

Some Analyses On The Growth Of Insects, With Special Reference To A Phasmid, *Phraortes* *kumamotoensis* Shiraki (Orthoptera)

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SOME ANALYSES ON THE GROWTH OF INSECTS,
WITH SPECIAL REFERENCE TO A PHASMID,
PHRAORTES KUMAMOTOENSIS
SHIRAKI (ORTHOPTERA)

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I. INTRODUCTION

In insects the growth is essentially a determinate process, and the size is also inherently determinate since it is the end product of growth. It is not very difficult to demonstrate the existence of a deep-seated and stable genetic constitution or the value of the constants of the relative growth function which determines size and the growth process by which it is attained in individual

insects. In other words the size may be said as the ultimate result from the interaction of a series of excitatory and inhibitory stimuli, modifiers or genetic constants of relative growth during the course of development and growth of an individual, whereby its growth follows quite closely a definite and predictable course, terminating when adult stage is attained. Further it must be noted that the termination of size growth is especially definite in the case of insects where almost without exception the imaginal or reproductive stage marks sharply the arrival of the final size and form. During the recent cycle of biological investigation much attention has been turned to the phenomenon of growth of insects. Many entomologists have attempted to analyze the growth of insects either in size or in weight, and the works in this line of research cover a great part of the literature in Entomology. Many hypotheses have been established upon several groups of insects and applied actually to detect the growth process of some injurious or non-injurious insects. Nevertheless it may seem surprising that much should be further investigated and re-examined from different points of view.

Further in studying the gradation of insect populations, especially in case of pests, economic entomologists should not forget to consider the status of parasites, the climatic environment, the reproductive powers and the food conditions. Since the primary requirement for growth is food we may expect to find that the size in insects is dependent at least to some extent upon quantity or quality of food. Vegetarian diet furnishes a much more constant and plentiful source of food material than that available for forms that depend upon animal foods, but larger amounts are necessary to supply equal energy. It should be actually necessary to take into account the quantity of food, and such consideration may be regarded as equally important or useful as those of chemical requirement of the food. Although almost every entomologist is aware of the fact that the food must play an important role on gradation in insect pests, it is nevertheless curious to see, how little study, as compared with those carried out on the effect of other factors, has yet been done in this line of investigation.

The present work has been carried out in the Entomological Laboratory of the Kyūsyū Imperial University, Hukuoka, using

a very convenient insect. *Phraortes kumamotoensis* SHIRAKI (Orthoptera, Phasmodidae), in order to fulfill some of these gaps. The aim of the former part of this paper is, firstly, to examine and record the growth of the regenerates in the course of the post-embryonic development; secondly, to note any possible variations in the growth of such regenerates from that of normal parts; thirdly, in using the records to analyze the growth of the regenerated parts, namely the growth-ratios and regeneration curves together with the laws of DYAR, PRZIBRAM and the formulae of TOKUNAGA and PAULIAN. The ultimate object is, if possible, to determine or establish norms of an ideal growth both in size and weight. The latter part of the present work is attempted, firstly, to determine the necessary amount of the food for the completion of a normal post-embryonic development and for the continuation of a normal oviposition; secondly, to establish a criterion for estimation of damage caused or will be caused by insects. For the economic entomologists the chief aim or the actual interest of the work is to prevent a calamity as early as possible and as a rule, little attention is paid by them what happens afterwards. In some cases, however, it may be necessary and useful to know some bases to estimate the losses for the future cultivation or protection of crops from injurious insects and further to know the effects of shortage of food on the gradation in the following generations of the pests. In this connection it should be stressed to remember that such theoretical prototypes as given in the present study have some limitations to its practical application already pointed out by WOODRUFF, but may serve as a guide for comparative study and a basis for quantitative consideration in the field of both theoretical and applied entomology.

II. ACKNOWLEDGMENTS

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III. NOTES ON THE MATERIAL

The Phasmids used in the present study were from an inbred stock which has been maintained for experimental purposes in the Entomological Laboratory of the Kyūsyū Imperial University, Hukuoka. They belong to *Phraortes kumamotoensis* SHIRAKI, which is very common in Japan proper and of a convenient size for experimental use, namely the newly hatched larvae measuring 11.39–13.24 millimetres in body-length and 0.0030–0.0039 grams in weight, the adults measuring 66.5–73.8 millimetres in body-length for the male, 86.1–102.9 millimetres for the female. The newly hatched Phasmids as well as those in the following instars are very quiet in motion and may be handled quite easily by availing their cataleptic attitude when they slip to the ground, either with their appendages spread out or all packed closely parallel to the body. Such attitude facilitates the use of the material in various kinds of apparatus in weighing and transferring from one container to another. They are voracious feeders and can consume many different species of plants as food, growing rapidly to the adult stage. Those dimensions as mentioned above are attained in 65–75 days for the male, 74–90 days for the female in natural conditions. The duration of the larval stadia are summarized in the following table.

As is seen in the Table 1, a general trend that the average number of days in completing each instar decreases with age, except for the last instar in the female, is to be noted, i.e., the first stadium is the longest, the fourth and fifth are almost equal

Table 1. A summary of development for *Phraortes kunmingensis* reared in the laboratory. Figures denote the time in days.

		Larval stadia						Total
		I	II	III	IV	V	VI	
	Maximum	29	19	14	13	13	17	90
	Minimum	21	12	11	10	9	10	74
	Average	25.3	15.4	12.2	11.6	11.0	12.9	83.4
	Maximum	29	18	15	12	12		75
	Minimum	23	11	11	9	8		65
	Average	25.0	14.7	13.1	11.0	11.1		71.1
Average	Maximum	29	19	15	13	13		90
	Minimum	21	11	11	9	8		65
	Average	25.2	15.1	12.6	11.3	10.5		78.1

and the shortest, and the second and third are successively longer. According to my rearing experiments of about 500 individuals, the males moult five times without exceptions while the females undergo normally six moults under natural conditions. In Hukuoka Province, the larvae hatch out early in April and reach maturity later in June or early in July. The length of life of adult females kept under natural conditions varies from three to five months. The male has a shorter life. Thus the insect has but a single generation each year. The population of the two sexes seems to be more or less equal. The females undergo a preoviposition period of about ten days. Thereafter, they drop one to ten eggs a day, the average for six females being 4.5 eggs. The number of eggs laid by a normal female is considerably variable. The results of my observations show that a single female is often capable of laying 600 eggs or even more but whether they lay this number of eggs under field conditions is questionable. The eggs dropped by the females were kept in paper or wooden boxes, placed in the room until the next spring under natural conditions and passed the winter, and no moisture control was provided. The incubation period varies from 150 to 250 days, thus covering an extreme range of about 200 days. Only a small percentage (28.6 per cent) of larvae are able to complete the hatching from

the eggs, and therefore a large number of eggs were needed for my experimental study. The range of temperature of the laboratory during the post-embryonic development of the material was between 15° and 23°C, and those of relative humidity was between 70 and 85 per cent. This range of temperature, though great, is believed not to have unduly affected the results of this study, as the object of the present investigation lies on the line of the normal growth of the insects under field or natural conditions, and often analyses of the experimented data were carried out under consideration of eliminating the time factors. The results of rearing experiments made in various relative humidities have shown that the optimum relative humidities lie between 65 and 90 per cent, and when the relative humidities are below 50 per cent or in water-saturated conditions the material cannot continue its normal development. Further detailed accounts of the material may be seen in my earlier papers (1930-1933).

IV. GROWTH IN LENGTH

A. Growth in Absolute Length

Percentage increase in length in each instar. The percentage increase (α) in length (or width) in each instar was calculated by the following formula

$$\alpha = \frac{L_{n+1} - L_n}{L_n} \times 100,$$

where L_n designates the length of a part in the instar n . The values are shown in the Table 4 and the following results were obtained.

1. In the second instar the highest values of α are found in the lengths of the pronotum, the mesonotum, the metanotum, the total length of the thorax, the antennae (φ), the fore femur, the fore tibia (φ), the mid-femur, the mid-tibia, the hind femur and of the hind tibia (φ).

2. In the third instar the highest values of α are observed in the length of the head (δ), the total length of the body and in the width of the head.

3. In the fourth instar the value of α in the length of the abdomen is the highest.

4. In the sixth instar the α takes the highest value in the lengths of the antenna (δ), the head (φ), the fore tibia (δ) and of the hind tibia (δ).

5. In the last instar the values of α in such items as the length and width of the head, the lengths of the pronotum, the abdomen and of the total body of the male sex are always lower than those in the female sex.

6. The curves showing the percentage increase in width of the head throughout the post-embryonic developmental period are similar to those of the length of the abdomen. The curves of the same of such parts as the whole thorax, the metanotum only, the femur and the tarsus show the same feature.

7. The sex differentiation in the rates of increase was emphasized in the following order: the length of the hind femur, the length of the antenna and of the fore tibia, the length of the fore femur, the length of the mid-femur, the length of the head and of the mid-tibia, the length of the pronotum, the length of the mesonotum, the total length of the thorax, the width of the head and the length of the hind tibia, the total length of the body and finally the length of the metanotum.

Percentage length of the allometric organs during the post-embryonic developmental period. The percentage length (β) of any allometric organs in each instar was calculated by the following formula

$$\beta = \frac{\text{Length of the part in the instar } n}{\text{Ultimate length of the part}} \times 100,$$

and the results are shown in the Table 5 given below.

From this table we can definitely see the following facts. In the appendages β takes the value of 50 per cent in the fourth instar. In the allometric organs (except for the appendages) of the female β secures the value of 50 per cent also in the fourth instar, while in the male β attains the value of 50 per cent as early as in the third instar.

Change of the partial indices of the allometric organs during the post-embryonic developmental period. The partial index (γ) of any allometric organ was calculated by the following formula.

$$\gamma = \frac{\text{Length of the allometric organ}}{\text{Total length of the body}} \times 100.$$

The results obtained are given in the Table 6.

Table 2. Average length (or width) of different parts in *Phraortes kumamotoensis* larvae at different instars of growth. In millimetres.

Instar	Head			Thorax												Abdomen	Body
	Length	Width	Antenna	Pronotum	Mesonotum	Metanotum	Total length	Fore leg		Mid-leg		Hind leg					
								Femur	Tibia	Femur	Tibia	Femur	Tibia				
I	1.2	1.0	7.7	0.9	3.2	2.0	6.1	3.4	3.2	2.8	2.8	3.0	3.5	11.3	18.5		
II	1.4	1.3	11.4	1.2	4.7	3.0	9.0	5.5	4.8	4.3	4.2	4.8	5.2	14.5	23.5		
III	1.9	1.7	16.1	1.5	6.5	4.3	12.4	7.8	7.1	5.9	6.0	6.6	7.3	19.3	33.6		
IV	2.4	2.2	22.7	1.9	8.8	5.6	16.4	10.5	9.7	7.8	8.1	8.9	9.5	25.8	44.7		
V	2.9	2.8	♂ 33.7	2.4	11.7	7.8	22.3	15.0	14.8	11.0	11.1	12.5	13.2	34.1	59.4		
			♀ 28.9					13.3	12.7	9.9	10.0	10.7	12.7				
VI*	♂ 3.5	3.1	54.3	2.7	15.6	9.9	28.8	21.0	22.8	16.0	16.0	18.6	20.2	39.7	71.3		
	♀ 4.0	3.4	38.0	3.0	14.5	9.6	24.5	16.7	15.9	12.7	12.2	14.1	14.6	42.8	74.1		
VII*	4.9	4.1	51.1	3.6	18.7	12.0	34.5	21.9	21.7	16.5	15.4	18.7	19.4	54.1	93.6		

* VI and VII represent male and female adults respectively.

Table 3. Average increase in length for width of different parts in *Phaenocarpa kumamotoensis* larvae in successive instars of growth. In millimeters.

Instar	Head			Thorax										Abdomen		Body
	Length	Width	Antenna	Pronotum	Mesonotum	Metanotum	Total length	Fore leg		Middle		Hind leg				
								Femur	Tibia	Femur	Tibia	Femur	Tibia	Femur	Tibia	
I-II	0.2	0.3	3.7	0.3	1.5	1.0	2.9	2.1	1.5	1.5	1.1	1.8	1.7	3.2	1.9	
II-III	0.5	0.4	4.7	0.3	1.5	1.3	4.4	2.3	2.3	1.6	1.3	1.8	2.1	4.8	3.1	
III-IV	0.5	0.5	6.6	0.4	2.3	1.3	4.0	2.7	2.6	1.9	2.1	2.3	2.2	6.5	4.1	
IV-V	0.5	0.6	$\left\{ \begin{array}{l} \delta 11.0 \\ \varphi 6.2 \end{array} \right.$	0.5	2.9	2.2	5.9	4.5	5.1	3.2	3.0	3.6	3.7	8.3	4.7	
								2.8	3.0	2.1	1.9	1.8	3.2			
V-VI	$\left\{ \begin{array}{l} \delta 0.5 \\ \varphi 1.1 \end{array} \right.$	0.3	20.6	0.3	3.9	2.1	6.5	6.0	8.0	5.0	4.9	6.1	7.0	5.6	11.9	
		0.6	9.1	0.6	2.8	1.8	2.2	3.4	3.2	2.8	2.2	3.4	1.9	8.7	14.7	
VI-VII	0.9	0.7	13.1	0.6	4.2	2.4	10.9	5.2	5.8	3.8	3.2	4.6	4.8	11.3	19.5	

Table 4. Percentage increase in length of different parts in
Phraortes kumamotoensis at different instars of growth.

