No.	Stage II	III	IV	V	VI	VII	VIII	IX
18	0	1½	—	2½ec	3½ec	12	16½	19	22
18	5	2¼	—	10	12¼	14	22	—	—
18	10	—	—	2	3¼	4	5¼	—	35
18	11	—	3	5ec	8¼ec	10¼ec	—	19½	43¼
18	12	1	1ec	1¾ec	3	5	5½ec	6ec	28½
18	13	—	1	2¾ec	—	5¾	9¾	9¾	34½
23	16	¾	1½	3	4¾	—	6½	—	—
23	17	1¼	4	—	8¾	—	10¾	—	34½
23	18	—	—	—	—	4½	—	—	11
23	19	—	—	—	—	4½	—	—	12
23	20	1½	—	—	5	7	8½	10	13½
23	21	3½	—	—	3¾	4	4½	—	9¾
26	6	2	2	2½	4½	6	6	7½	19½
26	7	—	1¼	2¼	3¼	6½	7¼	7¾	19¼
26	8	—	1	2	2½	3½	5	6½	11¼
26	9	—	1ec	1½ec	2ec	2¼	2½	3½	8½
Mean values: 18				4	6	8½	12	13½	32½
23				3	5½	5	7½	10	16
26				2¼	3	4½	5¼	6¼	14½

While the experiments at 18° C and 26° C were made for the purpose of elucidating the temperature relation of the time to the food passage, the experiments at 23° C are picked from other series. They are included in the material although they lack some continuity.

As pointed out by Krogh (1914, 1916), the relation between temperature and metabolism may be expressed

by a curve which is of the same shape for all the animals examined; this has been confirmed by all later observations. It was to be expected that the food passage of the grasshoppers, too, would follow Krogh's curve.

Now, as will be seen from table 1, the results show a considerable dispersion, but the means indicate that there is an obvious tendency to greater velocity at higher temperatures. (See also fig. 3).

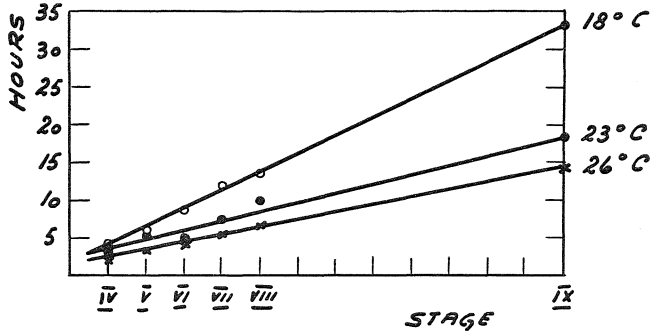

Fig. 3. Relation between the stage in the passage of the food and the time required to attain it at the three temperatures indicated.

In order to compare the temperature relation found with Krogh's curve a further treatment of the material will be necessary. The following manipulations are the simplest.

First of all it is necessary to consider the time required to attain each stage by plotting the time in hours as ordinate against the stages expressed in an arbitrary scale as abscissa (Fig. 3). As might be expected, the coefficient has a much more pronounced effect in the later stages than in the first. In the first stages the effect is less than the dispersion, and these stages are consequently omitted in the following. In order to eliminate the arbitrary scale and to pool the results for all the stages, the material must be arranged as shown in fig. 4, which

Table 2.

