

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

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## 2. Discussions

The effect of the regenerating legs upon the normally developing legs in the post-embryonic stages of some Arthropoda has been studied by several authors, including HÜBNER (1902, *Chloëon dipterum*), MEGUSAR (1907, *Hydrophilus caraboides*, *Tenebrio molitor*), PRZIBRAM (1917, *Sphodromantis bioculata*), GABRITCHEWSKY (1926-, Spiders), HUXLEY (1927, *Maia squinado*), SHAW (1928, *Inachus dorsettensis*), TAZELAAR (1938, *Chloëon dipterum*), DIXEY (1938, *Gammarus chevreuxii*) and PAULIAN (1938, *Palaemon squilla*, *Eupagurus prideauxii*, *Chloëon dipterum*, *Chloëon simile*). The study made by DUARTE (1938) on the African locust, *Locusta migratoria migratorioides*, is also of interest in the problem of the same line.

HÜBNER amputated the right-hand tracheal gill of the abdomen of *Chloëon dipterum* and observed the atrophy of the left-hand tracheal gill in successive instars. The experiment carried out by MEGUSAR on the larva of *Hydrophilus caraboides* showed a similar result (compensatory reduction) as that of HÜBNER. He amputated one mandible of the larva and found that the other mandible of the opposite side became smaller than in the preceding stadium in the next stage and more simplified in the successive stadia. He also amputated the hind leg of a full-grown larva of *Tenebrio molitor* and observed that the elytron of the same side as the operated hind leg of the newly emerged adult showed a considerable deformation. But this striking result may be merely of mechanical nature and seems to have been derived from the effect of the insufficient humidity of the rearing medium. PRZIBRAM made a series of experiments on *Sphodromantis bioculata* and found the positive effect produced by regenerating legs upon neighbouring appendages. His studies may be summarized as follows. After the amputation of a fore or mid-leg the growth-rate of the leg just posterior to it was first depressed during the period, in which the regeneration was most active, then was accelerated to a degree more than normal, and finally dropped to or below normal. After the amputation of a hind leg a similar effect was produced in the anterior legs, but the initial depression was greater and the later increase more slight than in the preceding case. GABRITCHEWSKY carried out a series of experiments on spiders and showed that

the regeneration of one leg caused some modifications (atrophy and hypertrophy in the chaetotaxy, claws and coloration) in neighbouring appendages. He called such an effect under the name "induction spécifique á distance" HUXLEY (in *Maia squinado*), SHAW (in *Inachus dorsettensis*) and TAZELAAR (in *Palaemon carcinus*) demonstrated the fact that there was a slight increase in size in the appendages just posterior to the regenerating (allometric) appendage, but there was also a slight decrease in size in those immediately anterior to it. In his further experiments on the mayfly larvae, TAZELAAR removed repeatedly the mid-leg of one side of young larvae of *Chloëon dipterum* and investigated the effect on the legs anterior and posterior to it. In the normal legs the relative length of tarsus decreased with increasing absolute size, while in the regenerating leg this percentage was initially smaller than in the controls, but increased with increasing absolute size until the control value was reached. The relative tibia-length and femur-length in the normal legs increased slightly with increase in size. In the regenerating legs the relative tibia-length was at first larger than normal and then decreased irregularly with increase in size; the relative femur-length remained about equal to that of the controls. His result implied that the mechanisms of regenerative and normal growth were independent and not identical with each other and rapid growth in regeneration did not affect the normal growth of neighbouring legs. DIXEY also made repeated amputations on the appendages of young *Gammarus chevreuxi* in order to determine the effects on the growth-rates of legs anterior and posterior to them and demonstrated that any effects produced in this way were of a temporary nature which could not be detected by his methods used. PAULIAN made some experimental studies on four species of Arthropoda. In *Palaemon squilla*, *Eupagurus prideauxii* and *Chloëon simile*, no sensible results were detected. In *Chloëon dipterum* the results were more or less complicated. DUARTE supposed that the gregarious phase of the African locust was a result of the jumping activity of the young locusts and studied the effect of the amputation of hind tibiae on crowded locusts. The locusts with their hind tibiae cut off did not develop well as those of the control, and the hind femur, as a consequence of its useless condition, became extremely short as compared with the elytra. Further the

occurrence of the black-orange coloration was stronger and more uniform in the normal locusts than in the operated ones.

In my opinion such problem as to detect the presence or absence of the effects of the regenerating legs upon the normally growing legs can be analysed safely only by the careful measurements of many individuals separately, as the considerations based upon the mean value of the measurements would often eliminate the fact hidden within the problem. It is evident from my results mentioned above, that the effects of the regenerating legs upon neighbouring appendages are either positive or negative. But it must not be forgotten that the normal legs as a whole never showed any atrophic nor hypertrophic growth, and the effects which I imply, if present, are only seen in the variation of the proportion of the components of the legs themselves. Further it must be borne in mind that the regeneration curves of many examples are of the same and a single type as investigated in the preceding chapter. It is true that the allometric organ influences the growth-gradients of neighbouring organs as well as parts of the body. This shows that a localized region of rapid growth cannot be regarded as completely isolated, but undoubtedly operates within the main growth gradient of the body. Amputation may be regarded as to make an artificially induced centre of high growth intensity, and a regenerating leg presumably forms a centre of very active growth. My results demonstrate partly that the regenerating legs give a similar effect on neighbouring appendages as normal allometric organ, and partly that they do not affect the normal growth of neighbouring legs as contrasted with the former case. In these points my experimental results do not coincide with those of TAZELAAR, etc. But there is, of course a distinct difference between normally growing and regenerating legs in their actual mechanisms of growth in nature, and the regeneration itself is not a simple phenomenon as to be expressed by PRZIBRAM (1919) under the name of accelerated growth. The regenerating leg seems to develop quite independently of the normal growth of neighbouring legs. Thus it may be supposed that certain specific growth-promoting and growth-inhibiting factors may play role within the regenerating legs in producing its characteristic growth.

G. The "Raison d'être" of DYAR's Rule, PRZIBRAM's Principle and TOKUNAGA's Formula

Consulting the literature and experiments as discussed above, I have to express some opinion concerning the growth of insects. The well known ideas illustrating the growth of insects are DYAR's rule, PRZIBRAM's principle and TOKUNAGA's formula, a modification of ROBERTSON's formula of monomolecular autocatalytic chemical reaction. Generally speaking, high growth-ratios are encountered in the early part of larval development, and there is a tendency of diminishing of the growth-ratios during the larval development. It is quite artificial to consider the first larval stage separately from the later stages, only because of the fact that the size of the first larval stage has already been decided in the embryonic development, while the growth of the later stages depends mainly upon nutrition. There exists also a reason to assume, that the size of the first larval stage is the standard or basis of all sizes of the later stages, including the determinate specific size of the adult insects, which are originated in the size of the first larval stage. Growth in insects is not a phenomenon of a closed system but an open one, taking nutriment from the environment and continuing excretion during the course of larval development and is a combined result of much more complicated biological phenomena. Notwithstanding it must be pointed out that the growth in insects is not performed at random but by a regular manner specific to each insect or to each organ. To explain the growth process in insects as a monomolecular autocatalytic chemical reaction means to treat insects as not living and homogeneous chemical substances. Apparently this idea may be considered as a fault. Therefore, the coincidence of the growth curve with that of the monomolecular autocatalytic chemical reaction must be taken as merely accidental and the growth rate must be analysed by some other method. In the least the growth of the appendages of my experiments must be analysed by the idea of the growth-promoting and growth-inhibiting factors. The general growth curve must be considered empirically, and the equation illustrating the curve, if needed, must be constructed by the aid of analytical geometry. The equations given by GAINS and CAMPBELL (1935) and WOODRUFF (1939), using three parameters

or constants, will be held good for the indication of the linear growth in insects. On the other hand, regeneration may be regarded as an exaggeration of normal growth in insects. The locus of equilibrium between the growth-promoting and growth-inhibiting factors takes several different routes in the growth process of regenerate appendages. Really, we cannot recognize both DYAR's rule and PRZIBRAM's principle for the growth of insect in general. Further BODENHEIMER's latent division steps theory is quite speculative, assuming often false cell divisions in the larval development. As a matter of fact both DYAR's and PRZIBRAM's laws may be regarded as representing a special case of insect growth following a regular geometrical progression. In case that the growth-ratio is 1.26, it is fairly safe to say that PRZIBRAM's principle is fully applicable to the growth of the insect in question.

#### H. Summary

1. The growth of larvae of *Phraortes kumamotoensis* was investigated with regard to the length.
2. The percentage increase in length (or width) in each instar was calculated by the formula

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

where  $L_n$  designates the length of part measured in the instar  $n$ . The results are seen in full detail in the Chapter IV, A.

3. The percentage length of the allometric organs in each instar was calculated by the formula,

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

In the cases of appendages  $\beta$  takes a value 50% in the fourth instar. In the allometric organs other than the appendages of the female  $\beta$  secures also a value 50% in the fourth instar, while in the male  $\beta$  attained a value 50% early in the third instar.

4. The change of the partial indices of the allometric organs during the post-embryonic developmental period was studied. The partial index ( $\gamma$ ) of any allometric organ was calculated by the formula,

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

The results are seen in full detail in the Chapter IV, A.

5. The relative growth of the allometric organs was investigated by using the allometric formula  $y = bx^a$ . The detailed account may be seen in the Chapter IV, B.
6. The growth of the regenerate allometric organs was investigated. Nineteen classes of regeneration experiments were performed using hundreds of individuals.
7. In the regenerate appendages there is seen a definite tendency of diminishing of the growth-ratios during development. The growth-ratios between the first regenerates and the regenerates after the subsequent moult show a marked tendency to exceed the value required by PRZIBRAM's theory and even a value of 2.
8. The percentage length ( $\beta'$ ) of any allometric organs in each instar was calculated by the formula,

$$\beta' = \frac{\text{Length of the regenerate in the instar } n}{\text{Ultimate length of the regenerate}} \times 100.$$

The  $\beta'$  takes the value fairly equal to that of  $\beta$  in the preadult instar, and  $\beta'$  value previous to the preadult instar is much smaller than that of  $\beta$ . In general  $\beta'$  never exceed the value 10 in the instar when the regenerate first appeared or even in the succeeding instars.

9. Convergence in length between regenerating and normal legs was investigated. The convergency quotient was calculated by the formula,

$$\delta = \frac{(\text{Length of normal appendage}) - (\text{Length of a regenerate})}{\text{Length of normal appendage}} \times 100.$$

10. The convergency quotient in the length of appendages is not constant in succeeding instars and may be divided into three phases which do not vary in a regular order. The first two instars may be regarded as representing the first phase where the change of the quotient is smaller than that of the second phase. The second phase consists of the two following instars and its quotient is slightly greater than that of the third phase, which is represented by the two last instars.

11. The absolute length of the radius of curvature of the first phase-curve seems to be slightly larger than that of the third phase-curve, and further the features of the former and the latter are entirely reverse to each other. Similarly the radii of curvature of the anterior and posterior halves of the second phase-curve are also reverse to each other.
12. During the process of regeneration the growth-ratios of any of the regenerates are much higher or lower than the normal and gradually approach the normal value, though the growth-ratios change their values at every instar irregularly.
13. The frequency distribution of the growth-ratios of the regenerates (femora and tibiae) in the second regeneration phase was investigated. The mode of distribution occurs between 6 and 7, and the majority of the growth-ratios are located between 0.0 and 11.7. There are found the exceptional growth-ratios such as 13.69, 14.00, 15.41, 17.11, 17.28, 18.57, 42.00 and 42.66.
14. The mode of distribution in the third regeneration phase occurs between 4 and 5, and the majority of the growth-ratios are situated between 0.2 and 9.1.
15. The mode of distribution in the fourth regeneration phase lies between 2 and 3, and the majority of the growth-ratios are located between 0.6 and 9.5.
16. The mode of distribution in the fifth regeneration phase occurs below 2.0, and the majority of the growth-ratios are located between 0.8 and 5.4.
17. The mode of distribution in the last regeneration phase lies about 1.5, and the majority of the growth-ratios are seen between 0.5 and 2.3.
18. Thus the growth-ratios show a marked tendency to reduce the value towards the last regeneration phase, and the width of the frequency distribution of the growth-ratios becomes narrower phase after phase.
19. PRZIBRAM's statement that the regeneration is an accelerated growth seems to be insufficient to explain the whole phenomenon of regeneration and needs revision to a certain extent. The regeneration curves may be classified into several groups. In spite of some irregularities, the following four trends of regeneration curves are to be noted during

the course of normal regeneration (regeneration caused by autotomy).

- A. Decreasing type (PRZIBRAM, 1917). The decreasing rate with age is perfectly evident.
  - B. Intermediate type (new type). The decreasing rate with age is recognizable in the earlier period, and the increasing rate is pronounced in the later period, or vice versa.
  - C. Uniform type (new type). The rate of regeneration may be expressed by a straight line throughout the instars.
  - D. Increasing type (new type). The increasing rate with age is noted.
20. The decreasing type is the commonest among the four ones taking 72.87%, and the intermediate type occurs less frequently, taking 16.42%. Both the uniform and increasing types are rarely observed, taking 7.32 and 3.39% respectively.
  21. The slope of the regeneration curve of the basitarsus is always steeper than that of the remaining parts of the tarsus.
  22. There exists a distinct and high correlation between the femur and tibia in a regenerate leg throughout a period of the post-embryonic growth. The combination of the same type of regeneration curve is predominant in the regenerate process. The decreasing-decreasing type encountered was 69.73%, the intermediate-intermediate type being 15.78%, the uniform-uniform type being 3.94% and the increasing-increasing type being 2.63%.
  23. The regeneration curve of the regenerate femur which is amputated at any point except for the trochantero-femoral part takes a J-shaped curve (new type), the highly decreasing rate with age is evident in the earlier period or the curve runs down below the X-axis, and then the curve takes the type same as the decreasing one of the normal regeneration.
  24. The regeneration curve of a newly produced tibia or tarsus takes one of the following types: decreasing type, intermediate type, uniform type, increasing type, or J-type.
  25. The regeneration curve of a tibia which has lost its apical part by amputation takes one of the following types: normal growth type, intermediate type, or increasing type.
  26. The regeneration curve of a tarsus which has lost its entire distal parts except for the base of the basitarsus by operation

takes either of the following types: decreasing type, increasing type.

27. The regeneration curve of an antenna which has lost its flagellum except its base by amputation takes one of the following types: J-type, decreasing type, intermediate type, uniform type, or increasing type.
28. The equation for the regeneration curve offered by PAULIAN seems to be insufficient to illustrate all the curves of regeneration.
29. In the epidermis of the appendages two factors, growth-promoting and growth-inhibiting, seems to reside and have no direct relationship with the amount of material in the body.
30. The distribution of two factors along the longitudinal axis within each segment of an appendage seems to be quite definite, *i.e.* the growth-promoting factor being much the densest at extreme apex while the growth-inhibiting one being homogeneously dense.
31. These two factors seem to stimulate each other. In normally developing appendages an equilibrium between two factors appears to be retained in each instar in each segments of the appendages.
32. Complete removal of a femur implies complete exposure of growth promoting factor at the trochantero-femoral suture, and such an operation results a highly positive action of the growth-promoting factor.
33. The partial removal of an appendage implies exposure of a part where relative density of the growth-promoting factor is low and the same of the growth-inhibiting factor is very high. As the result of the partial removal of the appendage, enantiometry occurs after the time of operation.
34. With the aid of such an idea of the growth-promoting and growth-inhibiting factors we may be able to explain the phenomenon of overgrowth of a regenerate.
35. As to the growth factors, basal two segments of the antenna are homologous to the segments of the legs, but the antennal flagellum is somewhat different from such parts as mentioned above both in nature and the distribution of the factors.
36. As to the segmentation of the regenerate tarsus the following exceptional cases were observed: one-segmented tarsus, two-

- segmented tarsus, three-segmented tarsus, five-segmented tarsus.
37. In the regenerate antennae the substitutional homoeosis is common.
  38. I have observed two examples, in which addition of new formation to a regenerate appendage occurred.
  39. The proximo-distal symmetry of a regenerate may be produced not only by the transplantation (of scape and pedicel in *Anisolabis maritima*) but also by the normal regeneration by means of the action of some stimuli. The regenerate tibia can produce not only the more distal but also the more proximal segments.
  40. Some examples of duplication and triplication of the regenerate were observed.
  41. A single case of segregation of the tarsus from the tibia was observed.
  42. Some examples of shortening of the regenerate tibia were observed.
  43. Some examples of the formation of an unknown segment, possibly a patella, between the regenerate femur and tibia were observed. This phenomenon seems to demonstrate the lower grade of differentiation of the tibial segment in the present insect.
  44. The effect of the regenerating legs upon the normally developing legs was investigated.
  45. Change of a proportional length of the segments in regenerating legs was studied. In regenerating fore legs three different types were observed. In regenerating mid-legs four types were observed. In regenerating hind legs six types were observed.
  46. Influence of a regenerating leg upon normally developing legs was investigated. Influence of the regenerating fore leg was classified into eight cases. Influence of the regenerating mid-leg was divided also into eight cases. Influence of the regenerating hind leg was divided into nine cases.
  47. Influence of two or three regenerating legs upon normally developing legs was studied, and ten different cases were observed.
  48. The effects of the regenerating legs upon neighbouring appendages are either positive or negative. The normal legs as a whole never showed any atrophic nor hypertrophic

growth, and the effects, if present, were only seen in the variation of the proportion of the components of the legs themselves.

49. There is a distinct difference in nature between normally growing and regenerating legs in their actual mechanisms of growth, and the regeneration itself is not a simple phenomenon as expressed by PRZIBRAM under the name "accelerated growth."
50. The regenerate seems to develop quite independently of the growth of normal neighbouring legs.
51. There seems to exist no fundamental basis to eliminate the first larval stage from the later stadia in the analysis of the growth in insects.
52. The coincidence of the growth curves with the curve of monomolecular autocatalytic chemical reaction is merely accidental. We can not recognize both DYAR's rule and PRZIBRAM's principle as illustrating the growth of insects in general. As a matter of fact both DYAR's and PRZIBRAM's laws can be regarded only as representing the special cases of insect growth, following a regular geometrical progression.

## V. GROWTH IN WEIGHT

### A. Historical

In his studies on Crustacea, BROOKS (1886) found that there is a definite increase in length at each successive moult of this group of Arthropoda. In the development of the larva of *Coronis* he found that the length of the larva increases uniformly at each moult by one-fourth of its length before the moult.

DYAR (1890) observed that in Lepidoptera, the width of the head of the larva in its successive stages follows a regular geometrical progression. This fact then became known as DYAR's rule or DYAR's law.

PRZIBRAM and MEGUSAR (1912), in their studies on the Egyptian praying mantis, *Sphodromantis bioculata*, found that the weight of the shed skin and of the newly moulted insect show a doubling from moult to moult, while increases in linear dimensions between two successive moults occurred as the cube root of 2 or 1.26 and in area as the square root of 2 or 1.41. Each instar having a

doubling of weight and a linear increase of 1.26 was called by the authors a true "division step" or "Teilungsschritt." These biological stages were assumed to follow after the fashion of a geometrical progression whose exponent is 2, corresponding to the division of cells. This was called as PRZIBRAM's principle. Such authors as PRZIBRAM (1913, 1930), SZTERN (1914), TITSCHACK (1924), EIDMANN (1924), TEISSIER (1926, 1928), BODENHEIMER (1927, 1932, 1933), FRIZA (1928), PRZIBRAM and BRECHER (1930), YAMANOUTI (1926), etc., have attempted to demonstrate the application of PRZIBRAM's principle to insects with incomplete metamorphosis. In this principle, the definite progression in the growth of the insect is supposed to be resulted from a single division of the body cells. The progression implies that each moult represents a definite increase in size which is correlated with a definite number of cell divisions. It also postulates that between two moults all cells have divided only once. SZTERN (1914) advanced the hypothesis that there is a simultaneous division of all cells in *Sphodromantis bioculata* in each stage, and BODENHEIMER (1933) again stated that a simultaneous division of all body-cells may occur in insects.

HUETTNER (1923) reported that in *Drosophila melanogaster* all cells are in the same stage of division during the early cleavage stages of the embryo. According to HODGE IV (1933), however, HUETTNER found that later cell divisions are very irregular and this condition is retained during the later embryonic and larval development. Hence, in *Drosophila*, it is definitely known that cell divisions are not simultaneous except in the early cleavage stages.

RIPLEY (1923) studied the post-embryonic growth of Noctuid larvae and concluded that the increase from first to second stadia is usually greater and from penultimate to last more often less than that at other moults.

YAGI (1926) especially endeavoured to apply the equation of monomolecular autocatalytic chemical reaction, which had been proposed by ROBERTSON (1923, 1926) and already used by others for various vertebrates as well as some insects, to silkworms and stick insects. This rate may be defined by the equation,

$$\log \frac{x}{A-x} = k(t-t_1),$$

where  $x$  is the observed value.  $A$  the maximum growth attainable,  $t_1$  is the time required to attain one-half the maximum growth, and  $k$  is the specific velocity constant. Applying this equation to his data on the silkworm, *Bombyx mori*, YAGI gave the conclusion that there were probably two distinct growth cycles during each period of feeding exclusive of the resting stages after and before moultings. This implies that in each larval instar there occurs the simultaneous cell division twice. The authenticity of ROBERTSON's idea of a limiting chemical reaction has been doubted by DAVIDSON (1930), DAVENPORT (1926), and OHTA (1933) among others.

BRODY (1926, 1927), DAVIDSON (1930), HENDRICKS (1931) and others have applied successfully the following equation, accepting the idea that growth power in mammals falls off at a constant percentile rate.

$$\log W = A - be^{-kt},$$

where  $A$  is the logarithm of the weight of the animal at maturity,  $100k$  is the constant percentile rate of decrease in growth power,  $b$  locates the curve in time, and  $W$  is the weight at any time  $t$ . According to WOODRUFF (1938), this equation fits the data for the roach fairly well for the early stadia but fails entirely for the later periods of life.

TITSCHACK (1926) showed in the clothes-moth, *Tineola biselliella*, that moulting does not depend upon body size, and, in fact, by changing the experimental conditions, he was able to vary the number of moults ranging from four to forty. He also showed that the increase in size becomes progressively less in succeeding moults.

BODENHEIMER (1927) used the principle of PRZIBRAM in his analysis of the linear growth of insects of different orders. Hence, some indication of the primitive number of instars in the phylogeny of a specialized species might be obtained from the increase in size per instar and an idea of latent division steps. The method of BODENHEIMER (1932, 1933) consists of dividing the final weight of each insect by 2 and the resulting figure again by 2, and so forth, until a figure corresponding to the weight of the newly hatched larva is obtained.

TOKUNAGA (1928) studied the growth of the head capsule in

the silkworm and gave the following formula for the growth of the part in question. His formula is a modification of ROBERTSON's equation, corresponding to the first half of it. Such Japanese authors as NISHIKAWA (1931), SHIBUYA (1932) and KATO (1935) called the formula under the name TOKUNAGA's formula.

NISHIKAWA (1931) demonstrated the excellence of the formula in the growth of the head capsule of the larva of *Chilo simplex*. SHIBUYA (1932) applied the formula to the growth of the head capsule in larvæ of a Pyralid, *Ephestia cautella*.

$$\log \frac{y}{M.V - y} = K(t - T),$$

where M. V is twice the measurement at the last instar, T the number of instars in the larval development, y the observed value at the instar t, and K is the TOKUNAGA's constant. In his excellent studies of the chestnut weevil, *Curculio dentipes*, KATO (1935) recommended the application of TOKUNAGA's formula to the growth of the insect and gave the opinion that it is not reasonable to consider the first larval stage and the later stages from the same point of view in the discussion of the growth, for the head size of the first larval stage has already been decided in the embryonic stage, while the growth in the later stages depends mainly upon nutrition. More recently TANAKA (1939) stated that in the larvae of *Chironomus dorsalis*, TOKUNAGA's formula stands quite well for the growth curve of this insect. He calculated the TOKUNAGA's constants for the width of the head and the length of the anal gill of that insect. He found that in the case of the head the deviation is very small when he excepts the first larval stage, while in the case of the anal gill the deviation is comparatively large when he excepts the first larval stage.

BACKMAN (1928) thought that the rate curve must have a maximum value and two points of inflection, beginning from the abscissa and finally becoming asymptotic to the abscissa, and found the logarithmic rate formula alone satisfactory.

In his studies on the growth of insects TEISSIER (1928) stated that the experiments hardly permit one to follow PRZIBRAM in his interpretation, and that the law proposed by PRZIBRAM is perhaps only of a certain statistical value but assuredly of no explicative value.

L'HERITIER and TEISSIER (1929) called attention to the fact that the growth is at each instant characterized by a parameter of velocity which varies only by abrupt jumps. At the beginning of each cycle one can thus conceive a sort of impulse launching growth in a direction, wherein it will persevere rigorously until there enters into play another impulse equally imperative. In this connection HODGE IV (1933) wrote a similar observation as follows. When the weight-growth curves—either the average of the individual curves—are further analysed of the rate of growth, plotted as a graph of the logarithm of the weight against percentage of the elapsed time of the preadult life, the resultant points fall onto a series of straight lines with a gradually but slightly different slope. This indicates the existence of a slightly different rate of growth specific to each instar, except the last, in which two or sometimes three different rates occur. The first one or two of these different rates of growth in the sixth instar are increasing and lead up to the pre-adult peak of excess weight at about 90 per cent of the pre-adult life-span; after which the last instar is characterized by a decreasing rate of growth.

KOGURE (1929) studied the growth curve of the silkworm and discussed the work by YAGI (1926). According to KOGURE the direct application of the formula of monomolecular autocatalytic chemical reaction to the growth of weight of the body, volume of the body and of the weight of the silk-glands is impossible and the equation may be used after certain modifications. In the fifth stage the growth of the body could not be considered as consisting of two growth cycles. At the later period of the fifth instar the growth of the silk-glands is peculiar and not parallel to that of the body. The growth in weight is not always parallel to that in volume. Contrary to YAGI's opinion that the growths of the silk-glands and other organs as well as tissues within the body are parallel to one another, the growths or impulses of certain organs may influence the harmony of the parts within the body and sometimes cause an extraordinary growth of the others as stated by DAVENPORT (1926).

ALPATOV (1929) found that in *Drosophila melanogaster* the relationship between the linear dimensions of the mouth-parts of two consecutive instars is better expressed by the coefficient  $(\sqrt[3]{2})^2$  than by  $\sqrt[3]{2}$ .

HENSEN (1929) found that the epithelium of the mid-gut of *Vanessa*-larvae grows both by the increase in size of the cells and by the addition of new cells.

CALVERT (1929) made measurements on different species of Odonata and showed that the growth factor often varied greatly from instar to instar. He gave an excellent review of the published works on the progression factor in the growth of Arthropods, considering in turn the application of BROOK's law, DYAR's law, and the principle of PRZIBRAM as impossible.

TITSCHACK (1930) found that in the bed-bug, *Cimex lectularius*, the progression factors decreased with the age of the animal. For successive instars he obtained the values 2.50, 2.06, 1.94, and 1.76 respectively.

In his work on sawfly larvae applying DYAR's rule, TAYLOR (1931) guardedly recommended the law for corroborating the number of instars observed.

YAGI (1931) gave a list of DYAR's ratios of 75 known species of insects.

YASUMATSU (1932) investigated the growth of *Phraortes kumamotoensis* in full detail and further discussed its allometric growth.

LUDWIG (1932) studied the growth of the Japanese beetle larvae at the temperatures of 20° and 25°C, and attempted to apply PRZIBRAM's principle. Because of the range and the variation in the constants obtained, he stated that his investigations do not substantiate the principle. This conclusion was questioned by BODENHEIMER (1933). LUDWIG (1934) made a more detailed analysis of his data on the growth of the Japanese beetle, using the method for calculating latent divisions advocated by BODENHEIMER (1932, 1933). As a result of his study, LUDWIG found that, at 25°C, the observed and calculated values seldom showed a close agreement and deviations usually ranged from 10 to more than 50 per cent. However, some larvae were found whose weights showed a close agreement with those calculated when eight cell divisions were assumed, and others which fitted the calculations when only six divisions were assumed, were also discovered.

OHTA (1932) discussed the growth in organism. His discussion was based upon the cell division of bacteria. OHTA stated that the coincidence of the growth curve of organism with the curve

of ROBERTSON's monomolecular autocatalytic chemical reaction was merely accidental and the growth rate must have been discussed on the rate of cell division and the growth resistance. The growth resistance is proportional to the square of the value of growth. Thus he gave the following formula for the growth of organism,

$$\log \frac{x}{\sqrt{\frac{k}{k^1} - x^2}} = 0.4343 K(t - T).$$

YASUMATSU (1933) made a detailed analysis of the growth in weight of *Phraortes kumamotoensis* (under the name *Phraortes stomphax*), and doubted the applicability of PRZIBRAM's principle and of the equation of ROBERTSON's monomolecular autocatalytic reaction. If PRZIBRAM's principle goes true, there should occur two cell divisions in the first instar and one cell division in each of the other instars. YAGI's equation (1926) derived from ROBERTSON's monomolecular autocatalytic reaction, was almost inapplicable to the growth of the material, owing to the value assigned for A. YASUMATSU applied the logarithmic chart as a means of depicting the growth in weight and gave the following for the growth curve of each stadium of this insect.

$$\log W = a + c(x - b)^2,$$

where W is the weight of the body at any time x, and a, b and c are constants of velocity. Further YASUMATSU recognized two (♂) or three (♀) phases of growth during the post-embryonic developmental period. The earlier three instars belong to the first phase of growth, the fourth (♀) or fourth and fifth (♂) are the second phase, and fifth and sixth (♀) are the third phase. In a most ideal case the deviation between the observed and calculated values was only 0.28 per cent.

HODGE IV (1933), in *Melanoplus differentialis*, also obtained growth factors which varied greatly, ranging from 1.08 to 1.64 and questioned the applicability of PRZIBRAM's principle.

FORBES (1934) noted a falling off in the ratios of *Agrotis ypsilon* towards the end of its development and stated that there is still much room for study of the exceptions and irregularity in DYAR's law.

In the larvae of holometabolous insects, increase in the size of the body is largely due to the growth of cells rather than to

the increase in cell number. TRAGER (1934) found that in the larvae of the flesh-fly, *Lucilia sericata*, all cells except brain and blood cells increased greatly in size in growth. Moreover, for hypodermis, mid-gut, hind-gut, muscles and tracheal matrix cells, this increase was proportional to the increase in length of the body.

KNOWLTON (1934) found that the measurements of the total length and width of the potato psyllid, *Paratrioza cockerelli*, followed quite closely a geometrical progression and the individual measurements composed a distinct frequency distribution that characterized the instars.

GAINS and CAMPBELL (1935) studied the corn ear worm, *Heliothis obsoleta*, and analysed certain observed and calculated progressions in order to judge the reliability of DYAR's law for corroborating the number of instars. They did not recommend the application of DYAR's rule, for the law did not hold in that case because the progression in question became unusual. High growth ratios were often encountered in the early part of larval development, and there was a tendency in the growth ratios diminishing during larval development. Two other examples taken from the literature were given as additional evidences in which the application of DYAR's rule may indicate instars that do not exist. He stated that a curve of best fit for the case was calculated from the equation,  $\log y = a + bx + cx^2$ , by the method of least squares.

MURRAY and TIEGS (1935), as a result of their study on *Calandra oryzae*, and TRAGER (1935), as a result of his work on the blow-fly and the silk worm, postulated that in those tissues which pass the period from the larval to the adult condition without much change, the growth was produced by a process of cell multiplication; while in those tissues which are replaced during metamorphosis, the growth was caused by an increase in the size of the constituent cells. MURRAY and TIEGS believed that the degeneration was traceable to an extent of a great hypertrophy which the specialized larval cells underwent.

ABERCROMBIE (1936) made an extensive study on the growth of the Japanese beetle. His results were summarized as follows. The average progression factors for increase in length were found to be 2.11, 1.62 and 1.36 for the first, second, and third instars respectively. The average progression factors for increase in

weight were 6.12, 4.36, and 2.50, in the first, second, and third instars respectively. In both the cases the progression factors decreased with successive moults, contrary to PRZIBRAM's principle. Due to the vast range and variation of all of these factors it was concluded that PRZIBRAM's principle was inapplicable. Japanese beetle larvae exhibit a continuous growth with respect to the increase in weight and length, and a discontinuous growth with respect to the increase in size of the head capsule. There is no increase in the number of cells in the region of the mid-intestine and of the brain at the time of moulting. The progression in weight and length could not be considered as correlated with an increase in cell number. In the first instar the progression for increase in weight was 5.73; while for the increase in cell number, it was 1.67 for the mid-intestine, and 1.19 for the brain.

In the second instar, the corresponding figures were 5.24, 1.98 and 1.69 respectively. In the third instar weight increased 3.18 times, but there was practically no increase in cell number. Thus, moulting did not represent a definite increase in the number of cells of the insect body, contrary to the assumption suggested by PRZIBRAM and MEGUSAR (1912), and BODENHEIMER's method of calculating the number of cell divisions seemed to be supported by no factual basis. Although many mitotic figures were seen, there was nothing to affirm the simultaneous cell divisions. The increase in size of the larva was largely due to an increase in cell size. The ratio of increase in total cell volume of the columnar cells of the mid-intestine was approximately the same as the ratio for weight increase. These results were in agreement with those reported by TRAGER (1934).

LUDWIG and ABERCROMBIE (1936) made a study on the histological changes accompanying the growth of the mid-intestine of the Japanese beetle larvae. The mid-intestinal epithelium of the Japanese beetle larva is composed of columnar cells, which do not divide, and of basal or interstitial cells which divide and produce new columnar cells. These new cells become elongated and push between adjacent columnar cells. They continue to grow until they have reached the size of columnar cells already present. During the first 4 days of both the first and second instars (at 25°C) there is no increase in the number of columnar cells, the growth being due entirely to an increase in the size of the cells

already present. The number of columnar cells begins to increase about the fifth day of each instar and continues to increase until the larva prepares for the succeeding moult. Cell multiplication and differentiation occur simultaneously, and are most rapid near the end of each instar.

YAMANOUTI (1936) studied the growth of *Sphodromantis bioculata*, especially its growth in eyes. The facet number in the newly hatched larva is 3804, and 9639 in the larva after ninth moulting; the average rate being 1.12 per instar. The average growth rate of the facet-volume is 1.77, thus the growth of the eye-mass shows roughly a doubling from moult to moult.

YAMANOUTI (1936) measured the size of excrements in each instar of *Sphodromantis bioculata*, *Dixippus morosus*, *Diapheromera femorata*, *Bacillus rossi*, *Eurycnema herculeana* and *Phyllium pulchrifolium* at 23°C and showed the applicability of PRZIBRAM's principle.

HARRIES and HENDERSON (1938) studied the growth of some species of Cicadellidae and made a detailed discussion on DYAR's law. His conclusion is as follows. DYAR's criterion for the increase in head width in successive larval instars of Lepidoptera was proved to be applied for describing the progression in head width in nymphal instars of several species of Cicadellidae. An analysis of other data has shown that the principle is generally of descriptive value but exceptions to the rule are fairly common. These may be due to a regular decrease in the supposed constant value of the growth quotient in successive stages, to irregularities or breaks in the progression, or to an abrupt change in the value of growth factor which would apparently indicate the existence of two or more growth phases. The same progression relationship, with similar limitations, may be applied to the increase in weight of insects in successive instars. Variation in the value of the progression factor among different species showed that PRZIBRAM's progression principle was of doubtful significance.

WOODRUFF (1938) studied the normal growth rate of *Blattella germanica*. In plotting the curves of growth from the data obtained, he has made use of semi-log or arithlog paper to give a ratio chart and gave the following excellent formula.

$$\log W = a + bt + c \log (t + 1) \\ (\text{or } W = t^c \cdot e^{bt}),$$

where  $W$  indicates the weight at any time  $t$  (in his case  $t$  is the ordinal number of the instar),  $a$ ,  $b$  and  $c$  are constants of velocity.

DUARTE (1938) investigated the problem of growth of the African migratory locust, *Locusta migratoria migratorioides*, and found that DYAR's rule held good for the growth in length of the mid-femur and the width of the head. PRZIBRAM's rule, as modified by BOBENHEIMER, held true for the growth in length of the different parts and showed that the occurrence of latent cell-divisions kept fairly constant in both phases. For wet weight PRZIBRAM's principle was inapplicable owing to a large percentage of differences between the actual and calculated values. Growth ratios declined throughout the instars.

WOODRUFF (1939) studied the linear growth ratios for *Blattella germanica*, using the ratio chart and gave the following result. Increases at the moults followed the same general curve previously determined for weight, namely a constantly diminishing rate which was best defined by the equation:

$$\log L = a + bt + c \log t$$

$$(\text{or } L = t^c \cdot e^{a+bt}).$$

The pronotum was exceptional in that the growth was completed in five stadia instead of in the normal number of six.

WOODRUFF (1939) emphasized the applicability of the ratio or logarithmic chart as a means of depicting the growth in insects and gave the following opinion. Difference charts, in which the absolute values are used in plotting growth curves of insects, are unsatisfactory, since the curve has no significance when interpretations of rate are desired, showing only the changes in magnitude. On the other hand, the ratio chart, whose basic concept is that of relative rather than absolute change, indicates the true rate of growth through the comparative changes in the curvature of the line. The features of a curve which attract the greatest attention are concerned with direction or slope. These features, therefore, should not be misleading as they are in the difference chart but a true representation of the course of growth. In the ratio chart, increases or decreases are shown proportionately by a curve which denotes the trend of the growth rate accurately and clearly, uniformly being designated by a straight line. Arithmetic value may be assigned to the logarithmic ordinates, so that changes

in absolute magnitude can be easily interpreted and thus a dual purpose chart is obtained.