Instar	Head			Thorax											Abdomen	Body
	Length	Width	Antenna	Pronotum	Mesonotum	Metanotum	Total length	Fore leg		Mid-leg		Hind leg				
								Femur	Tibia	Femur	Tibia	Femur	Tibia			
I- II	16.6	30.0	48.0	33.3	46.8	50.0	47.5	61.7	50.0	53.5	50.0	60.0	48.5	28.3	26.3	
II- III	35.7	30.7	41.2	25.0	38.2	43.3	37.7	41.8	47.9	37.2	42.8	37.5	40.3	33.1	42.9	
III- IV	26.3	29.4	40.9	26.6	35.3	30.3	32.2	34.6	36.6	32.2	35.0	34.8	30.1	33.5	33.0	
IV- V	20.8	27.2	♂ 48.4	26.3	32.9	39.2	35.9	42.8	52.5	41.0	37.0	40.4	38.9	32.1	32.8	
			♀ 27.3					26.6	30.9	26.9	23.4	20.2	32.6			
V- IV	♂ 20.6	10.7	61.1	12.5	33.3	26.9	29.1	40.0	54.0	45.4	44.1	48.8	53.0	16.4	20.0	
	♀ 37.9	21.4	31.4	25.0	23.9	23.0	9.8	25.5	25.1	28.2	22.0	31.6	14.9	25.5	24.7	
VI-VII	22.5	20.5	34.4	20.0	28.9	25.0	40.8	31.1	36.4	29.9	26.2	32.6	32.8	26.4	26.3	

Table 5. Percentage length of the allometric organs during the larval instars.

[illegible][illegible]

Table 6. Partial indices of the allometric organs of *Phraortes kumamotoensis* SHIRAKI during the instars.

Instar	Head length	Head width	Pronotum length	Mesonotum length	Metanotum length	Thorax length	Abdomen length
I	6.4	5.7	5.7	17.1	10.8	32.8	60.6
II	6.1	5.8	5.1	20.0	12.9	38.5	61.6
III	5.6	5.1	4.4	19.3	12.8	36.9	57.4
IV	5.5	4.9	4.2	19.6	12.7	36.8	57.3
V	4.9	4.6	3.9	19.6	13.2	37.4	57.4
VI	♂ 4.5	4.3	3.7	21.8	13.8	39.5	55.3
	♀ 5.2	4.6	4.1	19.5	13.0	36.8	57.6
VII	5.2	4.3	4.0	19.8	12.7	36.7	57.5

Instar	Antenna length	Fore femur length	Fore tibia length	Mid-femur length	Mid-tibia length	Hind femur length	Hind tibia length
I	41.3	19.9	18.4	16.1	16.4	17.6	20.1
II	48.5	22.8	20.5	18.5	17.5	20.4	22.3
III	47.9	23.2	21.2	17.7	17.8	19.8	21.6
IV	50.6	23.1	21.7	18.0	16.0	19.9	21.2
V	♂ 55.6	24.7	24.3	18.1	18.4	20.5	21.7
	♀ 49.6	22.8	21.8	17.0	17.0	19.1	20.6
VI	♂ 76.4	29.3	31.9	22.4	22.9	25.4	28.3
	♀ 51.2	22.5	21.4	17.1	16.5	19.0	19.9
VII	52.7	23.2	23.1	17.5	16.7	19.9	20.8

In careful observations on the data given above the following conclusions may be derived.

1. The value of r of the head length undergoes a very gradual reduction from the first instar to the adult stage. From the fourth instar the value of r of the head length in the female shows no change, thus the curve indicating the change of the value of r with the instars of the same sex may be represented by two straight lines. This fact means that in the three later instars the rates of increase in lengths of the head and of the body are entirely the same as each other. On the contrary the value of r of the head length in the male decreases steadily in the successive instars. Therefore the curve indicating the change of the value of r with the ages may be represented by a single straight line.

2. The value of r of the head width decreases more steadily in the successive instars. The behaviour of the values in the increase of the width of the head may be shown by a single straight line.

3. The value of r of the pronotum length undergoes a reduction in the earlier instars. The behaviour of the values of r is quite similar to those of the head length of the female sex.

4. The value of r of the length of the mesonotum shows a tendency to rise prominently in the second instar, which is followed by a constancy in the female sex and by a marked increase again in the sixth instar in the male sex. Thus the curve indicating the change of the value of r of the mesonotum length with the instars may be represented by two straight lines in the female and three in the male.

5. The behaviour of the values of r of the metanotum length is very much similar to that of the mesonotum.

6. The behaviour of the values of r of the total length of the thorax is also similar to that in the above case. But in this case the value of r of the thorax length shows a tendency to decrease prominently in the third instar.

7. The value of r of the length of the abdomen increases steadily in the second instar which is followed by a steep decrease in the third instar, then keeps practically constant value from the third instar to the adult stage in the female. In the male the value of r decreases prominently from the fifth instar to the adult stage or the relative increase in length of the abdomen is notably smaller in the instar in question. This fact has a close connection with the high value of r of the lengths of the male appendages from the fifth instar to the adult stage.

8. The behaviour of the value of r of the length of the female antenna is similar to those of the fore femur and of the fore tibia in the same sex. In the second instar the value increases prominently. The value of r of the length of the femur in the female keeps almost constant through the following instars. The value of r of the length of the female antenna shows a tendency to rise very much slowly in the following instars while those of the fore tibia shows a marked increase in the same instars.

9. The value of r of the length of the mid-femur increases

markedly in the second instar which is followed by a gradual decrease up to the fifth instar, then further followed by a slight increase from the next instar. The behaviour of the values of r of the lengths of the hind femur and tarsus is as follows: in the second instar the value increases markedly, from the third to the sixth instars the value decreases steadily, and in the seventh instar the value increases again though very slightly. The value of r of the length of the mid-tibia increases more or less in the second, third and the fifth instars and decreases in the fourth and the sixth instars. In the seventh instar the value keeps constant.

10. The curve indicating the change of the value of r of the lengths of the female antenna, fore tibia and fore femur with the instars may be represented by two straight lines. The curve showing the change of the value of r of the lengths of the female mid-tibia, mid-femur, hind tibia and hind femur may be divided into three straight lines.

11. The value of r of the lengths of the male appendages shows a marked increase in the sixth instar. Thus the curve indicating the change of the value of r with the instars may be shown by four straight lines.

12. Generally speaking the values of r show a tendency to fix themselves constant much earlier in the female than in the male, and this statement coincides very well with the results obtained in the case of the relative growth.

B. Relative Growth

In 1932 J. HUXLEY has produced an exponential formula which expresses by means of an abstract value the rate of growth of any one of allometric organs in relation to that of another organ whose growth is taken as a standard. Using his method we may be able to compare the rates of development of several parts and to investigate the intensity of growth which is characterized by the growth-gradients. I applied the formula established by HUXLEY to the data shown in Tables 2-3 in order to analyze the characteristics of the growth in length of several allometric organs measured in *Phraortes kumamotoensis* SHIRAKI. Taking the total length of the body as the standard growing organ (x), and the head, pronotum, mesonotum, metanotum, antenna, fore femur, fore

tibia, mid-femur, mid-tibia, hind femur, hind tibia and abdomen as the differential growing parts (y). I fitted the data into the expression $y=bx^a$ (from this formula is derived: $\log y=\log b+a \log x$; this means that if the logarithms of the magnitudes are plotted, we should expect a straight line, from the slope of which the value of a or the constant differential growth-ratio can be read off), which expresses logarithmically the relations between the body and the differential growing parts. Thus using the formula and assigning to x and y their corresponding values up to the adult stage, a series of results were secured and classified into several growth-phases. These were summarized in the following table.

Table 7. Values of a obtainable during the post-embryonic growth of *Phraortes kumamotoensis* SHIRAKI.

Sex		a			
		Phase I	Phase II	Phase III	Phase IV
♂	Head length	0.76	0.76	0.76	0.76
	Head width	0.85	0.62	0.62	0.62
	Pronotum length	1.09	1.00	0.62	0.62
	Mesonotum length	1.54	1.00	1.62	1.62
	Metanotum length	1.54	1.00	1.25	1.25
	Antenna length	1.54	1.08	1.41	2.62
	Fore femur length	1.90	1.00	1.25	1.87
	Fore tibia length	1.63	1.08	1.58	2.25
	Mid-femur length	1.72	0.96	1.25	2.00
	Mid-tibia length	1.63	0.93	1.16	2.00
	Hind femur length	1.90	0.98	1.25	2.12
	Hind tibia length	1.50	0.95	1.25	2.25
	Abdomen length	0.95	0.75	0.75	0.75
	Head length	0.76	0.76	1.55	0.81
♀	Head width	0.85	0.85	0.85	0.85
	Pronotum length	1.09	1.00	1.00	1.00
	Mesonotum length	1.54	1.00	1.00	1.00
	Metanotum length	1.54	1.00	1.00	1.00
	Antenna length	1.54	1.08	1.08	1.08
	Fore femur length	1.90	1.00	1.00	1.00
	Fore tibia length	1.63	1.08	1.08	1.08
	Mid-femur length	1.72	0.96	0.96	0.96
	Mid-tibia length	1.63	0.93	0.93	0.93
	Hind femur length	1.90	0.98	0.98	0.98
	Hind tibia length	1.50	0.95	0.95	0.95
	Abdomen length	0.95	0.95	0.95	0.95

1. The female insects generally exhibit two phases in the relative growth, while the males have one to three phases in the growth according to the different parts on the body-axis and four phases in the growth of the appendages.

2. In the male the head length shows a marked negative allometry with the growth coefficient 0.76 throughout the instars. In the female the relative increase in length of the head is divided into three phases, i.e. the first phase lasts during the four earlier instars, showing a marked negative allometry, the second phase is seen in the fifth instar indicating the value of α with a marked positive allometry, and the third phase shows a marked negative allometry in the sixth instar.

3. In the female the relative increase in the width of head shows a marked negative allometry with the growth coefficient 0.85 throughout the instars. A fall in the second instar occurs in the male, after which the value of α is constant until the adult stage.

4. The pronotum is characterized by its almost isometric growth. In the male a marked fall occurs in the fifth instar.

5. The mesonotum is a highly positive allometric part in the first instar in both sexes. After the second instar the mesonotum is characterized by its isometric growth throughout all the instars up to the adult in the female, while it attains its former value in the fifth instar (third phase) in the male.

6. The relative increase in length of the metanotum is almost similar to those of the mesonotum.

7. In the male the relative growth of the appendages may be represented by four phases. The first phase (the first instar) is characterized by a marked positive allometric growth. With increase in absolute size the velocity of growth of the appendages in length increases during the instars second to fifth. Therefore the allometry varies from isometric to highly positive.

8. In the female the relative growth of the appendages may be represented by only two phases. In the first instar the growth coefficient takes the value of highly positive. A fall takes place in the second instar, after which the value of α is constant and the growth is almost isometric until the adult stage.

9. A higher variation in the intensity of allometry of any of

the appendages between the sexes seems to initiate in the fourth instar.

10. The abdomen is also characterized by its almost isometric growth. In the male a slight fall occurs in the fifth instar.

In 1931 HUXLEY studied the relative growth of a stag-beetle, *Lucanus cervus*, and demonstrated that in this beetle the growth-gradient slopes down from the head to the hind legs, with the highest values in the mandibles, and between the first and second pair of legs the allometry changes from positive to negative. In 1934 DIXEY and GARDINER analyzed the allometric growth of an ant, *Messor barbarus*, and gave the following conclusions. In this ant the growth-gradient slopes down in an antero-posterior direction with a high value growth-centre localized in the head, and the gradient reaches a negative value in the last pair of legs. In 1938 I investigated the allometry of an ichneumon-fly, *Thalessa citraria* (δ), and found the following facts. Contrary to all the known cases of the allometry in insects, this ichneumon-fly has a high allometry-coefficient posteriorly and a postero-anterior gradient in the distribution of growth potential in other parts of the body. Correlated with positive allometry of the abdomen, in which the growth-centre seems to exist, the length of the hind leg shows a slight positive allometry. In the legs, there exists a distinct but slight growth-gradient sloping down centripetally. In the same year DUARTE published the results of his study on the allometry of a locust, *Locusta migratoria*. According to DUARTE the following three distinct features characterize the growth-gradients in this insect. The gradient rises steeply from a negative value in the head to a high positive value in some part of the pronotum, and falls to a negative value in the hind legs. Therefore the growth centre is localized in the zone of the pronotum. Generally with the increase of the insect in size the relative growth-ratio decreases correspondingly. The fall is more conspicuous in the middle (pronotum) than in the extremities. The most extreme variation is shown by the pronotum as against the little variation in the head. The decrease in intensity of the growth-centre is greater in the fifth-adult instar than in the previous instars. The third feature of the gradient is the reverse variation of the growth of the most posterior portions, viz., the hind femur, as if the curve was rotating round the middle femur in an anti-clockwise direc-

tion. This feature is more marked in gregarious forms than in the solitary.