1	2	3	4	5	6	7	8	9
Temperature °C	Stage	Time in hours (h)	log h	Correction (k)	k + log h	antilog (k+log h) (h')	$\frac{1}{h'}$	$(\frac{1}{h}) \times 1438$
18	IV	4	0.60	0	0.60	4.0	0.25	360
18	V	6	0.78	0.20	0.58	3.8	0.26	374
18	VI	$8\frac{1}{2}$	0.93	0.27	0.66	4.6	0.22	317
18	VII	12	1.08	0.37	0.61	4.1	0.24	345
18	VIII	$13\frac{1}{2}$	1.13	0.44	0.69	4.9	0.20	288
18	IX	$32\frac{1}{2}$	1.51	0.77	0.74	5.5	0.18	259
								Mean: 324
23	IV	3	0.48	0	0.48	3.0	0.33	475
23	V	$5\frac{1}{2}$	0.74	0.20	0.54	3.5	0.29	418
23	VI	5	0.70	0.27	0.43	2.7	0.37	533
23	VII	$7\frac{1}{2}$	0.87	0.37	0.50	3.2	0.31	446
23	VIII	10	1.00	0.44	0.56	3.6	0.28	403
23	IX	16	1.20	0.77	0.43	2.7	0.37	533
								Mean: 465
26	IV	$2\frac{1}{4}$	0.35	0	0.35	2.2	0.45	648
26	V	3	0.48	0.20	0.28	1.9	0.52	749
26	VI	$4\frac{1}{2}$	0.65	0.27	0.38	2.4	0.42	604
26	VII	$5\frac{1}{4}$	0.72	0.37	0.35	2.2	0.45	648
26	VIII	$6\frac{1}{4}$	0.80	0.47	0.36	2.3	0.44	633
26	IX	$14\frac{1}{2}$	1.16	0.77	0.39	2.5	0.40	576
								Mean: 643

is a temperature-log time diagram, each curve representing a single stage as indicated. The logarithms of the time are used instead of the time itself so as to enable pooling the curves, which now appear as nearly straight lines of approximately the same slope. By adding or subtracting a certain correction to the values of the ordinate, common, of course, to all the three points of each line, but different for the different stages, the lines may be parallelly displaced until they cover each other. Table 2 gives the values in hours (column 3), in the logarithm of the hours (col. 4), the correction

necessary for the pooling of the curves (col. 5), and (col. 6) the logarithms thus corrected. The next column (7) gives the antilogarithms of the transferred values.

Krogh's curve deals with the velocity of the process of metabolism, but we have so far worked with the time

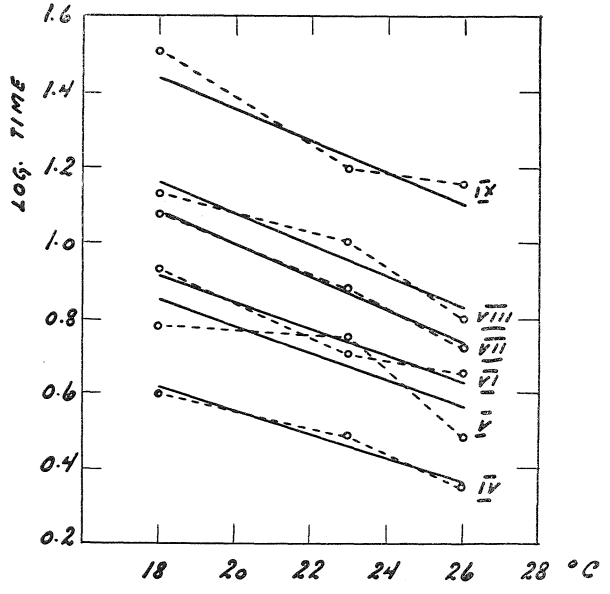

Fig. 4. Relation of the logarithms of the time required to attain the different stages of the passage of the food to the temperature.

necessary for the process. We must therefore convert these times to velocities by using the reciprocals (col. 8).

The ordinate of Krogh's curve has the numeric values of 320 at 18° C, 490 at 23°, and 620 at 26°. The corresponding values of the average of $\frac{1}{h'}$ at the three temperatures are . 225, . 325 and . 447.

Since $\frac{320}{.225} = 1420 \quad \frac{490}{.325} = 1510 \quad \frac{620}{.447} = 1385$

and $$\frac{1420 + 1510 + 1385}{3} = 1438,$$

we must multiply all the velocities found by 1438 in order to place them on a level with Krogh's curve (col. 9 and fig. 5).

Considering the great dispersion of the material it must be said that the accordance between the values found and the curve is very satisfying.