## B. Growth in Weight within a Single Instar

### 1. Application of Three Formulae to the Growth Curves

Larvae of *Phraortes kumamotoensis* were used throughout the investigation, and my experimental data and some other available ones given by several authors were analyzed at the same time. Larvae were weighed on a Faraday chemical balance, sensitive to one-tenth milligram, every 24 hours from hatching to the last ecdysis. Time in days was plotted against weight in milligrams, arithmetic values being assigned to the logarithmic ordinates of the latter for ease in inspection. The detailed account and discussions may be seen in my previous paper (YASUMATSU, 1933), as well as in WOODRUFF's paper (1938). All the growth curves thus given showed a general trend, indicating a similarity in rate of growth, and the decreasing rate with days was perfectly evident. In Text-figures 25-26 were shown idealized curves of normal development for *Phraortes kumamotoensis* (modified from YASUMATSU, 1933) and *Blattella germanica* (WOODRUFF, 1938). Under standardized conditions, the growth and its rate seemed to be defined very well by the following equations:

$$\log W = a + c(x-b)^2 \dots\dots\dots \text{YASUMATSU, 1933}$$

$$\log W = a + bx + cx^2 \dots\dots\dots \text{GAINS and CAMPBELL, 1935}$$

$$\log W = a + bt + c \log(t+1) \dots\dots \text{WOODRUFF, 1938}$$

#### 1. Growth of the second instar larva of *Phraortes kumamotoensis*, No. 1, ♀

(Data from YASUMATSU, 1933)

YASUMATSU's formula:  $\log W = 2.5708 - 0.00445(t - 11.132)^2$

WOODRUFF's formula:  $\log W = 1.72938 - 0.06928t + 1.5076 \log(t+1)$

GAINS and CAMPBELL's formula:

$$\log W = 2.01911 + 0.09928t - 0.00445t^2$$

Table 25. Observed and calculated values of the growth of the second instar larva of *Phraortes kumamotoensis*, No. 1, ♀.

| Age               | Observed weight in mg | Calculated  |           |             |           |              |           |
|-------------------|-----------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                       | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                       | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 1                 | 130                   | 130         | ± 0.00    | 130         | ± 0.00    | 130          | ± 0.00    |
| 2                 | 157                   | 158.3       | - 0.82    | 204.2       | -30.06    | 158.3        | - 0.82    |
| 3                 | 180                   | 189.0       | - 5.00    | 268.6       | -49.22    | 189.0        | - 5.00    |
| 4                 | 210                   | 221.0       | - 5.23    | 313.3       | -49.19    | 221.2        | - 5.33    |
| 5                 | 215                   | 253.2       | -17.76    | 321.7       | -48.69    | 253.5        | -17.90    |
| 6                 | 250                   | 284.1       | -13.64    | 387.0       | -54.80    | 284.6        | -13.84    |
| 7                 | 280                   | 312.4       | -11.57    | 403.5       | -44.10    | 313.0        | -11.78    |
| 8                 | 290                   | 336.6       | -16.06    | 410.9       | -41.68    | 337.3        | -16.31    |
| 9                 | 230                   | 364.0       | -58.26    | 410.6       | -78.52    | 356.0        | -54.78    |
| 10                | 320                   | 367.3       | -14.78    | 404.1       | -26.28    | 368.7        | -15.21    |
| 11                | 340                   | 372.0       | - 9.41    | 392.9       | -15.55    | 373.0        | - 9.70    |
| 12                | 390                   | 369.3       | + 5.30    | 377.9       | + 3.30    | 397.0        | - 1.79    |
| 13                | 360                   | 359.1       | + 0.25    | 360         | ± 0.00    | 351.7        | + 2.30    |
| 14                | 350                   | 341.4       | + 2.45    | 340.8       | + 2.62    | 342.8        | + 2.05    |
| 15                | 320                   | 319.3       | ± 0.00    | 320         | ± 0.00    | 320.0        | ± 0.00    |
| Average deviation |                       |             | - 9.66    |             | -28.81    |              | -10.04    |

2. Growth of the sixth instar larva of the same species, No. 1, ♀ (Data from YASUMATSU, 1933)

YASUMATSU's formula :  $\log W = 3.66485 - 0.00245 (t - 13.18)^2$

WOODRUFF's formula :  $\log W = 3.09321 - 0.02494 t + 0.7732 \log (t + 1)$

GAINS and CAMPBELL's formula :

$$\log W = 3.23884 + 0.06463 t - 0.00245 t^2$$

Table 26. Observed and calculated values for the growth of the sixth instar larva of the same species, No. 1, ♀

| Age               | Observed weight in mg | Calculated  |           |             |           |              |           |
|-------------------|-----------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                       | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                       | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 1                 | 2000                  | 2000        | ± 0.00    | 2000        | ± 0.00    | 2000         | ± 0.00    |
| 2                 | 2385                  | 2283        | + 4.27    | 2583        | -8.30     | 2282         | + 4.31    |
| 3                 | 2900                  | 2576        | +11.17    | 3047        | -5.06     | 2575         | +11.20    |
| 4                 | 3320                  | 2873        | +13.46    | 3418        | -2.95     | 2872         | +13.49    |
| 5                 | 3700                  | 3170        | +14.32    | 3716        | -0.43     | 3168         | +14.37    |
| 6                 | 3700                  | 3452        | + 8.43    | 3971        | -5.33     | 3454         | + 8.38    |
| 7                 | 3780                  | 3726        | + 1.42    | 4138        | -9.47     | 3725         | + 1.55    |
| 8                 | 4070                  | 3974        | + 2.35    | 4281        | -5.18     | 3972         | + 2.40    |
| 9                 | 4170                  | 4188        | - 0.43    | 4384        | -5.13     | 4187         | - 0.47    |
| 10                | 4400                  | 4366        | + 0.77    | 4430        | -0.68     | 4365         | + 0.79    |
| 11                | 4500                  | 4500        | ± 0.00    | 4502        | -0.04     | 4500         | ± 0.00    |
| 12                | 4700                  | 4586        | + 2.42    | 4520        | +3.82     | 4586         | + 2.42    |
| 13                | 4600                  | 4621        | - 0.45    | 4520        | +1.73     | 4621         | - 0.45    |
| 14                | 4665                  | 4605        | + 1.25    | 4501        | +3.51     | 4605         | + 1.25    |
| 15                | 4465                  | 4536        | - 1.59    | 4468        | -0.06     | 4536         | - 1.59    |
| 16                | 4420                  | 4420        | ± 0.00    | 4420        | ± 0.00    | 4420         | ± 0.00    |
| Average deviation |                       | +3.58       |           | -2.09       |           | + 3.60       |           |

3. Growth of the first instar larva of the same species, No. 2, ♀ (Data from YASUMATSU, 1933)

YASUMATSU's formula:  $\log W = 2.2894 - 0.00259 (t - 17.396)^2$

WOODRUFF's formula:  $\log W = 1.1312 - 0.05636 t + 1.715 \log (t + 1)$

GAINS and CAMPBELL's formula:

$$\log W = 1.50343 + 0.09022 t - 0.00259 t^2$$

Table 27. Observed and calculated values for the growth of the first instar larva of the same species, No. 2, ♀

| Age               | Observed weight in mg | Calculated  |           |             |           |              |           |
|-------------------|-----------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                       | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                       | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 1                 | 39                    | 39.2        | - 0.51    | 39.5        | - 1.28    | 39.0         | ± 0.00    |
| 2                 | 48                    | 47.4        | + 1.25    | 66.3        | -38.12    | 47.2         | + 1.66    |
| 3                 | 50                    | 56.6        | -13.20    | 98.8        | -97.60    | 56.3         | -12.60    |
| 4                 | 50                    | 66.8        | -33.60    | 127         | -154.00   | 66.5         | -33.00    |
| 5                 | 59                    | 82.7        | -40.16    | 153         | -161.01   | 77.6         | -31.52    |
| 6                 | 68                    | 90.3        | -32.79    | 175         | -157.35   | 89.4         | -31.47    |
| 7                 | 73                    | 102         | -39.72    | 202         | -176.71   | 102          | -39.72    |
| 8                 | 78                    | 115         | -47.43    | 207         | -137.17   | 115          | -47.43    |
| 9                 | 78                    | 128         | -39.06    | 218         | -179.47   | 128          | -39.06    |
| 10                | 79                    | 141         | -78.48    | 226         | -186.07   | 140          | -78.48    |
| 11                | 92                    | 153         | -66.30    | 230         | - 59.22   | 152          | -65.21    |
| 12                | 103                   | 164         | -59.22    | 232         | -125.24   | 163          | -58.25    |
| 13                | 118                   | 174         | -47.45    | 231         | - 95.76   | 173          | -46.61    |
| 14                | 140                   | 182         | -30.00    | 228         | - 62.85   | 182          | -30.00    |
| 15                | 140                   | 188         | -34.28    | 224         | - 60.00   | 188          | -34.28    |
| 16                | 153                   | 193         | -26.14    | 219         | - 43.13   | 193          | -29.14    |
| 17                | 163                   | 194         | -19.01    | 207         | - 26.99   | 194          | -19.01    |
| 18                | 177                   | 194         | - 9.60    | 204         | - 15.25   | 194          | - 9.60    |
| 19                | 185                   | 192         | - 3.78    | 196         | - 6.00    | 192          | - 3.78    |
| 20                | 187                   | 187         | ± 0.00    | 187         | ± 0.00    | 187          | ± 0.00    |
| 21                | 180                   | 180         | ± 0.00    | 174         | + 3.33    | 180          | ± 0.00    |
| 22                | 170                   | 171         | - 0.58    | 169         | - 0.58    | 172          | - 1.17    |
| 23                | 163                   | 162         | + 0.61    | 159         | + 2.45    | 162          | + 0.61    |
| 24                | 150                   | 150         | ± 0.00    | 150         | ± 0.00    | 150          | ± 0.00    |
| Average deviation |                       |             | -25.81    |             | -70.05    |              | -25.21    |

4. Growth of the fifth instar larva of the same species, No. 3, ♀ (Data from YASUMATSU, 1933)

YASUMATSU's formula:  $\log W = 3.39993 - 0.00236 (t - 11.816)^2$

WOODRUFF's formula:  $\log W = 2.94622 - 0.0273 t + 0.6806 \log (t + 1)$

GAINS and CAMPBELL's formula:  $\log W = 3.0707 + 0.0555 t - 0.00235 t^2$

Table 28. Observed and calculated values for the growth of the fifth instar larva of the same species, No. 3, ♀.

| Age               | Observed<br>weight<br>in mg | Calculated  |           |             |           |              |           |
|-------------------|-----------------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                             | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                             | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 1                 | 1330                        | 1330        | ±0.00     | 1330        | ± 0.00    | 1330         | ±0.00     |
| 2                 | 1415                        | 1487        | -5.08     | 1645        | -16.25    | 1487         | -5.08     |
| 3                 | 1630                        | 1646        | -0.98     | 1879        | -15.27    | 1644         | -0.85     |
| 4                 | 1880                        | 1802        | +4.14     | 2051        | - 9.09    | 1800         | +4.25     |
| 5                 | 2050                        | 1906        | +7.02     | 2184        | - 6.53    | 1947         | +5.02     |
| 6                 | 2280                        | 2090        | +8.24     | 2278        | + 0.08    | 2085         | +8.55     |
| 7                 | 2330                        | 2114        | +9.27     | 2342        | - 0.51    | 2208         | +5.23     |
| 8                 | 2400                        | 2320        | +3.33     | 2383        | + 0.70    | 2313         | +3.62     |
| 9                 | 2405                        | 2405        | ±0.00     | 2405        | ± 0.00    | 2453         | -1.98     |
| 10                | 2530                        | 2467        | +2.49     | 2410        | + 4.74    | 2458         | +2.84     |
| 11                | 2570                        | 2502        | +2.64     | 2401        | + 6.57    | 2493         | +2.99     |
| 12                | 2570                        | 2511        | +2.29     | 2380        | + 7.39    | 2502         | +2.64     |
| 13                | 2585                        | 2493        | +3.75     | 2351        | + 9.05    | 2483         | +3.94     |
| 14                | 2545                        | 2447        | +3.85     | 2314        | + 9.07    | 2438         | +4.20     |
| 15                | 2470                        | 2377        | +3.76     | 2273        | + 7.97    | 2375         | +3.84     |
| 16                | 2345                        | 2284        | +2.60     | 2222        | + 5.24    | 2276         | +2.94     |
| 17                | 2170                        | 2170        | ±0.00     | 2170        | ± 0.00    | 2163         | +0.32     |
| Average deviation |                             |             | +2.77     |             | +0.14     |              | +2.49     |

5. Growth of the first instar larva of the same species, No. 4, ♀ (Data from YASUMATSU, 1933)

YASUMATSU's formula:  $\log W = 2.20138 - 0.00256 (t - 17.851)^2$

WOODRUFF's formula:  $\log W = 1.06706 - 0.0442 t + 1.509 \log (t + 1)$

GAINS and CAMPBELL's formula:

$$\log W = 1.38869 + 0.09098 t - 0.00255 t^2$$

Table 29. Observed and calculated values for the growth of the first instar larva of the same species, No. 4, ♀

| Age               | Observed weight in mg | Calculated  |           |             |           |              |           |
|-------------------|-----------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                       | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                       | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 1                 | 30                    | 29.8        | + 0.66    | 30          | ± 0.00    | 30           | ± 0.00    |
| 2                 | 42                    | 36.2        | +13.80    | 49.9        | -18.80    | 36.3         | +13.57    |
| 3                 | 46                    | 43.3        | + 5.86    | 69.7        | -51.52    | 43.5         | + 5.43    |
| 4                 | 50                    | 51.3        | - 2.60    | 88.1        | -76.20    | 51.6         | - 3.20    |
| 5                 | 55                    | 60.1        | - 9.27    | 105         | -90.90    | 60.2         | - 9.45    |
| 6                 | 58                    | 69.5        | -19.82    | 119         | -105.17   | 69.6         | -20.00    |
| 7                 | 65                    | 79.4        | -22.15    | 132         | -103.07   | 79.5         | -22.30    |
| 8                 | 76                    | 89.7        | -18.02    | 142         | -86.84    | 89.8         | -18.15    |
| 9                 | 84                    | 101         | -20.23    | 151         | -79.76    | 100          | -19.04    |
| 10                | 86                    | 111         | -29.06    | 157         | -82.51    | 111          | -29.06    |
| 11                | 98                    | 120         | -22.44    | 162         | -65.30    | 120          | -22.44    |
| 12                | 104                   | 130         | -25.00    | 165         | -58.65    | 130          | -25.00    |
| 13                | 107                   | 138         | -28.97    | 166         | -55.14    | 138          | -28.97    |
| 14                | 130                   | 146         | -12.30    | 167         | -28.46    | 146          | -12.30    |
| 15                | 140                   | 152         | - 8.57    | 166         | -18.57    | 151          | - 7.85    |
| 16                | 146                   | 156         | - 6.85    | 165         | -13.01    | 157          | - 7.53    |
| 17                | 157                   | 158         | - 0.63    | 162         | - 3.18    | 158          | - 0.63    |
| 18                | 159                   | 159         | ± 0.00    | 159         | ± 0.00    | 159          | ± 0.00    |
| 19                | 147                   | 158         | - 7.48    | 155         | - 5.44    | 157          | - 6.79    |
| 20                | 145                   | 152         | - 4.82    | 151         | - 4.13    | 154          | - 6.20    |
| 21                | 144                   | 150         | - 4.16    | 143         | + 0.69    | 149          | - 3.47    |
| 22                | 144                   | 143         | + 0.69    | 141         | + 2.08    | 143          | + 0.69    |
| 23                | 136                   | 136         | ± 0.00    | 136         | ± 0.00    | 136          | ± 0.00    |
| Average deviation |                       |             | - 9.62    |             | -41.03    |              | - 9.68    |

6. Growth of the second instar larva of the same species, No. 4, ♀ (Data from YASUMATSU, 1933)

YASUMATSU's formula:  $\log W = 2.52536 - 0.0045 (t - 10.269)^2$

WOODRUFF's formula:  $\log W = 1.8382 - 0.05156 t + 1.1556 \log (t + 1)$

GAINS and CAMPBELL's formula:

$$\log W = 2.04445 + 0.09366 t - 0.00456 t^2$$

Table. 30. Observed and calculated values for the growth of the second instar larva of the same species, No. 4, ♀.

| Age               | Observed weight in mg | Calculated  |           |             |           |              |           |
|-------------------|-----------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                       | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                       | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 1                 | 136                   | 137         | - 0.73    | 136         | ± 0.00    | 136          | ± 0.00    |
| 2                 | 136                   | 165         | -21.32    | 193         | -41.91    | 163          | -19.85    |
| 3                 | 166                   | 193         | -16.26    | 239         | -43.97    | 192          | -15.66    |
| 4                 | 200                   | 223         | -11.50    | 275         | -37.50    | 221          | -10.50    |
| 5                 | 250                   | 251         | - 0.40    | 276         | - 6.40    | 256          | - 2.40    |
| 6                 | 255                   | 277         | - 8.62    | 320         | -25.49    | 276          | - 8.23    |
| 7                 | 287                   | 300         | - 4.52    | 331         | -15.33    | 299          | - 4.18    |
| 8                 | 290                   | 317         | - 9.31    | 337         | -16.20    | 317          | - 9.31    |
| 9                 | 340                   | 329         | + 3.23    | 338         | + 0.58    | 329          | + 3.23    |
| 10                | 355                   | 334         | + 5.91    | 335         | ± 0.00    | 335          | + 5.63    |
| 11                | 355                   | 333         | + 6.19    | 329         | + 7.32    | 333          | + 6.19    |
| 12                | 333                   | 324         | + 2.70    | 321         | + 3.60    | 324          | + 2.70    |
| 13                | 310                   | 310         | ± 0.00    | 310         | ± 0.00    | 310          | ± 0.00    |
| Average deviation |                       |             | -4.20     |             | -13.48    |              | - 4.02    |

7. Growth of the first instar larva of the same species, No. 5, ♀ (Data from YASUMATSU, 1933)

YASUMATSU's formula:  $\log W = 2.14739 - 0.0028 (t - 16.469)^2$

WOODRUFF's formula:  $\log W = 1.12626 - 0.0363 t + 1.2861 \log (t + 1)$

GAINS and CAMPBELL's formula:

$$\log W = 1.38765 + 0.09226 t - 0.0028 t^2$$

Table 31. Observed and calculated values for the growth of the first instar larva of the same species, No. 5, ♀.  
(Data from YASUMATSU, 1933)

| Age               | Observed weight in mg | Calculated  |           |             |           |              |           |
|-------------------|-----------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                       | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                       | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 1                 | 30                    | 30          | ± 0.00    | 30.8        | - 2.66    | 30           | ± 0.00    |
| 2                 | 43                    | 36.4        | +15.34    | 46.5        | - 8.13    | 36.4         | +15.34    |
| 3                 | 45                    | 43.6        | + 3.11    | 62.3        | -38.44    | 43.6         | + 3.11    |
| 4                 | 52                    | 51.5        | + 0.96    | 75.9        | -44.03    | 51.5         | + 0.96    |
| 5                 | 55                    | 60.1        | - 9.27    | 88.1        | -60.18    | 60.1         | - 9.27    |
| 6                 | 62                    | 69.3        | -11.77    | 95.6        | -54.19    | 69.3         | -11.77    |
| 7                 | 70                    | 78.8        | -12.57    | 108.0       | -57.14    | 78.8         | -12.57    |
| 8                 | 84                    | 88.4        | - 5.23    | 116.0       | -38.09    | 88.4         | - 5.23    |
| 9                 | 96                    | 97.9        | - 1.97    | 121.7       | -26.77    | 98.0         | - 2.08    |
| 10                | 102                   | 107         | - 4.80    | 126.6       | -24.11    | 107          | - 4.80    |
| 11                | 110                   | 116         | - 5.45    | 132.9       | -20.81    | 116          | - 5.45    |
| 12                | 119                   | 123         | - 3.36    | 134.3       | -12.01    | 123          | - 3.36    |
| 13                | 115                   | 129         | -12.17    | 135.0       | -17.39    | 130          | -13.04    |
| 14                | 135                   | 135         | ± 0.00    | 135.0       | ± 0.00    | 135          | ± 0.00    |
| 15                | 144                   | 139         | + 3.47    | 134.2       | + 6.80    | 142          | + 1.39    |
| 16                | 146                   | 140         | + 4.10    | 134.0       | + 8.21    | 140          | + 4.10    |
| 17                | 157                   | 140         | +10.82    | 132.0       | +15.92    | 140          | +10.82    |
| 18                | 155                   | 138         | +10.96    | 131.0       | +15.48    | 139          | +10.32    |
| 19                | 140                   | 135         | + 3.57    | 127.9       | + 5.07    | 135          | + 3.57    |
| 20                | 135                   | 129         | + 4.44    | 126.1       | + 6.59    | 130          | + 3.70    |
| 21                | 123                   | 123         | ± 0.00    | 123.0       | ± 0.00    | 123          | ± 0.00    |
| Average deviation |                       |             | - 0.46    |             | -16.70    |              | - 0.67    |

8. Growth of the second instar larva of the same species, No. 5 ♀ (Data from YASUMATSU, 1933)

YASUMATSU's formula:  $\log W = 2.57081 - 0.00342 (t - 12.894)^2$

WOODRUFF's formula:  $\log W = 1.7875 - 0.04076 t + 1.1399 \log (t + 1)$

GAINS and CAMPBELL's formula:

$$\log W = 2.01773 + 0.07513 t - 0.00295 t^2$$

Table 32. Observed and calculated values for the growth of the second instar larva of the same species, No. 5, ♀.

| Age               | Observed weight in mg | Calculated  |           |             |           |              |           |
|-------------------|-----------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                       | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                       | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 1                 | 123                   | 122         | + 0.81    | 123         | ± 0.00    | 123          | ± 0.00    |
| 2                 | 147                   | 146         | + 0.68    | 177         | -20.40    | 151          | - 2.72    |
| 3                 | 140                   | 176         | -25.71    | 224         | -60.00    | 173          | - 9.28    |
| 4                 | 180                   | 199         | -10.85    | 258         | -43.33    | 201          | -16.66    |
| 5                 | 210                   | 227         | - 8.09    | 295         | -40.47    | 229          | - 9.04    |
| 6                 | 240                   | 256         | - 6.66    | 321         | -33.75    | 257          | - 7.08    |
| 7                 | 270                   | 283         | - 4.81    | 340         | -25.92    | 284          | - 5.18    |
| 8                 | 310                   | 308         | + 0.64    | 354         | -12.22    | 310          | ± 0.00    |
| 9                 | 320                   | 330         | - 3.12    | 363         | -13.43    | 331          | - 3.43    |
| 10                | 335                   | 348         | - 3.88    | 368         | - 9.85    | 349          | - 4.17    |
| 11                | 345                   | 353         | - 2.31    | 370         | - 7.24    | 362          | - 4.92    |
| 12                | 370                   | 369         | + 0.27    | 369         | + 0.27    | 370          | ± 0.00    |
| 13                | 372                   | 371         | + 0.26    | 366         | + 1.61    | 372          | ± 0.00    |
| 14                | 355                   | 368         | - 3.66    | 360         | - 1.40    | 368          | - 3.66    |
| 15                | 350                   | 358         | - 2.28    | 354         | - 1.14    | 358          | - 2.28    |
| 16                | 345                   | 343         | + 0.57    | 345         | ± 0.00    | 343          | + 0.57    |
| Average deviation |                       |             | - 4.24    |             | -16.71    |              | - 4.24    |

9. Growth of the sixth instar larva of the same species,  
No. 6, ♀ (Data from YASUMATSU, 1933)

YASUMATSU's formula:  $\log W = 3.67366 - 0.00269 (t - 12.762)^2$

WOODRUFF's formula:  $\log W = 3.06237 - 0.0329 t + 0.9021 \log (t + 1)$

GAINS and CAMBELL's formula:

$$\log W = 3.2348 + 0.06893 t - 0.0027 t^2$$

Table 33. Observed and calculated values for the growth of the sixth instar larva of the same species, No. 6, ♀.

| Age               | Observed<br>weight<br>in mg | Calculated  |           |             |           |              |           |
|-------------------|-----------------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                             | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                             | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 1                 | 2000                        | 2002        | — 0.10    | 2000        | ± 0.00    | 2000         | ± 0.00    |
| 2                 | 2385                        | 2302        | + 3.48    | 2673        | —12.07    | 2301         | + 3.52    |
| 3                 | 2900                        | 2608        | +10.06    | 3212        | —10.75    | 2596         | +10.48    |
| 4                 | 3320                        | 3000        | + 9.63    | 3641        | — 9.66    | 2933         | +11.65    |
| 5                 | 3700                        | 3455        | + 6.62    | 3980        | — 7.56    | 3251         | +12.13    |
| 6                 | 3770                        | 3553        | + 5.75    | 4240        | —12.46    | 3558         | + 5.62    |
| 7                 | 3780                        | 3840        | — 1.58    | 4433        | —17.27    | 3846         | — 1.74    |
| 8                 | 4070                        | 4098        | — 0.51    | 4570        | —12.28    | 4106         | — 0.88    |
| 9                 | 4170                        | 4222        | — 1.24    | 4660        | —11.75    | 4330         | — 3.83    |
| 10                | 4400                        | 4499        | — 2.25    | 4708        | — 7.00    | 4510         | — 2.50    |
| 11                | 4500                        | 4627        | — 2.82    | 4720        | — 4.86    | 4638         | — 3.06    |
| 12                | 4700                        | 4699        | + 0.02    | 4700        | ± 0.00    | 4711         | — 0.23    |
| 13                | 4600                        | 4715        | — 2.50    | 4662        | — 1.30    | 4727         | — 2.76    |
| 14                | 4665                        | 4672        | — 0.15    | 4600        | + 1.39    | 4684         | — 0.40    |
| 15                | 4465                        | 4573        | — 2.41    | 4520        | — 1.23    | 4584         | — 2.66    |
| 16                | 4420                        | 4420        | ± 0.00    | 4426        | — 0.13    | 4430         | — 0.22    |
| Average deviation |                             |             | + 1.37    |             | — 6.67    |              | + 1.57    |

10. Growth of the fifth instar larva of the same species,  
No. 11, ♂ (Data from YASUMATSU, 1933)

YASUMATSU's formula:  $\log W = 3.50101 - 0.00386 (t - 8.9703)^2$

WOODRUFF's formula:  $\log W = 3.00281 - 0.05835 t + 1.0358 \log (t + 1)$

GAINS and CAMPBELL's formula:

$$\log W = 3.18971 + 0.06942 t - 0.00387 t^2$$

Table 34. Observed and calculated values for the growth of the fifth instar larva of the same species, No. 11, ♂.

| Age               | Observed weight in mg | Calculated  |           |             |           |              |           |
|-------------------|-----------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                       | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                       | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 1                 | 1800                  | 1801        | — 0.05    | 1780        | + 1.11    | 1800         | ± 0.00    |
| 2                 | 2100                  | 2049        | — 2.42    | 2402        | —14.38    | 2056         | + 2.04    |
| 3                 | 2300                  | 2309        | — 0.39    | 2826        | —22.86    | 2307         | — 0.30    |
| 4                 | 2600                  | 2550        | + 1.92    | 3115        | —19.80    | 2543         | + 2.19    |
| 5                 | 2620                  | 2780        | — 6.10    | 3117        | —18.58    | 2755         | — 5.15    |
| 6                 | 2860                  | 2930        | — 2.44    | 3373        | —17.94    | 2930         | — 2.44    |
| 7                 | 2995                  | 3063        | — 2.27    | 3382        | —12.92    | 3062         | — 2.23    |
| 8                 | 2970                  | 3145        | — 5.92    | 3345        | —15.99    | 3143         | — 5.82    |
| 9                 | 3000                  | 3160        | — 5.33    | 3262        | — 8.73    | 3170         | — 5.66    |
| 10                | 3140                  | 3140        | ± 0.00    | 3147        | — 0.22    | 3140         | ± 0.00    |
| 11                | 3295                  | 3055        | + 7.28    | 3012        | + 8.58    | 3055         | — 7.27    |
| 12                | 3020                  | 2915        | + 3.47    | 2842        | + 5.89    | 2921         | + 3.27    |
| 13                | 2860                  | 2743        | + 4.09    | 2701        | + 5.55    | 2742         | + 4.12    |
| 14                | 2530                  | 2532        | — 0.07    | 2584        | — 2.13    | 2530         | ± 0.00    |
| Average Deviation |                       | — 0.58      |           | — 8.03      |           | — 1.30       |           |

11. Growth of the fifth instar larva of the same species,  
No. 15, ♂ (Data from YASUMATSU, 1933)

YASUMATSU's formula:  $\log W = 3.48105 - 0.00344 (t - 7.93)^2$

WOODRUFF's formula:

$$\log W = 3.12247 - 0.05074 t + 0.81134 \log (t + 1)$$

GAINS and CAMPBELL's formula:

$$\log W = 3.26488 + 0.05451 t - 0.00343 t^2$$

Table 35. Observed and calculated values for the growth of the fifth instar larva of the same species, No. 15, ♂.

| Age               | Observed weight in mg | Calculated  |           |             |           |              |           |
|-------------------|-----------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                       | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                       | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 1                 | 2070                  | 2070        | ± 0.00    | 2070        | ± 0.00    | 2070         | ± 0.00    |
| 2                 | 2280                  | 2291        | — 0.48    | 2559        | —12.23    | 2291         | — 0.48    |
| 3                 | 2450                  | 2497        | — 1.91    | 2875        | —17.34    | 2497         | — 1.91    |
| 4                 | 2630                  | 2679        | — 1.86    | 3066        | —16.57    | 2679         | — 1.86    |
| 5                 | 2500                  | 2828        | —13.12    | 3163        | —26.52    | 2828         | —13.12    |
| 6                 | 2660                  | 2940        | —10.52    | 3189        | —19.88    | 2940         | —10.52    |
| 7                 | 3040                  | 3006        | + 1.18    | 3161        | —31.98    | 3006         | + 1.18    |
| 8                 | 3160                  | 3027        | + 4.33    | 3095        | + 2.05    | 3027         | + 4.33    |
| 9                 | 3000                  | 3000        | ± 0.00    | 3000        | ± 0.00    | 3000         | ± 0.00    |
| 10                | 2700                  | 2930        | — 8.51    | 2884        | — 6.81    | 2926         | — 8.37    |
| 11                | 2700                  | 2814        | — 4.22    | 2753        | — 1.96    | 2810         | — 4.07    |
| 12                | 2490                  | 2661        | — 6.86    | 2614        | — 4.97    | 2655         | — 6.62    |
| 13                | 2470                  | 2470        | ± 0.00    | 2470        | ± 0.00    | 2470         | ± 0.00    |
| Average deviation |                       |             | — 3.22    |             | — 8.32    |              | — 3.19    |

12. Growth of the mid-intestine of the first instar larva of *Popillia japonica* (Data from LUDWIG and ABERCROMBIE, 1936)

YASUMATSU's formula:  $\log W = 2.1673 - 0.0036 (t - 15.991)^2$

WOODRUFF's formula:

$$\log W = -0.21458 - 0.01760 t + 1.3423 \log (t + 1)$$

GAINS and CAMPBELL's formula:

$$\log W = 0.27217 + 0.10836 t - 0.00327 t^2$$

Table 36. Observed and calculated values for the growth of the mid-intestine of the first instar larva of *Popillia japonica*.

| Age               | Observed weight in mg | Calculated  |           |             |           |              |           |
|-------------------|-----------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                       | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                       | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 1                 | 2.8                   | 2.87        | - 2.50    | 1.49        | +46.78    | 2.38         | +15.00    |
| 2                 | 3.0                   | 2.9         | + 3.33    | 2.45        | +18.33    | 2.99         | + 0.33    |
| 3                 | 3.6                   | 3.6         | ± 0.00    | 3.5         | + 2.77    | 3.7          | - 2.77    |
| 4                 | 4.5                   | 4.5         | ± 0.00    | 4.5         | ± 0.00    | 4.5          | ± 0.00    |
| 5                 | 5.5                   | 5.4         | + 1.81    | 5.5         | ± 0.00    | 5.4          | + 1.81    |
| 6                 | 6.3                   | 6.4         | - 1.58    | 6.5         | - 3.17    | 6.4          | - 1.58    |
| 7                 | 7.6                   | 7.5         | + 1.31    | 7.5         | + 1.31    | 7.4          | + 2.63    |
| 8                 | 8.6                   | 8.6         | ± 0.00    | 8.4         | + 2.32    | 8.5          | + 1.16    |
| 9                 | 10.3                  | 9.8         | + 4.85    | 9.3         | + 9.70    | 9.6          | + 6.79    |
| 10                | 11.3                  | 10.9        | + 4.76    | 10.1        | +10.61    | 10.6         | + 6.19    |
| 11                | 13.3                  | 12.0        | + 9.77    | 10.9        | +18.04    | 11.6         | +12.78    |
| 12                | 13.1                  | 12.9        | + 1.52    | 11.5        | +12.21    | 12.6         | + 3.81    |
| 13                | 14.8                  | 13.7        | + 7.43    | 12.4        | +16.21    | 13.4         | + 9.45    |
| 14                | 14.3                  | 14.2        | + 0.69    | 13.1        | + 8.32    | 14.0         | + 2.09    |
| 15                | 16.0                  | 14.6        | +10.00    | 13.7        | +14.37    | 14.4         | +10.00    |
| 16                | 14.7                  | 14.2        | + 3.40    | 14.1        | + 4.08    | 14.7         | ± 0.00    |
| Average deviation |                       |             | + 3.11    |             | +10.11    |              | + 4.23    |

13. Growth of the mid-intestine of the second instar larva of the same species (Data from LUDWIG and ABERCROMBIE, 1936)

YASUMATSU's formula:  $\log W = 2.90692 - 0.0042 (t - 14.19)^2$

WOODRUFF's formula:

$$\log W = 0.69168 - 0.0274 t + 1.3566 \log (t + 1)$$

GAINS and CAMPBELL's formula:

$$\log W = 0.98504 + 0.13215 t - 0.00472 t^2$$

Table 37. Observed and calculated values for the growth of the mid-intestine of the second instar larva of the same species.

| Age               | Observed weight in mg | Calculated  |           |             |           |              |           |
|-------------------|-----------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                       | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                       | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 1                 | 15.6                  | 15.0        | + 3.84    | 11.5        | + 26.28   | 12.9         | + 17.30   |
| 2                 | 17.0                  | 18.8        | —10.58    | 18.8        | —10.58    | 17.0         | ± 0.00    |
| 3                 | 20.8                  | 24.0        | —15.38    | 26.1        | —25.48    | 21.3         | — 2.40    |
| 4                 | 24.5                  | 29.6        | —20.81    | 31.1        | —26.93    | 27.4         | —11.83    |
| 5                 | 33.4                  | 35.7        | — 6.88    | 39.8        | —19.16    | 33.8         | — 1.19    |
| 6                 | 41.6                  | 42.2        | — 1.44    | 46.1        | —10.81    | 40.5         | + 2.64    |
| 7                 | 38.0                  | 49.0        | — 2.63    | 51.9        | —36.57    | 47.7         | —25.52    |
| 8                 | 57.9                  | 56.8        | + 1.89    | 57.2        | + 1.20    | 54.9         | + 5.18    |
| 9                 | 61.9                  | 62.2        | — 0.48    | 61.9        | ± 0.00    | 62.3         | — 0.64    |
| 10                | 53.3                  | 68.1        | —27.76    | 66.1        | —24.01    | 68.2         | —27.95    |
| 11                | 85.3                  | 73.2        | +14.18    | 69.9        | +18.05    | 73.6         | +13.71    |
| 12                | 75.7                  | 77.1        | — 1.84    | 73.1        | + 3.43    | 77.7         | — 2.64    |
| 13                | 97.9                  | 79.6        | +18.69    | 75.9        | +22.47    | 80.4         | +17.87    |
| 14                | 92.7                  | 80.7        | +12.94    | 78.3        | +15.53    | 81.1         | +12.51    |
| 15                | 80.2                  | 80.2        | ± 0.00    | 30.2        | ± 0.00    | 80.2         | ± 0.00    |
| Average deviation |                       |             | —2.41     |             | — 4.17    |              | — 0.20    |

14. Growth of the fifth instar larva of *Bombyx mori*,  
Kokusan-niti-no. 107 (Data from KOGURE, 1929)

YASUMATSU's formula:  $\log W = 2.4372 - 0.0489 (t - 4.654)^2$

WOODRUFF's formula:  $\log W = 0.92026 - 0.24614 t + 3.5235 \log (t + 1)$

GAINS and CAMPBELL's formula:  $W = 1.37656 + 0.45576 t - 0.04896 t^2$

Table 38. Observed and calculated values for the growth of the fifth instar larva of *Bombyx mori*, Kokusan-niti-no. 107.

| Age               | Observed<br>weight<br>in g | Calculated  |           |             |           |              |           |
|-------------------|----------------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                            | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                            | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 1                 | 0.69                       | 0.61        | +11.59    | 0.54        | +21.73    | 0.61         | +11.59    |
| 2                 | 0.97                       | 1.23        | -26.80    | 1.29        | -32.98    | 1.23         | -26.80    |
| 3                 | 2.01                       | 2.01        | ± 0.00    | 2.01        | ± 0.00    | 2.01         | ± 0.00    |
| 4                 | 2.56                       | 2.61        | - 1.95    | 2.45        | + 4.29    | 2.61         | - 1.95    |
| 5                 | 2.70                       | 2.70        | ± 0.00    | 2.70        | ± 0.00    | 2.70         | ± 0.00    |
| Average deviation |                            |             | + 2.63    |             | -1.39     |              | -3.43     |

15. Growth of the fifth instar larva of *Bombyx mori*,  
Kokusan-niti-no. 1 (Data from KOGURE, 1929)

YASUMATSU's formula:  $\log W = 2.4599 - 0.0165 (t - 6.7732)^2$

WOODRUFF's formula:  $\log W = 1.5353 - 0.0425 t + 1.381 \log (t + 1)$

GAINS and CAMPBELL's formula:

$$\log W = 1.70204 + 0.2229 t - 0.01645 t^2$$

Table 39. Observed and calculated values for the growth of the fifth instar larva of *Bombyx mori*, Kokusan-niti-no. 1.

| Age               | Observed<br>weight<br>in g | Calculated  |           |             |           |              |           |
|-------------------|----------------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                            | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                            | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 1                 | 0.81                       | 0.81        | ±0.00     | 0.81        | ± 0.00    | 0.81         | ± 0.00    |
| 2                 | 1.12                       | 1.20        | -7.14     | 1.29        | -15.17    | 1.20         | - 7.14    |
| 3                 | 1.86                       | 1.68        | +9.62     | 1.74        | + 6.52    | 1.67         | +10.21    |
| 4                 | 2.14                       | 2.14        | ±0.00     | 2.14        | ± 0.00    | 2.14         | ± 0.00    |
| 5                 | 2.61                       | 2.56        | +1.91     | 2.50        | + 4.21    | 2.54         | + 2.68    |
| 6                 | 2.80                       | 2.80        | ±0.00     | 2.80        | ± 0.00    | 2.80         | ± 0.00    |
| Average deviation |                            |             | +0.87     |             | - 0.89    |              | + 1.15    |

16. Growth of the fifth instar larva of *Bombyx mori*,  
Aojuku, ♂ (Data from YAGI, 1926)

YASUMATSU's formula:  $\log W = 3.42309 - 0.0277 (t - 5.615)^2$

WOODRUFF's formula:  $\log W = 2.39765 - 0.06217 t + 1.6511 \log (t + 1)$

GAINS and CAMPBELL's formula:

$$\log W = 2.54844 + 0.31182 t - 0.02775 t^2$$

Table 40. Observed and calculated values for the growth  
of the fifth instar larva of *Bombyx mori*, Aojuku, ♂.

| Age                  | Observed<br>weight<br>in g | Calculated  |           |             |           |              |           |
|----------------------|----------------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                      |                            | Y's formula |           | W's formula |           | GC's formula |           |
|                      |                            | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 1                    | 0.680                      | 0.681       | - 0.14    | 0.680       | ± 0.00    | 0.680        | ± 0.00    |
| 2                    | 1.151                      | 1.151       | ± 0.00    | 1.151       | ± 0.00    | 1.151        | ± 0.00    |
| 3                    | 1.590                      | 1.712       | - 7.67    | 1.594       | - 0.25    | 1.714        | - 7.79    |
| 4                    | 1.800                      | 2.243       | -24.61    | 2.009       | -11.61    | 2.247        | -26.50    |
| 5                    | 2.400                      | 2.585       | - 7.70    | 2.358       | + 1.75    | 2.592        | - 8.00    |
| 6                    | 2.630                      | 2.624       | + 0.22    | 2.630       | ± 0.00    | 2.632        | - 0.07    |
| Average<br>deviation |                            |             | - 6.65    |             | - 1.68    |              | - 7.06    |

17. Growth of the fifth instar larva of *Bombyx mori*,  
Aojuku B, ♀ (Data from KOGURE, 1929)

YASUMATSU's formula:  $\log W = 3.4784 - 0.0251 (t - 5.919)^2$

WOODRUFF's formula:  $\log W = 2.40342 - 0.07488 t + 1.8039 \log (t + 1)$

GAINS and CAMPBELL's formula:

$$\log W = 2.59972 + 0.29692 t - 0.02507 t^2$$

Table 41. Observed and calculated values for the growth of the fifth instar larva of *Bombyx mori*, Aojukū B, ♀.

| Age               | Observed<br>weight<br>in mg | Calculated  |           |             |           |              |           |
|-------------------|-----------------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                             | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                             | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 1                 | 744                         | 743         | +0.13     | 744         | ± 0.00    | 744          | ±0.00     |
| 2                 | 1310                        | 1239        | +5.42     | 1301        | + 0.68    | 1240         | +5.34     |
| 3                 | 1840                        | 1840        | ±0.00     | 1840        | ± 0.00    | 1840         | ±0.00     |
| 4                 | 2360                        | 2432        | -2.96     | 2598        | -10.08    | 2433         | -3.09     |
| 5                 | 2770                        | 2866        | -3.42     | 2708        | + 2.23    | 2868         | -3.53     |
| 6                 | 3010                        | 3010        | ±0.00     | 3010        | ± 0.00    | 3010         | ±0.00     |
| Average deviation |                             |             | -0.13     |             | - 1.19    |              | -0.21     |

## 2. Considerations

Examinations of these growth curves show that the growth curve of insects may be regarded as representing a locus of a parabola in each instar, and each parabola characteristic to each instar of insects takes a similar shape with one another. There is an initial portion wherein the growth is most rapid, the velocity becomes gradually decreasing through greater part of time consumed in each instar. Then losses in weight prior to ecdysis are to be expected, causing slumps in the curve. As seen in the comparisons between the observed and calculated values, these three formulae representing a parabola may be applied equally well to the growth of not only paurometabolous insects but also holometabolous ones. Among seventeen applications of these formulae as mentioned above the equation given by WOODRUFF did not often show so close agreement between the calculated and observed values as the other two, the average error of estimate being 14.08 in value. Here we must remember that the equation given by him was not originally applied to the growth curve in each instar but to the curve representing the maximum weights in all the stadia.

### C. Growth in Weight during the Post-embryonic Developmental Period

#### 1. Application of Three Formulae to the Growth Curves

In this chapter the change of the special characters such as maximum weight and moulting weight during the post-embryonic developmental period was studied. Theoretically the maximum weight represents the maximum body-weight in each instar and is reached in the later period of the instar just before ecdysis. The moulting weight is the minimum weight at the beginning of each instar and may be definitely lower than the maximum in the preceding instar. We may be able to regard such weights as critical points. Of course the minimum weight must be selected as a more preferable criterion for the discussion of any growth curve than the maximum weight which is much more variable as compared with the former. The detailed report and discussions on this account were given in my previous paper (YASUMATSU, 1933). Here, the three formulae used in the preceding chapter were once more applied to the data of *Phraortes kumamotoensis* and *Blattella germanica* in order to determine their applicability. Under standardized conditions the locus of critical points seemed to be well defined by the three formulae.