In the case of *Phraortes kumamotoensis* SHIRAKI the features of the growth-gradients are quite different from any of the known cases given above and very much complicated.

11. In the first phase of allometry of the female sex, there exists a highly positive growth-centre in the regions of meso- and metathorax from where very steep growth-gradients are graded down both anteriorly and posteriorly along the main axis of the body. There is a high growth-gradient graded down proximally in the antennae. In the legs there is found a definite high growth-centre in the femoral region from where strong positive growth-gradients are graded both in centrifugal and centripetal directions.

12. In the second phase of allometry of the female sex, the growth of the thorax as well as the fore femur become completely isometric. The abdomen undergoes a low negative allometry. The head is a negative growth-centre along the main axis of the body. In the fore legs there exists a centripetal growth-gradient in the tibial region. In both the mid- and hind legs there is a centrifugal growth-gradient both in the femoral and tibial regions.

13. Meanwhile the head represents a high positive growth-centre only in the fifth instar, when very steep growth-gradients are sloping down from the head to the antennae and the pronotum.

14. In both the first and second phases of allometry of the male sex, the distribution of the growth-potential along the main axis of the body is quite similar to those of the female.

15. In the third phase of allometry of the male sex, the mesonotum becomes a high positive growth-centre from where steep positive gradients are sloping down both anteriorly and posteriorly. In the head region there exists a low growth-gradient sloping down towards the pronotum. A very steep growth-gradient is sloping down posteriorly from the metathorax to the abdomen. There exists a centripetal growth-gradient in the fore legs and a centrifugal one in the mid-legs. In the hind legs the value of the growth-partition coefficient of the femur is the same as those of the tibia as well as the metathorax.

16. In the fourth phase of allometry of the male sex, the distribution of the growth-potential along the main axis of the

body is similar to that of the third phase. As in the third phase there exists a definite growth-gradient sloping down proximally

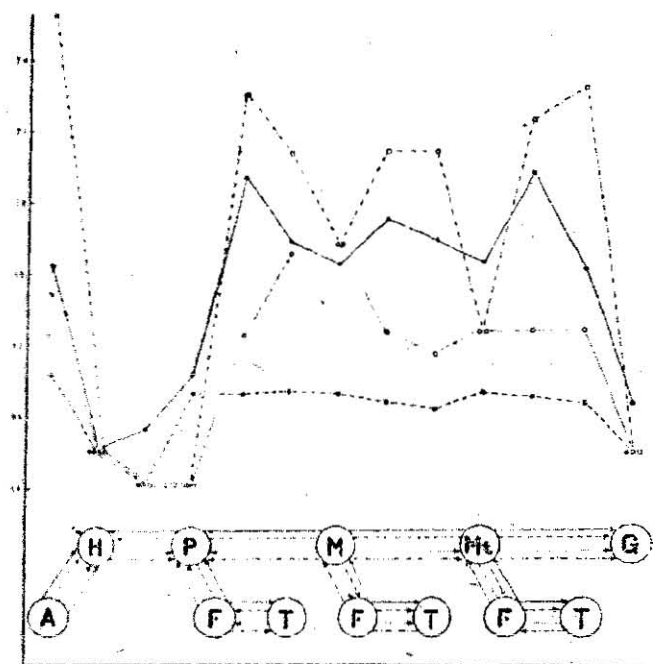


Fig. 1. Change of growth-gradient in the body of *Phraortes kumamotoensis* (δ). The abscissa axis represents the antero-posterior axis of the body. The ordinate axis represents the α value. A: antenna H: head P: pronotum F: femur T: tibia M: mesothorax Mt: metathorax G: abdomen ●: 1st phase ■: 2nd phase ○: 3rd phase □: 4th phase.

with a very high positive growth-centre in the antennae. In the fore legs there exists a definite growth-centre in the femoral region, from where strong positive growth-gradients are graded both in centripetal and centrifugal directions. In the mid-legs both the femur and tibia take the same value of a very high growth-partition coefficient and there exists a centripetal growth-gradient in the femur. In the hind legs a steep growth-gradient is graded centripetally and the tibia becomes a high positive growth-centre.

17. Generally with the increase of the insect in size the

relative growth-ratios of the antenna, thorax and all legs decrease correspondingly. The fall is prominent in such an order as follows: the hind femur, fore femur, mid-femur, mid-tibia, fore tibia, mesothorax, metathorax, hind tibia and the antenna.

18. From the third growth-phase of the male the relative growth-ratios of the antennae and all legs increase correspondingly with the growth of the insect in size. The rise is prominent in such an order as: the antenna, hind tibia, fore femur, hind femur, mid-tibia, mid-femur and fore tibia.

19. In the male pronotum the relative growth-ratio decreases in the third phase and does not change its value in the next phase.

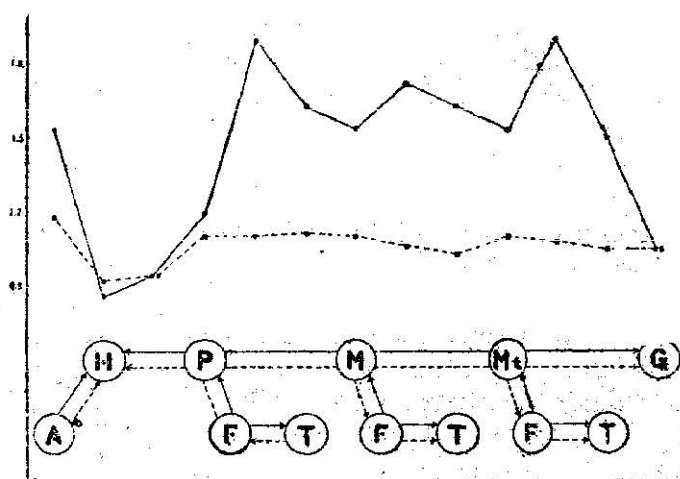


Fig. 2. Change of growth-gradient in the body of *Phraortes kumamotoensis* (♀)
The abscissa and ordinate as in Fig 1. ● : 1st phase ■ : 2nd phase.

20. In the male meso- and metathorax the relative growth-ratio increases conspicuously in the third phase and does not alter its value in the next phase. The rise is more conspicuous in the mesothorax than in the metathorax.

21. In the male abdomen the relative growth-ratio decreases slightly in the second phase, and then increases very slightly in the following phases with the increase of the insect in size correspondingly.

22. The increase or decrease in intensity of the growth-centre along the main axis of the body is greater in value in the second-third phase than in the first-second phase. The most extreme variation in intensity of the growth-centre along the main axis of the body is shown by the mesothorax or metathorax as against the little variation in the head or abdomen.

C. Regeneration Experiments

Material and Methods

In the present series of experiments on the growth of *Phraortes kumamotoensis* SHIRAKI, more than three hundred individuals were used, and *Lyonia Neziki* was used as food rearing the material. The observations were carefully made on insects isolated from the first instar one each in a separate rearing box. In all cases the insects were fed on plentiful food. Extensive biometrical works were begun from the first instar and covered all the instars up to the adult. The measurements were made in each case after the insect had moulted and the cuticle had acquired the usual degree of rigidity. The parts of the larvae in the first instar were measured under a microscope fitted with a micrometer eye-piece. When the parts became too large to be measured under an ordinary microscope, a binocular microscope fitted with a micrometer eye-piece was used.

Measurements were made on the following parts.

1. Length of body (B)
2. Length of mesonotum (M)
3. Length of metanotum (P)
4. Length of fore femur (F)
5. Length of fore tibia (FT)
6. Length of mid-femur (MF)
7. Length of mid-tibia (MT)
8. Length of hind femur (HF)
9. Length of hind tibia (HT)
10. Length of tarsus

In all cases the length of the mesonotum was taken as the standard growing organ (x), and the length of the femur, tibia and tarsus as the differential growing parts (y). By using the allometric formula $y=bx^a$, the constant differential growth-ratios of allometric organs were calculated, and the logarithms of the measurements were plotted graphically.

The legs of the material are very responsible for autotomy by a sudden stimulus. The autotomy of this species occurs at the trochantero-femoral suture as in all members of the family Phasmidae. This character of autotomy was utilized in the present investigation. Further it was needed to amputate the legs at any point and at any time. The amputations were made by means of a pair of fine scissors. In order to keep the insects quiet and to prevent the autotomy, this operation was performed with the larvae which were anesthetized with ether, otherwise it was very difficult or almost impossible to cut off the parts of the legs at any desired point.

The experiments were classified in the following groups.
Experiments class 1 : Operation of one fore leg in the first instar.

Twenty individuals just after hatching were selected for experimentation.

Experiments class 2 : Operation of one fore leg in the second instar. Ten individuals just after the first moult were used for this purpose.

Experiments class 3 : Operation of one fore leg in the third instar. Ten individuals just after the second moult were used.

Experiments class 4 : Operation of one fore leg in the fourth instar. Ten individuals just after the third moult were used.

Experiments class 5 : Operation of one mid-leg in the first instar. Twenty individuals just after hatching were selected.

Experiments class 6 : Operation of one mid-leg in the second instar. Ten individuals just after the first moult were used.

Experiments class 7 : Operation of one mid-leg in the third instar. Ten individuals just after the second moult were used.

Experiments class 8 : Operation of one mid-leg in the fourth instar. Eight individuals just after the third moult were used.

Experiments class 9 : Operation of one mid-leg in the fifth instar. Five individuals just after the fourth moult were selected.

Experiments class 10 : Operation of one hind leg in the first instar. Twenty individuals just after hatching were used.

Experiments class 11 : Operation of one hind leg in the second instar. Thirteen individuals just after the first moult were used.

Experiments class 12 : Operation of one hind leg in the third instar. Twenty individuals just after the second moult were selected.

Experiments class 13 : Operation of one hind leg in the fourth instar. Ten individuals just after the third moult were used.

Experiments class 14 : Operation of one hind leg in the fifth instar. Eight individuals just after the fourth moult were used.

Experiments class 15 : Operation of two fore legs. Four individuals were used.

Experiments class 16 : Operation of two mid-legs. Ten individuals were selected.

Experiments class 17 : Operation of two hind legs. Twenty individuals were used.

Experiments class 18 : Simultaneous operations of two or three different series of legs. Twenty individuals were used.

Experiments class 19 : Successive operations of two or more legs of different series. Sixty individuals were selected.

D. Descriptions of the Results

1. Experiments Series 1

Experiments Class 1

No. 1 The right-hand fore leg of a newly hatched larva was removed by amputation from the trochantero-femoral suture. This individual died just after the second ecdysis. The values of α for the growth of the regenerate were 3.61 for the tibia and 2.46 for the femur.

No. 2 The left-hand fore leg of a newly hatched female larva was removed by amputation from the trochantero-femoral suture. This individual lost its left-hand mid-leg by autotomy. The values of α for the growth of the fore regenerate were suc-

cessively 2.88 and 1.00 for the tibia and 0.88 and 1.90 for the femur during the two last larval instars respectively. The values of α for the growth of the mid-regenerate were 2.00 and 1.20 for the tibia and 2.00 and 1.30 for the femur during the same instar.

No. 23 Distal 1.75 mm of the right-hand fore tibia of a newly hatched male larva was removed by amputation. The operated tibia continued to grow during the course of the larval development and reached 17.5 mm in length in the last larval instar which was 1 mm shorter than the unamputated tibia of the opposite side. It was apparently demonstrated in this experiment that the growth of the fore femur with an amputated tibia was obviously checked by the regeneration of the lost parts and reached 18.5 mm in length (2 mm shorter than the opposite femur with the normal tibia) after the last ecdysis. Further it must be noted that the values of α for the growth of the regenerate tibia were increased 0.72, 2.20 and 2.42 successively. The differentiation of the segmentation in the regenerate tarsus appeared externally after the second ecdysis. The total length of the regenerate tarsus in succeeding instars were 0.7 mm (third instar), 3.50 mm (fifth instar) and 4.75 mm (sixth instar) respectively. The length of the regenerate tarsal segments attained 2.0 mm (1st segment) and 1.5 mm (2+3+4 segments) in the preadult instar and 3.0 mm (1st segment) and 1.75 mm (2+3+4 segments) just after the final ecdysis respectively. Here it is evident that the value of α for the growth of the regenerate first tarsal segment is larger than that of the distal segments.