It was shown in an earlier paper (Tetens Nielsen 1938) that the metabolism of *Tettigonia* agreed with

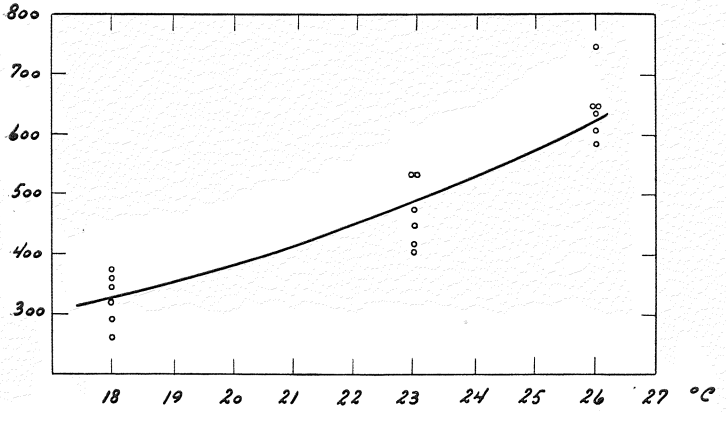

Fig. 5. Relation of the time of the food passage to the temperature compared with Krogh's temperature-metabolism curve.

Krogh's curve. But with the experiments then carried out, the relation was much more difficult to understand because the metabolism depended on the general activity rhythm attaching to the change of day and night. It is worth while to mention that this rhythm does not influence the functions of the alimentary canal.

The result of these experiments is another, too, in that it was seen to be absolutely necessary to keep the animals at a constant temperature during the experiments. All the following series of experiments were therefore carried out at a temperature of 23°.

4. Effect of starvation.

The great dispersion in the above-named experiments might be caused by the different conditions under which the animals were found. Some few experiments, therefore, were made to elucidate this problem. Comparisons were made between individuals after seven days starvation and other individuals which had been abundantly fed just before the experiment. T_{17}, e. g., $^{11}/_{9}$ received a grasshopper, $^{13}/_{9}$ another grasshopper, $^{18}/_{9}$ at 9 h one more, at 16 h 30' one more, and finally at 18 h 50' the fly with uran oxide.

Two such overfed *Tettigonia* showed no difference from four starving individuals. They arrived at stage V after 5 and 6 hours respectively and at stage VIII after just the same time, viz. 12 hours.

The manner in which the uran oxide is seen to progress in the gut is somewhat different in the two cases. In the starving animals, the food proceeds as a compact mass, but when the intestine is more or less filled with other food, the uran oxide appears gradually simultaneously over greater parts of the mid-gut as a kind of infiltration. It is especially (but not exclusively) in the animals with food in the mid- and hind-intestines that uran oxide penetrates into the enteric coeca.

5. Effect of the amount of food.

It was tried whether any variations might be seen corresponding to the amount of food taken by the *Tettigonia*. Table 3 gives the results:

Table 3.

Amount of food (fly)	Stage			
	III	V	VII	IX
1/2	1	6 3/4	8 1/4	13 1/2
3/4	1 1/2	4 3/4	6 1/2	—
1	3 3/4	4 1/4	4 1/2	9 3/4
1 1/2	4	8 3/4	10	34 1/2

It would seem that when there is only a small amount of food in the crop, this part of the gut is able to let the contents pass into the mid-gut at an earlier time than when there is much food to digest. For the latter parts of the gut no differences of importance could be seen from this material.

6. Experiments with other food than flies.

Only very little is known of the food of *Tettigonia* under natural conditions. The few earlier observations show that the animals are carnivorous, but on a certain occasion I saw a male feeding on the leaves of a Rumex acetosa (Tetens Nielsen 1938). Later on, in some experiments on the nocturnal activity of moths, I once saw a *Tettigonia* devouring a noctuid feeding on the bait. In the laboratory the animals may be fed on various insects, meal-worms, small grasshoppers, flies, and so on. But also vegetables or fruit, especially small bits of apple, are willingly eaten.

All the experiments so far reported in this paper were carried out with flies as food. In the sequel some experiments with other sorts of nutrition will be considered.

In four cases the food passage was observed after presenting small lumps of apple. They were cut up without the peel in pieces of about the same size as the house flies used in the previous experiments. They were soaked in a suspension of uran oxide in water. The time required for reaching the different stages are about the same as in the experiments with flies as food. The only difference I have found is that the content of the mid-gut looks more clotted, thus indicating that it has been mixed up with more aliments (Plate 1, fig. 7—8).