#### I. Growth of *Phraortes kumamotoensis*, No. 1, ♀

(Data from YASUMATSU, 1933)

YASUMATSU's formula:  $\log W = 6.82736 - 0.0000304 (t - 412.47)^2$

WOODRUFF's formula:  $\log W = 1.24095 + 0.018147 t + 0.404 \log (t + 1)$

GAINS and CAMPBELL's formula:

$$\log W = 1.651924 + 0.025155 t - 0.000031 t^2$$

Table 42. Observed and calculated values for the growth of *Phraortes kumamotoensis*, No. 1, ♀.

| Age | Observed weight in gm | Calculated  |           |             |           |              |           |
|-----|-----------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|     |                       | Y's formula |           | W's formula |           | GC's formula |           |
|     |                       | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 22  | 155                   | 155         | ± 0.00    | 155         | ± 0.00    | 155          | ± 0.00    |
| 37  | 390                   | 348         | +10.76    | 355         | + 8.89    | 347          | +11.05    |

|                   |      |      |        |      |        |      |        |
|-------------------|------|------|--------|------|--------|------|--------|
| 51                | 820  | 717  | +12.56 | 722  | +11.82 | 715  | +12.82 |
| 63                | 1300 | 1300 | ± 0.00 | 1300 | ± 0.00 | 1300 | ± 0.00 |
| 77                | 2550 | 2548 | + 0.07 | 2527 | + 0.90 | 2541 | + 0.35 |
| 91                | 4850 | 4850 | ± 0.00 | 4850 | ± 0.00 | 4834 | + 0.32 |
| Average deviation |      |      | + 3.88 |      | + 3.60 |      | + 4.09 |

## 2. Growth of the same species, No. 2, ♀

(Data from YASUMATSU, 1933)

YASUMATSU's formula:  $\log W = 4.457622 - 0.0000695 (t - 197.86)^2$ WOODRUFF's formula:  $\log W = 0.91088 + 0.01186 t + 0.8499 \log (t + 1)$ 

GAINS and CAMPBELL's formula:

$$\log W = 1.76154 + 0.026815 t - 0.000065 t^2$$

Table 43. Observed and calculated values for the growth of the same species, No. 2, ♀.

| Age               | Observed weight in mg | Calculated  |           |             |           |              |           |
|-------------------|-----------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                       | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                       | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 20                | 187                   | 187         | ± 0.00    | 187         | ± 0.00    | 187          | ± 0.00    |
| 34                | 455                   | 389         | +14.50    | 423         | + 7.03    | 397.9        | +12.54    |
| 50                | 935                   | 867         | + 7.27    | 902         | + 3.52    | 870.5        | + 6.89    |
| 63                | 1560                  | 1560        | ± 0.00    | 1560        | ± 0.00    | 1560         | ± 0.00    |
| 81                | 2700                  | 3226        | -19.48    | 3148        | -16.59    | 3214         | -19.03    |
| 95                | 5276                  | 5276        | ± 0.00    | 5276        | ± 0.00    | 5276         | ± 0.00    |
| Average deviation |                       |             | + 0.38    |             | - 1.00    |              | +0.066    |

## 3. Growth of the same species, No. 3, ♂

(Data from YASUMATSU, 1933)

YASUMATSU's formula:  $\log W = 3.49236 - 0.000171 (t - 105.282)^2$ WOODRUFF's formula:  $\log W = 0.22768 + 0.004159 t + 1.514 \log (t + 1)$ 

GAINS and CAMPBELL's formula:

$$\log W = 1.65417 + 0.036001 t - 0.000171 t^2$$

Table 44. Observed and calculated values for the growth of the same species, No. 3, ♂.

| Age               | Observed maximum weight in mg | Calculated  |           |             |           |              |           |
|-------------------|-------------------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                               | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                               | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 19                | 189                           | 186         | +1.58     | 189         | ± 0.00    | 189          | ±0.00     |
| 32                | 390                           | 428         | —9.74     | 457         | —17.18    | 427          | —9.48     |
| 47                | 930                           | 930         | ±0.00     | 932         | — 0.21    | 930          | ±0.00     |
| 62                | 1643                          | 1694        | —3.10     | 1621        | + 1.33    | 1694         | —3.10     |
| 77                | 2585                          | 2585        | ±0.00     | 2590        | — 0.19    | 2585         | ±0.00     |
| Average deviation |                               |             | —2.25     |             | — 3.25    |              | —2.51     |

4. Growth of the same species, No. 4, ♂  
(Data from YASUMATSU, 1933)

YASUMATSU's formula:  $\log W = 3.7105 - 0.0001285 (t - 126.326)^2$

WOODRUFF's formula:  $\log W = 0.667 + 0.00923 t + 1.07 \log (t + 1)$

GAINS and CAMPBELL's formula:

$$\log W = 1.65644 + 0.03259 t - 0.0001286 t^2$$

Table 45. Observed and calculated values for the growth of the same species, No. 4, ♂.

| Age               | Observed maximum weight in mg | Calculated  |           |             |           |              |           |
|-------------------|-------------------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                               | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                               | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 18                | 159                           | 159         | ±0.00     | 159         | ±0.00     | 159          | ±0.00     |
| 32                | 355                           | 369         | —3.94     | 387         | —9.01     | 378          | —6.47     |
| 46                | 760                           | 761         | —0.13     | 760         | ±0.00     | 778          | —2.38     |
| 61                | 1390                          | 1452        | —4.46     | 1405        | —1.08     | 1465         | —5.39     |
| 75                | 2355                          | 2355        | ±0.00     | 2353        | +0.08     | 2384         | —1.21     |
| Average deviation |                               |             | —1.70     |             | —2.00     |              | —3.09     |

5. Growth of the same species, No. 5, ♂  
(Data from YASUMATSU, 1933)

YASUMATSU's formula:  $\log W = 3.73742 - 0.000118 (t - 131.137)^2$

WOODRUFF's formula:

$$\log W = 0.823296 + 0.009832 t + 0.96132 \log (t + 1)$$

GAINS and CAMPBELL's formula:

$$\log W = 1.702458 + 0.031032 t - 0.000118 t^2$$

Table 46. Observed and calculated values for the growth of the same species, No. 5, ♂.

| Age               | Observed<br>maximum<br>weight<br>in mg | Calculated  |           |             |           |              |           |
|-------------------|----------------------------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                                        | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                                        | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 17                | 157                                    | 156         | + 0.63    | 156         | +0.63     | 157          | ± 0.00    |
| 33                | 372                                    | 385         | — 3.49    | 389         | —4.56     | 396          | — 6.45    |
| 47                | 795                                    | 798         | — 0.30    | 799         | —0.50     | 795          | ± 0.00    |
| 63                | 1380                                   | 1547        | —12.10    | 1510        | —9.42     | 1545         | —11.95    |
| 74                | 2250                                   | 2250        | ± 0.00    | 2250        | ±0.00     | 2251         | — 0.04    |
| Average deviation |                                        |             | — 3.07    |             | —2.77     |              | — 3.68    |

6. Growth of *Blattella germanica*, ♂  
(Data from WOODRUFF, 1938)

YASUMATSU's formula:  $\log W = 2.112759 - 0.000245 (t - 87.35)^2$

WOODRUFF's formula:

$$\log W = -0.0834 + 0.015633 t + 0.630123 \log (t + 1)$$

GAINS and CAMPBELL's formula:

$$\log W = 0.246067 + 0.042178 t - 0.000233 t^2$$

Table 47. Observed and calculated values for the growth of *Blattella germanica*, ♂.

| Age               | Observed maximum weight in mg | Calculated  |           |             |           |              |           |
|-------------------|-------------------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                               | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                               | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 3.7               | 2.5                           | 2.5         | ± 0.00    | 2.5         | ±0.00     | 2.5          | ± 0.00    |
| 10.0              | 5.1                           | 4.4         | +13.72    | 5.4         | -5.88     | 4.4          | +13.72    |
| 17.0              | 9.1                           | 7.9         | +13.19    | 9.4         | -3.29     | 7.9          | +13.19    |
| 26.8              | 16.7                          | 16.4        | + 1.79    | 17.6        | -5.38     | 16.2         | + 2.99    |
| 36.6              | 30.3                          | 28.5        | + 5.94    | 30.3        | ±0.00     | 30.0         | + 0.99    |
| 48.5              | 55.3                          | 55.3        | ± 0.00    | 55.3        | ±0.00     | 55.4         | - 0.18    |
| Average deviation |                               |             | + 5.77    |             | -2.42     |              | +5.11     |

## 7. Growth of the same species, ♀

(Data from WOODRUFF, 1938)

YASUMATSU's formula:  $\log W = 2.17599 - 0.00032 (t - 78.102)^2$ 

WOODRUFF's formula:

$$\log W = -0.078719 + 0.02002 t + 0.60215 \log (t + 1)$$

GAINS and CAMPBELL's formula:

$$\log W = 0.224563 + 0.050678 t - 0.000322 t^2$$

Table 48. Observed and calculated values for the growth of the same species, ♀.

| Age               | Observed maximum weight in mg | Calculated  |           |             |           |              |           |
|-------------------|-------------------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                               | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                               | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 3.9               | 2.6                           | 2.6         | ± 0.00    | 2.6         | ± 0.00    | 2.6          | ± 0.00    |
| 9.2               | 5.1                           | 4.5         | +11.76    | 4.0         | +21.56    | 3.6          | +29.41    |
| 15.7              | 9.9                           | 8.5         | +14.14    | 9.3         | + 6.45    | 8.5          | +14.14    |
| 24.7              | 18.4                          | 18.3        | + 0.54    | 18.4        | ± 0.00    | 18.4         | ± 0.00    |
| 34.1              | 35.5                          | 36.0        | - 1.40    | 57.6        | -62.25    | 36.1         | - 1.69    |
| 45.4              | 68.2                          | 68.2        | ± 0.00    | 68.2        | ± 0.00    | 68.2         | ± 0.00    |
| Average deviation |                               |             | + 4.17    |             | - 5.70    |              | + 7.14    |

## 8. Growth of the same species, ♀

(Data from WOODRUFF, 1938)

YASUMATSU's formula:  $\log W = 1.93203 - 0.000371 (t - 71.002)^2$ 

WOODRUFF's formula:

$$\log W = -0.44492 + 0.016771 t + 0.82891 \log (t + 1)$$

GAINS and CAMPBELL's formula:

$$\log W = 0.04679 + 0.053138 t - 0.000347 t^2$$

Table 49. Observed and calculated values for the growth of the same species, ♀.

| Age               | Observed maximum weight in mg | Calculated  |           |             |           |              |           |
|-------------------|-------------------------------|-------------|-----------|-------------|-----------|--------------|-----------|
|                   |                               | Y's formula |           | W's formula |           | GC's formula |           |
|                   |                               | Values      | Deviation | Values      | Deviation | Values       | Deviation |
| 5.8               | 2.2                           | 2.2         | ± 0.00    | 2.2         | ± 0.00    | 2.2          | ± 0.00    |
| 11.0              | 4.6                           | 3.9         | + 15.21   | 3.5         | + 23.9    | 3.8          | + 17.39   |
| 17.5              | 9.0                           | 7.4         | + 17.77   | 7.9         | + 12.22   | 7.3          | + 18.88   |
| 27.1              | 16.3                          | 16.5        | - 1.22    | 16.2        | + 0.61    | 16.3         | ± 0.00    |
| 37.0              | 32.1                          | 31.9        | + 0.62    | 30.5        | + 4.98    | 31.7         | + 1.24    |
| 49.4              | 57.4                          | 57.4        | ± 0.00    | 57.2        | + 0.34    | 57.4         | ± 0.00    |
| Average deviation |                               |             | + 5.39    |             | + 6.90    |              | + 6.25    |

## 2. Considerations

As seen in the comparisons between the observed and calculated values, these three formulae of a parabola may be applied equally well to the growth of paurometabolous insects. I attempted to apply PRZIBRAM's principle to my results. Because of the diverse range and the variation in the constants obtained, the investigations on *Phraortes kumamotoensis* did not substantiate the principle. The data obtained by PRZIBRAM and MEGUSAR (1912) on *Sphodromantis bioculata* (= *viridis*) are doubtful, as the weight of the moulted insects showed a doubling value from moult to moult.

## D. Discussions

In 1933 HODGE IV analysed the rate of growth of *Melanoplus differentialis* by plotting and making a graph of the logarithm of the weight against percentage of the elapsed time of the pre-adult life. His results showed that the resultant points fall onto a series of straight lines of slightly differing slopes. The data indicates a slightly different rate of growth specific to each instar, except the last, in which two or even three rates occur. But the figure given by him as representing an average growth rate curve is too artificial or simplified for indicating the true nature of the curve in each instar, but is very interesting as it is demonstrating a general trend of the locus connecting some critical points. From this curve we can expect the existence of several growth phases in the post-embryonic developmental period. But his curve seems to be too weak to elucidate the relationship until much more evidences in regard to the structural knowledge during the larval stadia have been accumulated.

WOODRUFF (1938) is the first entomologist who applied the equation of a parabola to the growth curve of insects in foreign countries. From his opinion the following lines may be cited here. "Whatever the cause of the variations from day to day, their effect is observed by inexorable growth, and a smoother curve results. Freed of distracting waves, the line appears in its true light as a slight downward curve. Of course, the retrogressions preceding each moult interrupt the continuity, but even so the slightly decreasing rate is apparent. When the points representing either the maximum weight or the moulting weight are connected by a continuous line, the character of the changing velocity is unmistakable." Thus in deriving a formula whose constants would best represent the data, the observations for the maximum weights of the stadia were submitted to the equation  $\log W = a + bt + c \log (t + 1)$ .

Apparently his observation was especially concentrated to the consideration of a locus of the maximum weights of the stadia, and, on the contrary, the minimum weights received little attention by him. The lack of any allometric study upon the material seems to suggest nothing about the growth phases which are

sometimes existing in animals. But in many growth curves demonstrated in his paper, I want to recognize two or three growth phases in *Blattella germanica*. As early as 1933, entirely independent of the work of HODGE IV, I published the results of my study on *Phraortes kumamotoensis*. My results showed that the growth of the material may be satisfactorily illustrated by a series of parabolic curves of a similar type and the critical points came onto two or three different straight lines.

The weight growth of the male may be separable into two phases, and those of the female being in three phases. The first phase lasts from hatching to the third ecdysis, and the critical points ride on a straight line  $y = \tan \theta' \cdot x + l$ . The second phase represents the fourth and fifth instars in the male and the fourth in the female, and the critical points are on a straight line  $y = \tan \theta'' \cdot x + m$ . The third phase represents the fifth and sixth instars in the female, and the critical points ride on a straight line  $y = \tan \theta''' \cdot x + n$ . Among these angles,  $\theta'$ ,  $\theta''$  and  $\theta'''$ , the following relations may be recognizable.  $90^\circ > \theta' > 0^\circ$ ,  $90^\circ > \theta'' > 0^\circ$ ,  $90^\circ > \theta''' > 0^\circ$ ,  $\theta' = \theta'''$ ,  $\theta' = \theta'''$  or  $\theta' > \theta'''$ ,  $\theta' > \theta''$ ,  $\theta''' > \theta''$ ,  $\theta'' (\delta) > \theta''' (\varphi)$ . Such a phenomenon as seen in the female will be explained partly by the growth of the ovaries and the accumulation of the fatty bodies in the course of the larval growth. In this connection it is very interesting to note that the linear growth of the abdomen is divided into two phases as indicated in my previous study (YASUMATSU, 1932).

Though the growth phases in the sense of the growth in length and growth in weight do not coincide with each other, such a non-coincidence is not worthy of wonder. The only coincidence of the data in the length of the abdomen and the weight of the body is of extremely valuable in considering the change of the weight during the larval stadia.

General observation on the critical points indicates that the curve may be illustrated very well by the parabolic equations as applied in the preceding paragraph, but the closer investigation may afford the growth of my material with two ( $\delta$ ) or three ( $\varphi$ ) phases. In this connection it must not be forgotten to notice that the three entomologists, myself (1933), HODGE IV (1933) and WOODRUFF (1938), have made use of semi-log method of plotting of the curves of growth from the data obtained in three different species of insects, and the growth curves were detected immedi-

ately with no danger of misinterpretation. From the method by the plotting of definite fractions of the total growth against definite fractions of the time consumed in completing the growth, we can get the curve showing only the change in magnitude, though the curve has no significance when interpretations of the rate are desired. Further the curves pictured by the method to take the instars with the same interval on the abscissa against definite fractions of the total growth are arbitrary and fail in showing the true growth rates.

### E. Summary

1. The growth of larvae of *Phraortes kumamotoensis*, *Popillia japonica*, *Bombyx mori* and *Blattella germanica* were studied with regard to weight in the course of the post-embryonic developmental period.
2. The literature concerning the growth in weight and length was reviewed.
3. In every case the progression factors decreased with succeeding moults, contrary to PRZIBRAM's principle.
4. The absolute values must not be used in plotting growth curves of insects. Because the curves thus pictured only show the changes in magnitude.
5. Arithmetic values must be assigned to the logarithmic ordinate. By the aid of semi-log method only we may be able to illustrate the true rate of growth by the comparative changes in the curvature of the line.
6. The growth curves of insects take the type of a parabola in each instar. This may be a general trend in all the curves indicating a similarity in rate of growth, though retardations or retrogressions in the rate will be often noted between two ecdyses, more frequently in the later stadia.
7. Under standardized conditions, the growth and its rate are well defined by the equations  $\log W = a + c(x-b)^2$  (for the stick insect by YASUMATSU, 1933),  $\log W = a + bx + cx^2$  (for the corn ear worm by GAINS and CAMPBELL, 1935) and  $\log M = a + bt + c \log(t+1)$  (for the roach by WOODRUFF, 1938). These parabolic equations may be applicable to many

other species of both paurometabolous and holometabolous insects.

8. Of the two critical points on the growth curves of insects, the minimum weight must be selected for the discussion of

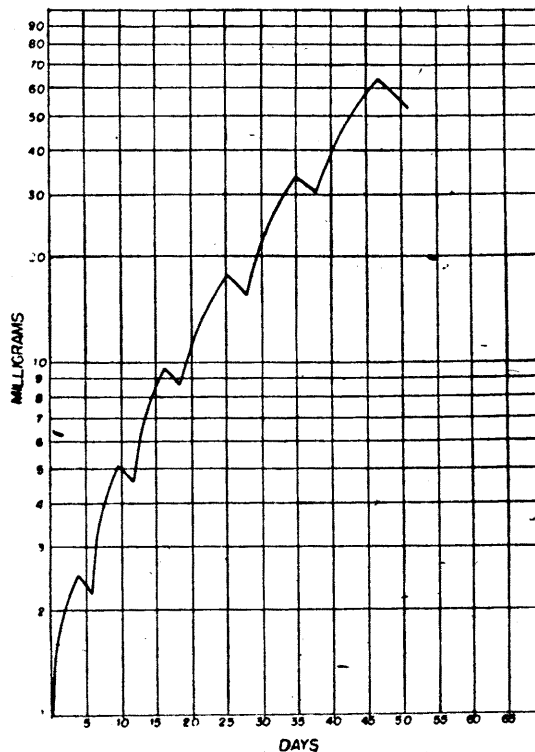


Fig. 25. An idealized curve of normal development for both sexes of *Blattella germanica* (After WOODRUFF, 1938).

any growth curve rather than the maximum weight. The minimum weight is the moulting weight at the beginning of each instar, the maximum weight is much more variable as it is influenced by a changing environment.

9. Under standardized conditions the locus of critical points is well defined by the equations given above.
10. The growth of *Phraortes kumamotoensis* may be divided into two ( $\delta$ ) or three ( $\varphi$ ) growth phases. This evidence is highly

correlated with the linear growth of the allometric organs. The first, second and third instars are all included in the first growth phase. The fourth (♀) or fourth and fifth (♂) instars represent the second growth phase. The rate of the growth in the second phase is slowest with respect to the increase in weight of the body. The fact seems to be illustrated by the changes of some morphological characters as well as the differentiation of such inner organ as the reproductive system and the temporary consumption of fatty body for the activating of the former.

11. The knowledge based upon the allometric study of any of the skeletal structures in insects seems to be very neces-

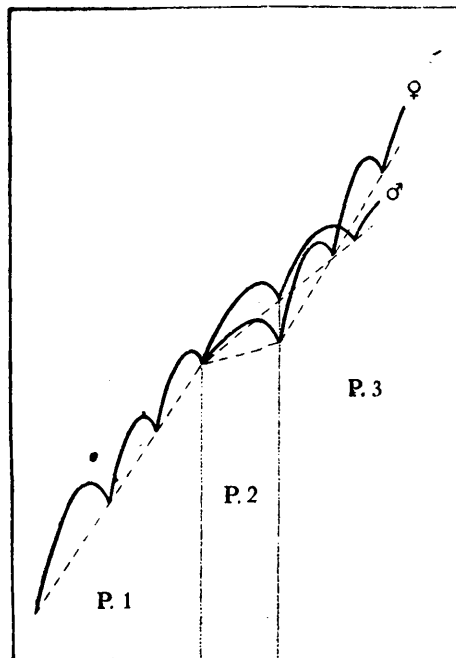


Fig. 26. An idealized curve of normal development for both sexes of *Phraortes kumamotoensis* (Modified from YASUMATSU, 1933). P. 1: The first phase. P. 2: The second phase. P. 3: The third phase.

sary and important for the unmistakable analyses of the growth in weight during the larval stadia.

## VI. FOOD CONSUMPTION

## A. Food Plants and Feeding Habits

Among the Phasmidae of Japan, Corea and Micronesia *Phraortes kumamotoensis* SHIRAKI is the most wide-ranging plant-feeder, while the other species show comparatively a narrower range of food plants, e.g. *Acanthograeffea denticulata* REDTENBACHER on *Cocos nucifera* LINNE; *Micadina yasumatsui* SHIRAKI and *M. fluctu-enoides* (REHN) on *Castanea crenata* SIEBOLD et ZUCCARINI, *Quercus acutissima* CARRUTHERS and *Pasania* sp.; *M. rotundata* SHIRAKI on *Pasania* sp.; *Phraortes elongatus* (THUNBERG) on *Zelkova serrata* MAKINO, *Kerria japonica* DC., *Wistaria floribunda* DC. and *W. brachybotrys* SIEBOLD et ZUCCARINI; *Phraortes formosanus* SHIRAKI on *Gossypium indicum* LAM.; *Sipylodea sipylus* (WESTWOOD) on *Gossypium indicum* LAM., *Megacrania tsudai* SHIRAKI on *Pandanus* sp.

Following is a list of the food plants of *Phraortes kumamotoensis* SHIRAKI. However, this shows merely some examples of the food plants, and by further researches the number of plants as food of this Phasmid may attain several hundreds.

## Rosaceae

1. *Rosa polyantha* SIEBOLD et ZUCCARINI
2. *Rosa microphylla* ROXBURGH
3. *Pyrus autumnalis* var. *culta* KOIDZUMI
4. *Malus pumila* MILLER
5. *Prunus mume* SIEBOLD et ZUCCARINI
6. *Prunus salicina* LINDLEY
7. *Prunus Persica* var. *vulgaris* MAXIMOWICZ
8. *Prunus Ansu* KOMAROV
9. *Prunus subhirtella* MIQUEL
10. *Prunus serrulata* var. *spontanea* MAKINO
11. *Kerria japonica* A. P. DE CANDOLLE
12. *Amelanchier asiatica* ENDLICHER

## Papilionaceae

13. *Lespedeza bicolor* var. *japonica* NAKAI
14. *Robinia pseudoacacia* LINNE

## Polygonaceae

- 15. *Peynoutria japonica* HOUTTUYN
- 16. *Polygonum tenuiflora* HARA

## Araliaceae

- 17. *Hedera Tobleri* NAKAI

## Caprifoliaceae

- 18. *Viburnum japonicum* SPRENGEL

## Ardisiaceae

- 19. *Bladhia japonica* THUNBERG

## Rhodoraceae

- 20. *Lyonia Neziki* NAKAI et HARA

## Celastraceae

- 21. *Celastrus orbiculatus* THUNBERG
- 22. *Euonymus japonicus* THUNBERG

## Ulmaceae

- 23. *Zelkova serrata* MAKINO

## Fagaceae

- 24. *Castanea crenata* SIEBOLD et ZUCCARINI
- 25. *Quercus serrata* THUNBERG
- 26. *Quercus acutissima* CARRUTHERS

Such plants as those having thick, tough, ciliate, downy, bristly, pubescent, tomentous or floccous leaves are usually free from attack of this Phasmid.

During the past twelve years, *Rosa polyantha* (Rosacéae), *Prunus Persica* (Rosaceae), *Prunus subhirtella* (Rosaceae), *Amelanchier asiatica* (Rosaceae), *Lespedeza bicolor* (Papilionaceae), *Viburnum japonicum* (Caprifoliaceae), *Lyonia Neziki* (Rhodoraceae), *Celastrus orbiculatus* (Celastraceae) and *Castanea crenata* (Fagaceae) have been used in rearing *Phraortes kumamotoensis*. In each cases,

records of the number of larvae surviving at each instar, and the length and weight of the insects at the completion of the growth were made. The result of these studies showed that all of these plants were good and quite satisfactory foods for completing the development and metamorphosis, most larvae completed any given stage at approximately the same time and secured definite size and weight, and practically no sensible differences were observed in, from the results in question mentioned above, and thus revealed the fact that this Phasmid was one of the best material in studying the minimum adequate amount of food in order to complete the normal development.

In feeding on the foliage of most plants the Phasmid is an edge feeder and not surface feeder, cutting off strip after strip of leaf and swallowing them down whole. When young the bite is clean and the veins are mostly avoided, as age increases it becomes jagged and rough and the veins are no more avoided. When decay approaches they often have difficulty in making the final bite to release the strip, and then when it moves the head backwardly the whole strip reappears out of its mouth still attached to the leaf. As in the other species of the Phasmidae this species is not gregarious but solitary in habit, as indicated by the fact that when one or more insects start to feed on a given foliage in a small rearing cage, other insects never respond to collect or feed on that plant but they feed at any time when they want. Thus the time of feeding of an individual in one day is independent of chemical changes of the fluid within the foliage of plants. Attempt was made to find how many times a day the insect takes food and the interval of the two consecutive feedings. In general the insect feeds three or four times a day. In the following I give an example of a single adult individual (♀).

|       |                    |   |                            |
|-------|--------------------|---|----------------------------|
| 14.00 | Observation begun. | } | 5.0 units of leaves taken. |
| 14.15 | Evacuated.         |   |                            |
| 14.30 | Evacuated.         |   |                            |
| 14.45 | Evacuated.         |   |                            |
| 15.02 | Began to feed.     | } |                            |
| 15.15 | Evacuated.         |   |                            |
| 15.37 | Stopped to feed.   |   |                            |
| 16.00 | Evacuated.         | } |                            |

|       |                  |                            |
|-------|------------------|----------------------------|
| 16.10 | Evacuated.       |                            |
| 16.30 | Evacuated.       |                            |
| 16.55 | Evacuated.       |                            |
| 17.18 | Evacuated.       |                            |
| 17.40 | Evacuated.       |                            |
| 18.00 | Evacuated.       |                            |
| 18.15 | Evacuated.       |                            |
| 18.42 | Evacuated.       |                            |
| 18.58 | Evacuated.       | About 347 minutes.         |
| 19.16 | Evacuated.       |                            |
| 19.35 | Evacuated.       |                            |
| 19.50 | Evacuated.       |                            |
| 20.10 | Evacuated.       |                            |
| 20.30 | Evacuated.       |                            |
| 20.50 | Evacuated.       |                            |
| 21.15 | Evacuated.       |                            |
| 21.25 | Began to feed.   |                            |
| 21.29 | Evacuated.       | 7.7 units of leaves taken. |
| 21.40 | Stopped to feed. |                            |
| 22.07 | Evacuated.       |                            |
| 22.26 | Evacuated.       |                            |
| 22.48 | Evacuated.       |                            |
| 23.10 | Evacuated.       |                            |
| 23.35 | Evacuated.       |                            |
| 23.51 | Evacuated.       | About 270 minutes.         |
| 24.37 | Evacuated.       |                            |
| 24.57 | Evacuated.       |                            |
| 24.59 | Evacuated.       |                            |
| 25.15 | Evacuated.       |                            |
| 1.30  | Evacuated.       |                            |
| 1.48  | Evacuated.       |                            |
| 2.10  | Began to feed.   |                            |
| 2.15  | Evacuated.       | 4.7 units of leaves taken. |
| 2.20  | Evacuated.       |                            |
| 2.28  | Stopped to feed. |                            |
| 2.54  | Evacuated.       |                            |
| 3.19  | Evacuated.       |                            |
| 3.40  | Evacuated.       |                            |
| 3.50  | Evacuated.       |                            |

|       |                     |                            |
|-------|---------------------|----------------------------|
| 4.05  | Evacuated.          |                            |
| 4.20  | Evacuated.          | About 193 minutes.         |
| 4.45  | Evacuated.          |                            |
| 5.05  | Evacuated.          |                            |
| 5.20  | Evacuated.          |                            |
| 5.40  | Evacuated.          |                            |
| 6.00  | Evacuated.          |                            |
| 6.05  | Evacuated.          |                            |
| 6.07  | Began to feed.      |                            |
| 6.20  | Stopped to feed.    | 4.6 units of leaves taken. |
| 6.50  | Evacuated.          |                            |
| 7.20  | Evacuated.          |                            |
| 8.15  | Evacuated.          |                            |
| 8.45  | Evacuated.          |                            |
| 9.08  | Evacuated.          |                            |
| 9.22  | Evacuated.          | About 246 minutes          |
| 9.40  | Evacuated.          |                            |
| 10.03 | Evacuated.          |                            |
| 10.19 | Evacuated.          |                            |
| 10.37 | Evacuated.          |                            |
| 10.56 | Evacuated.          |                            |
| 11.25 | Evacuated.          |                            |
| 11.26 | Began to feed.      |                            |
| 11.27 | Evacuated.          | 5.4 units of leaves taken. |
| 11.35 | Stopped to feed.    |                            |
| 11.50 | Evacuated.          |                            |
| 11.59 | Evacuated.          |                            |
| 12.24 | Evacuated.          |                            |
| 12.50 | Evacuated.          |                            |
| 13.08 | Evacuated.          | About 205 minutes.         |
| 13.30 | Evacuated.          |                            |
| 13.45 | Evacuated.          |                            |
| 14.00 | Observation ceased. |                            |

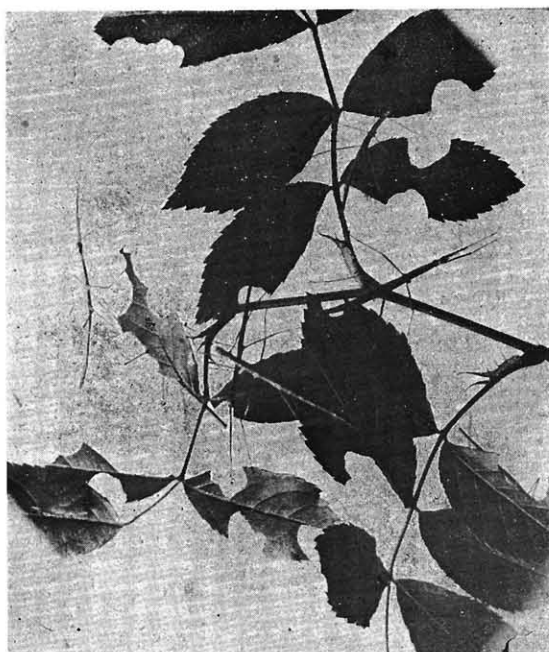


Fig. 28. *Phraortes kumamotoensis* resting on the foliage of the wild rose tree, *Rosa multiflora* Thunberg.

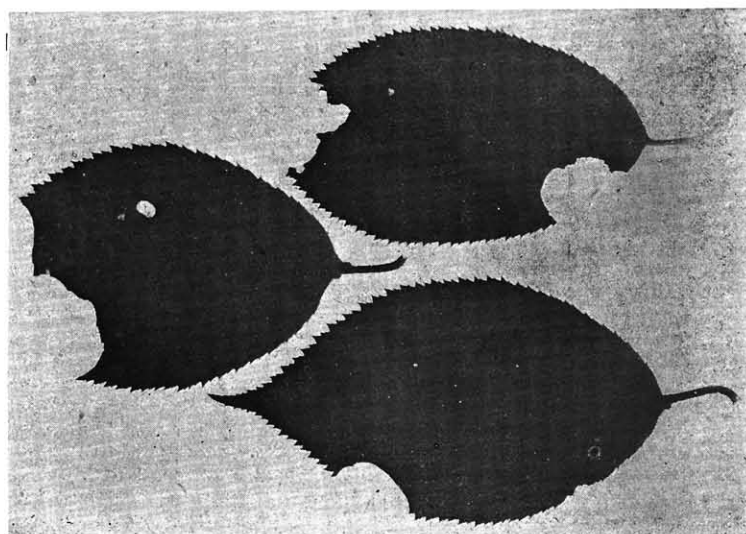


Fig. 27. Leaves of a cherry tree eaten by *Phraortes kumamotoensis*.

## B. Material and Methods

In the present series of experiments on the food consumption of *Phraortes kumamotoensis* SHIRAKI, about seventy individuals were used, and three types of plants (three species of two different families) were used in rearing the material. The experiments were arranged in the following twelve classes.

Experiments Class 1: Ten newly hatched larvae (Nos. 1-10) were used and fed three times (8 o'clock, 13 o'clock, 17 o'clock) a day on the leaves of *Lyonia Neziki* NAKAI et HARA.

Experiments Class 2: Eight newly hatched larvae (Nos. 11-18) were used and fed three times (8 o'clock, 13 o'clock, 17 o'clock) a day on the leaves *Prunus subhirtella* MIQUEL.

Experiments Class 3: Five larvae in the last instar (Nos. 19-23) were used and fed three times every other day on the leaves of *Lyonia Neziki* NAKAI et HARA.

Experiments Class 4: Five larvae in the last instar (Nos. 24-28) were used and fed three times every third day on the leaves of *Lyonia Neziki* NAKAI et HARA.

Experiments Class 5: Five larvae in the last instar (Nos. 29-33) were used and fed three times (8 o'clock, 13 o'clock, 17 o'clock) a day on the leaves of *Amelanchier asiatica* ENDLICHER.

Experiments Class 6: Five larvae in the last instar (Nos. 34-38) were used and fed three times every fourth day on the leaves of *Lyonia Neziki* NAKAI et HARA.

Experiments Class 7: Five larvae in the last instar (Nos. 39-43) were used and fed once a day (8 o'clock) on the leaves of *Lyonia Neziki* NAKAI et HARA.

Experiments Class 8: Five larvae in the last instar (Nos. 44-48) were used and fed three times every other day on the leaves of *Lyonia Neziki* NAKAI et HARA.

Experiments Class 9: Five larvae in the last instar (Nos. 49-53) were used and fed once a day (8 o'clock) on the leaves of *Lyonia Neziki* NAKAI et HARA.

Experiments Class 10: Five larvae in the last instar (Nos. 54-58) were used and fed three times every third day on the leaves of *Lyonia Neziki* NAKAI et HARA.

Experiments Class 11: Five larvae in the last instar (Nos. 59-63)

were used and fed freely all the day on the leaves of *Lyonia Neziki* NAKAI et HARA.

Experiments Class 12: Five male larvae in the last instar (Nos. 64-68) were used and fed freely all the day on the leaves of *Lyonia Neziki* NAKAI et HARA.

In order to ascertain the amount of food consumed, outlines of the leaves were drawn before feeding by placing the leaves on a sheet of paper ruled in mm squares and running a pencil along their edges; these leaves were then put at the disposal of the insects. Immediately after one meal the leaves were fitted into their respective outlines on the sheets, and the portion missing, *i.e.* consumed, was outlined. The number of square mm in the missing portion was then counted, and recorded day by day until an expected time of the growth of insects.

On the other hand, the following physical properties of the leaves eaten partly by the insects were calculated every day in the course of the experiments.

1. The thickness.
2. The live weight *per* unit volume.
3. The dry weight *per* unit volume.
4. Water contents *per* unit volume.
5. Organic matter contents *per* unit volume.
6. Ash contents *per* unit volume.

The technique used for preparing leaves for this purpose is summarized as follows.

The leaves after being measured (the live weight and the thickness) were transferred into a sulphuric acid desiccator for about two days; taken out and weighed (the dry weight and water contents) on a Farady chemical balance sensitive to one-tenth of a milligram. Next the dry leaves were subjected to a temperature of about 150°C for one or two hours, then they were taken out and weighed (ash and organic matter contents) on the same balance. These operations were repeated as often as necessary till constant weights were obtained. Comparison of the respective outlined consumed portions in square mm could confirm the actual amount of the following items taken by each individual.

1. Amount of leaves eaten.
2. Amount of organic matter consumed.
3. Amount of water taken.

In all cases the observations were made on insects isolated from the first instar in rearing cage (one insect in each). The conditions created by life in cages would not actually affect the growth of the insects. Therefore, the measurements of food consumption of the insects in captivity do represent the data that would be obtained in nature. As it did not take a long time to begin to feed on the leaves when insects were put on the given diet by forceps, the feeding experiments were easily and safely carried out from the first instar to the adult.

### C. Descriptions of the Results

The results of the present series of tests are summarized in sufficient details in Tables 50 to 159 as well as in Text-figures 29 to 49. In these tables the following abbreviations are used.

V: Volume of the leaf eaten *per* day by an insect ( $\text{mm}^3$ ).

O: (Organic matter contents in mg in V)  $\times 10^5$ .

W: (Water contents in mg in V)  $\times 10^5$ .

$\Sigma V$ : Volume of the leaf eaten by an insect in stadium n.

$\Sigma O$ : Organic matter contents in  $\Sigma V$ .

$\Sigma W$ : Water contents in  $\Sigma V$ .

$$F(\%): \frac{V_n}{V_1 + V_2 + \dots + V_n} \times 100$$

$$O': \frac{\Sigma O \text{ in stadium } n}{\text{Dry weight of exoskeleton of mesothorax of adult } *}$$

$$W': \frac{\Sigma W \text{ in stadium } n}{\text{Dry weight of exoskeleton of mesothorax of adult } *}$$

### 1. Experiments Series 1

#### Experiments Class 1

No. 1, ♀              No. 1 hatched out on April 25th and reached maturity on July 10th, its mesothorax in adult measured 17.0 mm

\* mid-legs excluded.

in length. This insect completed six moults, the normal number necessary before attaining maturity (First moult on May 7th, second on May 21st, third on June 10th, fourth on June 21st, fifth on June 29th and sixth on July 10th). The length of the post-embryonic development was 77 days (First stadium 13 days, second 14 days, third 20 days, fourth 11 days, fifth 8 days and sixth 11 days). Thus it may be said that this insect underwent a normal growth. This insect was killed on July 20th for measurement of the dry weight of the exoskeleton of mesothorax. The dry weight was 0.008 gr.

No. 2            No. 2 hatched out on April 25th and died on May 11th during the first moulting. The volume of the leaves consumed by this insect in the first stadium was equivalent to that of the insect No. 1.

No. 3, ♂            No. 3 hatched out on April 24th and attained maturity on July 5th, its mesothorax in adult measured 17.5 mm in length. This insect underwent five moults before attaining maturity (First moult on May 13th, second on May 23rd, third on June 12th, fourth on June 24th and fifth on July 5th).

The time required for the post-embryonic growth was 73 days (First stadium 20 days, second 10 days, third 20 days, fourth 12 days and fifth 11 days). After a pre-oviposition period of ten days this insect was killed on July 15th for measuring the dry weight of the exoskeleton of mesothorax. The dry weight was 0.0105 gr.

No. 4, ♀            No. 4 hatched out on April 26th and reached maturity on July 12th, its mesothorax in adult measured 16.4 mm in length. The post-embryonic development of this insect proceeded six intervals between moults (First stadium 16 days, first moult on May 12th, second stadium 17 days, second moult on May 29th, third stadium 16 days, third moult on June 14th, fourth stadium 10 days, fourth moult on June 24th, fifth stadium 8 days, fifth moult on July 2nd, sixth stadium 11 days, sixth moult on July 12th). Thus the length of the post-embryonic development was 78 days. After ten days this insect was killed for measuring of the dry weight of the exoskeleton of the mesothorax. The dry weight was 0.0098 gr.

No. 5, ♂            This insect hatched out on April 24th and attained maturity on July 7th, its mesothorax in adult measured 17.0 mm in length. This insect moulted in the normal way five times

in completing its growth (First moult on May 11th, second on May 28th, third on June 16th, fourth on June 27th and fifth moult on July 7th).

The post-embryonic growth period lasted 73 days (First stadium 16 days, second 17 days, third 19 days, fourth 11 days and fifth 10 days). This insect was killed on July 16th for measuring the dry weight of the exoskeleton of mesothorax. The dry weight was 0.0120 gr.

No. 6, ♀ No. 6 hatched out on April 24th and reached maturity on July 9th, its mesothorax in adult measured 17.0 mm in length. During the period of the post-embryonic development it underwent six moults (First moult on May 10th, second on May 21st, third on June 10th, fourth on June 21st, fifth on June 28th and the last on July 9th). The length of the post-embryonic development was 76 days (First stadium 16 days, second 11 days, third 20 days, fourth 11 days, fifth 7 days and the last 11 days). This insect was killed on July 20th after a pre-oviposition period of nine days for measuring the dry weight of the exoskeleton of mesothorax. The dry weight was 0.0104 gr.

No. 7, ♂ This insect hatched out on April 24th and reached maturity on July 9th, its mesothorax measured 16.4 mm in length. The duration of the post-embryonic development lasted 76 days (First stadium 17 days, second 12 days, third 25 days, fourth 11 days and fifth 11 days). This insect underwent in the normal manner five moults before attaining the adult stage (First moult on May 11th, second on May 23rd, third on June 16th, fourth on June 28th and fifth on July 9th). After attaining sexual maturity this insect was killed on July 20th for measuring the dry weight of the exoskeleton of mesothorax. The dry weight was 0.0048 gr.

No. 8, ♀ No. 8 hatched out on April 25th and attained maturity on July 14th, its mesothorax in adult measured 15.8 mm in length. The time necessary to pass through all stadia was 80 days (First instar 16 days, second 13 days, third 22 days, fourth 10 days, fifth 8 days and the final one 11 days). During the period of the post-embryonic growth it underwent six moults (First moult on May 11th, second on May 24th, third on June 15th, fourth on June 25th, fifth on July 3rd and the final on July 14th). This insect began to drop eggs on July 24th when it was

killed for measuring of the dry weight of the exoskeleton of mesothorax. The dry weight measured 0.0100 gr.