No. 40 The right-hand fore leg of a newly hatched female larva was removed by amputation from the trochantero-femoral suture. The observation was stopped at the sixth instar, as the regenerated leg was lost by autotomy after the sixth ecdysis. The values of α for the growth of the regenerate were decreasing in successive instars. The differentiation of the segmentation in the regenerate tarsus took place externally after the second ecdysis. The total length of the regenerate tarsus in succeeding instars was 0.7 mm (third instar), 2.1 mm (fifth instar) and 4.0 mm (sixth instar) respectively. The values of α for the growth of the regenerate first tarsal segment were larger than that of the regenerate distal tarsal segments as in the experiment No. 23.

No. 282 Distal 0.9 mm of the right-hand fore femur of a newly hatched male larva was removed by amputation. The wounded femur decreased in length at first, being 2.0 mm after the first ecdysis and 1.2 mm after the second one and then became 2.6 mm (still 0.1 mm shorter than in the first instar) after the third ecdysis. It is very clear that in this case the growth of the wounded femur was strikingly checked by the reconstruction or regeneration of the lost apical part of femur, entire tibia and tarsus. After the second ecdysis the femur increased in length very much. The bud of the tibia and tarsus did not appear externally in the second instar, but became observable as a small but distinct segment after the second ecdysis. The bud of the tarsus appeared separately after the third ecdysis. The values of α for the growth of the wounded femur for successive instars were -0.76 , -1.29 , 3.09 , 5.00 and 2.66 respectively. The last two values of α would indicate the existence of a regulation power within the regenerate itself.

No. 283 Distal 1.0 mm of the right-hand fore femur of a newly hatched male larva was removed by amputation. The wounded femur decreased in length from ecdysis to ecdysis at first, being 1.9 mm after the first ecdysis and 1.5 mm after the second one. The bud of the regenerate tibia and tarsus appeared externally in the third instar. In this case, too, the growth of the wounded femur was apparently influenced by the reconstruction of the lost parts. The values of α for the growth of the wounded femur for successive instars were -1.06 , -0.62 , 6.40 , 0.27 and 3.85 respectively. The growth of the regenerate was regulated twice during its larval developmental stages. The reason of the appearance of the second-regulation force in the fourth instar is not clear.

No. 284 Distal 1.7 mm of the left-hand fore femur of a newly hatched male larva was removed by amputation. The wounded femur decreased in length ecdysis after ecdysis, being 1.8 mm after the first ecdysis and 1.5 mm after the second one. The bud of the regenerate tibia appeared after the second ecdysis, and that of the tarsus was observed after the third ecdysis. In this case, too, the growth of the wounded femur was prominently checked by the regeneration of the lost parts.

No. 285 Distal 1.6 mm of the left-hand fore femur of a

newly hatched female larva was removed by amputation. The wounded femur decreased in length ecdysis after ecdysis at first, being 0.25 mm (one-eighth the length of the remaining part of the femur at the operation) after the first ecdysis and 1.0 mm, 1.0 mm and 1.5 mm after respective ecdyses. This fact demonstrates clearly that the growth of the wounded femur was very much checked by the reconstruction of the lost parts, or, in other words, there was needed a great quantity of energy to regenerate the lost part of the femur, entire tibia and tarsus. Consequently the external appearance of the bud of the tibia was exceedingly delayed as late as in the fifth instar. The bud of the tarsus appeared after the fifth ecdysis.

No. 289 Distal 0.5 mm length of the right-hand fore femur of a newly hatched larva was removed by amputation. The wounded femur gently reconstructed the lost parts ecdysis after ecdysis, being 4.0 mm after the first ecdysis and 4.5 mm after the second one. But the bud of the tibia and tarsus never appeared even in the third instar when death occurred.

No. 292 Distal 2.5 mm of the right-hand fore femur of a newly hatched male larva was removed by amputation. The growth of the wounded femur was apparently influenced by the regeneration of the lost parts and decreased in length in the two earlier instars, being 1.0 mm after the first ecdysis and 0.9 mm after the second one. The bud of the regenerate tibia and tarsus was first appeared just after the third moult.

No. 293 Distal 1.5 mm of the left-hand fore femur of a newly hatched female larva was cut. This individual died after the sixth ecdysis by an unknown cause. The growth of the wounded femur was very much influenced and delayed by the reconstruction of the lost parts. The length of the wounded femur decreased from ecdysis to ecdysis at first, being 2.0 mm after the first ecdysis, 1.6 mm after the second one and 1.7 mm after the third one. The bud of the regenerate tibia and tarsus appeared externally after the fourth ecdysis.

Experiments Class 2

No. 57 Distal 0.4 mm of the left-hand fore femur of a larva just after the first ecdysis was cut. This individual dropped

its regenerate in the adult stage without being measured and died. The growth of the wounded femur was very much affected by the reconstruction of the lost parts, and the values of α for it for successive instars were -0.80 , 0.90 , 0.00 and 0.30 respectively, all representing the negative allometric growth. The bud of the regenerate tibia appeared after the third ecdysis, and that of the regenerate tarsus was seen in the fifth instar. The value of α of the initial growth for the regenerate tibia was normal and very high. The regenerate tarsus was not tetramerous but composed of five segments and 0.75 mm in total length; the basal segment was 0.25 mm in length, and as long as the fourth, or as long as the second and third taken together, the second was as long as the third and the fifth was about one half as long as the basal one. After the next moult, the basal segment of the tarsus became 0.5 mm in length but the remaining segments were etiolated.

No. 58 The right-hand fore tibia of a male larva just after the first ecdysis was removed from the base. The growth of the fore femur without tibia was slightly but apparently affected and checked by the reconstruction of the distal segments. Therefore the values of α for the growth of the femur in question were 1.27 for the initial phase (1.36 for the control femur) and 0.66 for the second phase (1.11 for the control femur). In the adult stage the femur in question was 1.2 mm shorter than the control of the opposite side. The bud of the regenerate parts appeared just after the second ecdysis, and the parts were differentiated during the third instar. The growth of the regenerate tibia was very rapid, values of α being 5.63 , 4.61 and 8.80 for successive phases respectively. The growth of the regenerate basal tarsal segment was strikingly checked after the fourth ecdysis.

No. 76 Distal 2.6 mm of the right-hand fore tibia of a female larva just after the first ecdysis was removed by amputation. This individual died after the fifth ecdysis. The growth of the wounded tibia was checked after the operation by the regeneration of its lost parts. It must be noted that the growth of the femur with the wounded tibia was not at all affected by the reconstruction of the lost part of the tibia and the entire tarsus. The bud of the regenerate parts appeared after the second ecdysis. The regenerated part of the tibia was narrower than the basal part. As in the usual cases, the value of α for the growth

of the regenerate basal tarsal segment was larger than that of the remaining parts of the tarsus. In the fourth instar the basal segment of the regenerate tarsus was shorter than the remaining, while in the next instar the relation became reversed.

No. 12 Distal 1.45 mm of the right-hand fore femur of a newly hatched male larva was cut by amputation. The growth of the wounded femur was pronouncedly affected or checked by the reconstruction of the lost parts, and the values of α for the growth of it for successive instars were -0.64 , 0.80 , 2.09 , 2.83 and 2.16 respectively. The regenerate tibia appeared just after the second ecdysis and was bluish green in colour, measuring 0.5 mm in length. It is also apparent from this experiment that the growth of the regenerate tibia was at first checked by the reconstruction of the tarsus. The length of the regenerate tibia still remained 0.5 mm in the fourth instar. The values of α for the growth of the regenerate tibia were 5.83 and 3.61 in the two later phases. The bud of the regenerate tarsus appeared after the fourth ecdysis. The differentiation of the segments occurred in the fifth instar, and after the last ecdysis three-segmented tarsus appeared. The length of the tarsus was 0.75 mm, and the third segment was longer than the two basal ones taken together.

Experiments Class 3

No. 13 Distal 1.8 mm of the left-hand fore femur of a newly hatched female larva was removed by amputation. The growth of the wounded femur was distinctly checked by the reconstruction of the lost parts. The values of α for the growth of the two earlier phases were -0.55 and -1.54 respectively. The bud of the regenerate tibia appeared after the second ecdysis and looked like a cone, being 0.5 mm in length. In the next instar one side of the short regenerate tibia was almost completely fused with the apex of the femur, the tibia did not increase in length, and the apical part of the femur was somewhat thickened. From one side of the apex of the femur, where the tibia had been fused, a distinct regenerate tarsus appeared after the third ecdysis. The regenerate basal segment of the tarsus was 0.75 mm in length in the fifth instar, 1.5 mm in length in the sixth and 2.4 mm in

the seventh, i.e. the adult stage. The values of α for the growth of the regenerate basal tarsal segment were apparently larger than those of the remaining segment.

No. 31 The right-hand fore leg of a female larva just after the second ecdysis was removed by amputation. The regenerate developed similarly as in the case of the regenerate of the larva which was operated just after the hatching.

No. 78 The left-hand fore leg of a male larva just after the second ecdysis was removed by amputation. The values of α for the growth of the regenerate were successively 8.07 and 6.66 for the tibia and 3.61 and 5.55 for the femur. The values of α for the growth of the regenerate tarsus were 6.66 for the first segment and 2.55 for the remaining segments. The length of the regenerate first tarsal segment was 0.35 mm and 1.40 mm for successive instars, while those of the remaining tarsal segments were 0.60 mm and 1.0 mm respectively.

No. 79 The right-hand fore tibia of a female larva just after the second ecdysis was amputated from the base. The growth of the fore femur without the tibia was not at all affected by the reconstruction of the lost parts. The bud of the regenerate tibia appeared after the third ecdysis and was hemispherical in shape. In the fifth instar the regenerate tarsal segments were recognizable, and they were two in number, being of an equal length. In the sixth instar the differentiation of a tetramerous tarsus was seen. The basal segment was 0.7 mm in length, while the remaining parts being 0.7 mm. The apical (fourth) segment was slightly longer than the second segment. The values of α for the growth of the regenerate of the fore femur were 5.08, 4.81 and 5.66 respectively.

No. 211 The right-hand fore leg of a female larva just after the second ecdysis was removed by amputation from the trochantero-femoral suture. The values of α for the growth of the regenerate were 3.85, 5.09 and 3.10 in order for the tibia and 4.07, 5.27 and 2.10 in order for the femur. The bud of the regenerate tarsus appeared after the sixth ecdysis.

Experiments Class 4

No. 11 The left-hand antenna was amputated from the

base of the flagellum, and the right-hand antenna was cut near the base of the flagellum leaving only 0.5 mm length of the basal flagellar segment just after the first ecdysis. This individual was a female and lost its right-hand fore leg by autotomy at the end of the third instar. It was clearly shown that the growth of the antenna with a 0.5 mm long flagellar segment was at first checked by the reconstruction of the lost parts, and the values of a were changed as -1.30, 5.50, 2.77, 1.21 and 1.90 for successive phases. The left-hand antenna without any stump of the flagellum never regenerated the lost parts as the flagellum, but it developed as a leg. After the third ecdysis the apex of the pedicel was slightly constricted. In the next instar six segments were regenerated, the length of each segment being in the following decreasing order—III, II or V, VI, I, IV. The three basal segments were firmly united and slightly curved. The fourth segment was attached to the antero-lateral portion of the third one. The angle made by the longitudinal axes of the three basal and of the three apical segments was very acute. After the fifth ecdysis the three apical segments turned into a tetramerous tarsus, the third segment to the tibia and the two basal ones fused into the femur. The longitudinal axis of the femur and the same of the tarsus were almost parallel to each other. At the base of the femur an incomplete articulation was still observable, and the apical portion of the tibia was somewhat reflexed. The values of \bar{a} for the growth of the regenerate fore leg were 5.90 and 2.44 for the femur and 6.70 and 3.33 for the tibia respectively. The values of a for the growth of the regenerate fore tarsus were 2.33 for the first segment and 1.11 for the remaining ones respectively.

No. 86 Distal 5.2 mm of the left-hand fore tibia of a male larva just after the third ecdysis was cut by amputation. It must be noted that the growth of the femur with the wounded tibia was not affected by the regeneration of the lost parts of the leg. Further it was evident that the growth of the wounded tibia was more or less similar to that of the normal one. The bud of the regenerate tarsus appeared in the fifth instar. The absolute lengths of the first tarsal segment were 0.60 mm for the fifth instar and 2.00 for the adult stage. The same of the three remaining segments were 0.90 mm for the fifth instar and 1.50 mm for the adult stage. Here it was clearly demonstrated that the

values of α of the basal segment were greater than those of the remaining parts.