Other experiments were made with pure substances. In Exp. No. 27 a *Tettigonia* drunk some drops of the

pure water suspension of uran oxide. 7 minutes later the first exposure was made. It showed that a considerable amount was taken up in the crop. 40 minutes after the start some was entering the mid-gut (stage II) and after this the process was followed by exposures about one every hour on the first day, and thereafter at longer irregular intervals until 81 hours after the meal. The passage was very different from those usually observed. In the forepart of the crop as well as in the mid-intestine it is distinctly seen (plate 2, fig. 14) that the uran oxide separates from the water and adheres to the inner walls of the gut, while the water runs through to the hind-gut where it is most probably absorbed. Some of the uran oxide is isolated in the crop and remains there long after all the mid- and hind-gut has been drained. All the water has passed away and probably it is only possible for the crop to eject the contents if they are liquid. The remaining uran oxide forms a sort of concretion which perhaps passes away after a fresh intake of food. I have not had occasion to observe this.

Experiments with uran oxide suspended in sugar solutions (about 10 % saccharose) show a passage differing as well from the solid food as from the pure uran oxide suspension in water.

18 minutes after the meal the contrast medium is already seen in all parts of the intestine, even in the rectum. 20 minutes later this is a little more distinct (Plate 2, fig. 1). As the animal had never been fed on uran oxide before, it is certain that all the contrast medium in the intestine must have been from the food intake. In the hours that followed, the infiltration of the mid- and hind-gut became more and more pronounced. Plate 2, figs. 2 and 3 show the situation after 48 minutes and 6 hours respectively. The first defæcation was late, not until after 39 hours, but before 47 hours after the food intake.

In other cases of sugar feeding such a delay in defæcation did not take place; in Exp. 25 the first excrements appeared as early as $9\frac{1}{4}$ hour after the start. Plate 2, fig. 12 exhibits an earlier stage of this experiment 7 hours after the meal, showing that the contrast medium is entering the enteric coeca and that the gizzard is very conspicuous as is very often the case in experiments with sugar solutions.

Of experiments with saccharose the material comprises 7 series, but in the main features they are all of the same type as described above; and so also are 2 series with glucose used instead of saccharose.

In two cases it was tried to get the animal to eat fat. The fat from an ox was melted and the finely ground uran oxide suspended in it. After congealing, small bits were cut out and presented to the grasshopper, which chewed it eagerly. An X-ray examination afterwards showed, however, that nothing had arrived in the gut, not even in the oesophagus. This experiment therefore was discarded, but later on I realised that it would have been far better to give the fat in the form of a suspension in water, e. g. as cream.

Better results were obtained by presenting suspensions of uran oxide with protein. Two series were carried out with blood albumin and one with casein.

Especially in the first experiment the blood albumin had an extremely quick passage, arriving at stage VI $1\frac{3}{4}$ hours after the meal. Between 9 and 19 hours after the start more excrements had appeared, and in less than 33 hours all the contrast medium had passed through the animal. Plate 1, figs. 9—11 show the situations after $6\frac{1}{4}$ hours, 19 and $33\frac{1}{2}$ hours of the experiment. As it was the case with sugar solutions, the first stages (these pictures are not reproduced) are characterised by an infiltration of the content of the mid-gut with the contrast

medium growing more and more marked. In all the experiments with different food, the animal had been so long under starvation that this could not be caused by remains in the gut of an earlier meal.

The form of the contents in the crop (Plate 1, fig. 8) is most remarkable, with a diffuse border and a more compact nucleus. This feature has not been observed in any other case.

The passage of the food in the other experiment with blood albumin (as well as that with casein) was not quite so rapid but of the same type. Plate 2, figs. 7—9 give the situation after 10 minutes, $1\frac{1}{2}$ hours and 27 hours digestion of the series with blood albumin. In the first two pictures are seen the movements of the food in the crop, the last one shows how the contents in the mid-gut are mixed with aliments.