No. 9, ♂            No. 9 hatched out on April 24th and reached maturity on July 7th, its mesothorax in adult measured 14.2 mm in length. The length of each stadium is summarized as follows: first stadium 16 days, second 16 days, third 20 days, fourth 12 days and the last 10 days. Thus this insect underwent five moults during the post-embryonic growth period (First moult on May 11th, second on May 27th, third on June 16th, fourth on June 28th and the final on July 8th). This insect was killed on July 18th for measuring the dry weight of the exoskeleton of mesothorax. The dry weight gave the value 0.0117 gr.

No. 10, ♂            No. 10 hatched out on April 24th and underwent its first moult on May 12th. After 15 days the second moult took place, and the insect died on May 27th from an unknown cause.

#### Experiments Class 2

No. 11, ♂            No. 11 hatched out on April 26th and reached maturity on June 29th, its mesothorax in adult measured 16.2 mm in length. During the period of the post-embryonic growth it underwent five moults (First moult on May 10, second on May 22nd, third on June 2nd, fourth on June 12th and the final on July 29th). The length of the post-embryonic development was 66 days (First stadium 14 days, second 12 days, third 11 days, fourth 10 days and the last 17 days).

No. 12, ♂            This insect hatched out on May 1st and died on June 26th, five days after the fourth moult, when its mesothorax measured 16.0 mm in length. The first moult occurred on May 10th, the second on May 28th, the third on June 7th and the fourth on June 22nd respectively. The length of each stadium is summarized as follows: first stadium 9 days, second 18 days, third 10 days, fourth 15 days.

No. 13, ♂            No. 13 hatched out on April 26th and reached maturity on June 27th, its mesothorax in adult measured 17.0 mm in length. This insect moulted as normal five times before reaching the adult stage (First moult on May 11th, second on May

21st, third on June 1st, fourth on June 13th and fifth on June 27th). It took 62 days from the hatching to the emergence of the adult form (First stadium 15 days, second 10 days, third 11 days, fourth 12 days and the final 14 days). This insect was killed on July 5th for measuring the dry weight of the exoskeleton of mesothorax. The dry weight was 0.0140 gr.

No. 14, ♂ This insect hatched out on May 1st and attained maturity on June 30th, its mesothorax in adult measured 16.0 mm in length. The length of the larval growth period was 60 days (First stadium 13 days, second 11 days, third 10 days, fourth 13 days and the last 13 days). Thus the insect underwent five moults as normal during the larval period (First moult on May 13th, second on May 25th, third on June 4th, fourth on June 17th and the final on June 30th). This insect was killed on July 8th for measuring the dry weight of the exoskeleton of mesothorax. The dry weight was 0.0095 gr.

No. 15, ♂ No. 15 hatched out on April 26th and attained maturity on June 25th, its mesothorax in adult measured 16.8 mm in length. The length of the post-embryonic growth period was 60 days, taking the successive stadia as 13, 11, 10, 10 and 16 days respectively. The growth of this insect was normal and five moults took place during the larval stadia (First moult on May 9th, second on May 20th, third on May 30th, fourth on June 9th and the final on June 25th). This insect was killed on July 1st for measuring the dry weight of the exoskeleton of mesothorax. The dry weight measured 0.0090 gr.

No. 16, ♂ No. 16 hatched out on May 1st and matured on June 26th, its mesothorax in adult measured 17.0 mm in length. The duration of the post-embryonic development lasted 56 days (First stadium 11 days, second 9 days, third 10 days, fourth 12 days and fifth 14 days). During the larval stadia this insect moulted five times (First moult on May 12th, second on May 21st, third on May 31st, fourth on June 12th and the last on June 26th). This insect was killed on July 1st for measuring the dry weight of the exoskeleton of mesothorax. The dry weight was 0.0120 gr.

No. 17, ♀ No. 17 hatched out on April 26th and reached maturity on June 28th, its mesothorax measured 19.5 mm in length. The time necessary to pass through all larval stadia was 63 days

(First stadium 14 days, second 9 days, third 10 days, fourth 9 days, fifth 10 days and the final 11 days).

During the period of the post-embryonic development it underwent six moults (First moult on May 10th, second on May 10th, third on May 29th, fourth on June 7th, fifth on June 17th and the final on June 27th). After the pre-oviposition period of ten days, this insect was killed on July 7th for measuring the dry weight of the exoskeleton of mesothorax. The dry weight was 0.0245 gr. No. 18 No. 18 hatched out on April 29th, underwent two succeeding moults and died on June 2nd from an unknown cause. The first moult took place on May 13th and the second one occurred on May 29th. The first stadium lasted 15 days and the second one lasted 16 days.

Table 50. Amount of leaves eaten by *Phraortes kumamotoensis* during the larval stadia. No. 1.

| Date    | V    | O   | W   | Date    | V     | O    | W   |
|---------|------|-----|-----|---------|-------|------|-----|
| 25. iv. | 1.5  | 10  | 12  | 3. vi.  | 27.0  | 186  | 248 |
| 26. iv. | 6.2  | 43  | 57  | 4. vi.  | 51.0  | 352  | 469 |
| 27. iv. | 5.8  | 40  | 53  | 5. vi.  | 55.2  | 381  | 508 |
| 28. iv. | 8.2  | 57  | 75  | 6. vi.  | 55.0  | 380  | 506 |
| 29. iv. | 25.0 | 173 | 230 | 7. vi.  | 20.0  | 138  | 184 |
| 30. iv. | 16.0 | 110 | 147 | 8. vi.  | 50.0  | 345  | 460 |
| 1. v.   | 12.0 | 83  | 110 | 9. vi.  | 29.0  | 200  | 267 |
| 2. v.   | 16.0 | 110 | 147 | 10. vi. | 0.0   | 0    | 0   |
| 3. v.   | 14.5 | 100 | 133 | 11. vi. | 26.0  | 179  | 239 |
| 4. v.   | 11.0 | 76  | 101 | 12. vi. | 54.0  | 373  | 497 |
| 5. v.   | 24.8 | 171 | 228 | 13. vi. | 115.0 | 794  | 058 |
| 6. v.   | 0.0  | 0   | 0   | 14. vi. | 58.0  | 400  | 534 |
| 7. v.   | 0.0  | 0   | 0   | 15. vi. | 152.0 | 1049 | 398 |
| 8. v.   | 15.5 | 107 | 143 | 16. vi. | 79.0  | 545  | 727 |
| 9. v.   | 22.0 | 152 | 202 | 17. vi. | 79.0  | 545  | 727 |
| 10. v.  | 19.0 | 131 | 175 | 18. vi. | 88.0  | 607  | 810 |
| 11. v.  | 23.0 | 159 | 212 | 19. vi. | 107.0 | 738  | 984 |

|        |      |     |     |          |       |      |      |
|--------|------|-----|-----|----------|-------|------|------|
| 12. v. | 10.5 | 72  | 97  | 20. vi.  | 39.0  | 255  | 340  |
| 13. v. | 16.0 | 110 | 147 | 21. vi.  | 0.0   | 0    | 0    |
| 14. v. | 16.8 | 116 | 155 | 22. vi.  | 200.0 | 1380 | 1840 |
| 15. v. | 28.7 | 198 | 264 | 23. vi.  | 114.0 | 787  | 1049 |
| 16. v. | 38.0 | 262 | 350 | 24. vi.  | 424.0 | 2926 | 3901 |
| 17. v. | 23.0 | 159 | 212 | 25. vi.  | 375.0 | 2588 | 3450 |
| 18. v. | 97.0 | 669 | 892 | 26. vi.  | 513.0 | 3540 | 4720 |
| 19. v. | 37.0 | 255 | 340 | 27. vi.  | 237.0 | 1635 | 2180 |
| 20. v. | 20.0 | 134 | 184 | 28. vi.  | 11.0  | 76   | 101  |
| 21. v. | 20.5 | 141 | 189 | 29. vi.  | 0.0   | 0    | 0    |
| 22. v. | 11.0 | 76  | 101 | 30. vi.  | 215.0 | 1484 | 1978 |
| 23. v. | 13.0 | 89  | 120 | 1. vii.  | 486.0 | 3353 | 4471 |
| 24. v. | 13.7 | 95  | 126 | 2. vii.  | 124.0 | 856  | 1141 |
| 25. v. | 25.8 | 178 | 237 | 3. vii.  | 777.0 | 5361 | 7148 |
| 26. v. | 20.9 | 144 | 192 | 4. vii.  | 642.0 | 4430 | 5906 |
| 27. v. | 13.8 | 95  | 127 | 5. vii.  | 676.0 | 4764 | 6219 |
| 28. v. | 17.3 | 119 | 159 | 6. vii.  | 591.0 | 4078 | 5437 |
| 29. v. | 20.4 | 141 | 188 | 7. vii.  | 488.5 | 3371 | 4493 |
| 30. v. | 7.2  | 50  | 66  | 8. vii.  | 130.0 | 897  | 1196 |
| 31. v. | 23.0 | 159 | 212 | 9. vii.  | 0.0   | 0    | 0    |
| 1. vi. | 20.9 | 144 | 192 | 10. vii. | 0.0   | 0    | 0    |
| 2. vi. | 26.0 | 197 | 239 |          |       |      |      |

Table 51. The same as above. No. 2.

| Date    | V    | O  | W   | Date   | V    | O   | W   |
|---------|------|----|-----|--------|------|-----|-----|
| 25. iv. | 1.9  | 13 | 17  | 4. v.  | 22.2 | 153 | 204 |
| 26. iv. | 2.0  | 14 | 18  | 5. v.  | 22.2 | 153 | 204 |
| 27. iv. | 7.0  | 48 | 64  | 6. v.  | 0.0  | 0   | 0   |
| 28. iv. | 6.0  | 41 | 53  | 7. v.  | 1.2  | 8   | 11  |
| 29. iv. | 11.0 | 76 | 101 | 8. v.  | 1.5  | 10  | 14  |
| 30. iv. | 10.0 | 69 | 92  | 9. v.  | 20.0 | 138 | 184 |
| 1. v.   | 9.5  | 66 | 87  | 10. v. | 7.3  | 50  | 67  |
| 2. v.   | 11.5 | 79 | 106 | 11. v. | 0.0  | 0   | 0   |
| 3. v.   | 9.7  | 67 | 89  |        |      |     |     |

Table 52. The same as above. No. 3.

| Date    | V     | O   | W   | Date    | V     | O    | W    |
|---------|-------|-----|-----|---------|-------|------|------|
| 24. iv. | 2.0   | 14  | 18  | 1. vi.  | 28.5  | 197  | 262  |
| 25. iv. | 2.2   | 15  | 20  | 2. vi.  | 24.7  | 170  | 227  |
| 26. iv. | 1.8   | 12  | 17  | 3. vi.  | 27.0  | 186  | 248  |
| 27. iv. | 5.6   | 39  | 52  | 4. vi.  | 21.0  | 145  | 193  |
| 28. iv. | 7.9   | 55  | 73  | 5. vi.  | 50.6  | 349  | 466  |
| 29. iv. | 9.0   | 62  | 83  | 6. vi.  | 50.0  | 345  | 460  |
| 30. iv. | 10.0  | 69  | 92  | 7. vi.  | 51.0  | 352  | 469  |
| 1. v.   | 0.0   | 0   | 0   | 8. vi.  | 25.0  | 173  | 230  |
| 2. v.   | 8.0   | 55  | 74  | 9. vi.  | 53.9  | 372  | 496  |
| 3. v.   | 0.0   | 0   | 0   | 10. vi. | 53.2  | 367  | 489  |
| 4. v.   | 13.5  | 93  | 124 | 11. vi. | 39.0  | 269  | 359  |
| 5. v.   | 6.0   | 41  | 55  | 12. vi. | 0.0   | 0    | 0    |
| 6. v.   | 19.3  | 133 | 178 | 13. vi. | 0.0   | 0    | 0    |
| 7. v.   | 15.8  | 109 | 145 | 14. vi. | 90.0  | 628  | 828  |
| 8. v.   | 23.7  | 164 | 218 | 15. vi. | 60.7  | 419  | 568  |
| 9. v.   | 34.9  | 241 | 321 | 16. vi. | 99.0  | 683  | 911  |
| 10. v.  | 24.2  | 167 | 223 | 17. vi. | 42.0  | 290  | 386  |
| 11. v.  | 23.0  | 159 | 212 | 18. vi. | 64.0  | 442  | 589  |
| 12. v.  | 26.0  | 179 | 239 | 19. vi. | 168.0 | 1159 | 1546 |
| 13. v.  | 0.0   | 0   | 0   | 20. vi. | 120.0 | 828  | 1104 |
| 14. v.  | 0.0   | 0   | 0   | 21. vi. | 163.6 | 1129 | 1505 |
| 15. v.  | 0.0   | 0   | 0   | 22. vi. | 136.6 | 943  | 1257 |
| 16. v.  | 49.0  | 338 | 451 | 23. vi. | 174.0 | 1201 | 1601 |
| 17. v.  | 0.0   | 0   | 0   | 24. vi. | 0.0   | 0    | 0    |
| 18. v.  | 94.0  | 649 | 865 | 25. vi. | 25.0  | 173  | 230  |
| 19. v.  | 74.5  | 514 | 685 | 26. vi. | 289.0 | 1994 | 2659 |
| 20. v.  | 100.6 | 694 | 926 | 27. vi. | 303.5 | 2094 | 2792 |
| 21. v.  | 26.0  | 179 | 239 | 28. vi. | 265.0 | 1829 | 2438 |
| 22. v.  | 15.1  | 104 | 139 | 29. vi. | 320.7 | 2213 | 2950 |
| 23. v.  | 0.0   | 0   | 0   | 30. vi. | 311.0 | 2056 | 2861 |
| 24. v.  | 0.0   | 0   | 0   | 1. vii. | 397.0 | 2739 | 3652 |
| 25. v.  | 29.3  | 202 | 270 | 2. vii. | 290.0 | 2001 | 2668 |
| 26. v.  | 30.8  | 213 | 283 | 3. vii. | 293.5 | 2025 | 2700 |
| 27. v.  | 26.3  | 181 | 242 | 4. vii. | 0.0   | 0    | 0    |
| 28. v.  | 20.0  | 138 | 184 | 5. vii. | 0.0   | 0    | 0    |
| 29. v.  | 11.8  | 81  | 109 |         |       |      |      |
| 30. v.  | 47.2  | 326 | 434 |         |       |      |      |
| 31. v.  | 16.0  | 110 | 147 |         |       |      |      |

Table 53. The same as above. No. 4.

| Date    | V    | O   | W   | Date     | V     | O    | W    |
|---------|------|-----|-----|----------|-------|------|------|
| 26. iv. | 2.6  | 18  | 24  | 4. vi.   | 16.0  | 110  | 147  |
| 27. iv. | 2.3  | 16  | 21  | 5. vi.   | 27.9  | 193  | 257  |
| 28. iv. | 3.8  | 26  | 35  | 6. vi.   | 23.2  | 160  | 213  |
| 29. iv. | 7.3  | 50  | 67  | 7. vi.   | 34.5  | 238  | 317  |
| 30. iv. | 13.7 | 95  | 126 | 8. vi.   | 46.3  | 319  | 426  |
| 1. v.   | 0.0  | 0   | 0   | 9. vi.   | 43.8  | 302  | 403  |
| 2. v.   | 3.1  | 21  | 29  | 10. vi.  | 75.2  | 519  | 692  |
| 3. v.   | 10.2 | 70  | 94  | 11. vi.  | 38.0  | 262  | 350  |
| 4. v.   | 12.2 | 84  | 112 | 12. vi.  | 47.0  | 324  | 432  |
| 5. v.   | 0.0  | 0   | 0   | 13. vi.  | 0.0   | 0    | 0    |
| 6. v.   | 17.5 | 121 | 161 | 14. vi.  | 11.0  | 76   | 101  |
| 7. v.   | 31.5 | 217 | 290 | 15. vi.  | 49.8  | 344  | 458  |
| 8. v.   | 25.5 | 176 | 235 | 16. vi.  | 72.0  | 497  | 662  |
| 9. v.   | 37.2 | 257 | 342 | 17. vi.  | 62.0  | 428  | 570  |
| 10. v.  | 30.9 | 213 | 284 | 18. vi.  | 122.0 | 842  | 1122 |
| 11. v.  | 0.0  | 0   | 0   | 19. vi.  | 163.0 | 1123 | 1500 |
| 12. v.  | 0.0  | 0   | 0   | 20. vi.  | 162.0 | 1118 | 1490 |
| 13. v.  | 0.0  | 0   | 0   | 21. vi.  | 202.0 | 1394 | 1858 |
| 14. v.  | 0.0  | 0   | 0   | 22. vi.  | 84.0  | 580  | 773  |
| 15. v.  | 23.0 | 159 | 212 | 23. vi.  | 0.0   | 0    | 0    |
| 16. v.  | 13.8 | 95  | 127 | 24. vi.  | 0.0   | 0    | 0    |
| 17. v.  | 11.5 | 79  | 106 | 25. vi.  | 215.0 | 1484 | 1978 |
| 18. v.  | 78.8 | 544 | 725 | 26. vi.  | 399.0 | 2753 | 3671 |
| 19. v.  | 39.0 | 269 | 359 | 27. vi.  | 361.6 | 2395 | 2327 |
| 20. v.  | 5.2  | 36  | 48  | 28. vi.  | 502.8 | 3469 | 4626 |
| 21. v.  | 6.2  | 43  | 57  | 29. vi.  | 293.0 | 2022 | 2696 |
| 22. v.  | 31.6 | 218 | 291 | 30. vi.  | 272.0 | 1877 | 2502 |
| 23. v.  | 16.0 | 110 | 147 | 1. vii.  | 0.0   | 0    | 0    |
| 24. v.  | 32.5 | 224 | 299 | 2. vii.  | 6.0   | 414  | 552  |
| 25. v.  | 42.6 | 294 | 392 | 3. vii.  | 297.0 | 2049 | 2732 |
| 26. v.  | 6.3  | 43  | 58  | 4. vii.  | 288.0 | 1987 | 2650 |
| 27. v.  | 13.0 | 90  | 120 | 5. vii.  | 601.0 | 4147 | 5529 |
| 28. v.  | 7.0  | 48  | 64  | 6. vii.  | 515.5 | 3557 | 4743 |
| 29. v.  | 3.2  | 22  | 29  | 7. vii.  | 765.0 | 5279 | 7038 |
| 30. v.  | 17.8 | 123 | 164 | 8. vii.  | 253.0 | 1746 | 2328 |
| 31. v.  | 23.2 | 160 | 213 | 9. vii.  | 406.0 | 2801 | 3735 |
| 1. vi.  | 19.9 | 137 | 183 | 10. vii. | 150.0 | 1035 | 1380 |
| 2. vi.  | 28.8 | 199 | 265 | 11. vii. | 0.0   | 0    | 0    |
| 3. vi.  | 23.3 | 161 | 214 | 12. vii. | 0.0   | 0    | 0    |

Table 54. The same as above. No. 5.

| Date    | V    | O   | W   | Date    | V     | O    | W     |
|---------|------|-----|-----|---------|-------|------|-------|
| 24. iv. | 0.2  | 1   | 2   | 31. v.  | 27.9  | 193  | 257   |
| 25. iv. | 0.3  | 2   | 3   | 1. vi.  | 14.4  | 99   | 132   |
| 26. iv. | 1.4  | 10  | 13  | 2. vi.  | 28.9  | 199  | 266   |
| 27. iv. | 2.0  | 14  | 18  | 3. vi.  | 20.8  | 144  | 191   |
| 28. iv. | 13.0 | 90  | 120 | 4. vi.  | 25.5  | 176  | 235   |
| 29. iv. | 16.0 | 110 | 147 | 5. vi.  | 44.7  | 308  | 411   |
| 30. iv. | 11.1 | 77  | 102 | 6. vi.  | 54.2  | 374  | 499   |
| 1. v.   | 12.0 | 83  | 110 | 7. vi.  | 44.6  | 308  | 410   |
| 2. v.   | 0.0  | 0   | 0   | 8. vi.  | 41.4  | 286  | 381   |
| 3. v.   | 16.5 | 114 | 152 | 9. vi.  | 11.3  | 77   | 104   |
| 4. v.   | 14.3 | 99  | 132 | 10. vi. | 10.8  | 75   | 99    |
| 5. v.   | 15.4 | 106 | 142 | 11. vi. | 70.0  | 483  | 644   |
| 6. v.   | 25.0 | 173 | 230 | 12. vi. | 55.0  | 380  | 506   |
| 7. v.   | 26.8 | 185 | 247 | 13. vi. | 5.5   | 38   | 51    |
| 8. v.   | 0.0  | 0   | 0   | 14. vi. | 32.9  | 227  | 303   |
| 9. v.   | 0.0  | 0   | 0   | 15. vi. | 0.0   | 0    | 0     |
| 10. v.  | 0.0  | 0   | 0   | 16. vi. | 4.2   | 29   | 37    |
| 11. v.  | 11.0 | 76  | 101 | 17. vi. | 51.0  | 352  | 469   |
| 12. v.  | 0.0  | 0   | 0   | 18. vi. | 75.3  | 520  | 693   |
| 13. v.  | 8.4  | 58  | 77  | 19. vi. | 80.0  | 552  | 736   |
| 14. v.  | 0.0  | 0   | 0   | 20. vi. | 58.4  | 403  | 537   |
| 15. v.  | 20.8 | 144 | 191 | 21. vi. | 90.3  | 623  | 831   |
| 16. v.  | 53.9 | 372 | 496 | 22. vi. | 146.8 | 1013 | 1351  |
| 17. v.  | 49.0 | 338 | 451 | 23. vi. | 168.0 | 1159 | 1546  |
| 18. v.  | 23.2 | 160 | 213 | 24. vi. | 199.3 | 1375 | 1834  |
| 19. v.  | 38.0 | 262 | 350 | 25. vi. | 90.3  | 623  | 831   |
| 20. v.  | 17.0 | 117 | 156 | 26. vi. | 0.0   | 0    | 0     |
| 21. v.  | 28.7 | 198 | 264 | 27. vi. | 140.1 | 967  | 1289  |
| 22. v.  | 25.0 | 173 | 230 | 28. vi. | 430.7 | 2972 | 3962  |
| 23. v.  | 16.2 | 112 | 149 | 29. vi. | 211.0 | 1556 | 1941  |
| 24. v.  | 16.5 | 114 | 152 | 30. vi. | 407.8 | 2814 | 3752  |
| 25. v.  | 13.7 | 95  | 126 | 1. vii. | 270.0 | 1863 | 2484  |
| 26. v.  | 0.0  | 0   | 0   | 2. vii. | 360.6 | 2488 | 3316  |
| 27. v.  | 0.0  | 0   | 0   | 3. vii. | 333.0 | 2298 | 3064  |
| 28. v.  | 12.7 | 88  | 117 | 4. vii. | 120.0 | 8280 | 11040 |
| 29. v.  | 22.7 | 157 | 207 | 5. vii. | 0.0   | 0    | 0     |
| 30. v.  | 26.0 | 179 | 239 | 6. vii. | 0.0   | 0    | 0     |

Table 55. The same as above. No. 6.

| Date    | V    | O   | W   | Date    | V     | O    | W    |
|---------|------|-----|-----|---------|-------|------|------|
| 24. iv. | 1.2  | 8   | 11  | 2. vi.  | 32.5  | 224  | 299  |
| 25. iv. | 1.8  | 12  | 17  | 3. vi.  | 53.0  | 366  | 488  |
| 26. iv. | 1.7  | 12  | 16  | 4. vi.  | 66.0  | 455  | 607  |
| 27. iv. | 14.0 | 97  | 129 | 5. vi.  | 49.0  | 338  | 451  |
| 28. iv. | 11.0 | 76  | 101 | 6. vi.  | 87.0  | 600  | 800  |
| 29. iv. | 14.7 | 101 | 135 | 7. vi.  | 25.0  | 173  | 230  |
| 30. iv. | 8.0  | 55  | 74  | 8. vi.  | 40.0  | 276  | 368  |
| 1. v.   | 5.0  | 35  | 46  | 9. vi.  | 0.0   | 0    | 0    |
| 2. v.   | 11.5 | 79  | 106 | 10. vi. | 0.0   | 0    | 0    |
| 3. v.   | 6.2  | 43  | 57  | 11. vi. | 27.0  | 186  | 248  |
| 4. v.   | 14.9 | 103 | 137 | 12. vi. | 37.0  | 255  | 340  |
| 5. v.   | 21.8 | 150 | 201 | 13. vi. | 128.0 | 883  | 1178 |
| 6. v.   | 5.3  | 37  | 49  | 14. vi. | 82.8  | 571  | 762  |
| 7. v.   | 28.4 | 196 | 261 | 15. vi. | 206.0 | 1421 | 1895 |
| 8. v.   | 26.8 | 185 | 247 | 16. vi. | 79.8  | 451  | 734  |
| 9. v.   | 0.0  | 0   | 0   | 17. vi. | 134.5 | 928  | 1237 |
| 10. v.  | 4.2  | 29  | 39  | 18. vi. | 170.5 | 1176 | 1569 |
| 11. v.  | 22.5 | 155 | 207 | 19. vi. | 118.5 | 818  | 1090 |
| 12. v.  | 10.3 | 71  | 95  | 20. vi. | 0.0   | 0    | 0    |
| 13. v.  | 3.0  | 21  | 28  | 21. vi. | 6.3   | 43   | 58   |
| 14. v.  | 46.6 | 322 | 429 | 22. vi. | 254.5 | 1756 | 2341 |
| 15. v.  | 2.8  | 19  | 26  | 23. vi. | 230.0 | 1587 | 2116 |
| 16. v.  | 63.9 | 441 | 588 | 24. vi. | 400.3 | 2762 | 3683 |
| 17. v.  | 76.4 | 527 | 703 | 25. vi. | 415.0 | 2864 | 3818 |
| 18. v.  | 70.0 | 483 | 644 | 26. vi. | 420.7 | 2903 | 3870 |
| 19. v.  | 7.0  | 48  | 64  | 27. vi. | 292.5 | 2018 | 2691 |
| 20. v.  | 0.0  | 0   | 0   | 28. vi. | 0.0   | 0    | 0    |
| 21. v.  | 0.0  | 0   | 0   | 29. vi. | 175.5 | 1211 | 1615 |
| 22. v.  | 4.9  | 34  | 45  | 30. vi. | 706.2 | 4873 | 6497 |
| 23. v.  | 18.5 | 128 | 170 | 1. vii. | 721.6 | 4979 | 6639 |
| 24. v.  | 17.5 | 121 | 161 | 2. vii. | 581.8 | 4014 | 5353 |
| 25. v.  | 23.0 | 159 | 212 | 3. vii. | 671.2 | 4631 | 6175 |
| 26. v.  | 27.8 | 192 | 256 | 4. vii. | 850.0 | 5865 | 7820 |
| 27. v.  | 26.4 | 182 | 243 | 5. vii. | 724.4 | 4998 | 6664 |
| 28. v.  | 10.0 | 69  | 92  | 5. vii. | 492.5 | 3398 | 4531 |
| 29. v.  | 34.1 | 235 | 314 | 7. vii. | 103.5 | 714  | 952  |
| 30. v.  | 12.2 | 84  | 112 | 8. vii. | 0.0   | 0    | 0    |
| 31. v.  | 36.5 | 252 | 336 | 9. vii. | 0.0   | 0    | 0    |
| 1. vi.  | 29.0 | 200 | 267 |         |       |      |      |

Table 56. The same as above. No. 7.

| Date    | V    | O   | W   | Date    | V     | O    | W    |
|---------|------|-----|-----|---------|-------|------|------|
| 24. iv. | 1.9  | 13  | 17  | 2. vi.  | 15.2  | 105  | 140  |
| 25. vi. | 2.4  | 17  | 22  | 3. vi.  | 13.7  | 95   | 126  |
| 26. vi. | 2.3  | 16  | 21  | 4. vi.  | 20.8  | 143  | 191  |
| 27. vi. | 10.7 | 74  | 98  | 5. vi.  | 10.2  | 70   | 94   |
| 28. vi. | 10.1 | 70  | 93  | 6. vi.  | 35.0  | 242  | 322  |
| 29. vi. | 14.8 | 102 | 136 | 7. vi.  | 34.3  | 237  | 316  |
| 30. vi. | 7.3  | 50  | 67  | 8. vi.  | 29.0  | 200  | 267  |
| 1. v.   | 20.2 | 139 | 186 | 9. vi.  | 55.2  | 381  | 508  |
| 2. v.   | 8.3  | 57  | 76  | 10. vi. | 58.0  | 400  | 534  |
| 3. v.   | 28.0 | 193 | 258 | 11. vi. | 70.6  | 487  | 650  |
| 4. v.   | 13.0 | 90  | 120 | 12. vi. | 38.3  | 264  | 352  |
| 5. v.   | 11.8 | 81  | 109 | 13. vi. | 90.5  | 624  | 833  |
| 6. v.   | 35.0 | 242 | 322 | 14. vi. | 76.1  | 525  | 700  |
| 7. v.   | 35.9 | 248 | 330 | 15. vi. | 34.0  | 235  | 313  |
| 8. v.   | 32.0 | 221 | 294 | 16. vi. | 0.0   | 0    | 0    |
| 9. v.   | 0.0  | 0   | 0   | 17. vi. | 7.1   | 49   | 65   |
| 10. v.  | 0.0  | 0   | 0   | 18. vi. | 46.3  | 319  | 426  |
| 11. v.  | 4.2  | 29  | 37  | 19. vi. | 91.5  | 631  | 842  |
| 12. v.  | 24.2 | 167 | 223 | 20. vi. | 167.0 | 1152 | 1536 |
| 13. v.  | 26.0 | 179 | 239 | 21. vi. | 130.0 | 897  | 1196 |
| 14. v.  | 35.5 | 245 | 327 | 22. vi. | 91.0  | 628  | 837  |
| 15. v.  | 79.0 | 545 | 727 | 23. vi. | 169.0 | 1166 | 1555 |
| 16. v.  | 31.9 | 220 | 293 | 24. vi. | 170.0 | 1173 | 1564 |
| 17. v.  | 67.3 | 464 | 619 | 25. vi. | 183.5 | 1266 | 1688 |
| 18. v.  | 83.8 | 578 | 771 | 26. vi. | 83.0  | 573  | 764  |
| 19. v.  | 25.0 | 172 | 230 | 27. vi. | 0.0   | 0    | 0    |
| 20. v.  | 0.0  | 0   | 0   | 28. vi. | 0.0   | 0    | 0    |
| 21. v.  | 0.0  | 0   | 0   | 29. vi. | 127.2 | 878  | 1170 |
| 22. v.  | 80.5 | 555 | 741 | 30. vi. | 334.8 | 2310 | 3080 |
| 23. v.  | 11.0 | 76  | 101 | 1. vii. | 274.5 | 1894 | 2526 |
| 24. v.  | 0.0  | 0   | 0   | 2. vii. | 331.3 | 2286 | 3048 |
| 25. v.  | 0.0  | 0   | 0   | 3. vii. | 271.5 | 1873 | 2498 |
| 26. v.  | 13.3 | 92  | 122 | 4. vii. | 388.5 | 2681 | 3574 |
| 27. v.  | 21.0 | 145 | 193 | 5. vii. | 263.5 | 1818 | 2424 |
| 28. v.  | 11.9 | 82  | 109 | 6. vii. | 95.5  | 559  | 879  |
| 29. v.  | 19.0 | 131 | 175 | 7. vii. | 203.0 | 1401 | 1868 |
| 30. v.  | 30.4 | 210 | 280 | 8. vii. | 0.0   | 0    | 0    |
| 31. v.  | 8.6  | 59  | 79  | 9. vii. | 0.0   | 0    | 0    |
| 1. vi.  | 19.7 | 136 | 181 |         |       |      |      |

Table 57. The same as above. No. 8.

| Date    | V     | O    | W    | Date     | V     | O    | W    |
|---------|-------|------|------|----------|-------|------|------|
| 25. iv. | 0.0   | 0    | 0    | 5. vi.   | 29.0  | 200  | 267  |
| 26. iv. | 2.0   | 14   | 18   | 6. vi.   | 61.7  | 426  | 568  |
| 27. iv. | 2.5   | 17   | 23   | 7. vi.   | 53.0  | 366  | 488  |
| 28. iv. | 5.0   | 35   | 46   | 8. vi.   | 43.5  | 300  | 400  |
| 29. iv. | 7.0   | 48   | 64   | 9. vi.   | 71.0  | 490  | 653  |
| 30. iv. | 17.0  | 117  | 156  | 10. vi.  | 1.0   | 7    | 9    |
| 1. v.   | 15.9  | 110  | 145  | 11. vi.  | 24.3  | 168  | 224  |
| 2. v.   | 10.6  | 73   | 98   | 12. vi.  | 63.8  | 440  | 587  |
| 3. v.   | 1.8   | 12   | 17   | 13. vi.  | 27.0  | 206  | 248  |
| 4. v.   | 27.3  | 188  | 251  | 14. vi.  | 0.0   | 0    | 0    |
| 5. v.   | 0.0   | 0    | 0    | 15. vi.  | 0.0   | 0    | 0    |
| 6. v.   | 23.8  | 164  | 219  | 16. vi.  | 46.7  | 320  | 410  |
| 7. v.   | 8.0   | 55   | 74   | 17. vi.  | 77.5  | 535  | 713  |
| 8. v.   | 32.0  | 221  | 294  | 18. vi.  | 36.0  | 248  | 331  |
| 9. v.   | 18.8  | 130  | 173  | 19. vi.  | 184.5 | 1273 | 1697 |
| 10. v.  | 0.0   | 0    | 0    | 20. vi.  | 82.8  | 571  | 762  |
| 11. v.  | 0.0   | 0    | 0    | 21. vi.  | 125.0 | 863  | 1150 |
| 12. v.  | 15.8  | 109  | 145  | 22. vi.  | 130.0 | 897  | 1196 |
| 13. v.  | 26.5  | 183  | 245  | 23. vi.  | 120.8 | 836  | 1111 |
| 14. v.  | 3.8   | 26   | 35   | 24. vi.  | 167.0 | 1152 | 1536 |
| 15. v.  | 62.9  | 434  | 579  | 25. vi.  | 0.0   | 0    | 0    |
| 16. v.  | 20.5  | 141  | 189  | 26. vi.  | 21.3  | 147  | 196  |
| 17. v.  | 0.0   | 0    | 0    | 27. vi.  | 229.0 | 1580 | 2107 |
| 18. v.  | 77.2  | 533  | 710  | 28. vi.  | 182.3 | 1258 | 1677 |
| 19. v.  | 44.1  | 304  | 406  | 29. vi.  | 408.5 | 2819 | 3758 |
| 20. v.  | 149.7 | 1033 | 1377 | 30. vi.  | 286.8 | 1979 | 2639 |
| 21. v.  | 54.3  | 375  | 500  | 1. vii.  | 466.5 | 3219 | 4292 |
| 22. v.  | 0.0   | 0    | 0    | 2. vii.  | 167.0 | 1152 | 1536 |
| 23. v.  | 0.0   | 0    | 0    | 3. vii.  | 0.0   | 0    | 0    |
| 24. v.  | 0.0   | 0    | 0    | 4. vii.  | 91.8  | 633  | 845  |
| 25. v.  | 11.2  | 77   | 103  | 5. vii.  | 379.5 | 2619 | 3491 |
| 26. v.  | 24.5  | 169  | 225  | 6. vii.  | 766.5 | 5289 | 7052 |
| 27. v.  | 9.9   | 68   | 91   | 7. vii.  | 496.5 | 3426 | 4568 |
| 28. v.  | 17.6  | 121  | 162  | 8. vii.  | 576.0 | 3974 | 5299 |
| 29. v.  | 15.7  | 108  | 144  | 9. vii.  | 484.3 | 3342 | 4456 |
| 30. v.  | 26.0  | 179  | 239  | 10. vii. | 419.8 | 2897 | 3862 |
| 31. v.  | 11.9  | 82   | 109  | 11. vii. | 455.3 | 3142 | 4189 |
| 1. vi.  | 21.6  | 149  | 199  | 12. vii. | 270.0 | 1863 | 2484 |
| 2. vi.  | 10.0  | 69   | 92   | 13. vii. | 0.0   | 0    | 0    |
| 3. vi.  | 22.4  | 155  | 206  | 14. vii. | 0.0   | 0    | 0    |
| 4. vi.  | 28.8  | 199  | 265  |          |       |      |      |

Table 58. The same as above. No. 9.

| Date    | V    | O   | W   | Date    | V     | O    | W    |
|---------|------|-----|-----|---------|-------|------|------|
| 24. iv. | 1.8  | 12  | 17  | 1. vi.  | 33.0  | 228  | 304  |
| 25. iv. | 1.6  | 11  | 15  | 2. vi.  | 6.0   | 41   | 55   |
| 26. iv. | 1.7  | 12  | 16  | 3. vi.  | 18.1  | 125  | 167  |
| 27. iv. | 4.8  | 33  | 44  | 4. vi.  | 18.3  | 126  | 168  |
| 28. iv. | 8.5  | 53  | 78  | 5. vi.  | 21.3  | 147  | 196  |
| 29. iv. | 6.6  | 46  | 61  | 6. vi.  | 36.0  | 248  | 331  |
| 30. iv. | 14.0 | 97  | 129 | 7. vi.  | 40.0  | 276  | 368  |
| 1. v.   | 12.5 | 86  | 115 | 8. vi.  | 37.0  | 255  | 340  |
| 2. v.   | 11.6 | 80  | 107 | 9. vi.  | 53.0  | 366  | 488  |
| 3. v.   | 7.5  | 52  | 69  | 10. vi. | 28.0  | 193  | 258  |
| 4. v.   | 0.0  | 0   | 0   | 11. vi. | 50.0  | 345  | 460  |
| 5. v.   | 24.6 | 170 | 226 | 12. vi. | 43.0  | 297  | 396  |
| 6. v.   | 13.0 | 90  | 120 | 13. vi. | 44.8  | 309  | 412  |
| 7. v.   | 29.0 | 200 | 267 | 14. vi. | 5.2   | 36   | 48   |
| 8. v.   | 3.8  | 26  | 35  | 15. vi. | 0.0   | 0    | 0    |
| 9. v.   | 0.0  | 0   | 0   | 16. vi. | 13.0  | 90   | 120  |
| 10. v.  | 0.0  | 0   | 0   | 17. vi. | 43.3  | 299  | 399  |
| 11. v.  | 10.0 | 69  | 92  | 18. vi. | 0.0   | 0    | 0    |
| 12. v.  | 20.6 | 142 | 190 | 19. vi. | 70.6  | 487  | 650  |
| 13. v.  | 5.8  | 40  | 53  | 20. vi. | 40.0  | 276  | 368  |
| 14. v.  | 17.0 | 117 | 156 | 21. vi. | 125.0 | 863  | 1150 |
| 15. v.  | 0.0  | 0   | 0   | 22. vi. | 81.2  | 560  | 747  |
| 16. v.  | 14.7 | 101 | 135 | 23. vi. | 143.0 | 987  | 1316 |
| 17. v.  | 12.8 | 88  | 118 | 24. vi. | 77.0  | 531  | 708  |
| 18. v.  | 68.5 | 473 | 630 | 25. vi. | 203.0 | 1401 | 1868 |
| 19. v.  | 63.8 | 440 | 587 | 26. vi. | 51.5  | 355  | 474  |
| 20. v.  | 44.3 | 306 | 408 | 27. vi. | 0.0   | 0    | 0    |
| 21. v.  | 62.0 | 428 | 570 | 28. vi. | 314.5 | 2170 | 2893 |
| 22. v.  | 1.2  | 8   | 11  | 29. vi. | 192.0 | 1325 | 1766 |
| 23. v.  | 0.0  | 0   | 0   | 30. vi. | 261.3 | 1803 | 2404 |
| 24. v.  | 6.3  | 43  | 58  | 1. vii. | 237.2 | 1637 | 2182 |
| 25. v.  | 0.0  | 0   | 0   | 2. vii. | 148.5 | 1025 | 1366 |
| 26. v.  | 0.0  | 0   | 0   | 3. vii. | 293.7 | 2027 | 2702 |
| 27. v.  | 16.0 | 110 | 147 | 4. vii. | 361.1 | 2492 | 3322 |
| 28. v.  | 25.4 | 175 | 234 | 5. vii. | 257.8 | 1779 | 2372 |
| 29. v.  | 26.1 | 180 | 240 | 6. vii. | 80.2  | 553  | 738  |
| 30. v.  | 34.6 | 239 | 318 | 7. vii. | 0.0   | 0    | 0    |
| 31. v.  | 3.5  | 24  | 32  |         |       |      |      |

Table 59. The same as above. No. 10.