No. 88 The left-hand fore femur of a female larva just before the third ecdysis was amputated from the trochantero-femoral suture. The bud of the regenerate appeared after the fourth ecdysis. This individual died after the sixth ecdysis. The value of α for the growth of the regenerate femur was 6.33 for the first phase. The tibia and tarsus were not seen until the sixth instar.

No. 101 The left-hand fore femur of a female larva just before the third moult was amputated from the trochantero-femoral suture. The bud of the regenerate appeared after the fourth ecdysis. The absolute lengths of the regenerate basal segment were 0.9 mm and 2.0 mm successively, and the same of the remainder were 1.25 mm and 1.5 mm respectively. The value of α for the growth of the basal tarsal segment was 4.50, and that of the remaining parts was 0.80. The values of α for the growth of the regenerate were successively 11.37 and 4.60 for the femur and 7.12 and 5.60 for the tibia.

No. 102 The right-hand fore femur of a male larva just before the third ecdysis was amputated from the trochantero-femoral suture. The bud of the regenerate appeared just after the fourth ecdysis.

2. Experiments Series 2

Experiments Class 5

No. 3 The right-hand mid-leg of a newly hatched female larva was removed by amputation from the trochantero-femoral suture. The bud of the regenerate appeared after the first ecdysis. After the third ecdysis the regenerate tibia was deformed—there occurred a broad constriction at the base, and the entire tibia was deep green in colour. After the fourth ecdysis there occurred a distinct node just basal to the middle portion of the tibia, and this node never disappeared until the adult stage. The bud of the regenerate tarsus appeared after the second ecdysis, but the differentiation of the segments occurred just after the fourth ecdysis. The absolute lengths of the regenerate tarsal

basal segment were 0.7 mm, 1.8 mm and 2.6 mm for successive instars, and those of the remaining parts were 0.9 mm, 1.25 mm and 1.6 mm for respective instars. The values of α for the growth of the regenerate mid-femur were 5.06, 4.91, 2.91, 1.81 and 1.50 for successive instars, and those for the regenerate mid-tibia were 5.26, 1.37, 2.91, 3.63 and 1.90 respectively. The values of α for the regenerate basal tarsal segment were always larger than those of the remaining parts.

No. 4 The left-hand mid-leg of a newly hatched female larva was removed by amputation from the trochantero-femoral suture. The bud of the regenerate appeared after the first ecdysis. The bud of the regenerate tarsus appeared also after the second ecdysis, but it was conical in outline and deep greenish in colour. In the fourth instar the regenerate tarsus still remained in the same condition and not differentiated into segments. After the fourth ecdysis the regenerate tarsus was divided into two segments, the basal one being 0.75 mm in length and the apical one being 0.5 mm in length with the colour deep greenish-blue. The regeneration of this apical part was checked during the course of development. The absolute lengths of the basal part for successive instars were 1.65 mm and 3.0 mm.

No. 15 The left-hand mid-leg of a newly hatched male larva was removed by amputation from the trochantero-femoral suture. In this individual the bud of the regenerate tarsus was unable to differentiate. In the fourth instar about 3.2 mm length of the right-hand fore femur was removed by amputation. The growth of this wounded femur was arrested in the fifth instar. The values of α for the growth of the regenerate mid-femur were 6.36, 4.07, 4.60 and 5.40, and those of the mid-tibia were 6.36, 3.07, 6.00 and 5.40 for successive instars.

No. 24 Distal 1.15 mm length of the right-hand mid-tibia of a newly hatched female was removed by amputation. This individual died after the sixth ecdysis. The growth of the wounded femur was apparently checked in the first and second phases at first. The values of α for the growth of the regenerate mid-tibia were 0.45, 1.12, 0.91, 2.81 and 0.78 for successive instars. The bud of the regenerate tarsus appeared after the second ecdysis. After the third ecdysis the differentiation of the tetramerous segments took place. The absolute values of the regene-

rate tarsus were 1.0 mm and 1.5 mm in length both for the basal and the remaining segments for fifth and sixth instars respectively. There was a node just before the apex of the regenerate tibia.

No. 41 The right-hand mid-leg of a newly hatched larva was removed by amputation. This individual died after the fifth ecdysis. This individual regenerated the right-hand mid-leg with tetramerous tarsus just after the first ecdysis. The growth of the regenerate femur was strongly arrested, a deep incision occurred at the middle of the underside of it in the third instar, and the incised portion turned to a prominent constriction after the fourth ecdysis. Accordingly the growth of the regenerate tibia was also checked. The tetramerous tarsus was reduced to a single-segmented tarsus after the fourth ecdysis.

No. 47 The left-hand mid-leg of a newly hatched female larva was removed by amputation from the trochantero-femoral suture. The bud of the regenerate tarsus which had appeared after the first ecdysis was etiolated after the second ecdysis. After the third ecdysis the differentiation of the tetramerous segments took place. The absolute lengths of the basal segment were 0.35 mm, 1.4 mm and 1.9 mm for the fourth, sixth and seventh instars respectively. The absolute lengths of the remaining part were 0.3 mm, 1.5 mm, and 1.9 mm for the fourth, sixth and seventh instars respectively. The values of α for the growth of the regenerate were 3.25, 4.23 and 1.33 for the femur and 3.87, 3.38 and 1.44 for the tibia successively.

No. 62 Distal 2.5 mm length of the right-hand mid-tibia of a newly hatched female was removed by amputation. The growth of the wounded tibia was comparatively very slow, the values of α being 1.13, 0.87, 1.33 and 1.30 for successive instars. After the third ecdysis a tarsus was regenerated, measuring 0.35 mm in length, and the complete tetramerous segments was differentiated in the next instar (basal segment—0.6 mm, remaining parts 0.8 mm). But the regenerate tarsus was again reduced to a very small-single attachment after the fifth ecdysis. The regenerated part of the tibia was easily detectable owing to its narrowness and pale coloration.

No. 287 Distal 1.4 mm length of the right-hand mid-femur of a newly hatched female larva was removed by amputation. The growth of the wounded femur was highly arrested at first

by the reconstruction of the lost parts. The values of α for the regenerate femur were -3.15 , 1.33 , 2.60 , 2.72 and 1.38 for respective instars. The bud of the regenerate tibia and tarsus appeared just after the second ecdysis. The growth of the regenerate tibia and the basal segment of the tarsus was rapid at the third phase and gradually regulated to the slow development, the values of α being 4.66 , 4.27 and 1.38 for the tibia and 4.53 , 3.18 and 0.23 for the tarsus respectively.

No. 291 Distal 1.8 mm of the right-hand mid-femur of a newly hatched larva was removed by amputation. The growth of the wounded femur was highly checked at first by the reconstruction of the lost parts, the values of α being -0.92 , -1.00 , 4.44 and 2.64 for successive instars. The bud of the regenerate tibia appeared just after the second ecdysis. The bud of the regenerate tarsus appeared after the fourth ecdysis and 0.8 mm in length. This individual died in the fifth instar.

No. 296 Distal 2.0 mm length of the left-hand mid-femur of a newly hatched larva was removed by amputation. The growth of the wounded femur was apparently checked by the regeneration of the lost parts, the values of α being -0.95 , 0.33 , 3.07 , 3.09 , 1.87 and 0.72 for successive instars. The values of α for the regenerate basal tarsal segment were 2.81 , 2.12 and -0.27 for successive instars.

No. 301 Distal 1.2 mm length of the right-hand mid-femur of a newly hatched female larva was removed by amputation. The growth of the wounded femur was checked as in the experiment No. 296, the values of α being -1.66 , 2.12 , 1.87 , 2.63 and 1.80 successively. The bud of the regenerate tibia appeared just after the third ecdysis.

No. 14 Distal 1.6 mm length of the right-hand mid-femur of a newly hatched female larva was removed by amputation. The growth of the wounded femur was as in the experiment No. 301, the values of α being 0.00 , -1.21 , 3.00 , 1.23 , 4.25 and 2.77 for successive instars. After the second ecdysis the bud of the regenerate tibia appeared and it measured 0.5 mm in length. After the third ecdysis the tibia was very much curved, and the side was fused with the apex of the regenerate part of the femur. Further the tetramerous tarsus appeared and was 1.0 mm in length. The longitudinal axis of the tarsus was thus perpendicular to that of

the femur. The tibia made no change until the adult stage. After the fourth ecdysis the regenerate part of the femur was slightly narrowed, and the tarsus was 1.25 mm in length. The longitudinal axis of the tarsus made an acute angle with that of the femur. After the fifth ecdysis the longitudinal axis of the tarsus became again perpendicular to that of the femur. The absolute length of the tarsus was 1.0 mm for the metatarsus and 1.4 mm for the remaining parts.

Experiments Class 6

No. 32 The right-hand mid-leg of a male larva just after the first ecdysis was removed by amputation from the trochantero-femoral suture. After the second ecdysis the leg regenerated. The values of α for the growth of the regenerate were 8.14 for the femur and 7.57 for the tibia in the second phase of the regeneration. In the regenerate leg of the adult stage of this individual, the metatarsus (0.75 mm) was shorter than the remaining parts (1.0 mm).

No. 52 The left-hand mid-leg of a female larva just after the first ecdysis was removed by amputation from the trochantero-femoral suture. The values of α for the growth of the regenerate were 5.41 for the femur and tibia in the second phase of the regeneration. The absolute lengths of the mid-metatarsus were 0.35 mm for the fourth instar and 1.5 mm for the sixth instar. The absolute length of the remaining parts of the tarsus of the same adult was 1.9 mm, and distinctly longer than the metatarsus. The tarsus of the left-hand hind leg was cut by amputation from the base after the first ecdysis. After the second ecdysis the bud of the regenerate tarsus appeared, and it was 0.5 mm in length and two-segmented. After the third ecdysis the tarsus turned to tetramerous. The absolute lengths of the metatarsus were 0.3 mm for the fourth instar and 2.15 mm for the sixth instar, and those of the remaining parts were 0.75 mm for the fourth instar and 1.90 mm for the sixth instar. The value of α was greater for the regenerate hind metatarsus than that for the regenerate mid-metatarsus.

No. 55 Distal 2.5 mm of the right-hand mid-femur of a

male larva just after the first ecdysis was removed by amputation. The growth of the regenerate femur was very much arrested by the reconstruction of the lost parts. After the second ecdysis the bud of the regenerated tibia (0.35 mm) appeared. After the third ecdysis there appeared 0.5 mm length of the tibia with 0.5 mm length of the tarsus. The regenerate tarsus was two-segmented and very much constricted at the base. The colour of the apex of the tibia and the entire tarsus was deep bluish-green. After the fourth ecdysis the regenerate tibia and tarsus were almost entirely etiolated or diminished only leaving a very short, slender, blackish attachment, and the femur was gradually narrowing apically. After the fifth moult the rudiments of the regenerate tibia and tarsus entirely disappeared, and the apex of the regenerate femur was rounded. The values of α for the growth of the wounded femur were 0.42, -1.54 and 0.83 successively.

No. 59 The right-hand mid-tibia of a male larva just after the first ecdysis was cut from the base by amputation. The bud of the regenerate tibia appeared just after the second ecdysis, and was 0.35 mm in length and spherical in size. The growth of the regenerate tibia was very well, the values of α being 1.91, 6.91 and 6.71 for successive instars. The bud of the regenerate tarsus appeared just after the third ecdysis and 0.3 mm in length. After the fourth ecdysis the tetramerous tarsus appeared. The absolute lengths of the regenerate metatarsus were 0.8 mm for the fifth instar and 2.0 mm for the sixth instar, and those of the remaining parts were 1.0 mm for the fifth and 1.35 for the sixth instar. The growth of the femur with an imperfect tibia was almost unaffected by the regeneration of the tibia. It must be noted that the growth of the regenerate tibia was not at all influenced by the reconstruction of the tarsus. The value of α for the growth of the metatarsus was larger than those of the remaining portions.

No. 75 Distal 1.3 mm of the right-hand mid-tibia of a female larva just after the first ecdysis was removed by amputation. The growth of the right-hand mid-femur with a wounded tibia seemed to have been very slightly affected by the reconstruction of the lost parts. The values of α for the growth of the femur in question was 0.93, 1.00 and 0.86 successively. The bud of the regenerate tarsus appeared after the third ecdysis. The

regenerate tarsus was 0.75 mm in length and only one-segmented in the fourth instar. In the fifth instar it became tetramerous (the basitarsus was 0.35 mm and the distal part was 0.75 mm in length.). It is apparent that the growth of the wounded tibia was distinctly checked by the reconstruction of the lost parts, and the values of α were 0.06, 1.50 and 1.40 for successive instars.

No. 203 The right-hand mid-leg of a male larva just before the second ecdysis was removed by amputation from the trochantero-femoral suture. In this individual no regeneration took place. The reason was not clear.