7. General remarks.

Very soon after the meal is finished, all the food is found in the crop. The situation in Pl. 2, fig. 5, where after $1\frac{3}{4}$ hours food is still seen in the oesophagus, is an isolated case. When I say the food, I mean of course the contrast medium; but only in Exp. No. 27, where the animal received a pure mixture of uran oxide and water, is it obvious that the water separates from the contrast medium. The possibility cannot be totally excluded that this is to some extent also the case with the solutions of sugar, but the proceedings are so different from the case with pure water (and uran oxide) that it is evident that in these cases, too, the contrast medium is a reliable indicator. Immediately after the food has come into the crop, it is treated by kneading. Exposures made at intervals of a few minutes show the continuous displacing of the globular food content (Plate 2, figs. 10—11, 30 and 33 minutes after the start).

This kneading occurs with all kinds of food, also with the sugar solutions.

The conditions under which the gizzard is seen in the pictures are still obscure. That it is not an organ for mastication as implied in the name gizzard, is seen from the fact that it is very distinct on the exposures from series of animals fed on sugar.

The condition under which the food is transferred to the enteric coeca are also so far unknown, they are especially seen when there are still remains of an earlier meal in the intestine, and in the experiments with sugar solutions.

It is a point worth mentioning that although the coeca are considerably thicker than the mid-gut, in the pictures they are always seen to shade much less than the gut. This leaves only two possibilities: either the walls are clasped together, and only a thin film of the food is taken in; or the coeca are filled with a fluid, with which the food is mixed.

In the mid-gut a cross-striation of the contents is fairly often seen. A similar phenomenon is well known from the human duodenum, where it is caused by the movements of the villi. In other cases the contents are of a clotted structure, which is caused by the mixing with aliments. Peristaltic movements are very rare in the exposures; the most distinct is shown in fig. 18, Pl. 1, just at the point where the progress of the contents is generally most rapid. If there are remains of old food in the intestine, the contrast medium is seen to infiltrate the remains also in the colon (Pl. 1, fig. 17). Only in extreme cases with very watery food may this infiltration extend to the rectum (Pl. 2, fig. 1), but generally with normal food for the animal there is no mixing in the rectum, as may be seen from fig. 12 and fig. 13 (Pl. 1) where the cranial part of an excrement is mixed with uran oxide and the older, caudal part is not.

In some exposures (not reproduced) it is seen that the excrements in the colon are reduced up to 10 % in length, thus plainly demonstrating the water absorption in that part of the intestine.

Summary.

Series of X-ray exposures demonstrating the food passage in *Tettigonia (Locusta) viridissima* L. under different conditions and with different kinds of food are reported.

The rate of the passage is found to agree with the curve found by Krogh and others to express the relation between temperature and metabolism. The daily rhythm found in activity and metabolism in the same species is not found in the digestion.

Some special features of the passage are described.

Acknowledgements.

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Explanation of the plates:

Plate No.	Figure No.	Experiment No.	Exposure No.	Hours after start	Remarks
1	1	7	51	1 1/4	Stage 2
	2	7	55	2 1/4	Stage 3
	3	7	60	3 1/4	Stage 4
	4	7	71	5 3/4	Stage 5
	5	7	81	6 3/4	Stage 6
	6	7	94	7	Stage 7
	7	15	6	7	Kneading in the crop. Mixing with aliments in the mid-gut.
	8	15	7	9 1/4	
	9	32	18	6 1/4	— — —
	10	32	21	19	— — —
	11	32	22	33 1/2	Stage 10. Air in the intestine. Excrements.
	12	8	103	10	No mixing of the contents in the rectum.
	13	8	112	11 1/2	
	14	9	53	1 1/2	Cross-striping of the mid-gut.
	15	20	8	4 3/4	Gizzard. Enteric coeca. Progress in the mid-gut. Infiltration of old content in the hind-gut.
	16	20	21	8 1/4	
	17	20	23	9 1/2	
	18	20	28	13 1/2	Peristaltic restrictions.
2	1	22	3	1/2	Infiltration, also in the rectum.
	2	22	4	3/4	— Gizzard. Enteric coeca.
	3	22	15	4 1/4	Becomes more distinct.
	4	22	36	47	— — —
	5	12	C 2	1 3/4	Oesophagus, gizzard. Enteric coeca.
	6	31	17	55 1/2	Kneading in the crop.
	7	33	8	10 min	Displacing in the crop.
	8	33	9	1 1/2	
	9	33	12	8 1/2	Draining of the crop. Mixing in the mid-gut.
	10	36	34	30 min	Kneading in the crop.
	11	36	35	33 „	
	12	25	6	7	Gizzard. Enteric coeca.
	13	28	7	12	Granulations in the crop.
	14	27	8	9	Adherence to the walls of the intestine.