| Date    | V    | O   | W   | Date   | V    | O   | W   |
|---------|------|-----|-----|--------|------|-----|-----|
| 24. iv. | 0.5  | 3   | 5   | 11. v. | 0.0  | 0   | 0   |
| 25. iv. | 1.0  | 7   | 9   | 12. v. | 0.0  | 0   | 0   |
| 26. iv. | 2.5  | 17  | 22  | 13. v. | 7.0  | 48  | 64  |
| 27. iv. | 3.0  | 21  | 28  | 14. v. | 10.3 | 71  | 95  |
| 28. iv. | 3.2  | 22  | 29  | 15. v. | 20.0 | 138 | 184 |
| 29. iv. | 8.0  | 55  | 74  | 16. v. | 28.0 | 193 | 258 |
| 30. iv. | 12.0 | 73  | 110 | 17. v. | 6.8  | 47  | 63  |
| 1. v.   | 13.8 | 95  | 127 | 18. v. | 27.7 | 191 | 255 |
| 2. v.   | 11.0 | 76  | 101 | 19. v. | 48.4 | 334 | 445 |
| 3. v.   | 0.0  | 0   | 0   | 20. v. | 49.3 | 340 | 454 |
| 4. v.   | 18.9 | 130 | 174 | 21. v. | 4.0  | 28  | 37  |
| 5. v.   | 14.8 | 102 | 136 | 22. v. | 15.4 | 106 | 142 |
| 6. v.   | 19.0 | 131 | 175 | 23. v. | 4.2  | 29  | 39  |
| 7. v.   | 11.9 | 82  | 109 | 24. v. | 6.3  | 43  | 58  |
| 8. v.   | 17.9 | 119 | 159 | 25. v. | 11.7 | 81  | 108 |
| 9. v.   | 21.1 | 146 | 194 | 26. v. | 7.2  | 50  | 62  |
| 10. v.  | 3.0  | 21  | 28  |        |      |     |     |

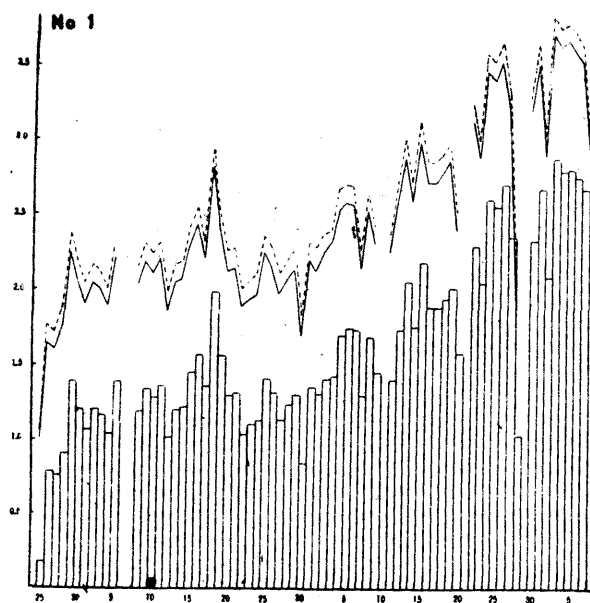
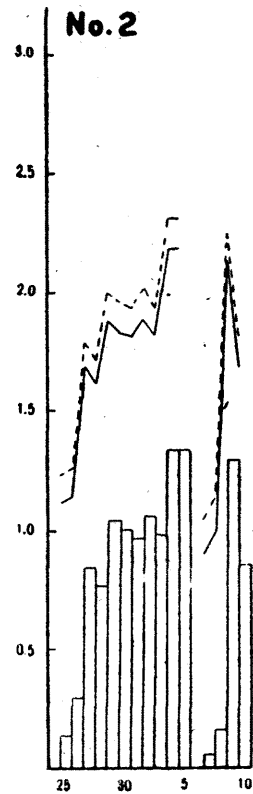
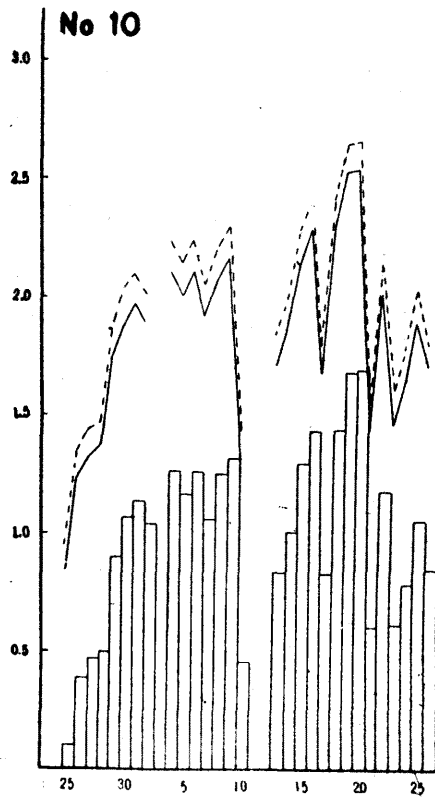
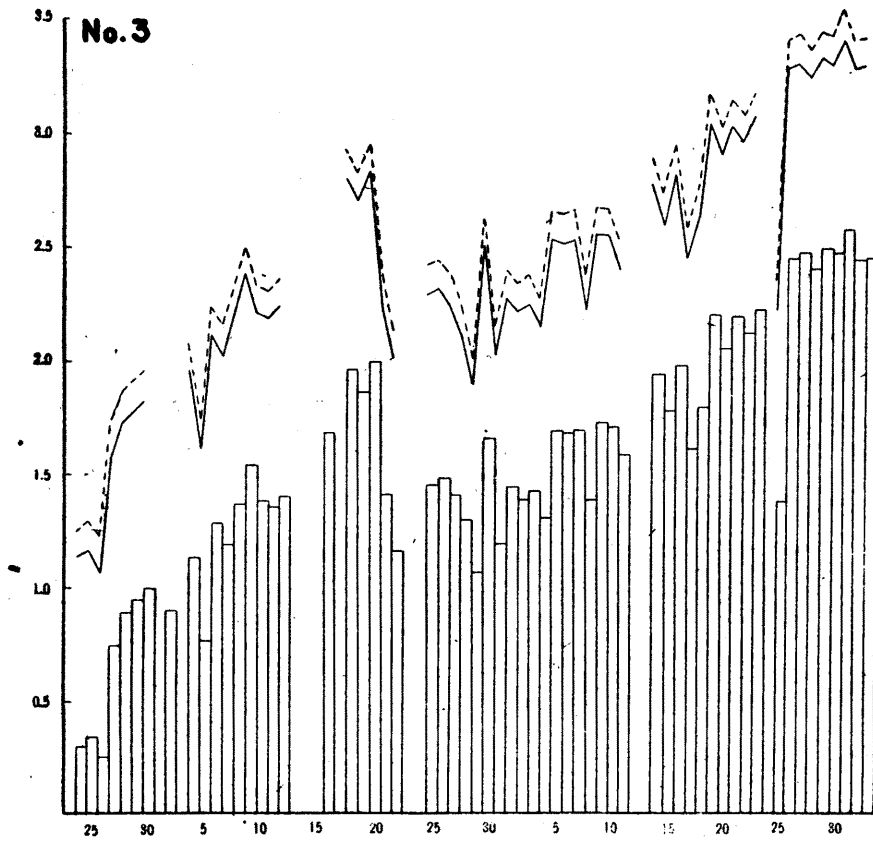
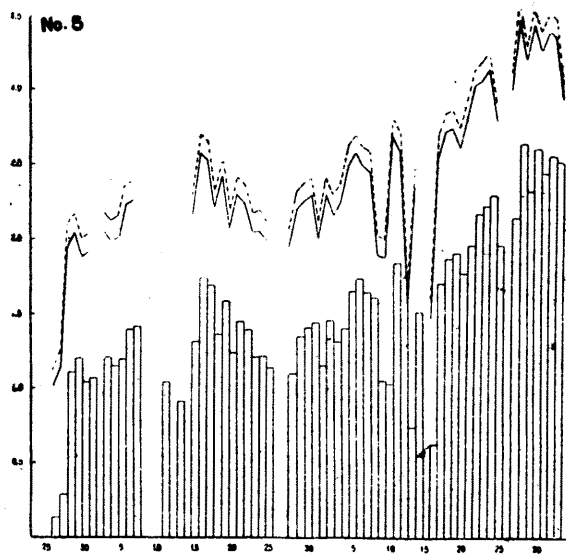
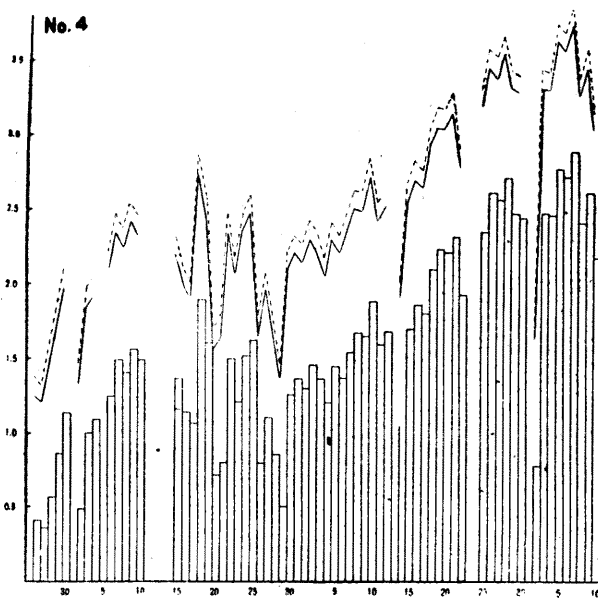


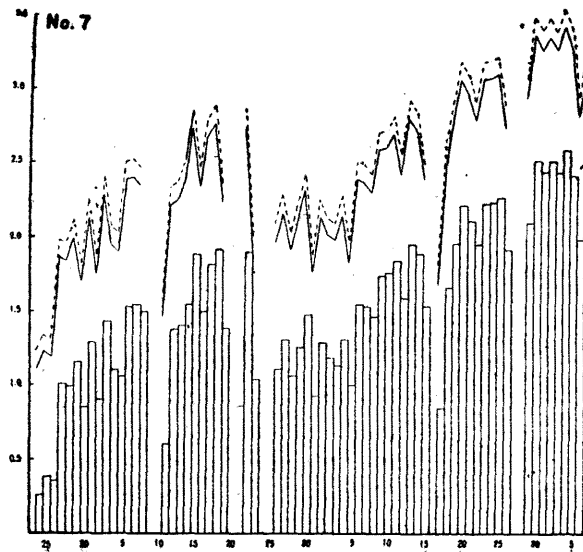
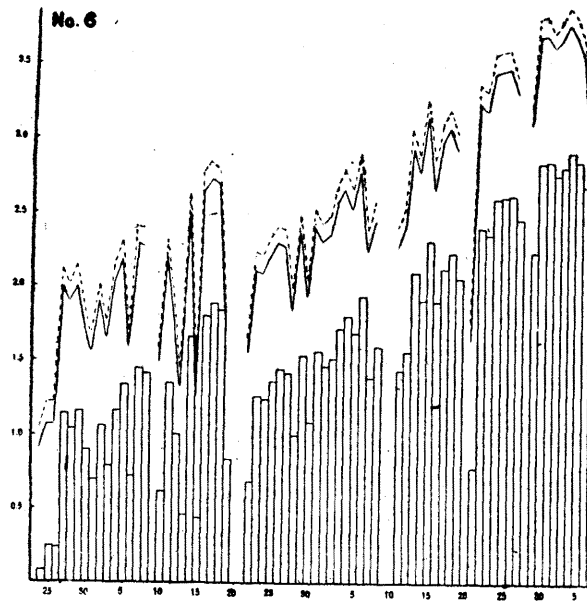
Fig. 29. Amount of leaves eaten by *Phraortes kumamotoensis* during the larval stadia. Abscissa represents time in date from April to July. Ordinate represents the logarithms of the measured values. Broken line indicates log W. Full line indicates log O. Square represents log V.







Keizo YASUMATSU



## Analyses on the Growth of Insects

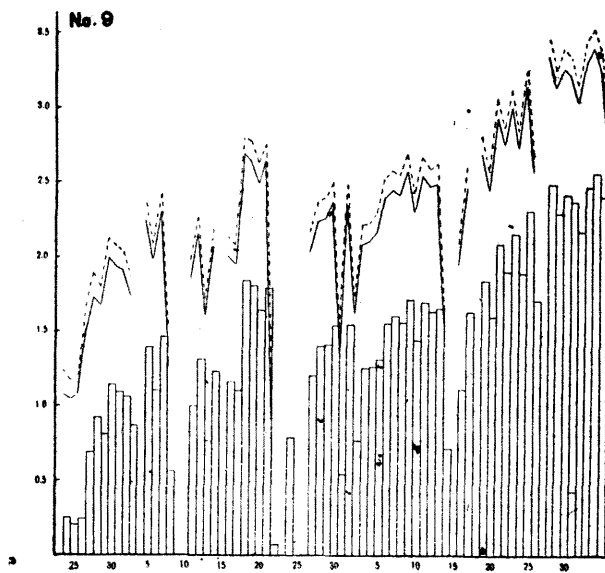
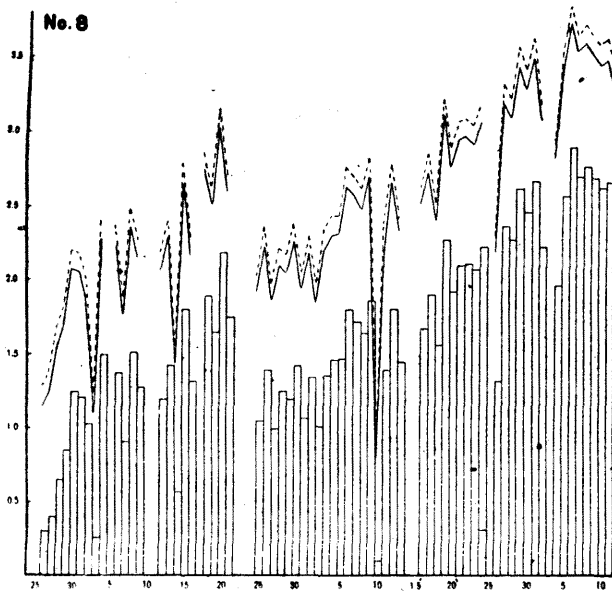


Table 60. Amount of leaves eaten by *Phraortes kumamotoensis* during the larval stadia. No. 11.

| Date    | V    | O   | W   | Date    | V     | O    | W    |
|---------|------|-----|-----|---------|-------|------|------|
| 26. iv. | 4.3  | 31  | 49  | 27. v.  | 61.5  | 437  | 707  |
| 27. iv. | 4.0  | 28  | 46  | 28. v.  | 80.0  | 568  | 920  |
| 28. iv. | 4.0  | 28  | 46  | 29. v.  | 75.0  | 523  | 863  |
| 29. iv. | 5.0  | 36  | 58  | 30. v.  | 121.0 | 859  | 1392 |
| 30. iv. | 3.5  | 35  | 40  | 31. v.  | 101.0 | 717  | 1162 |
| 1. v.   | 8.0  | 57  | 92  | 1. vi.  | 13.0  | 92   | 150  |
| 2. v.   | 3.8  | 27  | 44  | 2. vi.  | 0.0   | 0    | 0    |
| 3. v.   | 8.7  | 62  | 100 | 3. vi.  | 61.5  | 437  | 707  |
| 4. v.   | 4.0  | 28  | 46  | 4. vi.  | 125.5 | 891  | 1443 |
| 5. v.   | 11.8 | 84  | 136 | 5. vi.  | 128.0 | 909  | 1472 |
| 6. v.   | 7.4  | 53  | 85  | 6. vi.  | 122.0 | 866  | 1403 |
| 7. v.   | 13.9 | 99  | 160 | 7. vi.  | 184.5 | 1310 | 2122 |
| 8. v.   | 15.3 | 109 | 176 | 8. vi.  | 131.0 | 930  | 1507 |
| 9. v.   | 20.1 | 143 | 231 | 9. vi.  | 179.0 | 1271 | 2059 |
| 10. v.  | 0.0  | 0   | 0   | 10. vi. | 137.0 | 973  | 1575 |
| 11. v.  | 6.2  | 44  | 71  | 11. vi. | 87.0  | 618  | 1001 |
| 12. v.  | 0.0  | 0   | 0   | 12. vi. | 58.0  | 412  | 667  |
| 13. v.  | 20.0 | 142 | 230 | 13. vi. | 346.0 | 2457 | 3979 |
| 14. v.  | 23.5 | 167 | 270 | 14. vi. | 138.0 | 980  | 1587 |
| 15. v.  | 37.0 | 263 | 426 | 15. vi. | 309.0 | 2194 | 3554 |
| 16. v.  | 36.5 | 259 | 420 | 16. vi. | 198.0 | 1405 | 2277 |
| 17. v.  | 41.5 | 295 | 477 | 17. vi. | 211.0 | 1498 | 2427 |
| 18. v.  | 31.0 | 220 | 357 | 18. vi. | 162.0 | 1150 | 1863 |
| 19. v.  | 24.0 | 170 | 276 | 19. vi. | 236.0 | 1676 | 2714 |
| 20. v.  | 38.0 | 270 | 437 | 20. vi. | 246.0 | 1747 | 2829 |
| 21. v.  | 0.0  | 0   | 0   | 21. vi. | 165.0 | 1172 | 1898 |
| 22. v.  | 0.0  | 0   | 0   | 22. vi. | 198.0 | 1406 | 2277 |
| 23. v.  | 2.0  | 14  | 23  | 23. vi. | 175.0 | 1243 | 2013 |
| 24. v.  | 44.0 | 312 | 506 | 24. vi. | 158.5 | 1125 | 1823 |
| 25. v.  | 67.5 | 479 | 776 | 25. vi. | 223.0 | 1583 | 2565 |
| 26. v.  | 60.0 | 426 | 690 | 26. vi. | 38.0  | 270  | 437  |
|         |      |     |     | 27. vi. | 0.0   | 0    | 0    |

Table 61. The same as above. No. 12.

| Date   | V     | O   | W    | Date    | V     | O    | W    |
|--------|-------|-----|------|---------|-------|------|------|
| 1. v.  | 0.0   | 0   | 0    | 30. v.  | 136.6 | 970  | 1571 |
| 2. v.  | 0.0   | 0   | 0    | 31. v.  | 218.9 | 1554 | 2517 |
| 3. v.  | 9.4   | 66  | 108  | 1. vi.  | 95.5  | 678  | 1098 |
| 4. v.  | 5.5   | 39  | 63   | 2. vi.  | 165.3 | 1174 | 1901 |
| 5. v.  | 8.5   | 60  | 98   | 3. vi.  | 171.3 | 1216 | 1970 |
| 6. v.  | 16.7  | 119 | 192  | 4. vi.  | 126.6 | 899  | 1456 |
| 7. v.  | 17.0  | 121 | 196  | 5. vi.  | 380.4 | 2701 | 4375 |
| 8. v.  | 26.2  | 186 | 301  | 6. vi.  | 31.5  | 224  | 362  |
| 9. v.  | 0.0   | 0   | 0    | 7. vi.  | 0.0   | 0    | 0    |
| 10. v. | 0.0   | 0   | 0    | 8. vi.  | 88.3  | 627  | 1015 |
| 11. v. | 26.3  | 187 | 302  | 9. vi.  | 228.3 | 1621 | 2625 |
| 12. v. | 20.5  | 146 | 236  | 10. vi. | 219.9 | 1561 | 2529 |
| 13. v. | 28.7  | 204 | 330  | 11. vi. | 197.5 | 1402 | 2271 |
| 14. v. | 39.5  | 280 | 454  | 12. vi. | 225.0 | 1598 | 2588 |
| 15. v. | 51.6  | 366 | 593  | 13. vi. | 200.0 | 1420 | 2300 |
| 16. v. | 40.5  | 288 | 466  | 14. vi. | 110.1 | 782  | 1266 |
| 17. v. | 50.7  | 360 | 583  | 15. vi. | 239.7 | 1702 | 2757 |
| 18. v. | 29.0  | 206 | 334  | 16. vi. | 258.4 | 1835 | 2972 |
| 19. v. | 68.5  | 486 | 788  | 17. vi. | 187.8 | 1333 | 2160 |
| 20. v. | 40.0  | 284 | 460  | 18. vi. | 50.8  | 361  | 584  |
| 21. v. | 72.9  | 518 | 838  | 19. vi. | 122.4 | 869  | 1408 |
| 22. v. | 87.1  | 618 | 1002 | 20. vi. | 55.0  | 391  | 633  |
| 23. v. | 73.3  | 520 | 843  | 21. vi. | 0.0   | 0    | 0    |
| 24. v. | 108.5 | 770 | 1248 | 22. vi. | 0.0   | 0    | 0    |
| 25. v. | 81.9  | 581 | 942  | 23. vi. | 258.3 | 1834 | 2970 |
| 26. v. | 69.9  | 496 | 804  | 24. vi. | 265.5 | 1885 | 3053 |
| 27. v. | 23.1  | 164 | 266  | 25. vi. | 241.6 | 1715 | 2778 |
| 28. v. | 0.0   | 0   | 0    | 26. vi. |       |      |      |
| 29. v. | 77.3  | 552 | 893  |         |       |      |      |

Table 62. The same as above. No. 13.

| Date    | V     | O   | W    | Date    | V     | O    | W    |
|---------|-------|-----|------|---------|-------|------|------|
| 26. iv. | 1.2   | 9   | 14   | 28. v.  | 45.3  | 322  | 521  |
| 27. iv. | 2.5   | 18  | 29   | 29. v.  | 43.0  | 305  | 495  |
| 28. iv. | 3.0   | 21  | 35   | 30. v.  | 50.0  | 355  | 575  |
| 29. iv. | 6.0   | 43  | 69   | 31. v.  | 0.0   | 0    | 0    |
| 30. iv. | 14.4  | 102 | 166  | 1. vi.  | 0.0   | 0    | 0    |
| 1. v.   | 5.2   | 38  | 61   | 2. vi.  | 54.5  | 387  | 627  |
| 2. v.   | 5.0   | 36  | 58   | 3. vi.  | 91.8  | 652  | 1056 |
| 3. v.   | 9.0   | 64  | 104  | 4. vi.  | 76.8  | 545  | 883  |
| 4. v.   | 7.0   | 50  | 81   | 5. vi.  | 144.8 | 1028 | 1665 |
| 5. v.   | 10.0  | 71  | 115  | 6. vi.  | 116.4 | 826  | 1339 |
| 6. v.   | 8.7   | 62  | 100  | 7. vi.  | 149.2 | 1059 | 1716 |
| 7. v.   | 18.4  | 131 | 212  | 8. vi.  | 109.0 | 774  | 1254 |
| 8. v.   | 15.4  | 109 | 177  | 9. vi.  | 146.7 | 1042 | 1687 |
| 9. v.   | 20.7  | 147 | 238  | 10. vi. | 77.0  | 547  | 886  |
| 10. v.  | 0.0   | 0   | 0    | 11. vi. | 122.1 | 867  | 1404 |
| 11. v.  | 0.0   | 0   | 0    | 12. vi. | 0.0   | 0    | 0    |
| 12. v.  | 24.0  | 192 | 276  | 13. vi. | 0.0   | 0    | 0    |
| 13. v.  | 18.1  | 129 | 208  | 14. vi. | 148.0 | 1051 | 1702 |
| 14. v.  | 30.3  | 215 | 348  | 15. vi. | 156.8 | 1113 | 1797 |
| 15. v.  | 33.5  | 238 | 385  | 16. vi. | 189.3 | 1344 | 2177 |
| 16. v.  | 37.2  | 264 | 428  | 17. vi. | 125.4 | 890  | 1442 |
| 17. v.  | 45.1  | 320 | 519  | 18. vi. | 231.2 | 1642 | 2659 |
| 18. v.  | 47.3  | 336 | 544  | 19. vi. | 268.6 | 1907 | 3089 |
| 19. v.  | 76.7  | 545 | 882  | 20. vi. | 149.4 | 1061 | 1718 |
| 20. v.  | 0.0   | 0   | 0    | 21. vi. | 135.8 | 964  | 1562 |
| 21. v.  | 0.0   | 0   | 0    | 22. vi. | 150.0 | 1065 | 1725 |
| 22. v.  | 51.2  | 364 | 589  | 23. vi. | 153.7 | 963  | 1561 |
| 23. v.  | 42.3  | 300 | 486  | 24. vi. | 172.8 | 1227 | 1987 |
| 24. v.  | 49.3  | 350 | 567  | 25. vi. | 64.3  | 457  | 739  |
| 25. v.  | 65.8  | 467 | 757  | 26. vi. | 0.0   | 0    | 0    |
| 26. v.  | 105.2 | 747 | 1210 | 27. vi. | 0.0   | 0    | 0    |
| 27. v.  | 63.0  | 447 | 725  |         |       |      |      |

Table 63. The same as above. No. 14.

| Date   | V     | O   | W    | Date    | V     | O    | W    |
|--------|-------|-----|------|---------|-------|------|------|
| 1. v.  | 0.0   | 0   | 0    | 31. v.  | 81.2  | 577  | 934  |
| 2. v.  | 0.0   | 0   | 0    | 1. vi.  | 90.4  | 643  | 1040 |
| 3. v.  | 7.0   | 50  | 81   | 2. vi.  | 69.2  | 491  | 796  |
| 4. v.  | 5.7   | 40  | 66   | 3. vi.  | 26.0  | 185  | 299  |
| 5. v.  | 7.5   | 53  | 86   | 4. vi.  | 0.0   | 0    | 0    |
| 6. v.  | 9.9   | 70  | 114  | 5. vi.  | 68.2  | 484  | 784  |
| 7. v.  | 12.6  | 89  | 145  | 6. vi.  | 68.9  | 489  | 792  |
| 8. v.  | 9.6   | 68  | 110  | 7. vi.  | 116.2 | 825  | 1336 |
| 9. v.  | 16.5  | 117 | 190  | 8. vi.  | 68.3  | 485  | 785  |
| 10. v. | 31.0  | 220 | 357  | 9. vi.  | 134.0 | 951  | 1541 |
| 11. v. | 14.5  | 103 | 167  | 10. vi. | 149.0 | 1064 | 1724 |
| 12. v. | 4.8   | 34  | 55   | 11. vi. | 146.8 | 1042 | 1688 |
| 13. v. | 0.0   | 0   | 0    | 12. vi. | 153.2 | 1088 | 1762 |
| 14. v. | 0.0   | 0   | 0    | 13. vi. | 175.8 | 1248 | 2022 |
| 15. v. | 25.0  | 178 | 288  | 14. vi. | 128.2 | 910  | 1474 |
| 16. v. | 31.8  | 226 | 366  | 15. vi. | 0.0   | 0    | 0    |
| 17. v. | 28.3  | 201 | 325  | 16. vi. | 0.0   | 0    | 0    |
| 18. v. | 49.1  | 349 | 565  | 17. vi. | 0.0   | 0    | 0    |
| 19. v. | 18.9  | 134 | 217  | 18. vi. | 156.6 | 1112 | 1801 |
| 20. v. | 43.1  | 306 | 496  | 19. vi. | 246.2 | 1748 | 2831 |
| 21. v. | 47.3  | 336 | 544  | 20. vi. | 202.0 | 1434 | 2323 |
| 22. v. | 24.5  | 174 | 282  | 21. vi. | 229.5 | 1629 | 2639 |
| 23. v. | 25.0  | 178 | 288  | 22. vi. | 188.8 | 1340 | 2171 |
| 24. v. | 0.0   | 0   | 0    | 23. vi. | 231.0 | 1640 | 2657 |
| 25. v. | 0.0   | 0   | 0    | 24. vi. | 231.9 | 1646 | 2667 |
| 26. v. | 42.1  | 299 | 484  | 25. vi. | 210.0 | 1491 | 2415 |
| 27. v. | 51.4  | 365 | 591  | 26. vi. | 201.5 | 1431 | 2318 |
| 28. v. | 54.0  | 383 | 621  | 27. vi. | 154.0 | 1093 | 1771 |
| 29. v. | 77.7  | 552 | 894  | 28. vi. | 48.5  | 344  | 558  |
| 30. v. | 101.5 | 721 | 1167 | 29. vi. | 0.0   | 0    | 0    |

Table 64. The same as above. No. 15.

| Date    | V     | O   | W    | Date    | V     | O    | W    |
|---------|-------|-----|------|---------|-------|------|------|
| 26. iv. | 2.2   | 16  | 25   | 27. v.  | 63.5  | 451  | 730  |
| 27. iv. | 4.0   | 28  | 46   | 28. v.  | 52.0  | 369  | 598  |
| 28. iv. | 6.0   | 43  | 69   | 29. v.  | 32.7  | 232  | 376  |
| 29. iv. | 7.2   | 51  | 83   | 30. v.  | 0.0   | 0    | 0    |
| 30. iv. | 9.0   | 64  | 104  | 31. v.  | 86.9  | 617  | 999  |
| 1. v.   | 9.0   | 64  | 104  | 1. vi.  | 130.1 | 924  | 1496 |
| 2. v.   | 6.2   | 42  | 73   | 2. vi.  | 118.5 | 841  | 1363 |
| 3. v.   | 16.0  | 114 | 184  | 3. vi.  | 98.9  | 702  | 1137 |
| 4. v.   | 9.0   | 64  | 104  | 4. vi.  | 155.3 | 1103 | 1786 |
| 5. v.   | 15.3  | 109 | 176  | 5. vi.  | 176.8 | 1255 | 2033 |
| 6. v.   | 11.1  | 79  | 128  | 6. vi.  | 103.9 | 738  | 1195 |
| 7. v.   | 17.2  | 122 | 198  | 7. vi.  | 126.7 | 900  | 1457 |
| 8. v.   | 16.0  | 114 | 184  | 8. vi.  | 54.3  | 386  | 624  |
| 9. v.   | 0.0   | 0   | 0    | 9. vi.  | 0.0   | 0    | 0    |
| 10. v.  | 18.6  | 132 | 214  | 10. vi. | 80.6  | 572  | 927  |
| 11. v.  | 41.1  | 292 | 473  | 11. vi. | 159.5 | 1132 | 1834 |
| 12. v.  | 31.0  | 220 | 357  | 12. vi. | 234.1 | 1662 | 2692 |
| 13. v.  | 25.0  | 178 | 288  | 13. vi. | 223.5 | 1587 | 2570 |
| 14. v.  | 45.0  | 320 | 518  | 14. vi. | 267.5 | 1899 | 3076 |
| 15. v.  | 51.5  | 366 | 592  | 15. vi. | 41.8  | 297  | 481  |
| 16. v.  | 20.0  | 142 | 230  | 16. vi. | 238.5 | 1693 | 2743 |
| 17. v.  | 44.7  | 217 | 514  | 17. vi. | 180.0 | 1278 | 2070 |
| 18. v.  | 17.0  | 121 | 196  | 18. vi. | 153.5 | 1090 | 1765 |
| 19. v.  | 0.0   | 0   | 0    | 19. vi. | 162.0 | 1150 | 1863 |
| 20. v.  | 0.0   | 0   | 0    | 20. vi. | 157.0 | 1115 | 1806 |
| 21. v.  | 34.2  | 243 | 393  | 21. vi. | 170.0 | 1207 | 1955 |
| 22. v.  | 67.0  | 476 | 771  | 22. vi. | 118.3 | 840  | 1360 |
| 23. v.  | 107.0 | 760 | 1231 | 23. vi. | 0.0   | 0    | 0    |
| 24. v.  | 74.8  | 531 | 860  | 24. vi. | 0.0   | 0    | 0    |
| 25. v.  | 80.0  | 568 | 920  | 25. vi. | 0.0   | 0    | 0    |
| 26. v.  | 90.5  | 643 | 1041 |         |       |      |      |

Table 65. The same as above. No. 16.

| Date   | V    | O   | W   | Date    | V     | O    | W    |
|--------|------|-----|-----|---------|-------|------|------|
| 1. v.  | 0.0  | 0   | 0   | 30. v.  | 31.8  | 226  | 366  |
| 2. v.  | 3.4  | 24  | 39  | 31. v.  | 0.0   | 0    | 0    |
| 3. v.  | 6.6  | 47  | 76  | 1. vi.  | 46.5  | 330  | 535  |
| 4. v.  | 4.2  | 30  | 48  | 2. vi.  | 103.0 | 731  | 1185 |
| 5. v.  | 6.3  | 45  | 72  | 3. vi.  | 73.7  | 523  | 848  |
| 6. v.  | 6.1  | 43  | 70  | 4. vi.  | 116.7 | 829  | 1342 |
| 7. v.  | 6.7  | 48  | 77  | 5. vi.  | 107.5 | 763  | 1236 |
| 8. v.  | 7.2  | 51  | 83  | 6. vi.  | 92.7  | 658  | 1066 |
| 9. v.  | 4.4  | 31  | 51  | 7. vi.  | 119.0 | 845  | 1369 |
| 10. v. | 16.9 | 120 | 194 | 8. vi.  | 115.3 | 819  | 1326 |
| 11. v. | 4.5  | 32  | 52  | 9. vi.  | 92.5  | 657  | 1064 |
| 12. v. | 0.0  | 0   | 0   | 10. vi. | 65.0  | 462  | 748  |
| 13. v. | 0.0  | 0   | 0   | 11. vi. | 0.0   | 0    | 0    |
| 14. v. | 7.0  | 50  | 101 | 12. vi. | 0.0   | 0    | 0    |
| 15. v. | 11.2 | 80  | 129 | 13. vi. | 44.0  | 312  | 506  |
| 16. v. | 12.2 | 87  | 140 | 14. vi. | 103.6 | 736  | 1191 |
| 17. v. | 13.3 | 94  | 153 | 15. vi. | 194.5 | 1381 | 2237 |
| 18. v. | 4.6  | 33  | 53  | 16. vi. | 153.5 | 1090 | 1765 |
| 19. v. | 9.0  | 64  | 104 | 17. vi. | 207.8 | 1475 | 2390 |
| 20. v. | 0.0  | 0   | 0   | 18. vi. | 225.2 | 1599 | 2590 |
| 21. v. | 0.0  | 0   | 0   | 19. vi. | 88.6  | 629  | 1019 |
| 22. v. | 0.0  | 0   | 0   | 20. vi. | 191.1 | 1357 | 2198 |
| 23. v. | 10.8 | 77  | 124 | 21. vi. | 164.8 | 1170 | 1895 |
| 24. v. | 50.8 | 361 | 584 | 22. vi. | 152.5 | 1083 | 1754 |
| 25. v. | 67.3 | 478 | 774 | 23. vi. | 133.4 | 947  | 1534 |
| 26. v. | 62.8 | 446 | 722 | 24. vi. | 0.0   | 0    | 0    |
| 27. v. | 64.1 | 455 | 737 | 25. vi. | 31.0  | 220  | 357  |
| 28. v. | 71.3 | 506 | 820 | 26. vi. | 0.0   | 0    | 0    |
| 29. v. | 43.0 | 305 | 495 |         |       |      |      |

Table 66. The same as above. No. 17.

| Date    | V    | O   | W   | Date    | V     | O    | W    |
|---------|------|-----|-----|---------|-------|------|------|
| 26. iv. | 1.2  | 9   | 14  | 29. v.  | 0.0   | 0    | 0    |
| 27. iv. | 1.4  | 10  | 16  | 30. v.  | 83.8  | 595  | 964  |
| 28. iv. | 2.0  | 14  | 23  | 31. v.  | 117.5 | 834  | 1351 |
| 29. iv. | 5.0  | 36  | 58  | 1. vi.  | 120.8 | 858  | 1389 |
| 30. iv. | 11.0 | 78  | 127 | 2. vi.  | 184.0 | 1306 | 2116 |
| 1. v.   | 6.0  | 43  | 69  | 3. vi.  | 189.6 | 1346 | 2180 |
| 2. v.   | 13.0 | 92  | 150 | 4. vi.  | 185.1 | 1314 | 2129 |
| 3. v.   | 17.3 | 123 | 199 | 5. vi.  | 149.8 | 1064 | 1723 |
| 4. v.   | 8.0  | 57  | 92  | 6. vi.  | 61.1  | 434  | 703  |
| 5. v.   | 19.5 | 138 | 224 | 7. vi.  | 0.0   | 0    | 0    |
| 6. v.   | 12.3 | 87  | 141 | 8. vi.  | 311.3 | 2210 | 3580 |
| 7. v.   | 9.0  | 64  | 104 | 9. vi.  | 261.2 | 1855 | 3004 |
| 8. v.   | 21.8 | 155 | 251 | 10. vi. | 277.9 | 1973 | 3196 |
| 9. v.   | 5.2  | 37  | 59  | 11. vi. | 398.3 | 2828 | 4580 |
| 10. v.  | 0.0  | 0   | 0   | 12. vi. | 0.0   | 0    | 0    |
| 11. v.  | 37.5 | 266 | 431 | 13. vi. | 320.8 | 2278 | 3689 |
| 12. v.  | 33.0 | 734 | 380 | 14. vi. | 262.6 | 1864 | 3020 |
| 13. v.  | 26.2 | 186 | 301 | 15. vi. | 265.0 | 1882 | 3048 |
| 14. v.  | 27.9 | 198 | 321 | 16. vi. | 0.0   | 0    | 0    |
| 15. v.  | 39.5 | 283 | 464 | 17. vi. | 0.0   | 0    | 0    |
| 16. v.  | 42.5 | 302 | 489 | 18. vi. | 465.5 | 3305 | 5353 |
| 17. v.  | 48.0 | 341 | 552 | 19. vi. | 532.7 | 3782 | 6126 |
| 18. v.  | 24.8 | 176 | 285 | 20. vi. | 505.0 | 3586 | 5808 |
| 19. v.  | 0.0  | 0   | 0   | 21. vi. | 394.4 | 2800 | 4536 |
| 20. v.  | 15.0 | 107 | 173 | 22. vi. | 680.7 | 4833 | 7828 |
| 21. v.  | 57.0 | 405 | 676 | 23. vi. | 443.5 | 3149 | 5100 |
| 22. v.  | 64.4 | 457 | 740 | 24. vi. | 671.0 | 4764 | 7717 |
| 23. v.  | 85.9 | 610 | 988 | 25. vi. | 621.0 | 4409 | 7142 |
| 24. v.  | 60.5 | 430 | 696 | 26. vi. | 543.8 | 3861 | 6254 |
| 25. v.  | 69.2 | 491 | 796 | 27. vi. | 0.0   | 0    | 0    |
| 26. v.  | 76.3 | 522 | 877 | 28. vi. | 0.0   | 0    | 0    |
| 27. v.  | 72.0 | 511 | 828 |         |       |      |      |
| 28. v.  | 34.0 | 241 | 391 |         |       |      |      |

Table 67. The same as above. No. 18.

| Date    | V    | O   | W   | Date   | V    | O    | W   |
|---------|------|-----|-----|--------|------|------|-----|
| 29. iv. | 2.0  | 14  | 23  | 17. v. | 3.0  | 21   | 35  |
| 30. iv. |      |     |     | 18. v. | 7.6  | 54   | 87  |
| 1. v.   | 3.0  | 21  | 35  | 19. v. | 16.2 | 115  | 185 |
| 2. v.   | 5.8  | 41  | 67  | 20. v. | 26.4 | 187  | 304 |
| 3. v.   | 9.0  | 64  | 104 | 21. v. | 20.0 | 142  | 230 |
| 4. v.   | 4.6  | 33  | 53  | 22. v. | 33.4 | 237  | 384 |
| 5. v.   | 7.9  | 56  | 91  | 23. v. | 20.9 | 148  | 240 |
| 6. v.   | 4.8  | 34  | 55  | 24. v. | 25.8 | 1183 | 297 |
| 7. v.   | 7.5  | 53  | 86  | 25. v. | 15.7 | 111  | 181 |
| 8. v.   | 12.0 | 85  | 138 | 26. v. | 33.2 | 236  | 382 |
| 9. v.   | 20.2 | 143 | 232 | 27. v. | 31.1 | 221  | 358 |
| 10. v.  | 17.9 | 127 | 206 | 28. v. | 9.3  | 66   | 107 |
| 11. v.  | 41.2 | 293 | 474 | 29. v. | 0.0  | 0    | 0   |
| 12. v.  | 0.0  | 0   | 0   | 30. v. | 8.6  | 61   | 99  |
| 13. v.  | 0.0  | 0   | 0   | 31. v. | 8.6  | 61   | 99  |
| 14. v.  | 10.4 | 74  | 120 | 1. vi. | 11.0 | 78   | 127 |
| 15. v.  | 5.3  | 38  | 61  |        |      |      |     |
| 16. v.  | 5.0  | 36  | 58  |        |      |      |     |