No. 280 Distal 1.2 mm of the right-hand mid-femur of a female larva just after the first ecdysis was removed by amputation. The growth of the wounded femur was highly checked by the reconstruction of the lost parts in the earlier phases of the regeneration. The values of α of the wounded femur were -0.08, -1.50, 2.66, 2.91 and 0.80 for successive instars. The regeneration of the lost tibia was not complete, the regenerate was 1.2 mm in length in the fifth instar, but it disappeared in the next instar. In the seventh instar the tibia again regenerated and it was 3.3 mm in length.

Experiments Class 7

No. 77 The right-hand mid-leg of a female larva just after the second ecdysis was removed by amputation from the trochantero-femoral suture. After the third ecdysis the bud of the regenerate appeared. The growth of the regenerate was very rapid in the two earlier phases of the regeneration, but checked in the third phase. The length of the regenerate tarsus was 2.0 mm for the basal segment and 1.75 mm for the remaining parts in the sixth instar. The same of the regenerate tarsus in the adult stage was 2.9 mm for the basal segment and 2.00 mm for the remaining parts. The value of α for the growth of the basal segment of the regenerate tarsus was larger than those of the remaining parts. The left-hand mid-leg was dropped by amputation in the fifth instar. The bud of the regenerate appeared in the sixth instar, the femur being 0.75 mm in length, the tibia being of the same length as the femur and the tarsus being 0.5 mm in length.

No. 204 The left-hand mid-leg of a female larva just after the second ecdysis was removed by amputation from the trochantero-femoral suture. After the third ecdysis the bud of the regenerate appeared. The values of α for the growth of the regenerate were 5.66, 3.91 and 3.28 for the bibia, 5.66, 2.25 and 1.00 for the femur and 3.83 and 1.00 for the basal tarsal segment for successive phases. It must be noted that in the experimental individual the growth of the mid-femur was much more checked than that of the mid-tibia in the two later phases.

No. 210 The left-hand mid-leg of a larva just after the second ecdysis was removed by amputation from the trochantero-femoral suture. This individual died after the sixth ecdysis. No regeneration of the lost leg occurred during three phases.

No. 213 The right-hand mid-leg of a larva just after the second ecdysis was removed by amputation from the trochantero-femoral suture. The result was almost the same as that of the experiment No. 210.

No. 215 Distal 0.3 mm of the right-hand mid-femur of a male larva just after the second ecdysis was removed by amputation. The growth of the wounded femur was slightly but distinctly checked by the reconstruction of the lost parts, the values of α being 0.53, 0.58 and 0.66 for successive instars, and smaller than those of the normal legs. The growth of the regenerate tibia was slightly rapid.

No. 220 The left-hand mid-leg of a male larva just after the second ecdysis was removed by amputation from the trochantero-femoral suture. In this case the growth of the regenerate femur was much more checked than that of the regenerate tibia in the third phase of regeneration. The values of α for the growth of the regenerate were 8.30 and 6.71 for the tibia, 7.60 and 4.42 for the femur and 6.14 for the basitarsus for successive phases.

No. 64 - Distal 0.2 mm of the left-hand mid-tibia of a male larva just after the second ecdysis was removed by amputation. The bud of the regenerate appeared after the third ecdysis, the regenerate apex of the tibia was paler in colour, and the regenerate tarsus was 1.0 mm in length and of four-segmented; the third being the shortest, first and second of the same length, fourth the largest. The growth of the wounded tibia was posi-

tively accelerated in the two later phases of regeneration, and the values of a were larger than those of the normal legs. After the fourth ecdysis each of the tarsal segments was elongated, the basitarsus being 0.8 mm and the remaining parts being 1.5 mm in length. After the fifth ecdysis the absolute length of the basitarsus was 2.25 mm and that of the distal part was 1.9 mm. This indicates that the growth-rate of the basitarsus in the regenerate leg was higher than those of the remaining parts.

Experiments Class 8

No. 87 Distal 3.5 mm of the left-hand mid-tibia of a female larva just after the third ecdysis was removed by amputation. After the fourth ecdysis the lost part of the tibia and the tetramerous tarsus were regenerated. The growth of the wounded tibia was not affected by the reconstruction of the lost parts. Further the growth of the femur with the wounded tibia was also unaffected by the regeneration of the lost part of the tibia in question. The lengths of the tetramerous tarsus were 0.50 mm, 1.00 mm and 1.60 mm successively for the basal segment and 0.60 mm, 1.50 mm and 1.80 mm for the remaining parts. The values of a for the growth of the basal segment were 2.38 and 2.22, and those of the remaining parts were 3.07 and 0.88 respectively.

No. 93 The left-hand mid-leg of a larva just after the third ecdysis was removed by amputation from the trochantero-femoral suture. After the fourth ecdysis the regenerate leg appeared, its tarsus being 0.6 mm in length. The values of a for the growth of the regenerate were 8.11 for the femur and 8.11 for the tibia. This individual died after the sixth ecdysis.

No. 103 The right-hand mid-leg of a larva just after the third ecdysis was removed by amputation from the trochantero-femoral suture. After the fourth ecdysis the regenerate leg appeared, the femur being 1.15 mm in length, the tibia being 1.0 mm, and the tarsus being 0.9 mm. The values of a for the growth of the regenerate were 8.88 for the tibia and 7.22 for the femur.

No. 104 The left-hand mid-leg of a female larva just after the third ecdysis was removed by amputation from the trochantero-femoral suture. The regenerate leg was 0.25 mm for the femur

and 0.75 mm for the tibia in the fifth instar. The values of α for the growth of the regenerate femur were larger than those of the regenerate tibia. The absolute lengths of the regenerate tarsus were 0.25 mm, 0.75 mm and 1.4 mm for the basitarsus successively, and 0.1 mm, 1.0 mm and 1.4 mm for the remaining parts successively. The value of α for the growth of the regenerate basitarsus was larger than that of the distal part in the first regenerating phase, while an entire reverse was true in the second regenerating phase.

Experiments Class 9

No. 227 The left-hand mid-leg of a female larva was removed by amputation from the trochantero-femoral suture after the fourth ecdysis. After the fifth ecdysis the bud of the regenerate appeared, the femur being 3.0 mm and the tibia being 2.2 mm in length. The values of α for the growth of the regenerate were 10.16 for the tibia and 8.00 for the femur.

No. 94 The left-hand mid-leg of a male larva was removed by amputation from the trochantero-femoral suture just after the fourth ecdysis. The regenerate femur was 2.7 mm in length, being 0.4 mm longer than the regenerate tibia.

No. 95 Mid-legs of a male larva were removed by amputation from the trochantero-femoral suture after the fourth ecdysis. The right-hand regenerate femur was 2.3 mm in length, being 0.2 mm shorter than the regenerate tibia. No regeneration occurred on the left side.

3. Experiments Series 3

Experiments Class 10

No. 5 The right-hand hind leg of a newly hatched female larva was removed by amputation from the trochantero-femoral suture. The values of α for the growth of the regenerate were 3.00, 7.66, 2.30 and 1.50 for the femur and 3.00, 7.66, 2.30 and 1.60 for the tibia for successive phases.

No. 6 The right-hand hind leg of a newly hatched female larva was removed by amputation from the trochantero-femoral suture. The values of α for the growth of the regenerate were

4.40, 2.16, 2.14, 1.70 and 1.55 for the femur and 5.50, 3.33, 2.78, 2.80 and 1.88 for the tibia for successive phases. The bud of the regenerate tarsus appeared just after the first ecdysis, but segmentation was never seen at that time. Further the segmentation of the regenerate tarsus had never been observed until the fourth instar when the bud was 0.35 mm in length and conical in shape. After the fourth ecdysis the tetramerous tarsus was observed, the basitarsus being 0.75 mm and the remaining parts being 0.9 mm in length. The absolute lengths of the regenerate basitarsus were 1.9 mm for the sixth instar and 2.5 mm for the seventh one, and those of the remaining parts were 1.7 mm for the sixth instar and 2.0 mm for the seventh one. The values of α for the growth of the regenerate basitarsus were 4.00 and 1.33, and those of the remaining parts were 2.80 and 0.77 for successive phases.

No. 16 Distal 1.6 mm of the left-hand leg of a newly hatched larva was removed by amputation. After the third ecdysis the regenerate was dropped, and the observation was stopped. The bud of the tarsus did not appear even after the third ecdysis. The growth of the wounded femur was very rapid in the first regenerating phase, and that of the regenerating tarsus was very rapid in the second phase.

No. 17 Distal 1.65 mm of the left-hand fore femur of a newly hatched larva was removed by amputation. The growth of the wounded femur was apparently checked by the reconstruction of the lost parts, the absolute lengths being 1.5 mm, 1.4 mm, 1.25 mm, 2.25 mm and 5.0 mm for successive instars. The regenerate femur was slightly twisted at the regenerating portion. After the third ecdysis the basitarsus was curved very much.

No. 22 The left-hand hind leg of a newly hatched female larva was removed by amputation from the trochantero-femoral suture. The values of α for the growth of the regenerate femur were 2.77, 8.83, 2.69, 1.45 and 1.27 and those of the tibia were 2.77, 7.66, 2.92, 2.00 and 1.27 for successive phases. The absolute lengths of the regenerate basitarsus were 0.75 mm, 1.5 mm and 2.0 mm, and those of the remaining parts were 1.0 mm, 1.75 mm and 1.9 mm for successive instars (V, VI, VII). The values of α for the growth of the regenerating basitarsus were 2.72 and 1.18, and those of the remaining parts were 2.18 and 0.27 for successive regenerating phases.

No. 25 The right-hand hind leg of a newly hatched female larva was removed by amputation from the trochantero-femoral suture. The values of α for the growth of the regenerate femur were 2.81, 6.00, 2.25, 1.72 and 2.00, and those of the regenerate tibia were 3.36, 5.10, 2.50, 1.72 and 1.57 for successive phases. The absolute lengths of the regenerate tarsus for successive instars were 1.6 mm, 2.25 mm and 2.6 mm, for the basitarsus and 1.6 mm, 2.0 mm and 2.0 mm for the remaining tarsal segments. The values of α for the growth of the regenerate tarsus were 1.36 and 0.85 for the basitarsus and 0.90 and 0.00 for the remaining parts respectively. No growth in length was seen in the regenerating three apical tarsal segments (taken together) in the last regenerating phase.

No. 42 The right-hand hind leg of a newly hatched larva was removed by amputation from the trochantero-femoral suture. This individual died just after the second ecdysis. The absolute lengths of the regenerate were 0.6 mm for the femur and 0.6 mm for the tibia.

No. 48 The left-hand hind leg of a newly hatched female larva was removed by amputation from the trochantero-femoral suture. This individual died in the course of the sixth ecdysis. The values of α for the growth of the regenerate femur were 2.60 for the first phase and 3.00 for the fourth and those of the tibia were 2.60 for the first and 2.10 for the fourth. In this individual the regenerate of the tarsus never appeared during the larval period.

No. 53 The antennae of a newly hatched larva were amputated at the base of the fourth segment. The left-hand hind leg was dropped at the middle of the first instar. The absolute lengths of the regenerate antennae were 3.0 mm (IV) and 5.5 mm (V) for the left side and 3.7 mm (IV) and 5.5 mm (V) for the right side. The values of α for the growth of the regenerate left-hand antenna were very high but slightly lower than those of the hind leg.

No. 286 Distal 2.4 mm of the right-hand hind femur of a newly hatched male larva was removed by amputation. The growth of the regenerate tibia was very slow or entirely stopped. Of course the regeneration of the tarsus never occurred. The growth of the wounded femur was very much arrested by the

reconstruction of the lost parts. It is noteworthy that the wounded femur had never increased in length during the larval stage. Thus the values of α for the growth of the wounded femur were -3.15, -1.33, 0.90, -1.00 and 0.00 for successive regenerating phases.

No. 288 Distal 2.1 mm of the left-hand hind femur of a newly hatched female larva was removed by amputation. The growth of the wounded femur was apparently arrested for the two first phases, the values of α being -2.00, -1.25, 4.35, 4.33, 2.10 and 1.54 for successive phases. The regenerate tibia was very much curved, and the measurement was almost impossible. The values of α for the growth of the regenerate basitarsus were comparatively large and 4.11, 1.60 and 2.72 for three later phases.

No. 290 Distal 1.2 mm of the right-hand hind femur of a newly hatched female larva was removed by amputation. This individual died during the fourth ecdysis. The growth of the wounded femur was very slow owing to the regeneration of the lost parts. After the third ecdysis the bud of the tibia appeared and was 0.5 mm in length.

No. 294 Distal 0.9 mm of the right-hand hind femur of a newly hatched female larva was removed by amputation. The growth of the wounded femur was checked for the earlier phases, the values of α being -0.52, 3.50, 1.46 and 1.85 for successive phases. The bud of the regenerate tibia appeared after the second ecdysis and the values of α were 3.90, 2.27 and 1.85 for successive phases. The value of α for the fourth regenerating phase of the basitarsus was so high as 3.00, but in the next phase it became negative, taking the value -0.27.