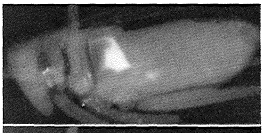
Dansk Oversigt.

Kitinen hos Insekterne er ret uigennemtrængelig for Röntgenstraaler, og med de sædvanlige Kontrastmidler tilblandet Føden er det ikke muligt at undersøge Tarmfunktionen. Bergh, Funder og Tetens Nielsen (1943) har imidlertid vist, at med Uranilte U_3O_8, som Kontrastmiddel er det muligt, selv med en ret primitiv Opstilling, at faa brugbare Billeder.

I nærværende Afhandling forelægges Resultaterne af en Undersøgelse af Fødens Passage gennem Tarmen hos den store, grønne Løvgræshoppe, *Tettigonia (Locusta) viridissima* L. Passagen foregaar hurtigere ved høj Temperatur end ved lav, og denne Afhængighed svarer til den Funktion, Krogh har fundet for Stofskiftets Temperaturafhængighed. Derimod finder man ikke i Tarmfunktionen den Døgnrytme, som er saa karakteristisk for Muskelaktivitet og Stofskifte hos denne Art.

Iøvrigt er Tarmpassagen fulgt ved forskellig Føde og der er paavist forskellige ejendommelige Enkeltheder.