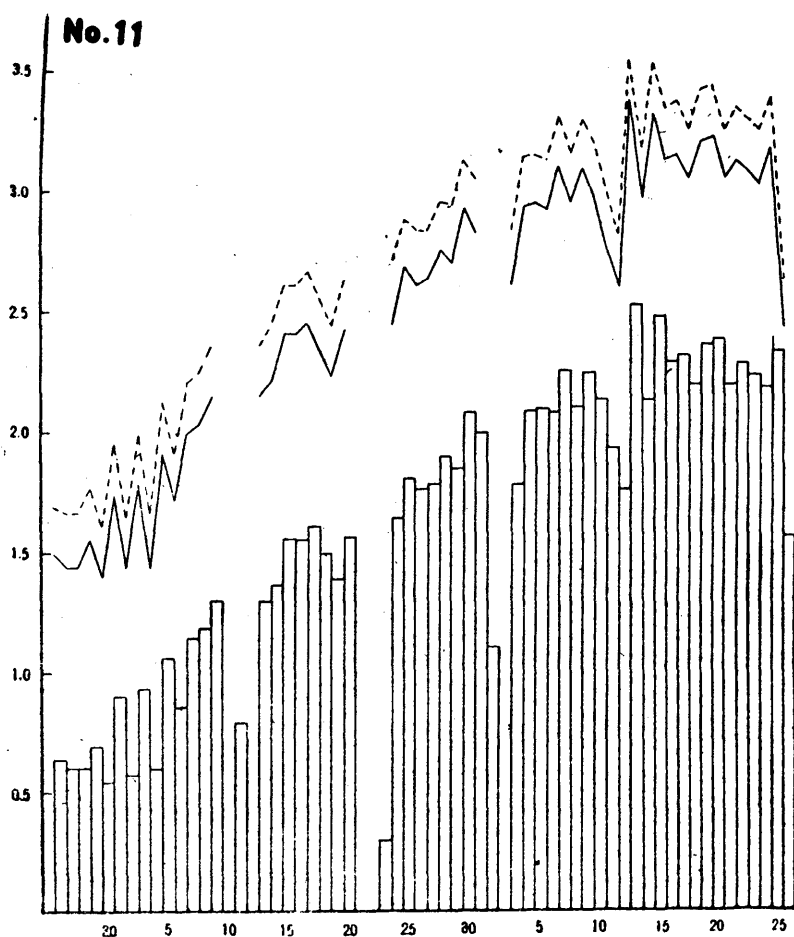
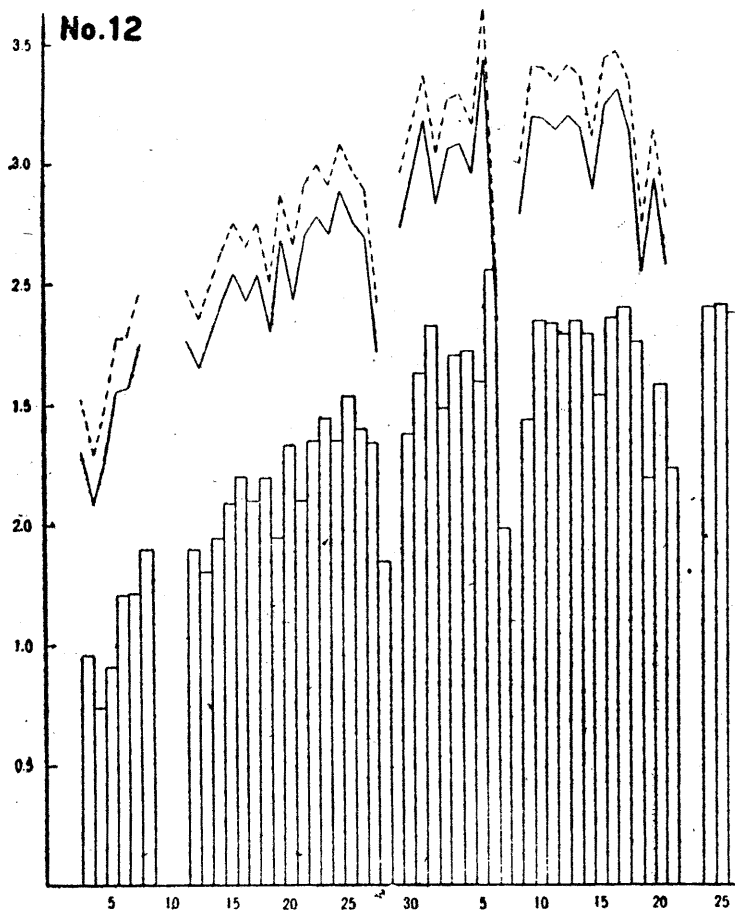
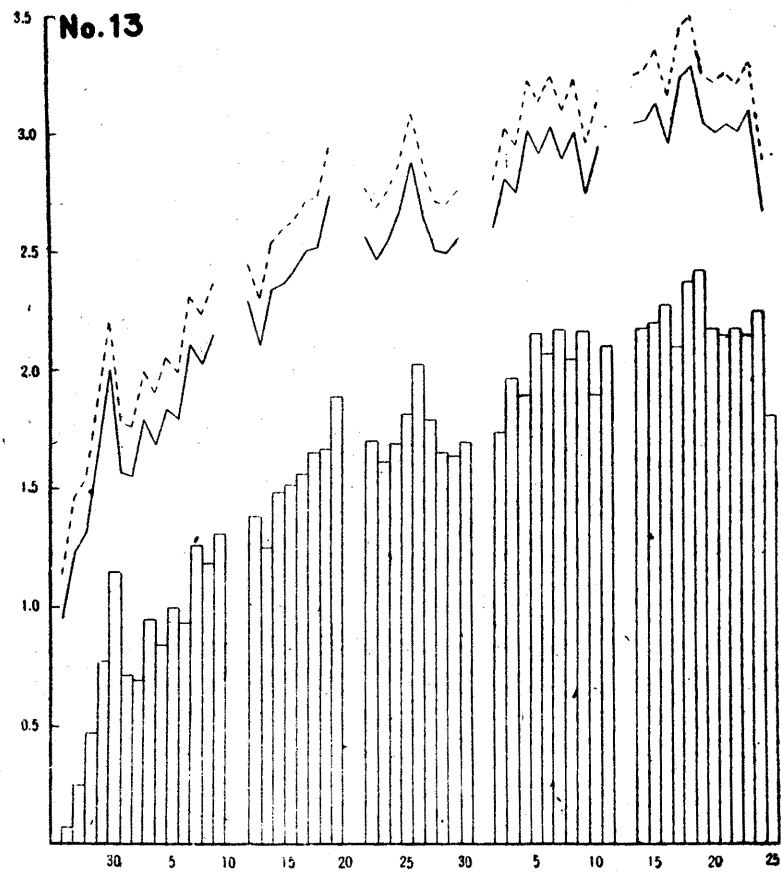
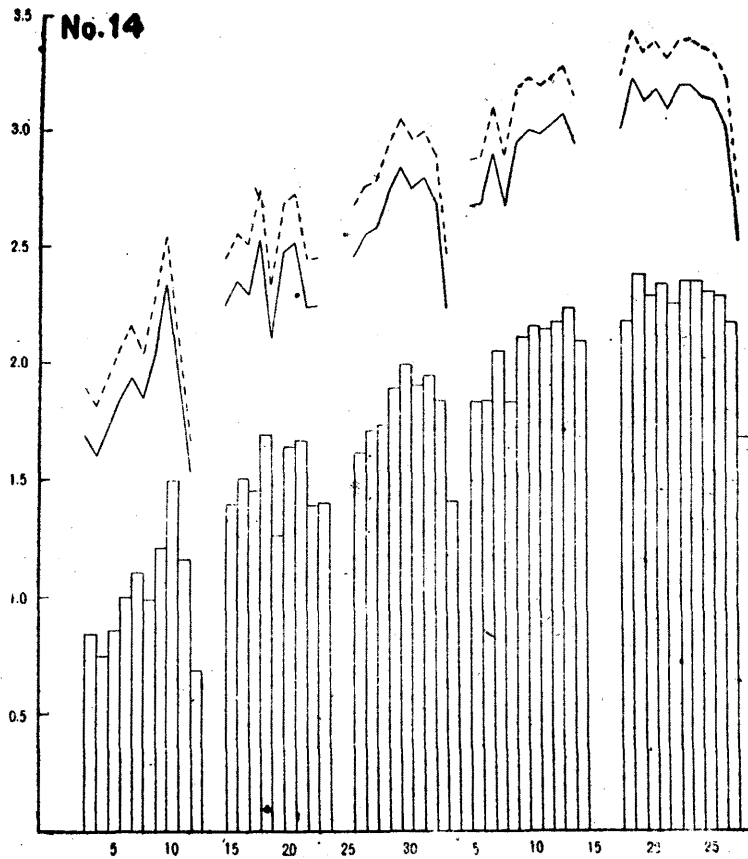
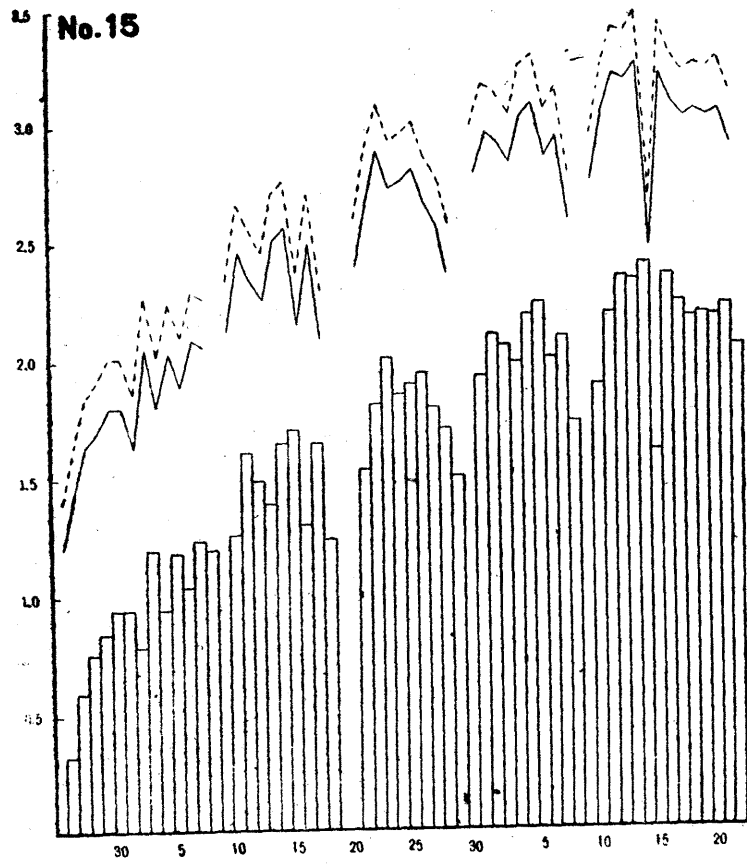


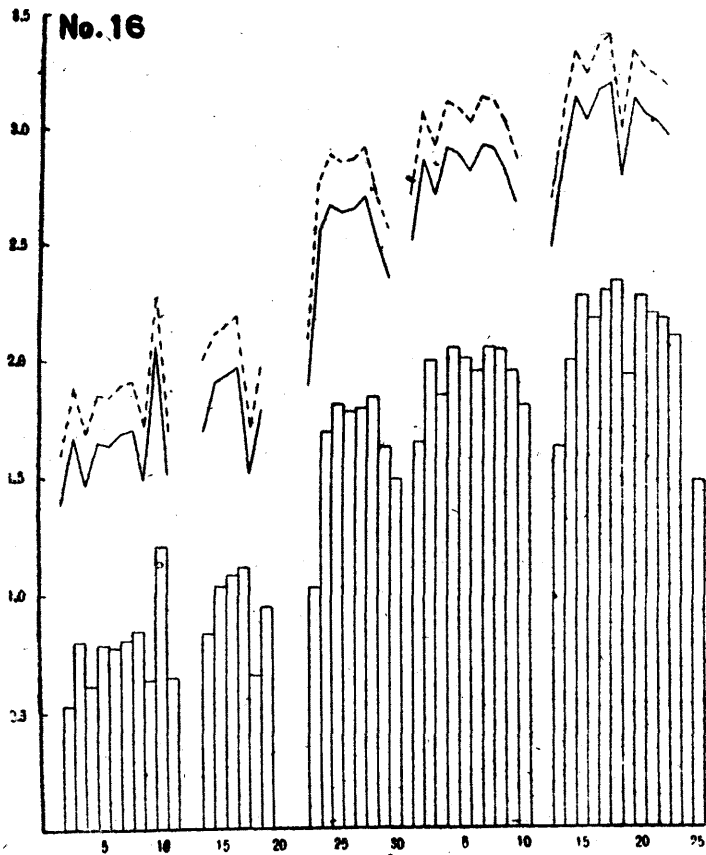
Fig. 30. Amount of leaves eaten by *Phraortes kumamotoensis* during the larval stadia.

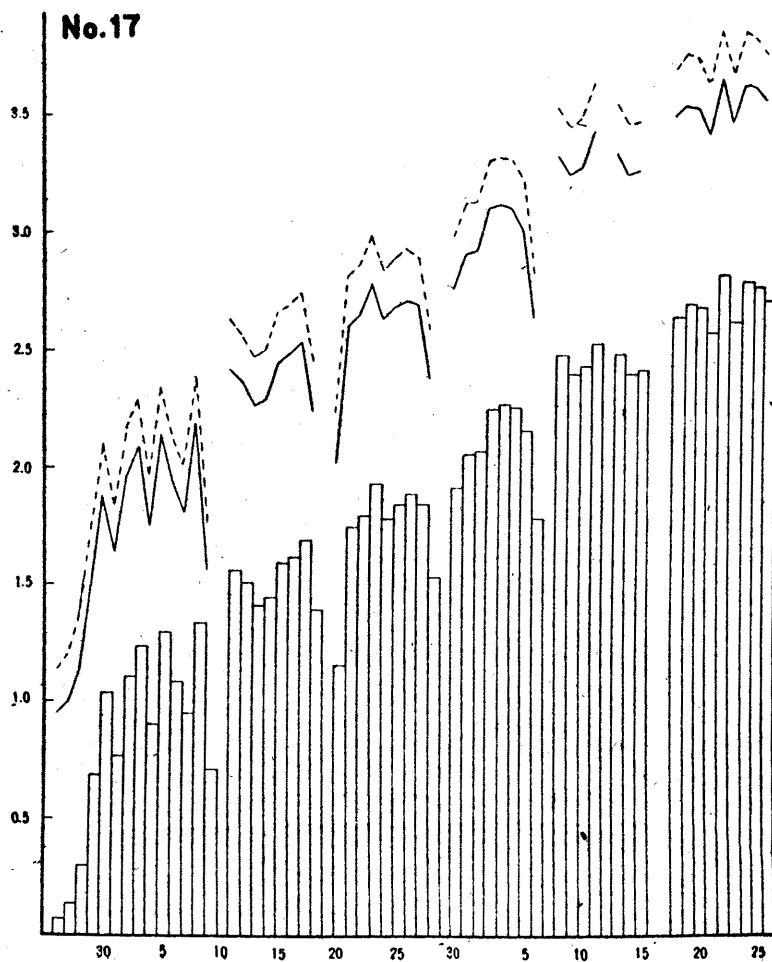












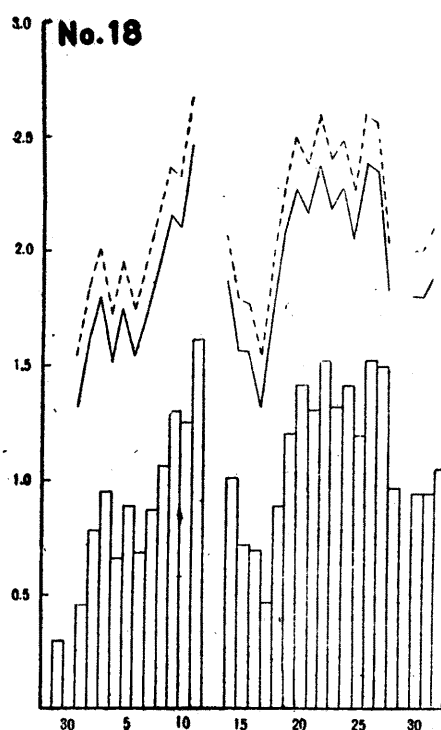


Table 68. Amount of leaves eaten by *Phraortes kumamotoensis* in each larval instar. No. 1.

| Larval stadia | $\Sigma V$ | $\Sigma O$ | $\Sigma W$ | F(%)  | O'    | W'    |
|---------------|------------|------------|------------|-------|-------|-------|
| I             | 141.0      | 973        | 1293       | 1.9   | 1.22  | 1.62  |
| II            | 387.0      | 2669       | 3562       | 5.0   | 3.33  | 4.45  |
| III           | 500.2      | 3451       | 4601       | 6.4   | 4.31  | 5.75  |
| IV            | 795.0      | 5485       | 7314       | 10.1  | 6.86  | 9.14  |
| V             | 1874.0     | 12932      | 17241      | 23.9  | 16.16 | 21.55 |
| VI            | 4128.5     | 28594      | 37989      | 52.7  | 35.74 | 47.49 |
| I - II        | 528.0      | 3642       | 4855       | 6.9   | 4.55  | 6.07  |
| I - III       | 1028.2     | 7093       | 9456       | 13.3  | 8.86  | 11.82 |
| I - IV        | 1823.2     | 12578      | 16770      | 23.4  | 15.72 | 20.96 |
| I - V         | 3692.2     | 25510      | 34011      | 47.3  | 31.88 | 42.51 |
| I - VI        | 7825.7     | 54104      | 72000      | 100.0 | 67.62 | 90.00 |

|          |        |       |       |      |       |       |
|----------|--------|-------|-------|------|-------|-------|
| II - III | 887.2  | 6120  | 8163  | 11.4 | 7.64  | 10.20 |
| II - IV  | 1682.2 | 11605 | 15477 | 21.5 | 14.50 | 19.34 |
| II - V   | 3556.2 | 24537 | 32718 | 45.4 | 30.66 | 40.48 |
| II - VI  | 6684.7 | 53131 | 70707 | 98.1 | 66.40 | 87.97 |
| III - IV | 1295.2 | 8936  | 11915 | 16.5 | 11.17 | 14.89 |
| III - V  | 3169.2 | 21868 | 29156 | 40.4 | 27.33 | 36.44 |
| III - VI | 6297.7 | 50462 | 67145 | 93.1 | 63.07 | 83.93 |
| IV - V   | 2669.0 | 18417 | 23555 | 34.0 | 23.02 | 30.69 |
| IV - VI  | 6797.5 | 47011 | 61544 | 86.7 | 58.76 | 78.18 |
| V - VI   | 6002.5 | 41526 | 55230 | 76.6 | 51.90 | 69.04 |

Table 69. The same as above. No. 2.

| Larval stadia | $\Sigma V$ | $\Sigma O$ | $\Sigma W$ | F(%) | O' | W' |
|---------------|------------|------------|------------|------|----|----|
| I             | 143.0      | 985        | 1311       |      |    |    |

Table 70. The same as above. No. 3.

| Larval stadia | $\Sigma V$ | $\Sigma O$ | $\Sigma W$ | F(%)  | O'    | W'    |
|---------------|------------|------------|------------|-------|-------|-------|
| I             | 232.9      | 1607       | 2144       | 4.8   | 1.53  | 2.04  |
| II            | 359.2      | 2477       | 3305       | 7.4   | 2.36  | 3.15  |
| III           | 605.3      | 4176       | 5568       | 12.5  | 3.98  | 5.30  |
| IV            | 1117.9     | 7722       | 10295      | 23.2  | 7.35  | 9.80  |
| V             | 2494.7     | 17124      | 22950      | 52.1  | 16.31 | 21.86 |
| I - II        | 592.1      | 4084       | 5449       | 12.2  | 3.89  | 5.19  |
| I - III       | 1197.4     | 8260       | 11017      | 24.7  | 7.87  | 10.49 |
| I - IV        | 2315.3     | 15982      | 21312      | 47.9  | 15.22 | 20.29 |
| I - V         | 4810.0     | 33106      | 44262      | 100.0 | 31.53 | 42.15 |
| II - III      | 964.5      | 6653       | 8873       | 19.9  | 6.34  | 8.45  |
| II - IV       | 2082.4     | 14375      | 19168      | 43.1  | 13.69 | 18.20 |
| II - V        | 4577.1     | 31499      | 42118      | 95.2  | 80.00 | 40.11 |
| III - IV      | 1723.2     | 11898      | 15863      | 35.7  | 11.33 | 15.10 |
| III - V       | 4217.9     | 29022      | 38813      | 87.8  | 27.64 | 36.96 |
| IV - V        | 3612.6     | 24846      | 33245      | 75.3  | 23.66 | 31.66 |

Table 71. The same as above. No. 4

| Larval stadia | $\Sigma V$ | $\Sigma O$ | $\Sigma W$ | F(%)  | O'    | W'    |
|---------------|------------|------------|------------|-------|-------|-------|
| I             | 197.8      | 1394       | 1820       | 2.7   | 1.39  | 1.86  |
| II            | 329.7      | 2274       | 3034       | 4.5   | 2.33  | 3.10  |
| III           | 464.9      | 3207       | 4276       | 6.3   | 3.27  | 4.36  |
| IV            | 927.8      | 6402       | 8534       | 12.7  | 6.53  | 8.71  |
| V             | 2043.4     | 14000      | 17800      | 27.8  | 14.29 | 18.16 |
| VI            | 3335.5     | 23015      | 30687      | 46.0  | 23.48 | 31.31 |
| I - II        | 527.5      | 3638       | 4854       | 7.2   | 3.72  | 4.96  |
| I - III       | 992.4      | 6845       | 9130       | 13.5  | 6.99  | 9.32  |
| I - IV        | 1920.2     | 13247      | 17664      | 26.2  | 13.52 | 18.03 |
| I - V         | 3963.6     | 27247      | 35464      | 54.0  | 27.81 | 36.19 |
| I - VI        | 7299.1     | 50262      | 66151      | 100.0 | 51.29 | 67.50 |
| II - III      | 794.6      | 5481       | 7310       | 10.8  | 5.60  | 7.46  |
| II - IV       | 1722.4     | 11883      | 15844      | 23.6  | 11.13 | 16.17 |
| II - V        | 3765.8     | 25883      | 33644      | 51.3  | 25.42 | 34.33 |
| II - VI       | 7101.3     | 48898      | 64331      | 97.3  | 48.90 | 65.64 |
| III - IV      | 1392.7     | 9609       | 12810      | 19.0  | 9.80  | 13.07 |
| III - V       | 3436.1     | 23609      | 30610      | 46.8  | 24.09 | 31.23 |
| III - VI      | 6771.6     | 46624      | 61297      | 92.8  | 47.57 | 62.54 |
| IV - V        | 2971.2     | 20402      | 26334      | 40.5  | 20.82 | 26.87 |
| IV - VI       | 6306.7     | 43417      | 57021      | 86.5  | 44.30 | 58.18 |
| V - VI        | 5378.9     | 37015      | 43487      | 73.8  | 37.77 | 49.47 |

Table 72. The same as above. No. 5.

| Larval stadia | $\Sigma V$ | $\Sigma O$ | $\Sigma W$ | F(%)  | O'    | W'    |
|---------------|------------|------------|------------|-------|-------|-------|
| I             | 164.0      | 1064       | 1418       | 3.0   | 0.89  | 1.18  |
| II            | 321.4      | 2219       | 2956       | 6.0   | 1.85  | 2.46  |
| III           | 549.3      | 3791       | 5052       | 10.2  | 3.16  | 4.21  |
| IV            | 963.0      | 6649       | 8865       | 17.9  | 5.54  | 7.39  |
| V             | 3353.2     | 23238      | 30848      | 62.9  | 19.37 | 25.71 |
| I - II        | 485.4      | 3283       | 4374       | 9.0   | 2.74  | 3.64  |
| I - III       | 1034.7     | 7074       | 9426       | 19.2  | 5.90  | 7.85  |
| I - IV        | 1997.7     | 13723      | 18291      | 37.1  | 11.44 | 15.24 |
| I - V         | 5350.9     | 36961      | 49139      | 100.0 | 30.81 | 40.95 |

|          |        |       |       |      |       |       |
|----------|--------|-------|-------|------|-------|-------|
| II - III | 870.7  | 6010  | 8008  | 16.2 | 5.01  | 6.67  |
| II - IV  | 1833.7 | 12659 | 16873 | 34.1 | 10.55 | 14.06 |
| II - V   | 5186.9 | 35897 | 47721 | 97.0 | 29.92 | 39.77 |
| III - IV | 1212.3 | 10440 | 13917 | 28.1 | 8.70  | 11.60 |
| III - V  | 4565.5 | 33678 | 44765 | 91.0 | 28.07 | 37.31 |
| IV - V   | 4316.2 | 29887 | 39713 | 80.8 | 24.91 | 33.10 |

Table 73. The same as above. No. 6.

| Larval stadia | $\Sigma V$ | $\Sigma O$ | $\Sigma W$ | F(%)  | O'    | W'    |
|---------------|------------|------------|------------|-------|-------|-------|
| I             | 172.3      | 1189       | 1587       | 1.9   | 1.14  | 1.53  |
| II            | 306.7      | 2116       | 2823       | 3.3   | 2.04  | 2.71  |
| III           | 592.4      | 4088       | 5451       | 6.5   | 3.82  | 5.24  |
| IV            | 984.1      | 6689       | 9053       | 10.8  | 6.43  | 8.70  |
| V             | 2019.3     | 13933      | 18577      | 22.1  | 13.40 | 17.86 |
| VI            | 5026.7     | 34683      | 46246      | 55.4  | 33.35 | 44.46 |
| I - II        | 479.0      | 3305       | 4410       | 5.2   | 3.18  | 4.24  |
| I - III       | 1071.4     | 7393       | 9861       | 11.7  | 7.00  | 9.48  |
| I - IV        | 2055.5     | 14082      | 18914      | 22.5  | 13.43 | 18.18 |
| I - V         | 4074.3     | 28015      | 37491      | 44.6  | 26.83 | 36.04 |
| I - VI        | 9101.5     | 92698      | 73737      | 100.0 | 60.18 | 80.51 |
| II - III      | 899.1      | 6204       | 8274       | 9.8   | 5.86  | 7.95  |
| II - IV       | 1883.2     | 12893      | 17327      | 20.6  | 12.29 | 16.65 |
| II - V        | 3902.5     | 26826      | 35904      | 42.7  | 25.69 | 34.51 |
| II - VI       | 8929.2     | 61509      | 82150      | 98.1  | 59.04 | 78.98 |
| III - IV      | 1576.5     | 10777      | 14504      | 17.3  | 10.25 | 13.94 |
| III - V       | 3595.8     | 24710      | 33081      | 38.4  | 23.65 | 31.80 |
| III - VI      | 8622.5     | 59393      | 79327      | 93.8  | 57.00 | 76.27 |
| IV - V        | 3003.4     | 20622      | 27630      | 32.9  | 19.83 | 26.56 |
| IV - VI       | 8030.1     | 55305      | 73876      | 88.3  | 53.18 | 71.03 |
| V - VI        | 7046.0     | 48616      | 64823      | 77.5  | 46.75 | 62.33 |

Table 74. The same as above. No. 7.

| Larval stadia | $\Sigma V$ | $\Sigma O$ | $\Sigma W$ | F(%)  | O'    | W'    |
|---------------|------------|------------|------------|-------|-------|-------|
| I             | 233.7      | 1613       | 2149       | 4.8   | 3.34  | 4.48  |
| II            | 468.4      | 3230       | 4301       | 9.6   | 6.73  | 8.96  |
| III           | 704.8      | 4863       | 6485       | 14.5  | 10.13 | 13.51 |
| IV            | 1138.4     | 7854       | 10473      | 23.5  | 16.36 | 21.81 |
| V             | 2289.8     | 15800      | 21066      | 47.6  | 32.92 | 43.89 |
| I - II        | 702.1      | 4843       | 6457       | 14.4  | 10.07 | 13.44 |
| I - III       | 1406.9     | 9706       | 12942      | 28.9  | 20.20 | 26.95 |
| I - IV        | 2545.3     | 17560      | 23415      | 52.4  | 36.56 | 48.76 |
| I - V         | 4835.1     | 33360      | 44481      | 100.0 | 69.48 | 92.65 |
| II - III      | 1173.2     | 8093       | 10786      | 24.1  | 16.86 | 22.47 |
| II - IV       | 2311.6     | 15947      | 21259      | 47.6  | 33.22 | 44.28 |
| II - V        | 4601.4     | 31747      | 42325      | 95.2  | 66.14 | 88.17 |
| III - IV      | 1843.2     | 12717      | 16958      | 39.0  | 26.49 | 35.32 |
| III - V       | 3133.0     | 28517      | 38024      | 86.6  | 59.41 | 79.21 |
| IV - V        | 3428.2     | 23654      | 31539      | 71.1  | 49.28 | 65.70 |

Table 75. The same as above. No. 8.

| Larval stadia | $\Sigma V$ | $\Sigma O$ | $\Sigma W$ | F(%)  | O'    | W'    |
|---------------|------------|------------|------------|-------|-------|-------|
| I             | 171.7      | 1184       | 1578       | 2.2   | 1.18  | 1.58  |
| II            | 454.8      | 3138       | 4186       | 5.7   | 3.14  | 4.19  |
| III           | 573.9      | 3979       | 5279       | 7.2   | 3.98  | 5.28  |
| IV            | 970.3      | 6695       | 8976       | 12.3  | 6.70  | 8.91  |
| V             | 1761.4     | 12154      | 16205      | 22.3  | 12.15 | 16.21 |
| VI            | 3939.7     | 27185      | 36246      | 50.3  | 27.19 | 36.25 |
| I - II        | 626.5      | 4322       | 5764       | 7.9   | 4.32  | 5.77  |
| I - III       | 1200.4     | 8301       | 11034      | 15.1  | 8.30  | 11.05 |
| I - IV        | 2170.7     | 14996      | 19949      | 27.4  | 15.00 | 19.96 |
| I - V         | 3932.1     | 27150      | 36154      | 49.7  | 27.15 | 36.17 |
| I - VI        | 7871.8     | 54335      | 72400      | 100.0 | 54.34 | 72.42 |
| II - III      | 1028.7     | 7117       | 9465       | 12.9  | 7.12  | 9.47  |
| II - IV       | 1999.0     | 13812      | 18371      | 25.2  | 13.82 | 18.38 |
| II - V        | 3760.4     | 25966      | 34576      | 47.5  | 25.97 | 34.59 |
| II - VI       | 7700.1     | 53151      | 70822      | 97.8  | 53.16 | 70.84 |

|          |        |       |       |      |       |       |
|----------|--------|-------|-------|------|-------|-------|
| III - IV | 1544.2 | 10674 | 14188 | 19.5 | 10.68 | 14.19 |
| III - V  | 3305.6 | 22828 | 30393 | 41.8 | 22.83 | 30.40 |
| III - VI | 7245.3 | 50013 | 66639 | 92.1 | 50.02 | 66.65 |
| IV - V   | 2731.7 | 18849 | 25111 | 34.6 | 18.85 | 25.12 |
| IV - VI  | 6671.4 | 46037 | 61357 | 84.9 | 46.84 | 61.37 |
| V - VI   | 5701.1 | 39339 | 52451 | 72.6 | 39.34 | 52.46 |

Table 76. The same as above. No. 9.

| Larval stadia | $\Sigma V$ | $\Sigma O$ | $\Sigma W$ | F(%)  | O'    | W'    |
|---------------|------------|------------|------------|-------|-------|-------|
| I             | 175.2      | 968        | 1299       | 4.3   | 0.83  | 1.11  |
| II            | 327.0      | 2255       | 3008       | 8.1   | 1.93  | 2.57  |
| III           | 539.3      | 3621       | 4840       | 13.3  | 3.09  | 4.14  |
| IV            | 847.6      | 5849       | 7800       | 21.0  | 5.00  | 6.67  |
| V             | 2146.3     | 14811      | 19745      | 53.3  | 12.66 | 16.88 |
| I - II        | 502.2      | 3223       | 4307       | 12.4  | 2.76  | 3.68  |
| I - III       | 1041.5     | 6844       | 9147       | 25.7  | 5.85  | 7.82  |
| I - IV        | 1889.1     | 12693      | 16947      | 46.7  | 10.85 | 14.49 |
| I - V         | 4035.4     | 27504      | 36692      | 100.0 | 23.51 | 31.37 |
| II - III      | 866.3      | 5876       | 7848       | 21.4  | 5.02  | 6.71  |
| II - IV       | 1713.9     | 11725      | 15648      | 42.4  | 10.02 | 13.38 |
| II - V        | 3860.2     | 26535      | 35393      | 95.7  | 22.68 | 30.26 |
| III - IV      | 1386.9     | 9470       | 12640      | 34.3  | 8.09  | 10.81 |
| III - V       | 3533.2     | 24281      | 32385      | 82.6  | 20.75 | 27.69 |
| IV - V        | 2993.9     | 20660      | 27545      | 74.3  | 17.66 | 23.55 |

Table 77. The same as above. No. 10.

| Larval stadia | $\Sigma V$ | $\Sigma O$ | $\Sigma W$ | F(%) | O' | W' |
|---------------|------------|------------|------------|------|----|----|
| I             | 161.0      | 1100       | 1480       |      |    |    |
| II            | 246.3      | 1699       | 2268       |      |    |    |
| I - II        | 407.3      | 2799       | 3748       |      |    |    |

Table 78. Amount of leaves eaten by *Phraortes kumamotoensis* in each larval instar. No. 11.

| Larval stadia | $\Sigma V$ | $\Sigma O$ | $\Sigma W$ | F(%)  | O'    | W'    |
|---------------|------------|------------|------------|-------|-------|-------|
| I             | 113.8      | 810        | 1309       | 2.2   | 0.82  | 1.38  |
| II            | 257.7      | 1830       | 2964       | 5.1   | 1.93  | 3.12  |
| III           | 625.0      | 4427       | 7189       | 12.4  | 4.66  | 7.57  |
| IV            | 1155.5     | 8205       | 13290      | 23.2  | 8.64  | 13.99 |
| V             | 2861.5     | 20318      | 31910      | 57.1  | 21.39 | 34.64 |
| I - II        | 371.5      | 2130       | 4273       | 7.3   | 2.75  | 4.50  |
| I - III       | 996.5      | 6557       | 11462      | 19.7  | 7.41  | 12.07 |
| I - IV        | 2152.0     | 14762      | 24752      | 42.9  | 16.05 | 26.06 |
| I - V         | 5013.5     | 35080      | 57662      | 100.0 | 37.44 | 60.70 |
| II - III      | 882.7      | 6257       | 10153      | 17.5  | 6.49  | 10.69 |
| II - IV       | 2038.2     | 14462      | 23443      | 40.7  | 15.13 | 24.68 |
| II - V        | 4899.7     | 34780      | 56353      | 97.8  | 36.52 | 59.32 |
| III - IV      | 1780.5     | 12632      | 20479      | 35.6  | 13.30 | 21.56 |
| III - V       | 4642.0     | 32950      | 53389      | 92.7  | 34.69 | 56.20 |
| IV - V        | 4017.0     | 28523      | 46200      | 80.3  | 30.03 | 48.63 |

Table 79. The same as above. No. 12.

| Larval stadia | $\Sigma V$ | $\Sigma O$ | $\Sigma W$ | F(%) | O' | W' |
|---------------|------------|------------|------------|------|----|----|
| III           | 912.0      | 6474       | 10489      |      |    |    |
| IV            | 1403.8     | 9968       | 16143      |      |    |    |
| V             | 2183.2     | 15502      | 25108      |      |    |    |
| III - IV      | 2315.8     | 16442      | 26632      |      |    |    |
| III - V       | 4499.0     | 31944      | 51740      |      |    |    |
| IV - V        | 3587.0     | 25470      | 41251      |      |    |    |

Table 80. The same as above. No. 13.

| Larval stadia | $\Sigma V$ | $\Sigma O$ | $\Sigma W$ | F(%)  | O'    | W'    |
|---------------|------------|------------|------------|-------|-------|-------|
| I             | 126.6      | 901        | 1459       | 3.2   | 0.64  | 1.04  |
| II            | 312.2      | 2239       | 3690       | 7.8   | 1.60  | 2.64  |
| III           | 515.1      | 3857       | 5923       | 12.9  | 2.76  | 4.23  |
| IV            | 1088.3     | 7737       | 12517      | 27.6  | 5.53  | 8.94  |
| V             | 1927.3     | 13684      | 22158      | 48.5  | 9.77  | 15.83 |
| I - II        | 438.8      | 3140       | 5149       | 11.0  | 2.24  | 3.68  |
| I - III       | 953.9      | 6997       | 11072      | 23.9  | 5.00  | 7.91  |
| I - IV        | 2042.2     | 14734      | 23589      | 51.5  | 10.53 | 16.85 |
| I - V         | 3969.5     | 28418      | 45747      | 100.0 | 20.30 | 32.68 |
| II - III      | 827.3      | 6096       | 9613       | 20.7  | 4.36  | 6.87  |
| II - IV       | 1915.6     | 13833      | 22130      | 48.3  | 9.89  | 15.81 |
| II - V        | 3842.9     | 27517      | 44288      | 96.8  | 19.66 | 31.64 |
| III - IV      | 1603.4     | 11594      | 18440      | 40.5  | 8.29  | 13.17 |
| III - V       | 3530.7     | 25278      | 40598      | 89.0  | 18.06 | 29.00 |
| IV - V        | 3015.6     | 21421      | 34675      | 76.1  | 15.30 | 24.77 |

Table 81. The same as above. No. 14.

| Larval stadia | $\Sigma V$ | $\Sigma O$ | $\Sigma W$ | F(%)  | O'    | W'    |
|---------------|------------|------------|------------|-------|-------|-------|
| I             | 119.1      | 844        | 1371       | 2.7   | 0.89  | 1.44  |
| II            | 293.0      | 2082       | 3371       | 6.7   | 2.19  | 3.55  |
| III           | 593.5      | 4216       | 6826       | 13.7  | 4.44  | 7.19  |
| IV            | 1209.5     | 8586       | 13908      | 28.0  | 9.04  | 14.64 |
| V             | 2100.0     | 14908      | 24151      | 48.9  | 15.69 | 25.42 |
| I - II        | 412.1      | 2926       | 4742       | 9.4   | 3.08  | 4.99  |
| I - III       | 1005.6     | 7142       | 11568      | 23.1  | 7.52  | 12.18 |
| I - IV        | 2215.1     | 15728      | 25476      | 51.1  | 16.56 | 26.82 |
| I - V         | 4315.1     | 30636      | 49627      | 100.0 | 32.25 | 52.24 |
| II - III      | 886.5      | 6298       | 10197      | 20.4  | 6.63  | 10.74 |
| II - IV       | 2096.0     | 14884      | 24105      | 48.4  | 15.67 | 25.38 |
| II - V        | 4196.0     | 29792      | 48256      | 97.3  | 31.36 | 50.80 |
| III - IV      | 1803.0     | 12802      | 20734      | 41.7  | 13.48 | 21.83 |
| III - V       | 3903.0     | 27710      | 44885      | 90.6  | 19.17 | 47.25 |
| IV - V        | 3309.5     | 23494      | 38059      | 76.9  | 24.73 | 40.06 |

Table 82. The same as above. No. 15.

| Larval stadia | $\Sigma V$ | $\Sigma O$ | $\Sigma W$ | F(%)  | O'    | W'    |
|---------------|------------|------------|------------|-------|-------|-------|
| I             | 128.2      | 912        | 1478       | 3.0   | 1.01  | 1.64  |
| II            | 293.9      | 1988       | 3382       | 6.8   | 2.21  | 3.65  |
| III           | 601.7      | 4273       | 6920       | 14.1  | 4.75  | 7.80  |
| IV            | 1051.4     | 7466       | 12090      | 24.7  | 8.30  | 13.43 |
| V             | 2186.3     | 15522      | 25142      | 51.4  | 17.25 | 27.94 |
| I - II        | 422.1      | 2900       | 4860       | 9.8   | 3.22  | 5.29  |
| I - III       | 1023.8     | 7173       | 11780      | 23.9  | 7.97  | 13.09 |
| I - IV        | 2075.2     | 14639      | 23870      | 48.6  | 16.27 | 26.52 |
| I - V         | 4261.5     | 30161      | 49012      | 100.0 | 36.52 | 54.46 |
| II - III      | 895.6      | 6261       | 10302      | 20.9  | 6.96  | 11.45 |
| II - IV       | 1947.0     | 13727      | 22392      | 45.6  | 15.26 | 24.88 |
| II - V        | 4133.3     | 29249      | 47534      | 97.0  | 32.51 | 52.82 |
| III - IV      | 1653.1     | 11739      | 19010      | 38.8  | 13.05 | 21.23 |
| III - V       | 3839.4     | 27261      | 44152      | 90.2  | 30.30 | 49.17 |
| IV - V        | 3237.7     | 22988      | 37232      | 76.1  | 25.55 | 41.37 |

Table 83. The same as above. No. 16.

| Larval stadia | $\Sigma V$ | $\Sigma O$ | $\Sigma W$ | F(%)  | O'    | W'    |
|---------------|------------|------------|------------|-------|-------|-------|
| II            | 123.6      | 879        | 1442       | 4.1   | 0.73  | 1.20  |
| III           | 401.9      | 2854       | 4622       | 12.7  | 2.38  | 3.85  |
| IV            | 931.9      | 6617       | 10718      | 29.6  | 5.51  | 8.93  |
| V             | 1690.0     | 11989      | 19436      | 53.6  | 9.99  | 16.20 |
| II - III      | 525.5      | 3733       | 6064       | 16.8  | 3.11  | 5.05  |
| II - IV       | 1457.4     | 10350      | 16782      | 46.4  | 8.62  | 13.98 |
| II - V        | 3147.4     | 22339      | 36218      | 100.0 | 18.61 | 30.18 |
| III - IV      | 1333.8     | 9571       | 15340      | 42.3  | 7.89  | 12.78 |
| III - V       | 3023.8     | 21560      | 34776      | 95.9  | 12.88 | 28.98 |
| IV - V        | 2621.9     | 18606      | 30154      | 83.2  | 15.50 | 25.13 |

Table 84. The same as above. No. 17.

| Larval stadia | $\Sigma V$ | $\Sigma O$ | $\Sigma W$ | F(%)  | O'    | W'    |
|---------------|------------|------------|------------|-------|-------|-------|
| I             | 132.7      | 943        | 1527       | 1.4   | 0.38  | 0.62  |
| II            | 279.4      | 2486       | 3223       | 3.1   | 1.01  | 1.32  |
| III           | 534.3      | 3774       | 6170       | 5.9   | 1.54  | 2.52  |
| IV            | 1091.7     | 7751       | 12555      | 12.1  | 3.16  | 5.12  |
| V             | 2097.1     | 14890      | 24117      | 23.3  | 6.08  | 9.84  |
| VI            | 4857.6     | 34489      | 55864      | 54.2  | 14.08 | 22.80 |
| I - II        | 412.1      | 3429       | 4750       | 4.5   | 1.39  | 1.94  |
| I - III       | 946.4      | 7203       | 10902      | 10.4  | 2.93  | 4.46  |
| I - IV        | 2038.1     | 14954      | 23475      | 22.5  | 6.09  | 9.58  |
| I - V         | 4135.2     | 29844      | 47592      | 45.8  | 12.17 | 19.42 |
| I - VI        | 8992.8     | 64333      | 103459     | 100.0 | 26.25 | 42.22 |
| II - III      | 813.7      | 6260       | 9393       | 9.0   | 2.55  | 3.84  |
| II - IV       | 1905.4     | 13011      | 21948      | 21.1  | 5.71  | 8.96  |
| II - V        | 4002.5     | 28901      | 46065      | 44.4  | 11.79 | 18.80 |
| II - VI       | 8860.1     | 63390      | 102029     | 98.6  | 25.87 | 41.60 |
| III - IV      | 1626.0     | 11525      | 18725      | 18.0  | 4.70  | 7.64  |
| III - V       | 3723.1     | 26415      | 42842      | 41.3  | 10.78 | 17.48 |
| III - VI      | 8580.7     | 60904      | 98706      | 95.5  | 24.86 | 40.28 |
| IV - V        | 3188.8     | 22641      | 36672      | 35.4  | 9.24  | 14.96 |
| IV - VI       | 8046.4     | 57130      | 92536      | 89.6  | 23.32 | 37.76 |
| V - VI        | 6954.7     | 49379      | 79981      | 77.5  | 20.16 | 32.64 |

Table 85. The same as above. No. 18.

| Larval stadia | $\Sigma V$ | $\Sigma O$ | $\Sigma W$ | F(%) | O' | W' |
|---------------|------------|------------|------------|------|----|----|
| I             | 135.9      | 964        | 1564       |      |    |    |
| II            | 263.3      | 1869       | 3030       |      |    |    |
| I - II        | 399.2      | 2833       | 4594       |      |    |    |

## Observations

The object of the experiments mentioned above was to examine the food consumption of normally developing larvae of *Phraortes kumamotoensis*. For this purpose two classes of feeding experiments were performed. In the first, the leaves of *Lyonia Neziki* NAKAI et HARA (Ericaceae) were given three times a day (8 o'clock, 13 o'clock, 17 o'clock); whilst in the second *Prunus subhirtella* MIQUEL, a member of the Family Rosaceae, taxonomically not close to the Ericaceae, was used. It seems to be convenient to show here an example of the differences between the leaves of the two species of plants on which the insects were fed.