No. 295 Distal 0.6 mm of the left-hand hind femur of a newly hatched larva was removed by amputation. This individual died after the third ecdysis. The growth of the wounded femur was also checked by the reconstruction of the lost parts. The regeneration never occurred on the tibia.

No. 297 Distal 1.7 mm of the right-hand hind femur of a newly hatched larva was removed by amputation. The growth of the wounded femur was highly checked at first. The values of α for the femur were -6.50, 6.28, 0.85, 2.55 and 11.1 for successive phases. The values of α for the growth of the regen-

nerate tibia were 3.25 and 3.00, and those of the basitarsus were 4.20 and 1.22 for successive phases.

Experiments Class 11

No. 33 The left-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the first ecdysis. The growth of the regenerate leg was quite ideal in curve when plotted on the chart. The values of a for the growth of the regenerate were 4.81, 4.90, 2.40 and 1.33 for the femur and 4.81, 4.90, 2.30 and 1.36 for the tibia for successive phases.

No. 38 The left-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the first ecdysis. This individual lost its right-hand fore leg by autotomy just after the first ecdysis. The values of a for the growth of the regenerate fore leg were 4.70, 4.83, 2.40 and 1.30 for the femur and 4.30, 6.06, 2.10 and 1.90 for the tibia for successive phases. Those of the regenerate hind leg were 2.60, 2.83, 2.90 and 1.60 for the femur for successive phases. The growth of the regenerate hind tibia was abnormal.

No. 56 The left-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the first ecdysis. The values of a for the growth of the regenerate were 2.43, 4.00, 1.90 and 1.33 for the femur and 2.35, 4.15, 1.90 and 1.33 for the tibia for successive phases. The absolute lengths of the regenerate tarsus were 1.5 mm, 2.4 mm and 3.0 mm for the basitarsus and 1.5 mm, 2.2 mm and 2.4 mm for the remaining parts. The values of a for the growth of the basitarsus were always larger than those of the remaining parts.

No. 60 The right-hand hind leg of a larva was removed by amputation from the trochantero-femoral suture just after the first ecdysis. This individual died during the fourth ecdysis. The absolute lengths of the regenerate were 0.5 mm and 2.0 mm for successive phases.

No. 63 The right-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the first ecdysis. The values of a for the growth of the regenerate were 5.72, 7.25 and 2.25 for the femur and 5.72, 6.62

and 2.87 for the tibia for successive phases. The absolute lengths of the regenerate tarsus were 1.25 mm and 1.8 mm for the basitarsus, and 1.25 mm and 1.5 mm for the remaining parts. The value of α for the growth of the basitarsus was larger than that of the distal part.

No. 68 The right-hand hind leg of a larva was removed by amputation from the trochantero-femoral suture just after the first ecdysis. This individual died after the fifth ecdysis. The values of α for the growth of the regenerate were 6.42 and 3.57 for the femur, and 5.57 and 4.42 for the tibia for successive phases. The absolute lengths of the regenerate tarsus were 0.75 mm and 2.00 mm for the basitarsus, and 0.75 mm and 1.50 mm for the remaining parts. The value of α for the growth of the basitarsus was larger than that of the distal part.

No. 71 Distal 1.8 mm of the right-hand hind femur was removed by amputation just after the first ecdysis. The growth of the wounded femur was highly affected by the regeneration of the lost parts. After the second ecdysis a pit-like bud of the regenerate appeared. After the third ecdysis 0.65 mm of a tetramerous tarsus was regenerated. After the next ecdysis the regenerate tarsus was entirely diminished, and the femur was gradually narrowed apically. In this case no regeneration took place in the tibia.

No. 72 Distal 0.2 mm of the right-hand hind femur of a larva was removed by amputation just after the first ecdysis. The growth of the wounded femur was normal, and the regeneration of the lost parts never occurred. The apex of the wounded femur had a very small tubercle-like minute process.

No. 73 Distal 2.9 mm of the right-hand hind tibia was removed by amputation just after the first ecdysis. This individual died just after the sixth ecdysis. The values of α for the growth of the wounded tibia were 1.00 for the first phase and 0.92 for the third phase. No regeneration took place in the tarsus.

No. 278 Distal 2.3 mm of the left-hand hind femur of a female larva was removed by amputation just after the first ecdysis. The growth of the wounded femur was apparently affected by the reconstruction of the lost parts at the earlier regeneration phases, the values of α being 0.00, 0.58, -2.40, 4.30 and 4.25 for successive phases. The regenerate tibia at

first appeared just after the fourth ecdysis. The values of α for the growth of the regenerate tibia were 2.50 and 7.28 for successive phases.

No. 281 Distal 2.2 mm of the left-hand hind-femur of a male larva was removed by amputation just after the first ecdysis. The growth of the wounded femur was very much checked by the reconstruction of the lost parts, the values of α were -0.41, 0.14, 0.46 and 0.00 for successive phases. After the third ecdysis 0.45 mm length of the regenerate tibia appeared, but the bud diminished just after the third ecdysis.

Experiments Class 12

No. 55 The left-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the second ecdysis. This individual died after the sixth ecdysis. The values of α for the growth of the regenerate were 4.40 and 2.55 for the femur, and 4.90 and 2.22 for the tibia for successive phases. The absolute lengths of the regenerate tarsus were 1.85 mm and 2.5 mm for the basitarsus, and 1.85 mm and 2.0 mm for the remaining parts. The value of α for the growth of the basitarsus was larger than that of the remaining parts.

No. 80 The right-hand hind leg of a male larva was removed by amputation from the trochantero-femoral suture just after the second ecdysis. The values of α for the growth of the regenerate were 3.75 and 2.80 for the femur, and 5.41 and 3.20 for the tibia for successive phases. The absolute lengths of the regenerate tarsus were 0.6 mm and 2.0 mm for the basitarsus, and 1.0 mm and 1.5 mm for the remaining parts. The value of α for the growth of the basitarsus was very large (5.30) and that of the distal part was 1.70.

No. 206 The right-hand hind leg of a male larva was removed by amputation from the trochantero-femoral suture just after the second ecdysis. In this individual the regeneration never occurred.

No. 207 The right-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the second ecdysis. In this individual the regeneration never occurred.

No. 209 The right-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the second moult. After the fourth ecdysis the bud of the regenerate appeared. The values of α for the growth of the regenerate were 6.55 for the femur and 7.44 for the tibia. The regenerate was dropped during the sixth ecdysis.

No. 212 The right-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the second moult. Until the adult stage the regeneration was never observed.

No. 214 The result was the same as in the experiment No. 212.

No. 216 The left-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the second ecdysis. After the fifth ecdysis the bud of the hind leg was regenerated, the femur being 1.5 mm and the tibia being 1.2 mm in length. After the sixth ecdysis the regenerate was etiolated and diminished.

No. 217 The result was the same as in the experiment No. 214. No regeneration took place.

No. 218 The right-hand hind leg of a male larva was removed by amputation from the trochantero-femoral suture just after the second ecdysis. The values of α for the growth of the regenerate were 7.80 and 4.30 for the femur, 6.10 and 6.00 for the tibia and 5.60 for the basitarsus. The basitarsus appeared just after the fourth ecdysis.

No. 223 The right-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the second ecdysis. The bud of the regenerate basitarsus appeared just after the fourth ecdysis. The growth of the regenerate was quite ideal. The values of α for the growth of the regenerate were 8.45, 3.75 and 1.90 for the femur, 7.27, 5.08 and 2.50 for the tibia, and 3.83 and 1.40 for the basitarsus for successive phases.

No. 224 The left-hand hind leg of a male larva was removed by amputation from the trochantero-femoral suture just after the second ecdysis. In this individual the regenerate tarsus never appeared at all. The values of α for the growth of the

regenerate were 5.23 and 8.11 for the femur, and 5.38 and 8.00 for the tibia for successive phases.

No. 225 The right-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the second ecdysis. The growth of the regenerate of this individual was typical. The values of α for the growth of the regenerate were 8.63, 5.90 and 1.90 for the femur, 9.27, 5.60 and 2.09 for the tibia, and 4.60 and 1.54 for the basitarsus for successive phases. It must be noted that the regenerate basitarsus was as long as the normal basitarsus of the opposite side in the adult stage.

No. 226 The left-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the second ecdysis. This individual lost its right-hand hind leg by autotomy in the third instar. The growths of the regenerates were quite typical. The values of α for the left side were 7.00, 5.10 and 2.33 for the femur and 7.50, 5.33 and 3.44 for the tibia, and those for the right side were 8.50, 5.10 and 2.55 for the femur and 7.60, 6.20 and 2.77 for the tibia for successive phases.

Experiments Class 13

No. 92 The left-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the third ecdysis. The individual died during the sixth ecdysis. The growth of the regenerate femur was rapid, the value of α being 6.00, but that of the tibia was slow, owing to the reconstruction of the tarsus, the value of α being 2.10. But the bud of a regenerate tarsus never appeared.

No. 97 The right-hand hind leg of a male larva was removed by amputation from the trochantero-femoral suture just after the third ecdysis. The values of α for the growth of the regenerate were 3.90 for the femur and 6.90 for the tibia.

No. 98 The left-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the third ecdysis. The values of α for the growth of the regenerate were 11.70 and 7.71 for the femur, and 10.80 and 7.57 for the tibia for successive phases.

No. 99 The left-hand hind leg of a male larva was re-

moved by amputation from the same suture just after the third ecdysis. The growth of the regenerate was slightly more rapid than that of the experiment No. 97.

No. 228 The right-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the third ecdysis. In this individual no regeneration took place in the lost leg.

No. 229 The right-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the third ecdysis. The values of α for the growth of the regenerate were 9.40 for the femur and 9.10 for the tibia.

No. 234 The right-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the third ecdysis. The values of α for the growth of the regenerate were 9.46 and 5.22 for the femur, and 9.76 and 4.33 for the tibia for successive phases.

Experiments Class 14

No. 46 The right-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the fourth ecdysis. After the fifth ecdysis the regenerate appeared, the femur being 2.1 mm and the tibia 2.0 mm in length. The metatarsus of the regenerate was 0.35 mm in length. This individual died just before the sixth ecdysis. The right-hand antenna of this individual was cut at the base of the fourth segment. The growth of the regenerate antenna was at first slightly checked.

No. 236 The right-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the fourth ecdysis. In this individual no regeneration took place.

No. 238 Distal 10.2 mm of the right-hand hind leg of a larva was removed by amputation just after the fourth ecdysis. After the fifth ecdysis the wounded femur regenerated the lost parts, the femur being 6.0 mm and the tibia 4.2 mm in length. In this case the growth of the wounded femur was not checked by the regeneration of the lost parts, the value of α being 4.00.

No. 237 The left-hand hind leg of a female larva was



removed by amputation from the trochantero-femoral suture just after the fourth ecdysis. The values of α for the growth of the regenerate were 5.90 for the femur, 7.20 for the tibia and 3.10 for the basitarsus.

4. Experiments Series 4

Experiments Class 15

No. 43 The mid-legs of a larva were removed by amputation from the trochantero-femoral suture just after the hatching. In the next instar the regenerates appeared, the femur measuring 0.5 mm and the tibia also being 0.5 mm in length. This individual died just before the second ecdysis.

No. 36 The mid-legs of a female larva just after the first ecdysis were amputated from the trochantero-femoral suture. The growth of the regenerate mid-legs was as rapid as an ideal case. The values of α for the growth of the left-hand mid-leg were 4.72, 3.50, 1.58 and 2.14 for the femur and 4.63, 3.41, 1.75 and 2.00 for the tibia for successive phases. The same of the right-hand mid-leg were 4.72, 3.50, 1.58 and 2.14 for the femur, and 4.63, 3.41, 1.75 and 2.00 for the tibia. The left-hand fore leg was dropped by autotomy from the trochantero-femoral suture just after the third ecdysis. The growth of the regenerate fore leg was also very rapid, the values of α being 4.75 and 4.00 for the femur and 4.75 for the tibia. The left-hand hind tibia was damaged in the fourth instar, and distal 7.0 mm of the tibia was lost. The growth of the femur with the wounded tibia was apparently checked, the values of α being 0.83, 0.50 for the first two phases. The growth of the wounded tibia was highly influenced by the reconstruction of the lost parts. The values of α were -1.41, 2.91 and 5.00 for successive phases.

No. 58 b The mid-legs of a female larva were amputated from the trochantero-femoral suture just after the second ecdysis. The values of α for the growth of the left-hand mid-leg were 2.54, 2.80 and 1.50 for the femur, and 2.45, 2.60 and 1.62 for the tibia for successive phases. The same of the right-hand mid-leg were 2.70 and 2.00 for the femur, and 2.45, 2.80 and 1.50 for the tibia for successive phases.

No. 96 The mid-legs of a male larva were removed from the trochantero-femoral suture just after the third ecdysis. The values of α were 5.70 for the growth of the regenerate femur and 6.00 for the regenerate tibia.