Tavle I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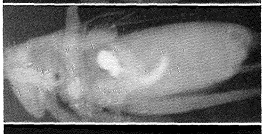
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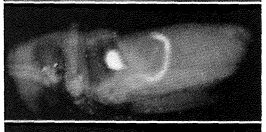
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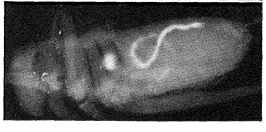
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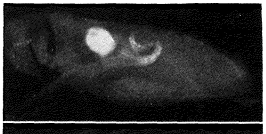
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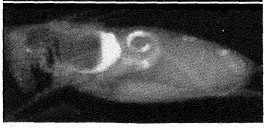
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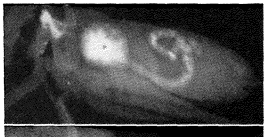
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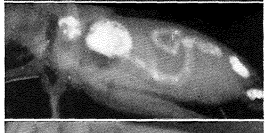
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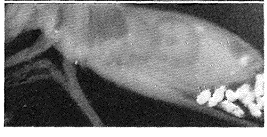
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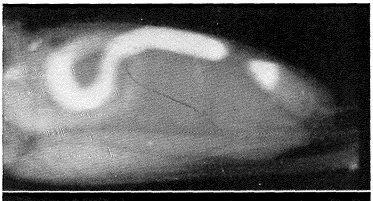
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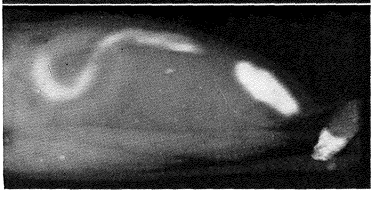
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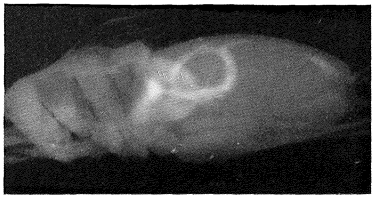
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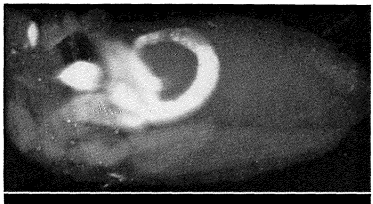
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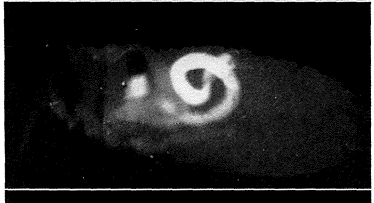
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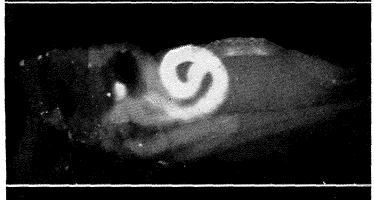
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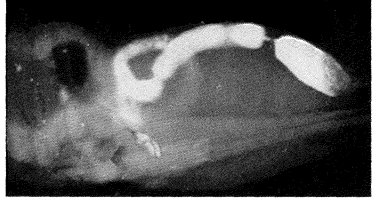
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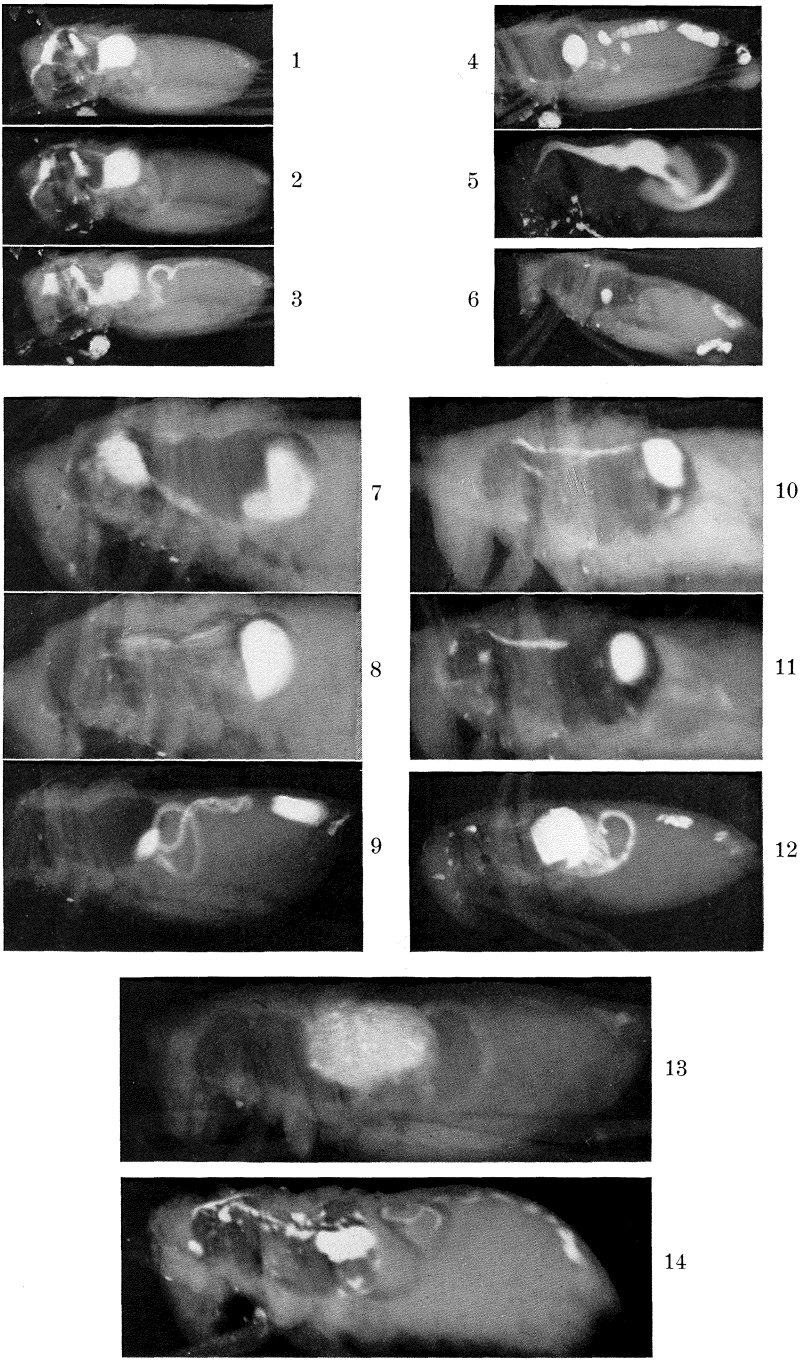
E. Tetens Nielsen

TAVLE II



E. TETENS NIELSEN