Table 86. Differences between the leaves of *Lyonia Neziki* and *Prunus subhirtella* on July 15th. Measurements were carried out on the leaves of 400 mm<sup>3</sup> in volume.

| Food plants             | <i>Lyonia Neziki</i> | <i>Prunus subhirtella</i> |
|-------------------------|----------------------|---------------------------|
| Live weight             | 0.0650 gr.           | 0.0770 gr.                |
| Dry weight              | 0.0280 gr.           | 0.0310 gr.                |
| Water contents          | 0.0370 gr.           | 0.0460 gr.                |
| Organic matter contents | 0.0276 gr.           | 0.0275 gr.                |
| Ash contents            | 0.0004 gr.           | 0.0025 gr.                |

As shown in the tables given before, there is wide variation in the duration of each instar even of those fed on the same food, and under the same rearing conditions. But one might say that the total length of the post-embryonic growth period in each individual showed a much closer value to the mean of a number of cases. This fact proves that the development during the course of the present experiments was normal and ideal.

In spite of the irregularities, a general trend, indicating a similarity in food consumption, was to be noted in all the individuals. Several interesting and instructive points may be taken from these tables and figures.

Approximately 50 per cent of the total volume of food consumed during the entire larval period was taken during the last

sixth stadium (sixth in the female and fifth in the male). The relation may be written:

$$V_6 = V_1 + V_2 + V_3 + V_4 + V_5 \dots \text{♀} \dots (1)$$

$$V_5 = V_1 + V_2 + V_3 + V_4 \dots \text{♂} \dots (2)$$

Approximately 50 per cent of food consumed during the stadia except the last was taken in the last stadium but one (fifth in the female, fourth in the male). The relation takes the form:

$$V_6 = V_1 + V_2 + V_3 + V_4 \dots \text{♀} \dots (3)$$

$$V_4 = V_1 + V_2 + V_3 \dots \text{♂} \dots (4)$$

Similar relation was observed also in the preceding stadium and it may be expressed:

$$V_4 = V_1 + V_2 + V_3 \dots \text{♀} \dots (5)$$

$$V_3 = V_1 + V_2 \dots \text{♂} \dots (6)$$

In the female the similar relation was again observed in the third larval stadium, thus:

$$V_3 = V_1 + V_2 \dots \text{♀} \dots (7)$$

In both sexes the amount of the food consumption in the second stadium becomes approximately equal to a doubling of that in the first stadium. This may take the form:

$$V_2 = 2V_1 \dots \text{♀} \text{♂} \dots (8)$$

From the eight empirical formulae above cited the following relations can be derived.

$$V_2 = 2V_1$$

$$V_3 = 2V_2 = 4V_1$$

$$V_4 = 2V_3 = 4V_2 = 8V_1$$

$$V_5 = 2V_4 = 4V_3 = 8V_2 = 16V_1$$

$$V_6 = 2V_5 = 4V_4 = 8V_3 = 16V_2 = 32V_1$$

Thus under normal conditions, the increase of food consumption with age may be well defined by the formula

$$V_n = 2^{n-1} V_1,$$

where  $V$  is either the volume of food or of the contents of

organic matter in it consumed in the stadium  $n$ , and  $V_1$  is the same for the first stadium.

The food consumption of the two sexes is practically the same up to the fifth post-embryonic developmental stadia. As this insect exhibits five stadia in larval development in the case of the males, while six in the case of the females, the food consumed by the male in its larval period is approximately 50 per cent of that of the female.

Next, the amount of organic matter eaten by each individual during the post-embryonic developmental period in order to produce a unit weight (1 gram) of the adult was calculated in use of the dry weight of the mesothoracic exoskeleton as shown in the following tables.

Table 87. Organic matter (in gram) taken by the larvae to produce the unit weight of the adult female.

| No.     | Stadia |      |      |       |       |       |
|---------|--------|------|------|-------|-------|-------|
|         | I      | II   | III  | IV    | V     | VI    |
| 1       | 2.74   | 7.40 | 9.70 | 15.43 | 36.36 | 80.39 |
| 4       | 3.12   | 5.26 | 7.36 | 14.69 | 32.15 | 52.83 |
| 6       | 2.56   | 4.59 | 8.59 | 14.47 | 30.15 | 75.04 |
| 8       | 2.65   | 7.00 | 8.96 | 15.06 | 27.38 | 61.78 |
| Average | 2.76   | 6.06 | 8.65 | 14.91 | 31.51 | 67.53 |

Table 88. Organic matter (in gram) taken by the larvae to produce the unit weight of the adult male.

| No.     | Stadia |      |       |       |       |
|---------|--------|------|-------|-------|-------|
|         | I      | II   | III   | IV    | V     |
| 3       | 3.44   | 5.31 | 9.00  | 16.50 | 36.69 |
| 5       | 2.00   | 4.16 | 7.11  | 12.50 | 43.50 |
| 9       | 1.86   | 4.34 | 7.00  | 11.30 | 28.40 |
| 11      | 1.84   | 4.34 | 10.48 | 19.40 | 48.10 |
| 13      | 1.44   | 3.60 | 6.21  | 12.40 | 22.09 |
| 14      | 2.00   | 4.92 | 9.99  | 22.30 | 35.30 |
| 15      | 2.27   | 4.97 | 10.68 | 18.70 | 38.31 |
| Average | 2.12   | 4.52 | 8.62  | 15.89 | 36.14 |

| I | II | III | IV | V | VI |         |
|---|----|-----|----|---|----|---------|
|   |    |     |    |   |    | No. 1   |
|   |    |     |    |   |    | No. 4   |
|   |    |     |    |   |    | No. 6   |
|   |    |     |    |   |    | No. 8   |
|   |    |     |    |   |    | No. 17  |
|   |    |     |    |   |    | AVERAGE |

Fig. 31. Relative amount of leaves eaten by the female of *Phraortes kumamotoensis* in each larval instar.

| I | II | III | IV | V |         |
|---|----|-----|----|---|---------|
|   |    |     |    |   | No. 3   |
|   |    |     |    |   | No. 5   |
|   |    |     |    |   | No. 7   |
|   |    |     |    |   | No. 9   |
|   |    |     |    |   | No. 11  |
|   |    |     |    |   | No. 13  |
|   |    |     |    |   | No. 14  |
|   |    |     |    |   | No. 15  |
|   |    |     |    |   | AVERAGE |

Fig. 32. Relative amount of leaves eaten by the male of *Phraortes kumamotoensis* in each larval instar.

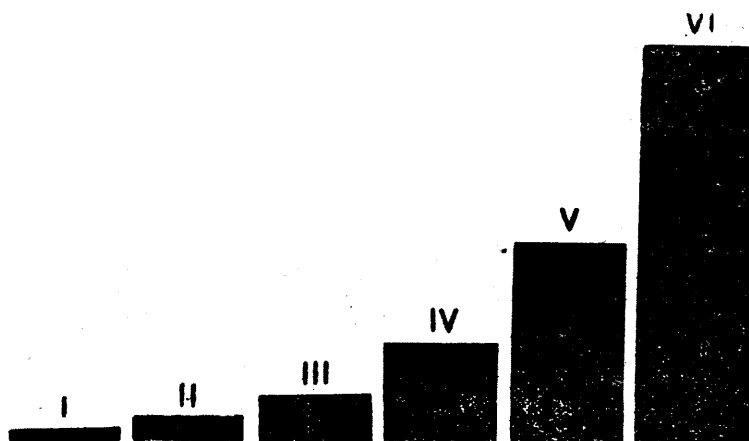


Fig. 33. A diagram showing the amount of leaves eaten by *Phraortes kumamotoensis* in each larval stadium.

|                    |                    |
|--------------------|--------------------|
| I: First stadium   | II: Second stadium |
| III: Third stadium | IV: Fourth stadium |
| V: Fifth stadium   | VI: Sixth stadium  |

## 2. Experiments Series 2

### Experiments Class 3

No. 19, ♀ This insect underwent the fifth moult on June 17th, then having its weight 0.1015 gr. After a very long interval of 29 days, during which the larva attained a maximum weight of 0.3420 gr., the last moult took place on July 16th. The insect was killed on July 16th for measurement just after the last moult. The mesothorax was 14.6 mm in length and 0.0052 gr. in dry weight.  $\Sigma V=4102.0$ ,  $\Sigma Q=28190$ ,  $\Sigma W=37584$ .

No. 20, ♂ On June 19th this insect underwent the fourth moult, then having its weight 0.0980 gr. After 16 days, during which it attained a maximum weight of 0.1854 gr., the last moult took place on July 4th. It was killed for measurement on July 5th.  $\Sigma V=1601.8$ ,  $\Sigma Q=11042$ ,  $\Sigma W=14725$ .

No. 21, ♀ This insect underwent the fifth moult on June 18th, then having its weight 0.1050 gr. As in the case of No. 19, after a very long interval of 33 days; during which it attained a max-

imum weight of 0.4236 gr., the last moult took place on July 20th. The insect was killed for measurement on July 21st. The mesothorax was 15.0 mm in length and 0.0073 gr. in dry weight.  $\Sigma V=5836.3$ ,  $\Sigma O=39574$ ,  $\Sigma W=52768$ .

No. 22, ♂ This insect underwent the fourth moult on June 19th, then having its weight 0.1013 gr. After 17 days, during which it attained a maximum weight of 0.2125 gr., the last moult occurred on July 6th. The insect was killed for measurement on July 7th. The mesothorax was 13.4 mm in length and 0.0028 gr. in dry weight.  $\Sigma V=1759.1$ ,  $\Sigma O=11445$ ,  $\Sigma W=15264$ .

No. 23, ♂ This insect underwent the fourth moult on June 20th, then having its weight 0.0465 gr. After 19 days, during which it attained a maximum weight of 0.1547 gr., the last moult occurred on July 9th. The insect was killed for measurement on July 10th. The mesothorax was 10.0 mm in length and 0.0024 gr. in dry weight.  $\Sigma V=1313.3$ ,  $\Sigma O=9060$ ,  $\Sigma W=12084$ .

#### Experiments Class 4

No. 24, ♀ This insect underwent the fifth moult on July 1st, then having its weight 0.2000 gr. After a long time of 36 days this insect died on August 8th and could not undergo the sixth moult. The mesothorax was 13.5 mm in length and 0.0098 gr. in dry weight. It attained a maximum weight of 0.3810 gr. two weeks before death.  $\Sigma V=3222.5$ ,  $\Sigma O=22235$ ,  $\Sigma W=29648$ .

No. 25, ♀ This insect underwent the fifth moult on June 20th, then having its weight 0.0914 gr. After a very long interval of 53 days this insect underwent the sixth moult and reached maturity on August 11th. The insect was killed after the last moult. The mesothorax was 12.0 mm in length and 0.0060 gr. in dry weight. It attained a maximum weight of 0.2500 gr. four days before the last moult.  $\Sigma V=2543.5$ ,  $\Sigma O=17451$ ,  $\Sigma W=23401$ .

No. 26, ♀ This insect underwent the fifth moult on June 20th, then having its weight 0.0854 gr. After a long interval of 23 days this insect died on July 12th and could not undergo the sixth moult. The mesothorax was 12.6 mm in length and 0.0075 gr. in dry weight. It attained a maximum weight of 0.1135 gr. a week before death.  $\Sigma V=918.0$ ,  $\Sigma O=6436$ ,  $\Sigma W=8445$ .

No. 27, ♂ This insect underwent the fourth moult on June 19th, then having its weight 0.1500 gr. After a very long interval of 42 days this insect died on July 12th and could not undergo the last moult. The mesothorax was 11.5 mm in length and 0.0032 gr. in dry weight. It attained a maximum weight of 0.1170 gr. a week before death.  $\Sigma V=3090.8$ ,  $\Sigma O=21326$ ,  $\Sigma W=28434$ .

No. 28, ♂ This insect underwent the fourth moult on June 20th, then having its weight 0.0892 gr. After 12 days this insect died on July 2nd and could not undergo the fifth moult. The mesothorax was 11.8 mm in length and 0.0033 gr. in dry weight. It attained a maximum weight of 0.1310 gr. three days before death.  $\Sigma V=549.1$ ,  $\Sigma O=3859$ ,  $\Sigma W=5144$ .

#### Experiments Class 6

No. 34, ♀ This insect underwent the fifth moult on July 18th, then having its weight 0.1172 gr. The insect then lived only 15 days and died on July 3rd. It attained a maximum weight of 0.1700 gr. eight days before death. The mesothorax was 13.2 mm in length and 0.0054 gr. in dry weight.  $\Sigma V=401.7$ ,  $\Sigma O=2772$ ,  $\Sigma W=3695$ .

No. 35, ♀ This insect underwent the fifth moult on July 17th, then having its weight 0.0790 gr. The insect then lived only nine days and died on July 25th.

No. 36, ♂ This insect underwent the fourth moult on June 22nd, then having its weight 0.0540 gr. The insect then lived only seven days and died on July 29th.

No. 37, ♂ This insect underwent the fourth moult on June 18th, then having its weight 0.1124 gr. The insect then lived as long as only two weeks, and could not undergo the last moult and died on July 2nd.  $\Sigma V=204.3$ ,  $\Sigma O=1410$ ,  $\Sigma W=1779$ .

No. 38, ♂ This insect underwent the fourth moult on June 19th, then having its weight 0.0965 gr. The insect then lived fifteen days, but could not undergo the last moult and died on July 3rd.  $\Sigma V=422.0$ ,  $\Sigma O=2912$ ,  $\Sigma W=3882$ .

## Experiments Class 7.

No. 39, ♂ The insect underwent the third moult on June 18th, then having its weight 0.1107 gr. After 17 days the insect underwent the fourth moult on July 4th, its body measured 0.2000 gr. This insect reached maturity 28 days later, on August 1st. The mesothorax was 13.2 mm in length and 0.0054 gr. in dry weight. It attained a maximum weight of 0.3128 gr. a week before the last moult.  $\Sigma V=1113.5$ ,  $\Sigma O=7682$ ,  $\Sigma W=10258$  in the fourth instar.  $\Sigma V=1584.0$ ,  $\Sigma O=10932$ ,  $\Sigma W=14573$  in the fifth instar.

No. 40, ♀ This insect underwent the fifth moult on June 18th, then having its weight 0.1100 gr. After a long interval of 40 days the insect died on July 27th and could not undergo the last moult.  $\Sigma V=1702.3$ ,  $\Sigma O=11747$ ,  $\Sigma W=15665$ .

No. 41, ♂ This insect underwent the fourth moult on June 20th, then having its weight 0.1140 gr. After a long interval of 23 days the insect reached maturity on July 12th. The mesothorax was 14.0 mm in length and 0.0036 gr. in dry weight. It attained a maximum weight of 0.1945 gr. three days before the last moult.  $\Sigma V=1452.0$ ,  $\Sigma O=10022$ ,  $\Sigma W=13365$ .

No. 42, ♂ This insect underwent the fourth moult on June 23rd, its body weighed 0.0734 gr. After a long interval of 28 days the insect died on July 20th and could not undergo the last moult.  $\Sigma V=1481.3$ ,  $\Sigma O=10227$ ,  $\Sigma W=13583$ .

No. 43, ♂ This insect underwent the fourth moult on June 18th, then having its weight 0.1130 gr. After a long interval of 23 days the insect reached maturity on July 11th. The mesothorax was 14.0 mm in length and 0.0050 gr. in dry weight. It attained a maximum weight of 0.2250 gr. three days before the last moult.  $\Sigma V=1830.0$ ,  $\Sigma O=12613$ ,  $\Sigma W=16832$ .

## Observations

From the Experiments Class 3 the following fact can be derived. The duration of the sixth stadium is strongly lengthened. This result contrasts sharply with those reared normally.

Table 89. Duration of life in experimental and control stick insects.

| No.  | Stadium | Experimental | Control   |           |
|------|---------|--------------|-----------|-----------|
|      |         |              | Average   | Maximum   |
| 19 ♀ | VI      | 29 days      | 12.9 days | 17.0 days |
| 21 ♀ | VI      | 33 days      |           |           |
| 20 ♂ | V       | 16 days      | 11.1 days | 12.0 days |
| 22 ♂ | V       | 17 days      |           |           |
| 23 ♂ | V       | 19 days      |           |           |

Although the length of the mesothorax in the experimental insects is either shorter than, or equal to, those of the normally fed insects, the dry weight of the same part of the former insects is exclusively smaller than those of the latter ones. It suggests from the above observations that the feeding on every other day in this insect is insufficient to complete the normal development. In other words, the feeding on every other day apparently affects the normal larval growth both in the duration of life and the dry weight of the body.

Similar and more exaggerative results were obtained from the Experiments Class 4. In these experimental insects the duration of the pre-adult stage was highly influenced and very much lengthened.

Table 90. Duration of life in experimental and control stick insects.

| No.  | Stadium | Experimental | Control   |           |
|------|---------|--------------|-----------|-----------|
|      |         |              | Average   | Maximum   |
| 24 ♀ | VI      | 36 days      | 12.9 days | 17.0 days |
| 25 ♀ | VI      | 53 days      |           |           |
| 26 ♀ | VI      | 23 days      |           |           |
| 27 ♂ | V       | 42 days      | 11.1 days | 12.0 days |
| 28 ♂ | V       | Over 12 days |           |           |

Nos. 25 and 27 passed a very long time of the pre-adult stadium, making a remarkable contrast even to the maximum value in the normal growth (3.1 to 3.5-times). Further No. 28 could not undergo the final moult. The length of the mesothorax was also extremely influenced by the insufficient amount of food and very much shorter than that of the normal individuals. The dry weight of the mesothorax was mostly smaller than that of the normal individuals. Thus the feeding three times on every third day was much more insufficient than that on every other day.

In the Experiments Class 6 all the insects could not undergo the final moult and died 7-15 days after the moult previous to the last one. In this series of experiments it was necessary to supply water at least once a day. Very interesting was the fact that the insects which were obliged to hunger over two days did not respond quickly to food so long as they did not drink water.

Experiments Class 7 was fundamentally in agreement with those obtained in classes 3 and 4. The duration of the pre-adult stadium was strongly lengthened as seen in the following table.

Table 91. Duration of life in experimental and control stick insects.

| No.  | Stadium | Experimental | Control   |           |
|------|---------|--------------|-----------|-----------|
|      |         |              | Average   | Maximum   |
| 39 ♂ | V       | 17 days      | 11.1 days | 12.0 days |
| 40 ♀ | VI      | 40 days      | 12.9 days | 17.0 days |
| 41 ♂ | V       | 23 days      | 11.1 days | 12.0 days |
| 42 ♂ | V       | Over 28 days |           |           |
| 43 ♂ | V       | 23 days      |           |           |

No. 42 could not undergo the last moult. The length of the mesothorax was either smaller than or equal to that of the normally fed insects. But the dry weight of the mesothorax was always smaller than that of the normally fed individuals. From this experiment it is clear that the feeding once a day was also insufficient to complete the normal growth.

## Experiments Series 3

## Experiments Class 5

No. 29, ♀ This insect underwent the fifth moult on June 17th and arrived at maturity 19 days later, on July 6th, its mesothorax measured 16.5 mm in length and 0.0076 gr. in dry weight.

$\Sigma V=6178.8$ ,  $\Sigma O=30900$ ,  $\Sigma W=38307$ .

No. 30, ♀ This insect underwent the fifth moult on June 17th and reached maturity on July 6th, its mesothorax measured 18.8 mm in length and 0.0125 gr. in dry weight.  $\Sigma V=6836.0$ ,  $\Sigma O=34183$ ,  $\Sigma W=42386$ .

No. 31, ♀ This insect underwent the fifth moult on June 16th and reached maturity 19 days later, on July 4th, its mesothorax measured 17.5 mm in length and 0.0112 gr. in dry weight.

$\Sigma V=7124.8$ ,  $\Sigma O=35669$ ,  $\Sigma W=44244$ .

No. 32, ♂ This insect underwent the fourth moult on June 16th and attained maturity 17 days later, on July 3rd. The mesothorax was 15.5 mm in length and 0.0075 gr. in dry weight.

$\Sigma V=2224.0$ ,  $\Sigma O=11125$ ,  $\Sigma W=13790$ .

No. 33, ♂ This insect underwent the fourth moult on June 19th and reached maturity 14 days later, on July 3rd, its mesothorax measured 17.0 mm in length and 0.0100 gr. in dry weight.

$\Sigma V=2433.7$ ,  $\Sigma O=12171$ ,  $\Sigma W=15090$ .

## Observations

Experimental insects, Nos. 29-33, were fed on the foliage of *Amelanchier asiatica* C. KOCH (Rosaceae). An example of the measurements of the leaves of 400 mm<sup>3</sup> in volume of this plant is given in the following lines (July 15th).

|                         |            |
|-------------------------|------------|
| Live weight             | 0.0457 gr. |
| Dry weight              | 0.0209 gr. |
| Water contents          | 0.0248 gr. |
| Organic matter contents | 0.0201 gr. |
| Ash contents            | 0.0008 gr. |

From the above measurements it is evident that the unit volume of the leaves of *Amelanchier asiatica* contains a smaller

amount of water or organic matter in comparison with that of *Lyonia Neziki* or *Prunus subhirtella*. This would be apparently the probable reason that the females, Nos. 29-31, exhibited the greater values of  $\Sigma V$ , i.e. 6178.8, 6836.0 and 7124.8 respectively, than those of the insects fed on *Lyonia Neziki* or *Prunus subhirtella*. On the other hand, the males, Nos. 32-33, consumed an almost equal amount of food as that of Nos. 1-19. This fact may indicate the existence of the fundamental differences in the requirement of nourishment between the sexes. In correlation with this fact it may be reasonable that the duration of the sixth stadium was a little lengthened in the female sex. It follows from the above experiments that each of the three kinds of plants represents an adequate diet for this stick insect to complete the normal post-embryonic development.

Table 92. Growth in weight of *Phraortes kumamotoensis* in larval period.

| Date     | No. 19 | No. 20 | No. 21 | No. 22 | No. 23 |
|----------|--------|--------|--------|--------|--------|
| 17. vii. | 0.1015 |        |        |        |        |
| 18. vii. | 0.1000 |        | 0.1050 |        |        |
| 19. vii. | 0.1355 | 0.0980 | 0.1220 | 0.1013 |        |
| 20. vii. | 0.1179 | 0.0890 | 0.1161 | 0.0930 | 0.0465 |
| 21. vii. | 0.1657 | 0.1180 | 0.1620 | 0.1241 | 0.0741 |
| 22. vii. | 0.1434 | 0.1063 | 0.1425 | 0.1135 | 0.0655 |
| 23. vii. | 0.1676 | 0.1362 | 0.1591 | 0.1430 | 0.0785 |
| 24. vii. | 0.1524 | 0.1240 | 0.1475 | 0.1320 | 0.0742 |
| 25. vii. | 0.1875 | 0.1400 | 0.1940 | 0.1573 | 0.0906 |
| 26. vii. | 0.1621 | 0.1282 | 0.1638 | 0.1436 | 0.0900 |
| 27. vii. | 0.2030 | 0.1600 | 0.2146 | 0.1780 | 0.1100 |
| 28. vii. | 0.1800 | 0.1430 | 0.1771 | 0.1560 | 0.1095 |
| 29. vii. | 0.1640 | 0.1740 | 0.2420 | 0.2008 | 0.1444 |
| 30. vii. | 0.1521 | 0.1542 | 0.2119 | 0.1755 | 0.1133 |
| 31. vii. | 0.2330 | 0.1854 | 0.2100 | 0.2182 | 0.1485 |
| 1. viii. | 0.2100 | 0.1600 | 0.1880 | 0.1900 | 0.1300 |

|           |        |        |        |        |        |
|-----------|--------|--------|--------|--------|--------|
| 2. viii.  | 0.2476 | 0.1558 | 0.2620 | 0.2125 | 0.1564 |
| 3. viii.  | 0.2128 |        | 0.2163 | 0.1957 | 0.1350 |
| 4. viii.  | 0.2600 |        | 0.2900 | 0.1930 | 0.1547 |
| 5. viii.  | 0.2260 |        | 0.2450 |        | 0.1436 |
| 6. viii.  | 0.2800 |        | 0.2912 |        | 0.1458 |
| 7. viii.  | 0.2520 |        | 0.2640 |        | 0.1500 |
| 8. viii.  | 0.2930 |        | 0.2656 |        |        |
| 9. viii.  | 0.2700 |        | 0.2400 |        |        |
| 10. viii. | 0.3300 |        | 0.3220 |        |        |
| 11. viii. | 0.2900 |        | 0.2725 |        |        |
| 12. viii. | 0.3420 |        | 0.3461 |        |        |
| 13. viii. | 0.3095 |        | 0.3010 |        |        |
| 14. viii. | 0.3000 |        | 0.3737 |        |        |
| 15. viii. |        |        | 0.3200 |        |        |
| 16. viii. |        |        | 0.4236 |        |        |
| 17. viii. |        |        | 0.3735 |        |        |
| 18. viii. |        |        | 0.4100 |        |        |
| 19. viii. |        |        | 0.3830 |        |        |

Table 93. Growth in weight of *Phraortes kumamotoensis* in larval period.

| Date     | No. 34 | No. 35 | No. 36 | No. 37 | No. 38 |
|----------|--------|--------|--------|--------|--------|
| 17. vii. |        | 0.0900 |        |        |        |
| 18. vii. | 0.1172 | 0.0851 |        | 0.1124 |        |
| 19. vii. | 0.1118 | 0.0784 |        | 0.1000 | 0.0965 |
| 20. vii. | 0.1335 | 0.0935 |        | 0.1135 | 0.1162 |
| 21. vii. | 0.1554 | 0.1021 |        | 0.1491 | 0.1390 |
| 22. vii. | 0.1400 | 0.0934 |        | 0.1366 | 0.1241 |
| 23. vii. | 0.1339 | 0.0839 | 0.0540 | 0.1258 | 0.1200 |
| 24. vii. | 0.1230 | 0.0790 | 0.0500 | 0.1140 | 0.1100 |
| 25. vii. | 0.1500 |        | 0.0500 | 0.1455 | 0.1220 |
| 26. vii. | 0.1700 |        | 0.0564 | 0.1600 | 0.1577 |
| 27. vii. | 0.1500 |        | 0.0620 | 0.1484 | 0.1433 |
| 28. vii. | 0.1380 |        | 0.0564 | 0.1198 | 0.1196 |

|          |        |        |        |        |
|----------|--------|--------|--------|--------|
| 29. vii. | 0.1285 | 0.0556 | 0.1084 | 0.1072 |
| 30. vii. | 0.1503 |        | 0.1289 | 0.1670 |
| 31. vii. | 0.1300 |        | 0.1141 | 0.1386 |
| 1. viii. | 0.1200 |        |        | 0.1278 |
| 2. viii. |        |        |        | 0.1095 |

Table 94. Growth in weight of *Phraortes kumamotoensis* in larval period.

| Date      | No. 39 | No. 40 | No. 41 | No. 42 | No. 43 |
|-----------|--------|--------|--------|--------|--------|
| 18. vii.  | 0.1107 | 0.1100 |        |        | 0.1130 |
| 19. vii.  | 0.1154 | 0.1280 |        |        | 0.1423 |
| 20. vii.  | 0.1188 | 0.1240 | 0.1140 |        | 0.1555 |
| 21. vii.  | 0.1430 | 0.1334 | 0.1336 |        | 0.1468 |
| 22. vii.  | 0.1558 | 0.1352 | 0.1335 |        | 0.1547 |
| 23. vii.  | 0.1700 | 0.1450 | 0.1490 | 0.0734 | 0.1599 |
| 24. vii.  | 0.1700 | 0.1350 | 0.1550 | 0.1000 | 0.1660 |
| 25. vii.  | 0.1700 | 0.1300 | 0.1435 | 0.1035 | 0.1635 |
| 26. vii.  | 0.1745 | 0.1145 | 0.1400 | 0.0940 | 0.1559 |
| 27. vii.  | 0.1665 | 0.1199 | 0.1395 | 0.1050 | 0.1651 |
| 28. vii.  | 0.1697 | 0.1140 | 0.1490 | 0.0934 | 0.1699 |
| 29. vii.  |        |        |        |        |        |
| 30. vii.  | 0.2015 | 0.1409 | 0.1710 | 0.1250 | 0.2002 |
| 31. vii.  | 0.1988 | 0.1488 | 0.1889 | 0.1280 | 0.1800 |
| 1. viii.  | 0.1928 | 0.1520 | 0.1845 | 0.1134 | 0.1725 |
| 2. viii.  | 0.1940 | 0.1400 | 0.1840 |        | 0.1600 |
| 3. viii.  |        | 0.1450 | 0.1910 | 0.1700 |        |
| 4. viii.  |        | 0.1400 | 0.1800 | 0.1000 |        |
| 5. viii.  | 0.2000 | 0.1435 | 0.1780 | 0.1170 | 0.2120 |
| 6. viii.  | 0.2025 | 0.1571 | 0.1800 |        | 0.2170 |
| 7. viii.  | 0.2248 | 0.1580 |        |        |        |
| 8. viii.  | 0.2020 | 0.1380 | 0.1945 | 0.1349 | 0.2250 |
| 9. viii.  | 0.2395 | 0.1330 | 0.1790 | 0.1320 | 0.2200 |
| 10. viii. | 0.2400 | 0.1360 | 0.1750 | 0.1330 | 0.2100 |
| 11. viii. | 0.2430 | 0.1400 |        | 0.1400 |        |
| 12. viii. | 0.2425 | 0.1440 |        | 0.1430 |        |
| 13. viii. | 0.2450 | 0.1400 |        | 0.1452 |        |
| 14. viii. | 0.2537 | 0.1400 |        | 0.1460 |        |

|           |        |        |        |
|-----------|--------|--------|--------|
| 15. viii. | 0.2670 | 0.1490 | 0.1480 |
| 16. viii. | 0.2775 | 0.1500 | 0.1495 |
| 17. viii. | 0.2790 | 0.1535 | 0.1400 |
| 18. viii. | 0.2680 | 0.1536 | 0.1564 |
| 19. viii. | 0.2767 | 0.1500 | 0.1500 |
| 20. viii. | 0.2850 | 0.1600 |        |
| 21. viii. | 0.2952 | 0.1545 |        |
| 22. viii. | 0.2800 | 0.1380 |        |
| 23. viii. | 0.2800 | 0.1500 |        |
| 24. viii. | 0.3128 | 0.1500 |        |
| 25. viii. | 0.2900 | 0.1428 |        |
| 26. viii. | 0.2837 | 0.1500 |        |
| 27. viii. | 0.2800 |        |        |
| 28. viii. | 0.3000 |        |        |
| 29. viii. | 0.2540 |        |        |
| 30. viii. | 0.2325 |        |        |

Table 95. Growth in weight of *Phraortes kumamotoensis* in larval period.

| Date     | No. 24 | Date    | No. 25 | No. 26 | No. 27 | No. 28 |
|----------|--------|---------|--------|--------|--------|--------|
| 1. vii.  | 0.2000 | 19. vi. |        |        | 0.1500 |        |
| 2. vii.  | 0.2434 | 20. vi. | 0.0914 | 0.0854 | 0.1667 | 0.0892 |
| 3. vii.  | 0.2300 | 21. vi. | 0.0842 | 0.0773 | 0.1632 | 0.0888 |
| 4. vii.  | 0.2125 | 22. vi. | 0.0821 | 0.0725 | 0.1557 | 0.0825 |
| 5. vii.  | 0.3295 | 23. vi. | 0.1046 | 0.0890 | 0.1990 | 0.1130 |
| 6. vii.  | 0.2850 | 24. vi. | 0.0980 | 0.0800 | 0.1778 | 0.1040 |
| 7. vii.  | 0.2600 | 25. vi. | 0.0900 | 0.0750 | 0.1650 | 0.1000 |
| 8. vii.  | 0.3520 | 26. vi. | 0.1140 | 0.0978 | 0.1979 | 0.1228 |
| 9. vii.  | 0.2920 | 27. vi. | 0.1000 | 0.0900 | 0.1740 | 0.1100 |
| 10. vii. | 0.2643 | 28. vi. | 0.0900 | 0.0870 | 0.1577 | 0.1020 |
| 11. vii. | 0.3075 | 29. vi. | 0.1262 | 0.1102 | 0.2020 | 0.1310 |
| 12. vii. | 0.2855 | 30. vi. | 0.1079 | 0.0959 | 0.1749 | 0.1048 |
| 13. vii. | 0.2664 | 1. vii. | 0.1000 | 0.0900 | 0.1600 | 0.0972 |
| 14. vii. | 0.3650 | 2. vii. | 0.1334 | 0.1170 | 0.2200 |        |

|           |        |           |        |        |        |
|-----------|--------|-----------|--------|--------|--------|
| 15. vii.  | 0.3230 | 3. vii.   | 0.1182 | 0.0956 | 0.2190 |
| 16. vii.  | 0.2900 | 4. vii.   | 0.1030 | 0.0894 | 0.1700 |
| 17. vii.  | 0.3861 | 5. vii.   | 0.1440 | 0.1135 | 0.2100 |
| 18. vii.  | 0.3298 | 6. vii.   | 0.1240 | 0.0970 | 0.1735 |
| 19. vii.  | 0.2920 | 7. vii.   | 0.1131 | 0.0868 | 0.1625 |
| 20. vii.  | 0.3355 | 8. vii.   | 0.1520 | 0.1030 | 0.2100 |
| 21. vii.  | 0.3018 | 9. vii.   | 0.1240 | 0.0864 | 0.1800 |
| 22. vii.  | 0.2800 | 10. vii.  | 0.1135 | 0.0800 | 0.1678 |
| 23. vii.  | 0.3740 | 11. vii.  | 0.1590 | 0.0820 | 0.2030 |
| 24. vii.  | 0.3500 | 12. vii.  | 0.1345 |        | 0.1700 |
| 25. vii.  | 0.3260 | 13. vii.  | 0.1265 |        | 0.1590 |
| 26. vii.  | 0.3810 | 14. vii.  | 0.1700 |        | 0.1900 |
| 27. vii.  | 0.3500 | 15. vii.  | 0.1540 |        | 0.1745 |
| 28. vii.  | 0.3000 | 16. vii.  | 0.1400 |        | 0.1600 |
| 29. vii.  | 0.3450 | 17. vii.  | 0.1660 |        | 0.2259 |
| 30. vii.  | 0.3100 | 18. vii.  | 0.1547 |        | 0.2025 |
| 31. vii.  | 0.2855 | 19. vii.  | 0.1400 |        | 0.1800 |
| 1. viii.  | 0.3400 | 20. vii.  | 0.1855 |        | 0.2200 |
| 2. viii.  | 0.2925 | 21. vii.  | 0.1650 |        | 0.1900 |
| 3. viii.  | 0.2674 | 22. vii.  | 0.1500 |        | 0.1738 |
| 4. viii.  | 0.3140 | 23. vii.  | 0.2070 |        | 0.1950 |
| 5. viii.  | 0.2853 | 24. vii.  | 0.1870 |        | 0.1768 |
| 6. viii.  | 0.2743 | 25. vii.  | 0.1790 |        | 0.1590 |
| 7. viii.  | 0.3182 | 26. vii.  | 0.2247 |        | 0.1900 |
| 8. viii.  | 0.2975 | 27. vii.  | 0.1957 |        | 0.1700 |
| 9. viii.  |        | 28. vii.  | 0.1600 |        | 0.1400 |
| 10. viii. |        | 29. vii.  | 0.2060 |        | 0.1600 |
| 11. viii. |        | 30. vii.  | 0.1812 |        | 0.1400 |
| 12. viii. |        | 31. vii.  | 0.1718 |        |        |
| 13. viii. |        | 1. viii.  | 0.2234 |        |        |
| 14. viii. |        | 2. viii.  | 0.1866 |        |        |
| 15. viii. |        | 3. viii.  | 0.1830 |        |        |
| 16. viii. |        | 4. viii.  | 0.2390 |        |        |
| 17. viii. |        | 5. viii.  | 0.2130 |        |        |
| 18. viii. |        | 6. viii.  | 0.1970 |        |        |
| 19. viii. |        | 7. viii.  | 0.2500 |        |        |
| 20. viii. |        | 8. viii.  | 0.2300 |        |        |
| 21. viii. |        | 9. viii.  | 0.2084 |        |        |
| 22. viii. |        | 10. viii. | 0.2390 |        |        |

Table 96. Amount of leaves eaten by *Phraortes kumamotoensis* in larval period. No. 19.

| Date    | V     | O    | W    | Date     | V     | O    | W    |
|---------|-------|------|------|----------|-------|------|------|
| 17. vi. | 0.0   | 0    | 0    | 1. vii.  | 545.5 | 3764 | 5019 |
| 18. vi. | 0.0   | 0    | 0    | 2. vii.  | 0.0   | 0    | 0    |
| 19. vi. | 151.7 | 1047 | 1396 | 3. vii.  | 257.5 | 1777 | 2369 |
| 20. vi. | 0.0   | 0    | 0    | 4. vii.  | 0.0   | 0    | 0    |
| 21. vi. | 200.9 | 1448 | 1931 | 5. vii.  | 322.7 | 2227 | 2969 |
| 22. vi. | 0.0   | 0    | 0    | 6. vii.  | 0.0   | 0    | 0    |
| 23. vi. | 223.0 | 1539 | 2052 | 7. vii.  | 526.0 | 3698 | 4931 |
| 24. vi. | 0.0   | 0    | 0    | 8. vii.  | 0.0   | 0    | 0    |
| 25. vi. | 0.0   | 0    | 0    | 9. vii.  | 528.4 | 3646 | 4861 |
| 26. vi. | 0.0   | 0    | 0    | 10. vii. | 0.0   | 0    | 0    |
| 27. vi. | 302.0 | 2084 | 2778 | 11. vii. | 570.7 | 3939 | 5250 |
| 28. vi. | 0.0   | 0    | 0    | 12. vii. | 0.0   | 0    | 0    |
| 29. vi. | 68.0  | 469  | 626  | 13. vii. | 369.8 | 2552 | 3402 |
| 30. vi. | 0.0   | 0    | 0    |          |       |      |      |

Table 97. The same as above. No. 20.

| Date    | V     | O    | W    | Date    | V     | O    | W    |
|---------|-------|------|------|---------|-------|------|------|
| 17. vi. | 82.0  | 566  | 754  | 26. vi. | 0.0   | 0    | 0    |
| 18. vi. | 0.0   | 0    | 0    | 27. vi. | 307.5 | 2122 | 2829 |
| 19. vi. | 0.0   | 0    | 0    | 28. vi. | 0.0   | 0    | 0    |
| 20. vi. | 0.0   | 0    | 0    | 29. vi. | 444.5 | 3067 | 4089 |
| 21. vi. | 142.0 | 980  | 1306 | 30. vi. | 0.0   | 0    | 0    |
| 22. vi. | 0.0   | 0    | 0    | 1. vii. | 316.9 | 2187 | 2915 |
| 23. vi. | 247.7 | 1709 | 2279 | 2. vii. | 0.0   | 0    | 0    |
| 24. vi. | 0.0   | 0    | 0    | 3. vii. | 61.2  | 421  | 553  |
| 25. vi. | 0.0   | 0    | 0    | 4. vii. |       |      |      |