Experiments Class 16

No. 10 The hind legs of a newly hatched female larva were removed by amputation from the trochantero-femoral suture. The values of α for the growth of the left-hand regenerate were 4.36, 4.16 and 2.30 for the tibia, and 5.00, 2.08 and 1.50 for the femur, and those of the right-hand regenerate were 4.36, 1.08 and 1.50 for the tibia, and 4.90, 0.75 and 1.20 for the femur for successive phases. The absolute lengths of the regenerate tarsi were 0.75 mm, 2.25 mm and 3.00 mm respectively for the left-hand basitarsus, 1.25 mm, 2.10 mm and 2.60 mm respectively for the left-hand remaining parts, 1.60 mm, 2.35 mm and 2.80 mm respectively for the right-hand basitarsus, 1.50 mm, 1.75 mm and 2.10 mm respectively for the right-hand remaining parts. The growth of the regenerate basitarsus was greater than that of the remaining parts. The right-hand mid-leg of this individual had a two-segmented tarsus in the fifth instar, but in the next stage the latter became to assume the normal form with five segments.

No. 44 • The hind legs of a newly hatched male larva were removed by amputation from the trochantero-femoral suture. The growth of the regenerates was typical. The lengths of the regenerate left-hand tarsus were 1.0 mm and 2.0 mm for the basitarsus, and 1.1 mm and 2.0 mm for the remaining parts for successive instars. Here it is evident that the growth of the regenerate basitarsus was higher than that of the remaining parts. The lengths of the regenerate right-hand tarsus were 1.25 mm and 1.25 mm for the basitarsus, and 0.75 mm and 1.50 mm for the remaining parts for successive phases. In this case the regenerate basitarsus showed no development in length, and only the remaining parts made a rapid growth.

No. 37 The hind legs of a newly hatched female larva were removed by amputation from the trochantero-femoral suture. The values of α for the growth of the left-hand regenerate were 4.50, 5.09, 1.50 and 2.00 for the femur, and 4.63, 1.83 and 1.75

for the tibia for successive phases. The values of α for the growth of the right-hand regenerate were 4.50, 5.09, 1.50 and 1.87 for the femur, and 4.50, 4.63, 1.83 and 1.62 for the tibia for successive phases. The absolute lengths of the regenerate tarsus were 2.0 mm and 2.5 mm for the basitarsus, and 2.0 mm and 2.2 mm for the remaining parts for successive phases. In this case the growth of the regenerate basitarsus was evidently more rapid than that of the distal part.

No. 67 The hind legs of a larva were removed by amputation from the trochantero-femoral suture just after the first ecdysis. The right-hand regenerate was dropped during the fourth ecdysis. This individual died in the fifth instar. The values of α for the growth of the right-hand regenerate were very high, being 6.66 for the femur and 5.60 for the tibia. The same of the left-hand regenerate were 6.66 and 5.09 for the femur, and 5.40 and 4.90 for the tibia for successive phases. The absolute lengths of the regenerate tarsus were 0.90 mm. and 2.25 mm for the basitarsus, and 0.75 mm and 1.75 mm for the remaining parts for successive phases. The growth of the regenerate tarsus was very rapid both for the basitarsus and for the remaining parts.

No. 201 The hind legs of a male larva were amputated from the trochantero-femoral suture just after the first ecdysis. The growth of the left-hand regenerate was very rapid, the values of α being 5.58, 11.66 and 2.23 for the femur, and 5.58, 11.77 and 2.07 for the tibia for successive phases, while that of the right-hand regenerate was very slow, the values of α being 0.1 for the femur and tibia. The right-hand regenerate was dropped during the fourth ecdysis.

No. 208 The hind legs of a male larva were amputated from the trochantero-femoral suture just after the second ecdysis. No regeneration took place on the right side. The values of α for the growth of the left-hand regenerate were 9.77 and 5.80 for the femur, and 8.66 and 6.70 for the tibia for successive phases. The absolute lengths of the regenerate basitarsus were 0.5 mm for the fifth instar and 1.9 mm for the next. Therefore, the growth of the regenerate basitarsus was very rapid, the value of α being 6.70.

No. 221 The hind legs of a female larva were amputated from the trochantero-femoral suture just after the second ecdysis.

The growth of the right-hand regenerate was rapid at first, but very much checked by the etiolation of the tarsus. The value of α for the femur was 1.71 in the last phase, and those for the tibia were 8.27, -0.30 and -1.85 for successive phases. In the left-hand regenerate the growth was as rapid as in the normal case, the values of α being 8.54, 5.40 and 3.85 for the femur, and 8.54, 4.70 and 4.71 for the tibia for successive phases.

No. 222 The hind legs of a male larva were amputated from the trochantero-femoral suture just after the second ecdysis. The growth of the regenerates was typical. The values of α of the left-hand regenerate were 10.87 and 4.38 for the femur, 10.87 and 4.07 for the tibia and 4.15 for the basitarsus for successive phases. The same of the right-hand regenerate were 9.87 and 3.92 for the femur, 7.50 and 4.92 for the tibia and 5.84 for the basitarsus for successive phases.

No. 90 The hind legs of a female larva were removed by amputation from the trochantero-femoral suture just after the third ecdysis. This individual died in the sixth instar. The values of α for the regenerate femur and tarsus were 10.00 and 9.75 respectively.

No. 100 The hind legs of a female larva were amputated from the trochantero-femoral suture just after the third ecdysis. The growth of the right-hand regenerate was abnormal. The values of α for the growth of the regenerate femur and tibia were 5.70 and 5.70 respectively.

Experiments Class 17

No. 30 The right-hand mid-leg and the left-hand hind leg of a female larva were removed from the trochantero-femoral suture just after the hatching. The growth of the regenerates was typical. The values of α for the growth of the regenerates were 5.50 and 1.54 for the hind tibia, 5.50 and 1.18 for the hind femora, 5.50 and 1.09 for the mid-tibia, and 5.50 and 1.27 for the mid-femur for successive phases. This female died in the sixth instar. The regenerate mid-tibia was almost as long as the normal mid-tibia of the opposite side in the sixth instar.

No. 34 The right-hand fore leg and the left-hand mid-leg

of a male larva were amputated from the trochantero-femoral suture just after the first ecdysis. The growth of the regenerate fore leg was typical, the values of α being 5.10, 4.38 and 2.50 for the femur, and 4.30, 4.76 and 2.90 for the tibia for successive phases. Just after the third ecdysis the apical portion of the regenerate mid-femur was slightly constricted and curved, and the tibia and tarsus took quite abnormal situation as shown in the text-figure. In the next ecdysis the tibia and tarsus diminished and were attaching to the apex of the femora as a small tubercle. The growth of the femur was checked at the third regenerating phase. The values of α for the growth of the regenerate mid-femur were 4.80, -0.38 and 2.40 for successive phases.

No. 35 The right-hand mid-leg and the left-hand hind leg of a female larva were amputated from the trochantero-femoral suture just after the first ecdysis. The values of α for the growth of the regenerates were 4.27, 7.83 and 2.71 for the mid-femur, 4.27, 8.33 and 1.57 for the mid-tibia, 5.00, 12.00 and 1.00 for the hind femur, and 5.00, 11.33 and 1.00 for the hind tibia for successive phases. This individual died in the sixth instar.

No. 45 The left-hand mid-leg and the right-hand hind leg of a newly hatched male larva were removed from the trochantero-femoral suture. The growth of the regenerates was normal. In the adult stage the regenerate mid-leg was exactly as long as the normal mid-leg of the opposite side. The absolute lengths of the regenerate mid-tarsus were 2.0 mm and 3.0 mm for the basitarsus, and 1.8 mm and 2.0 mm for the remaining parts for the fifth and sixth instars respectively.

No. 54 b The hind legs and the left-hand fore leg of a female larva were amputated from the trochantero-femoral suture. The values of α for the growth of the hind regenerates were 6.55, 3.69 and 2.22 for the left-hand femur, 5.77, 4.23 and 2.55 for the left-hand tibia, 6.55, 3.69 and 2.22 for the right-hand femur, and 5.77, 3.07 and 3.55 for the right-hand tibia for successive phases.

No. 59 b The left-hand fore leg and the right-hand mid-leg of a male larva were removed from the trochantero-femoral suture just after the second ecdysis. The values of α for the growth of the regenerates were 3.69 and 5.44 for the left-hand fore femur, 3.46 and 6.00 for the left-hand fore tibia, 3.53 and 5.00 for the

right-hand mid-femur, and 3.61 and 5.33 for the right-hand mid-tibia for successive phases.

No. 65 b The left-hand mid-leg and the right-hand hind leg of a larva were amputated from the trochantero-femoral suture just after the first ecdysis. The values of α for the growth of the regenerates were 6.50 and 5.20 for the left-hand mid-femur, 7.75 and 5.20 for the left-hand mid-tibia, 7.00 and 4.70 for the right-hand hind femur, and 6.50 and 5.40 for the right-hand hind tibia for successive phases. The growth of the regenerate mid-basitarsus was more rapid than that of the distal part of the regenerate mid-tarsus. On the contrary the growth of the regenerate hind tarsus was much more rapid than that of the distal part. This individual died during the fifth ecdysis.

No. 66 The right-hand fore leg of a larva was amputated from the trochantero-femoral suture just after the first ecdysis. This individual lost its left-hand mid-leg in the second instar by autotomy. The values of α for the growth of the regenerates were 6.33 and 5.08 for the right-hand fore femur, 9.22 and 4.91 for the right-hand fore tibia, 4.20 and 5.00 for the left-hand mid-femur, and 5.00 and 3.50 for the left-hand mid-tibia for successive phases. This individual died in the fifth instar. The regenerate tarsus of the mid-leg was two-segmented.

No. 69 The left-hand fore leg and the right-hand hind leg of a larva were amputated from the trochantero-femoral suture just after the first ecdysis. This insect died in the fifth instar. The values of α for the growth of the regenerates were 7.30 and 3.00 for the left-hand fore femur, 7.61 and 3.68 for the left-hand fore tibia, 6.38 and 3.25 for the right-hand hind femur, and 6.69 and 3.50 for the right-hand hind tibia for successive phases. The absolute lengths of the regenerate tarsi were 0.9 mm and 2.00 mm for the fore basitarsus, 0.9 mm and 1.75 mm for the remaining parts of the tarsus, 0.75 mm and 2.00 mm for the hind basitarsus, and 0.9 mm and 1.75 mm for the remaining parts for successive phases.

No. 74 The right-hand fore leg of a larva was amputated from the trochantero-femoral suture just after the first ecdysis. Distal 2.6 mm of the left-hand mid-leg was removed by amputation in the same instar. The values of α for the growth of the regenerate fore leg were 9.27 and 3.92 for the femur, and 8.45 and

4.50 for the tibia for successive phases. The growth of the wounded mid-femur was apparently checked by the reconstruction of the lost parts, the values of α being 0.70, -0.45 and 0.00 for successive phases. After the second ecdysis there appeared a very low tubercle-like process on the apex of the wounded femur. After the third ecdysis this process made a slight growth, the length being 0.35 mm, with an attachment on the apex. In the next instar it became 0.5 mm in length. No tarsus was regenerated at all. This individual died in the fifth instar.

No. 82 The right-hand hind leg of a female larva was removed by amputation from the trochantero-femoral suture just after the second ecdysis. Distal 4.6 mm of the left-hand mid-femur was removed by amputation in the same instar. The growth of the regenerates was normal. The lengths of the regenerate hind tarsus were 0.65 mm and 2.20 mm for the femur, and 0.75 mm and 2.00 mm for the tibia for successive phases. The regenerate mid-leg was dropped in the sixth instar. The wounded femur was very much constricted at the base just before the third ecdysis, but never dropped. After the fourth ecdysis there appeared very curious segments: the femur (2.1 mm in length) and the tibia (2.0 mm in length) were normal, the basitarsus was 0.5 mm in length, the second and third tarsal segments were 0.25 mm in length taken together, the fourth one was very curious and 0.35 mm in length. At the middle of the fourth segment there was attached an empodium-like process. At the apex of the fourth segment there was attached another leg (consisting of a tibia and a tetramerous tarsus), thus the fourth segment playing a mirror, of both legs. The measurements of this curious leg are as follows: tibia 1.5 mm, basitarsus 0.5 mm, second and third segments taken together 0.30 mm. There was recognizable a deep bluish tubercle on the top of the tibia. The apex of the tibia was irregularly shaped. This curious leg was dropped in the course of the next ecdysis.

No. 91 The right-hand fore leg and the left-hand hind leg of a female larva were amputated from the trochantero-femoral suture. The values of α for the regenerate legs for the second regenerating phase were 18.57 for the fore femur, 15.41 for the fore tibia, 17.28 for the hind femur and 13.00 for the hind tibia. This individual died in the sixth instar.