Table 98. The same as above. No. 21.

| Date    | V     | O    | W    | Date     | V     | O    | W    |
|---------|-------|------|------|----------|-------|------|------|
| 17. vi. | 0.0   | 0    | 0    | 5. vii.  | 447.7 | 3089 | 4119 |
| 18. vi. | 0.0   | 0    | 0    | 6. vii.  | 0.0   | 0    | 0    |
| 19. vi. | 108.8 | 751  | 1001 | 7. vii.  | 465.2 | 3210 | 4280 |
| 20. vi. | 0.0   | 0    | 0    | 8. vii.  | 0.0   | 0    | 0    |
| 21. vi. | 261.5 | 1804 | 2406 | 9. vii.  | 425.3 | 2935 | 3913 |
| 22. vi. | 0.0   | 0    | 0    | 10. vii. | 0.0   | 0    | 0    |
| 23. vi. | 156.8 | 1082 | 1443 | 11. vii. | 501.9 | 3463 | 4617 |
| 24. vi. | 0.0   | 0    | 0    | 12. vii. | 0.0   | 0    | 0    |
| 25. vi. | 0.0   | 0    | 0    | 13. vii. | 422.4 | 2915 | 3886 |
| 26. vi. | 0.0   | 0    | 0    | 14. vii. | 0.0   | 0    | 0    |
| 27. vi. | 341.8 | 2358 | 3145 | 15. vii. | 421.0 | 2905 | 3873 |
| 28. vi. | 0.0   | 0    | 0    | 16. vii. | 0.0   | 0    | 0    |
| 29. vi. | 557.0 | 3843 | 5124 | 17. vii. | 738.5 | 5096 | 6794 |
| 30. vi. | 0.0   | 0    | 0    | 18. vii. | 0.0   | 0    | 0    |
| 1. vii. | 87.4  | 603  | 807  | 19. vii. | 277.5 | 1915 | 2553 |
| 2. vii. | 0.0   | 0    | 0    | 20. vii. | 0.0   | 0    | 0    |
| 3. vii. | 410.0 | 2829 | 3772 | 21. vii. | 112.5 | 776  | 1035 |
| 4. vii. | 0.0   | 0    | 0    |          |       |      |      |

Table 99. The same as above. No. 22.

| Date    | V     | O    | W    | Date    | V     | O    | W    |
|---------|-------|------|------|---------|-------|------|------|
| 18. vi. | 0.0   | 0    | 0    | 27. vi. | 321.2 | 2216 | 2955 |
| 19. vi. | 0.0   | 0    | 0    | 28. vi. | 0.0   | 0    | 0    |
| 20. vi. | 0.0   | 0    | 0    | 29. vi. | 426.8 | 2945 | 3927 |
| 21. vi. | 157.5 | 1087 | 1440 | 30. vi. | 0.0   | 0    | 0    |
| 22. vi. | 0.0   | 0    | 0    | 1. vii. | 318.1 | 2195 | 2927 |
| 23. vi. | 182.7 | 1261 | 1681 | 2. vii. | 0.0   | 0    | 0    |
| 24. vi. | 0.0   | 0    | 0    | 3. vii. | 183.3 | 1265 | 1686 |
| 25. vi. | 0.0   | 0    | 0    | 4. vii. | 0.0   | 0    | 0    |
| 26. vi. | 0.0   | 0    | 0    | 5. vii. | 69.5  | 476  | 669  |

Table 100. The same as above. No. 23.

| Date    | V     | O    | W    | Date    | V     | O    | W    |
|---------|-------|------|------|---------|-------|------|------|
| 17. vi. | 0.0   | 0    | 0    | 29. vi. | 218.0 | 1504 | 2006 |
| 18. vi. | 0.0   | 0    | 0    | 30. vi. | 0.0   | 0    | 0    |
| 19. vi. | 0.0   | 0    | 0    | 1. vii. | 249.2 | 1719 | 2293 |
| 20. vi. | 0.0   | 0    | 0    | 2. vii. | 0.0   | 0    | 0    |
| 21. vi. | 39.1  | 270  | 360  | 3. vii. | 198.3 | 1368 | 1824 |
| 22. vi. | 0.0   | 0    | 0    | 4. vii. | 0.0   | 0    | 0    |
| 23. vi. | 91.8  | 633  | 845  | 5. vii. | 227.1 | 1567 | 2089 |
| 24. vi. | 0.0   | 0    | 0    | 6. vii. | 0.0   | 0    | 0    |
| 25. vi. | 0.0   | 0    | 0    | 7. vii. | 61.8  | 426  | 569  |
| 26. vi. | 0.0   | 0    | 0    | 8. vii. | 0.0   | 0    | 0    |
| 27. vi. | 228.0 | 1573 | 2098 | 9. vii. | 0.0   | 0    | 0    |
| 28. vi. | 0.0   | 0    | 0    |         |       |      |      |

Table 101. Amount of leaves eaten by *Phraortes kumamotoensis* in larval period. No. 24.

| Date     | V     | O    | W    | Date     | V     | O    | W    |
|----------|-------|------|------|----------|-------|------|------|
| 1. vii.  | 0.0   | 0    | 0    | 13. vii. | 0.0   | 0    | 0    |
| 2. vii.  | 311.0 | 2146 | 2861 | 14. vii. | 403.0 | 2781 | 3708 |
| 3. vii.  | 0.0   | 0    | 0    | 15. vii. | 0.0   | 0    | 0    |
| 4. vii.  | 0.0   | 0    | 0    | 16. vii. | 0.0   | 0    | 0    |
| 5. vii.  | 441.8 | 3048 | 4065 | 17. vii. | 580.5 | 4005 | 5341 |
| 6. vii.  | 0.0   | 0    | 0    | 18. vii. | 0.0   | 0    | 0    |
| 7. vii.  | 0.0   | 0    | 0    | 19. vii. | 0.0   | 0    | 0    |
| 8. vii.  | 587.0 | 4050 | 5400 | 20. vii. | 247.2 | 1706 | 2274 |
| 9. vii.  | 0.0   | 0    | 0    | 21. vii. | 0.0   | 0    | 0    |
| 10. vii. | 0.0   | 0    | 0    | 22. vii. | 0.0   | 0    | 0    |
| 11. vii. | 284.0 | 1960 | 2613 | 23. vii. | 368.0 | 2539 | 3386 |
| 12. vii. | 0.0   | 0    | 0    |          |       |      |      |

Table 102. The same as above. No. 25.

| Date    | V     | O    | W    | Date     | V     | O    | W    |
|---------|-------|------|------|----------|-------|------|------|
| 17. vi. | 0.0   | 0    | 0    | 6. vii.  | 0.0   | 0    | 0    |
| 18. vi. | 0.0   | 0    | 0    | 7. vii.  | 0.0   | 0    | 0    |
| 19. vi. | 0.0   | 0    | 0    | 8. vii.  | 253.0 | 1746 | 2328 |
| 20. vi. | 25.0  | 173  | 230  | 9. vii.  | 0.0   | 0    | 0    |
| 21. vi. | 0.0   | 0    | 0    | 10. vii. | 0.0   | 0    | 0    |
| 22. vi. | 0.0   | 0    | 0    | 11. vii. | 259.0 | 1787 | 2383 |
| 23. vi. | 185.2 | 1278 | 1704 | 12. vii. | 0.0   | 0    | 0    |
| 24. vi. | 0.0   | 0    | 0    | 13. vii. | 0.0   | 0    | 0    |
| 25. vi. | 0.0   | 0    | 0    | 14. vii. | 258.0 | 1780 | 2374 |
| 26. vi. | 195.0 | 1346 | 1794 | 15. vii. | 0.0   | 0    | 0    |
| 27. vi. | 0.0   | 0    | 0    | 16. vii. | 0.0   | 0    | 0    |
| 28. vi. | 0.0   | 0    | 0    | 17. vii. | 170.0 | 1173 | 1564 |
| 29. vi. | 248.0 | 1711 | 2282 | 18. vii. | 0.0   | 0    | 0    |
| 30. vi. | 0.0   | 0    | 0    | 19. vii. | 0.0   | 0    | 0    |
| 1. vii. | 0.0   | 0    | 0    | 20. vii. | 165.0 | 1139 | 1518 |
| 2. vii. | 291.0 | 2008 | 2677 | 21. vii. | 0.0   | 0    | 0    |
| 3. vii. | 0.0   | 0    | 0    | 22. vii. | 0.0   | 0    | 0    |
| 4. vii. | 0.0   | 0    | 0    | 23. vii. | 287.0 | 1980 | 2640 |
| 5. vii. | 207.3 | 1330 | 1907 |          |       |      |      |

Table 103. The same as above. No. 26.

| Date    | V     | O    | W    | Date     | V     | O    | W    |
|---------|-------|------|------|----------|-------|------|------|
| 17. vi. | 31.0  | 214  | 285  | 30. vi.  | 0.0   | 0    | 0    |
| 18. vi. | 0.0   | 0    | 0    | 1. vii.  | 0.0   | 0    | 0    |
| 19. vi. | 0.0   | 0    | 0    | 2. vii.  | 179.1 | 1236 | 1648 |
| 20. vi. | 0.0   | 0    | 0    | 3. vii.  | 0.0   | 0    | 0    |
| 21. vi. | 0.0   | 0    | 0    | 4. vii.  | 0.0   | 0    | 0    |
| 22. vi. | 0.0   | 0    | 0    | 5. vii.  | 112.0 | 773  | 1030 |
| 23. vi. | 94.0  | 649  | 865  | 6. vii.  | 0.0   | 0    | 0    |
| 24. vi. | 0.0   | 0    | 0    | 7. vii.  | 0.0   | 0    | 0    |
| 25. vi. | 0.0   | 0    | 0    | 8. vii.  | 101.0 | 697  | 929  |
| 26. vi. | 114.9 | 793  | 1057 | 9. vii.  | 0.0   | 0    | 0    |
| 27. vi. | 0.0   | 0    | 0    | 10. vii. | 0.0   | 0    | 0    |
| 28. vi. | 0.0   | 0    | 0    | 11. vii. | 21.0  | 145  | 193  |
| 29. vi. | 265.0 | 1829 | 2438 |          |       |      |      |

Table 104. The same as above. No. 27.

| Date    | V     | O    | W    | Date     | V     | O    | W    |
|---------|-------|------|------|----------|-------|------|------|
| 17. vi. | 0.0   | 0    | 0    | 6. vii.  | 0.0   | 0    | 0    |
| 18. vi. | 0.0   | 0    | 0    | 7. vii.  | 0.0   | 0    | 0    |
| 19. vi. | 0.0   | 0    | 0    | 8. vii.  | 237.0 | 1635 | 2180 |
| 20. vi. | 157.0 | 1083 | 1444 | 9. vii.  | 0.0   | 0    | 0    |
| 21. vi. | 0.0   | 0    | 0    | 10. vii. | 0.0   | 0    | 0    |
| 22. vi. | 0.0   | 0    | 0    | 11. vii. | 209.7 | 1447 | 1929 |
| 23. vi. | 346.0 | 2387 | 3183 | 12. vii. | 0.0   | 0    | 0    |
| 24. vi. | 0.0   | 0    | 0    | 13. vii. | 0.0   | 0    | 0    |
| 25. vi. | 0.0   | 0    | 0    | 14. vii. | 232.0 | 1601 | 2134 |
| 26. vi. | 231.3 | 1596 | 2128 | 15. vii. | 0.0   | 0    | 0    |
| 27. vi. | 0.0   | 0    | 0    | 16. vii. | 0.0   | 0    | 0    |
| 28. vi. | 0.0   | 0    | 0    | 17. vii. | 303.4 | 2093 | 2791 |
| 29. vi. | 404.2 | 2789 | 3719 | 18. vii. | 0.0   | 0    | 0    |
| 30. vi. | 0.0   | 0    | 0    | 19. vii. | 0.0   | 0    | 0    |
| 1. vii. | 0.0   | 0    | 0    | 20. vii. | 152.7 | 1054 | 1405 |
| 2. vii. | 302.2 | 2085 | 2780 | 21. vii. | 0.0   | 0    | 0    |
| 3. vii. | 0.0   | 0    | 0    | 22. vii. | 0.0   | 0    | 0    |
| 4. vii. | 0.0   | 0    | 0    | 23. vii. | 271.3 | 1872 | 2496 |
| 5. vii. | 244.0 | 1684 | 2245 |          |       |      |      |

Table 105. The same as above. No. 28.

| Date    | V     | O    | W    | Date    | V     | O    | W    |
|---------|-------|------|------|---------|-------|------|------|
| 17. vi. | 65.0  | 449  | 598  | 25. vi. | 0.0   | 0    | 0    |
| 18. vi. | 0.0   | 0    | 0    | 26. vi. | 167.5 | 1156 | 1541 |
| 19. vi. | 0.0   | 0    | 0    | 27. vi. | 0.0   | 0    | 0    |
| 20. vi. | 10.0  | 69   | 92   | 28. vi. | 0.0   | 0    | 0    |
| 21. vi. | 0.0   | 0    | 0    | 29. vi. | 170.0 | 1173 | 1564 |
| 22. vi. | 0.0   | 0    | 0    | 30. vi. | 0.0   | 0    | 0    |
| 23. vi. | 146.6 | 1012 | 1349 |         |       |      |      |
| 24. vi. | 0.0   | 0    | 0    |         |       |      |      |

Table 106. Amount of leaves eaten by *Phraortes kumamotoensis* in larval period. No. 29.

| Date    | V     | O    | W    | Date    | V     | O    | W    |
|---------|-------|------|------|---------|-------|------|------|
| 17. vi. | 0.0   | 0    | 0    | 27. vi. | 40.0  | 200  | 248  |
| 18. vi. | 76.5  | 383  | 474  | 28. vi. | 499.0 | 2495 | 3094 |
| 19. vi. | 144.8 | 724  | 898  | 29. vi. | 752.0 | 3760 | 4662 |
| 20. vi. | 256.0 | 1280 | 1587 | 30. vi. | 444.0 | 2220 | 2753 |
| 21. vi. | 187.0 | 935  | 1159 | 1. vii. |       |      |      |
| 22. vi. | 258.0 | 1290 | 1600 | 2. vii. | 920.0 | 4600 | 5704 |
| 23. vi. | 209.0 | 1045 | 1296 | 3. vii. | 631.5 | 3158 | 3915 |
| 24. vi. | 295.3 | 1477 | 1831 | 4. vii. | 396.0 | 1980 | 2455 |
| 25. vi. | 232.0 | 1160 | 1438 | 5. vii. | 629.4 | 3147 | 3902 |
| 26. vi. | 208.3 | 1046 | 1291 | 6. vii. | 0.0   | 0    | 0    |

Table 107. The same as above. No. 30.

| Date    | V     | O    | W    | Date    | V      | O    | W    |
|---------|-------|------|------|---------|--------|------|------|
| 17. vi. | 0.0   | 0    | 0    | 27. vi. | 61.0   | 305  | 378  |
| 18. vi. | 33.0  | 165  | 205  | 28. vi. | 118.0  | 590  | 732  |
| 19. vi. | 197.2 | 986  | 1223 | 29. vi. | 525.0  | 2625 | 3255 |
| 20. vi. | 175.0 | 875  | 1085 | 30. vi. | 790.0  | 3950 | 4898 |
| 21. vi. | 274.5 | 1373 | 1702 | 1. vii. | 385.9  | 1930 | 2393 |
| 22. vi. | 174.0 | 870  | 1079 | 2. vii. | 638.0  | 3190 | 3956 |
| 23. vi. | 289.5 | 1448 | 1795 | 3. vii. | 1042.0 | 5210 | 6460 |
| 24. vi. | 422.7 | 2114 | 2621 | 4. vii. | 758.7  | 3794 | 4704 |
| 25. vi. | 325.0 | 1625 | 2015 | 5. vii. | 283.0  | 1415 | 1755 |
| 26. vi. | 343.5 | 1718 | 2130 | 6. vii. | 0.0    | 0    | 0    |

Table 108. The same as above. No. 31.

| Date    | V     | O    | W    | Date    | V      | O    | W    |
|---------|-------|------|------|---------|--------|------|------|
| 16. vi. | 6.0   | 30   | 37   | 25. vi. | 276.0  | 1380 | 1711 |
| 17. vi. | 122.5 | 623  | 760  | 26. vi. | 0.0    | 0    | 0    |
| 18. vi. | 235.2 | 1176 | 1458 | 27. vi. | 180.3  | 902  | 1118 |
| 19. vi. | 246.5 | 1233 | 1528 | 28. vi. | 602.0  | 3010 | 3732 |
| 20. vi. | 196.1 | 981  | 1216 | 29. vi. | 609.4  | 3047 | 3778 |
| 21. vi. | 257.5 | 1288 | 1597 | 30. vi. | 1211.0 | 6055 | 7508 |
| 22. vi. | 323.5 | 1618 | 2006 | 1. vii. | 784.0  | 3920 | 4861 |
| 23. vi. | 294.3 | 1472 | 1855 | 2. vii. | 1094.0 | 5470 | 6783 |
| 24. vi. | 369.0 | 1845 | 2288 | 3. vii. | 323.8  | 1619 | 2008 |
|         |       |      |      | 4. vii. | 0.0    | 0    | 0    |

Table 109. The same as above. No. 32.

| Date    | V     | O   | W   | Date    | V     | O    | W    |
|---------|-------|-----|-----|---------|-------|------|------|
| 16. vi. | 91.0  | 458 | 564 | 25. vi. | 199.0 | 995  | 1234 |
| 17. vi. | 105.0 | 525 | 651 | 26. vi. | 256.0 | 1280 | 1587 |
| 18. vi. | 89.5  | 448 | 555 | 27. vi. | 329.5 | 1648 | 2043 |
| 19. vi. | 62.0  | 310 | 384 | 28. vi. | 260.0 | 1300 | 1612 |
| 20. vi. | 49.0  | 245 | 304 | 29. vi. | 242.2 | 1211 | 1502 |
| 21. vi. | 0.0   | 0   | 0   | 30. vi. | 101.4 | 507  | 629  |
| 22. vi. | 0.0   | 0   | 0   | 1. vii. | 209.5 | 1048 | 1299 |
| 23. vi. | 106.0 | 530 | 657 | 2. vii. | 0.0   | 0    | 0    |
| 24. vi. | 123.9 | 620 | 769 | 3. vii. | 0.0   | 0    | 0    |

Table 110. The same as above. No. 33.

| Date    | V     | O    | W    | Date    | V     | O    | W    |
|---------|-------|------|------|---------|-------|------|------|
| 19. vi. | 0.0   | 0    | 0    | 27. vi. | 248.8 | 1244 | 1543 |
| 20. vi. | 64.0  | 320  | 397  | 28. vi. | 295.0 | 1475 | 1829 |
| 21. vi. | 84.1  | 421  | 521  | 29. vi. | 256.4 | 1282 | 1590 |
| 22. vi. | 157.3 | 787  | 975  | 30. vi. | 322.5 | 1613 | 2000 |
| 23. vi. | 218.7 | 1094 | 1356 | 1. vii. | 167.8 | 839  | 1040 |
| 24. vi. | 169.0 | 845  | 1048 | 2. vii. | 0.0   | 0    | 0    |
| 25. vi. | 167.6 | 838  | 1039 | 3. vii. | 0.0   | 0    | 0    |
| 26. vi. | 282.5 | 1413 | 1752 |         |       |      |      |

Table 111. Amount of leaves eaten by *Phraortes kumamotoensis* in larval period. No. 34.

| Date    | V     | O    | W    | Date    | V     | O    | W    |
|---------|-------|------|------|---------|-------|------|------|
| 21. vi. | 210.9 | 1455 | 1940 | 26. vi. | 0.0   | 00   | 00   |
| 22. vi. | 0.0   | 0    | 0    | 27. vi. | 0.0   | 0    | 0    |
| 23. vi. | 0.0   | 0    | 0    | 28. vi. | 0.0   | 0    | 0    |
| 24. vi. | 0.0   | 0    | 0    | 29. vi. | 0.0   | 0    | 0    |
| 25. vi. | 0.0   | 0    | 0    | 30. vi. | 190.8 | 1317 | 1755 |

Table 112. The same as above. No. 37.

| Date    | V     | O    | W    | Date    | V    | O   | W   |
|---------|-------|------|------|---------|------|-----|-----|
| 21. vi. | 155.8 | 1075 | 1433 | 26. vi. | 0.0  | 0   | 0   |
| 22. vi. | 0.0   | 0    | 0    | 27. vi. | 0.0  | 0   | 0   |
| 23. vi. | 0.0   | 0    | 0    | 28. vi. | 0.0  | 0   | 0   |
| 24. vi. | 0.0   | 0    | 0    | 29. vi. | 0.0  | 0   | 0   |
| 25. vi. | 0.0   | 0    | 0    | 30. vi. | 48.5 | 335 | 446 |

Table 113. The same as above. No. 38.

| Date    | V     | O    | W    | Date    | V     | O    | W    |
|---------|-------|------|------|---------|-------|------|------|
| 21. vi. | 235.0 | 1622 | 2162 | 26. vi. | 0.0   | 0    | 0    |
| 22. vi. | 0.0   | 0    | 0    | 27. vi. | 0.0   | 0    | 0    |
| 23. vi. | 0.0   | 0    | 0    | 28. vi. | 0.0   | 0    | 0    |
| 24. vi. | 0.0   | 0    | 0    | 29. vi. | 0.0   | 0    | 0    |
| 25. vi. | 0.0   | 0    | 0    | 30. vi. | 187.0 | 1290 | 1720 |

Table 114. Amount of leaves eaten by *Phraortes kumamotoensis* in larval period. No. 39.

| Date    | V     | O    | W    | Date     | V     | O   | W    |
|---------|-------|------|------|----------|-------|-----|------|
| 18. vi. | 31.0  | 214  | 285  | 10. vii. | 73.0  | 504 | 672  |
| 19. vi. | 41.0  | 283  | 387  | 11. vii. | 77.0  | 531 | 702  |
| 20. vi. | 34.5  | 238  | 317  | 12. vii. | 69.0  | 476 | 635  |
| 21. vi. | 36.0  | 248  | 331  | 13. vii. | 91.0  | 628 | 837  |
| 22. vi. | 86.0  | 593  | 791  | 14. vii. | 89.0  | 614 | 819  |
| 23. vi. | 69.0  | 476  | 639  | 15. vii. | 78.0  | 538 | 718  |
| 24. vi. | 68.0  | 469  | 626  | 16. vii. | 132.0 | 911 | 1214 |
| 25. vi. | 54.0  | 373  | 497  | 17. vii. | 78.0  | 538 | 718  |
| 26. vi. | 86.0  | 593  | 791  | 18. vii. | 115.0 | 796 | 1058 |
| 27. vi. | 88.0  | 607  | 810  | 19. vii. | 88.0  | 607 | 810  |
| 28. vi. | 85.0  | 587  | 782  | 20. vii. | 77.0  | 531 | 700  |
| 29. vi. | 226.0 | 1559 | 2079 | 21. vii. | 65.0  | 449 | 598  |
| 30. vi. | 0.0   | 0    | 0    | 22. vii. | 102.0 | 704 | 938  |
| 1. vii. | 60.0  | 414  | 552  | 23. vii. | 73.0  | 504 | 672  |
| 2. vii. | 76.0  | 724  | 699  | 24. vii. | 137.0 | 945 | 1260 |
| 3. vii. | 73.0  | 504  | 672  |          |       |     |      |
| 4. vii. | 0.0   | 0    | 0    |          |       |     |      |
| 5. vii. | 30.0  | 207  | 276  |          |       |     |      |
| 6. vii. |       |      |      |          |       |     |      |
| 7. vii. | 73.0  | 504  | 672  |          |       |     |      |
| 8. vii. | 76.0  | 524  | 699  |          |       |     |      |
| 9. vii. | 61.0  | 421  | 561  |          |       |     |      |

Table 115. The same as above. No. 40.

| Date    | V     | O    | W    | Date     | V    | O   | W   |
|---------|-------|------|------|----------|------|-----|-----|
| 18. vi. | 23.0  | 158  | 212  | 7. vii.  | 63.5 | 435 | 580 |
| 19. vi. | 25.8  | 178  | 237  | 8. vii.  | 42.0 | 290 | 386 |
| 20. vi. | 30.0  | 207  | 276  | 9. vii.  | 26.0 | 179 | 239 |
| 21. vi. | 76.5  | 528  | 704  | 10. vii. | 28.0 | 193 | 258 |
| 22. vi. | 58.0  | 400  | 534  | 11. vii. | 23.0 | 159 | 212 |
| 23. vi. | 55.0  | 380  | 506  | 12. vii. | 23.0 | 159 | 212 |
| 24. vi. | 50.0  | 345  | 460  | 13. vii. | 33.0 | 228 | 304 |
| 25. vi. | 36.0  | 248  | 331  | 14. vii. | 28.0 | 193 | 258 |
| 26. vi. | 31.0  | 214  | 285  | 15. vii. | 44.0 | 304 | 405 |
| 27. vi. | 65.9  | 449  | 598  | 16. vii. | 39.0 | 269 | 359 |
| 28. vi. | 42.0  | 290  | 386  | 17. vii. | 38.0 | 262 | 350 |
| 29. vi. | 169.0 | 1166 | 1555 | 18. vii. | 54.0 | 373 | 499 |
| 30. vi. | 0.0   | 0    | 0    | 19. vii. | 44.0 | 304 | 405 |
| 1. vii. | 36.0  | 248  | 331  | 20. vii. | 27.0 | 186 | 248 |
| 2. vii. | 62.0  | 428  | 570  | 21. vii. | 58.0 | 400 | 534 |
| 3. vii. | 65.0  | 449  | 598  | 22. vii. | 42.0 | 290 | 386 |
| 4. vii. | 40.0  | 276  | 368  | 23. vii. | 36.0 | 248 | 331 |
| 5. vii. | 62.0  | 428  | 570  | 24. vii. | 70.0 | 483 | 644 |
| 6. vii. | 58.0  | 400  | 534  |          |      |     |     |

Table 116. The same as above. No. 41.

| Date    | V     | O    | W    | Date     | V     | O   | W    |
|---------|-------|------|------|----------|-------|-----|------|
| 18. vi. | 15.0  | 104  | 138  | 30. vi.  | 0.0   | 0   | 0    |
| 19. vi. |       |      |      | 1. vii.  | 65.0  | 450 | 608  |
| 20. vi. | 15.0  | 104  | 138  | 2. vii.  | 117.0 | 807 | 1076 |
| 21. vi. | 61.0  | 421  | 561  | 3. vii.  | 95.0  | 656 | 874  |
| 22. vi. | 35.0  | 242  | 322  | 4. vii.  | 75.0  | 518 | 690  |
| 23. vi. | 42.0  | 290  | 386  | 5. vii.  | 79.0  | 545 | 727  |
| 24. vi. | 51.0  | 352  | 469  | 6. vii.  | 82.0  | 566 | 754  |
| 25. vi. | 47.0  | 324  | 432  | 7. vii.  | 79.0  | 545 | 727  |
| 26. vi. | 77.0  | 531  | 708  | 8. vii.  | 72.0  | 497 | 662  |
| 27. vi. | 69.0  | 476  | 634  | 9. vii.  | 73.0  | 504 | 672  |
| 28. vi. | 66.0  | 455  | 607  | 10. vii. | 50.0  | 345 | 460  |
| 29. vi. | 187.0 | 1290 | 1720 | 11. vii. | 0.0   | 0   | 0    |

Table 117. The same as above. No. 43.

| Date    | V     | O   | W    | Date     | V     | O   | W    |
|---------|-------|-----|------|----------|-------|-----|------|
| 18. vi. | 11.5  | 79  | 106  | 5. vii.  | 38.0  | 262 | 350  |
| 19. vi. | 28.0  | 193 | 258  | 6. vii.  | 40.0  | 276 | 368  |
| 20. vi. | 22.8  | 157 | 210  | 7. vii.  | 117.0 | 807 | 1076 |
| 21. vi. | 56.0  | 386 | 515  | 8. vii.  | 72.0  | 497 | 662  |
| 22. vi. | 0.0   | 0   | 0    | 9. vii.  | 128.0 | 883 | 1178 |
| 23. vi. | 0.0   | 0   | 0    | 10. vii. | 37.0  | 255 | 340  |
| 24. vi. | 81.5  | 562 | 750  | 11. vii. | 43.0  | 297 | 350  |
| 25. vi. | 18.0  | 124 | 166  | 12. vii. | 29.0  | 200 | 267  |
| 26. vi. | 14.0  | 97  | 129  | 13. vii. | 42.0  | 290 | 386  |
| 27. vi. | 51.0  | 352 | 469  | 14. vii. | 43.0  | 297 | 396  |
| 28. vi. | 102.0 | 704 | 938  | 15. vii. | 46.0  | 317 | 422  |
| 29. vi. | 111.0 | 766 | 1021 | 16. vii. | 50.0  | 345 | 460  |
| 30. vi. | 0.0   | 0   | 0    | 17. vii. | 25.0  | 173 | 230  |
| 1. vii. | 31.5  | 217 | 290  | 18. vii. | 49.0  | 338 | 451  |
| 2. vii. | 18.0  | 124 | 166  | 19. vii. | 50.0  | 345 | 460  |
| 3. vii. | 45.0  | 318 | 414  | 20. vii. | 39.0  | 269 | 359  |
| 4. vii. | 43.0  | 297 | 396  |          |       |     |      |

Table 118. The same as above. No. 42.

| Date    | V     | O    | W    | Date     | V     | O    | W    |
|---------|-------|------|------|----------|-------|------|------|
| 18. vi. | 25.0  | 153  | 230  | 30. vi.  | 0.0   | 0    | 0    |
| 19. vi. | 37.0  | 255  | 340  | 1. vii.  | 47.0  | 324  | 432  |
| 20. vi. | 51.0  | 352  | 469  | 2. vii.  | 73.0  | 504  | 672  |
| 21. vi. | 0.0   | 0    | 0    | 3. vii.  | 71.5  | 493  | 658  |
| 22. vi. | 80.0  | 552  | 736  | 4. vii.  | 47.0  | 324  | 432  |
| 23. vi. | 43.0  | 297  | 396  | 5. vii.  | 123.0 | 849  | 1132 |
| 24. vi. | 91.0  | 628  | 837  | 6. vii.  | 363.0 | 2505 | 3340 |
| 25. vi. | 62.0  | 428  | 570  | 7. vii.  | 70.0  | 483  | 644  |
| 26. vi. | 65.0  | 449  | 598  | 8. vii.  | 108.0 | 745  | 994  |
| 27. vi. | 73.5  | 507  | 676  | 9. vii.  | 86.0  | 593  | 791  |
| 28. vi. | 63.0  | 435  | 580  | 10. vii. | 69.0  | 478  | 635  |
| 29. vi. | 182.0 | 1256 | 1674 | 11. vii. | 0.0   | 0    | 0    |

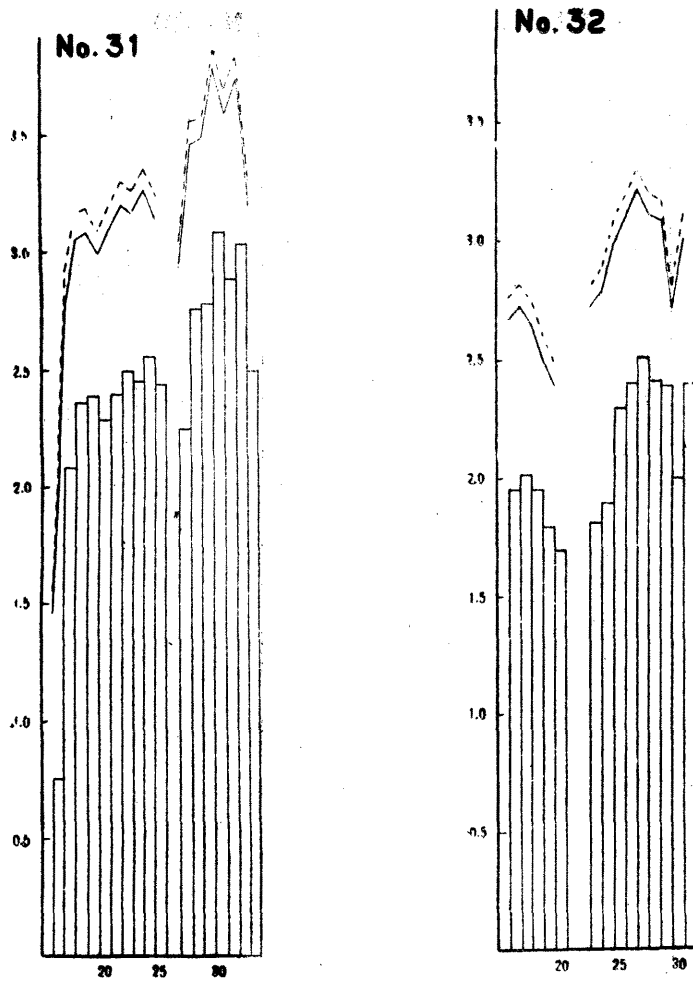
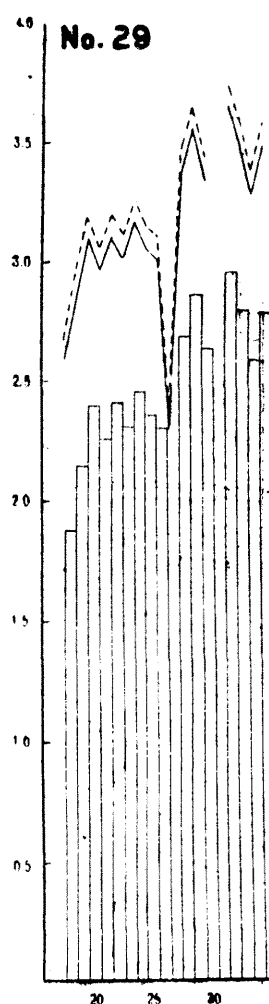
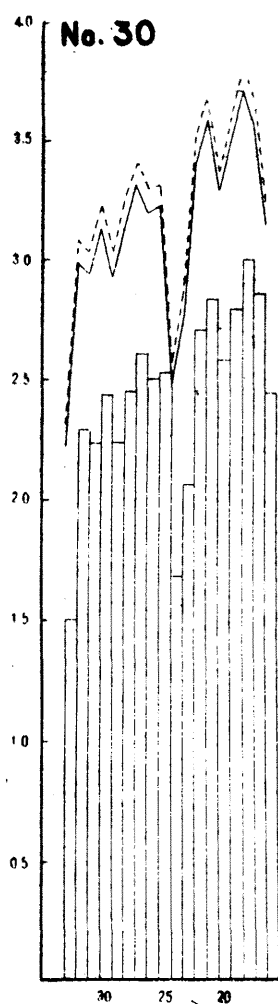
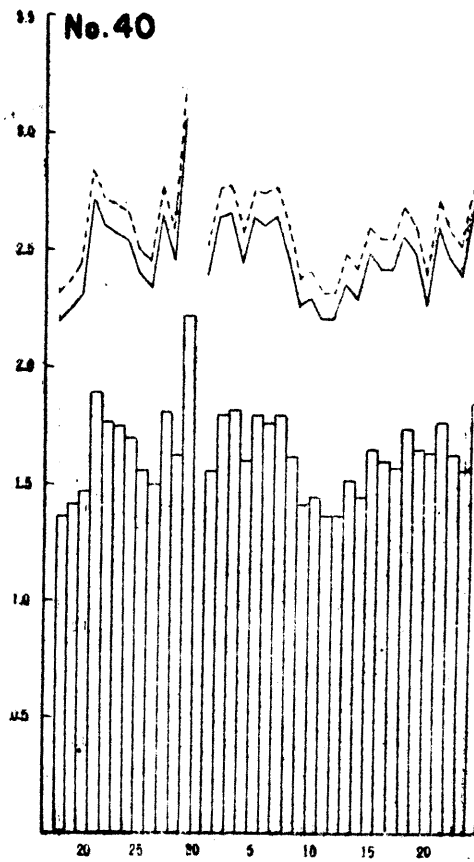
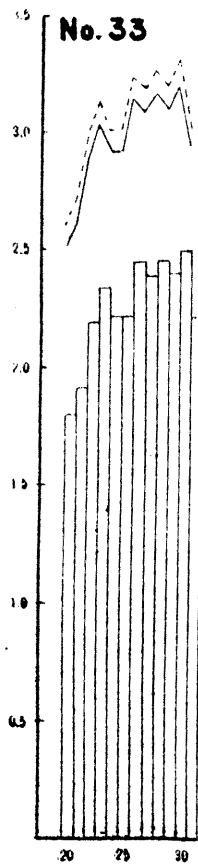
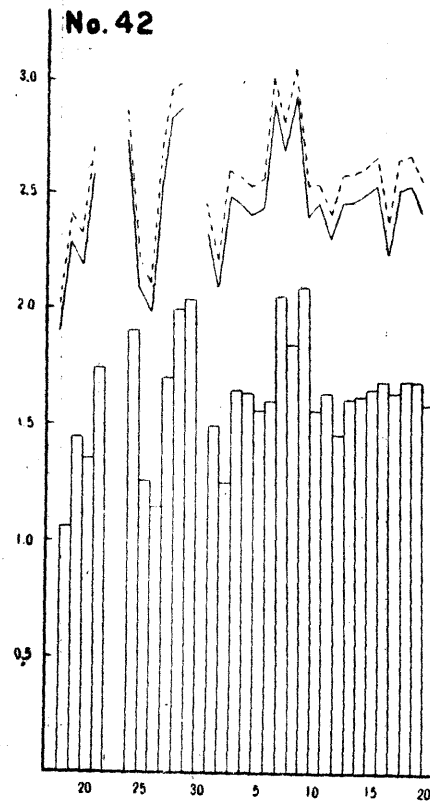
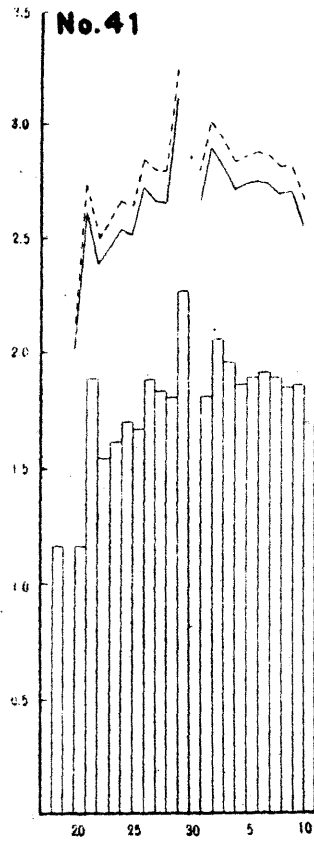
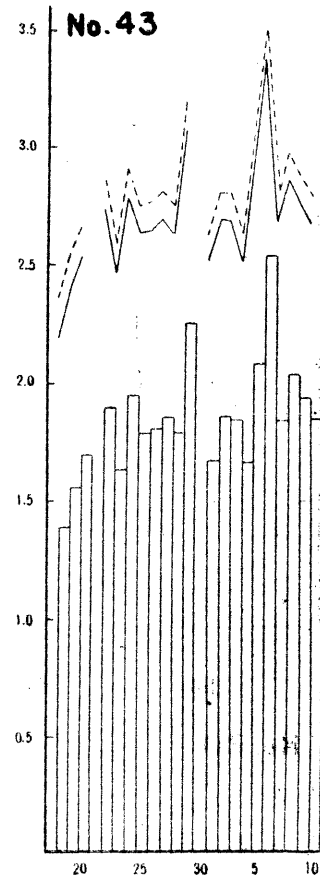
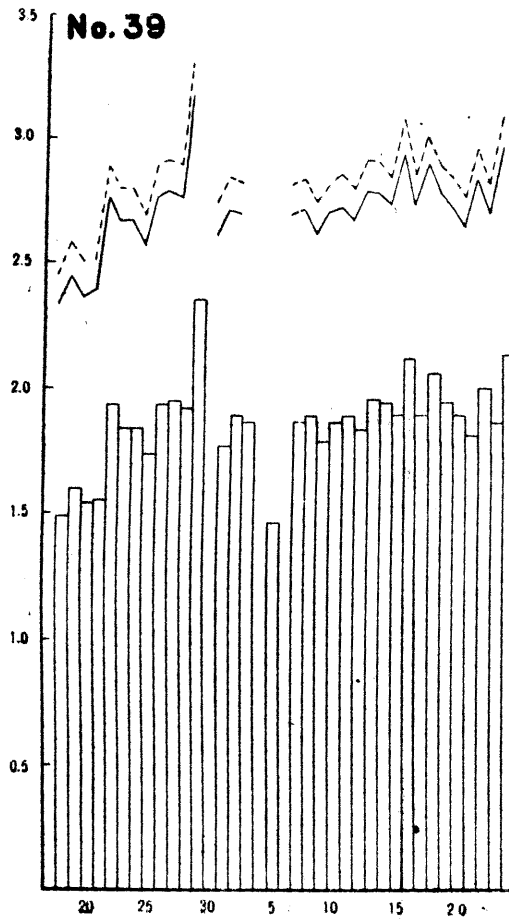


Fig. 34. Amount of leaves eaten by *Phraortes kumamotoensis* during the larval stadia. Abscissa represents time in date from June to July.









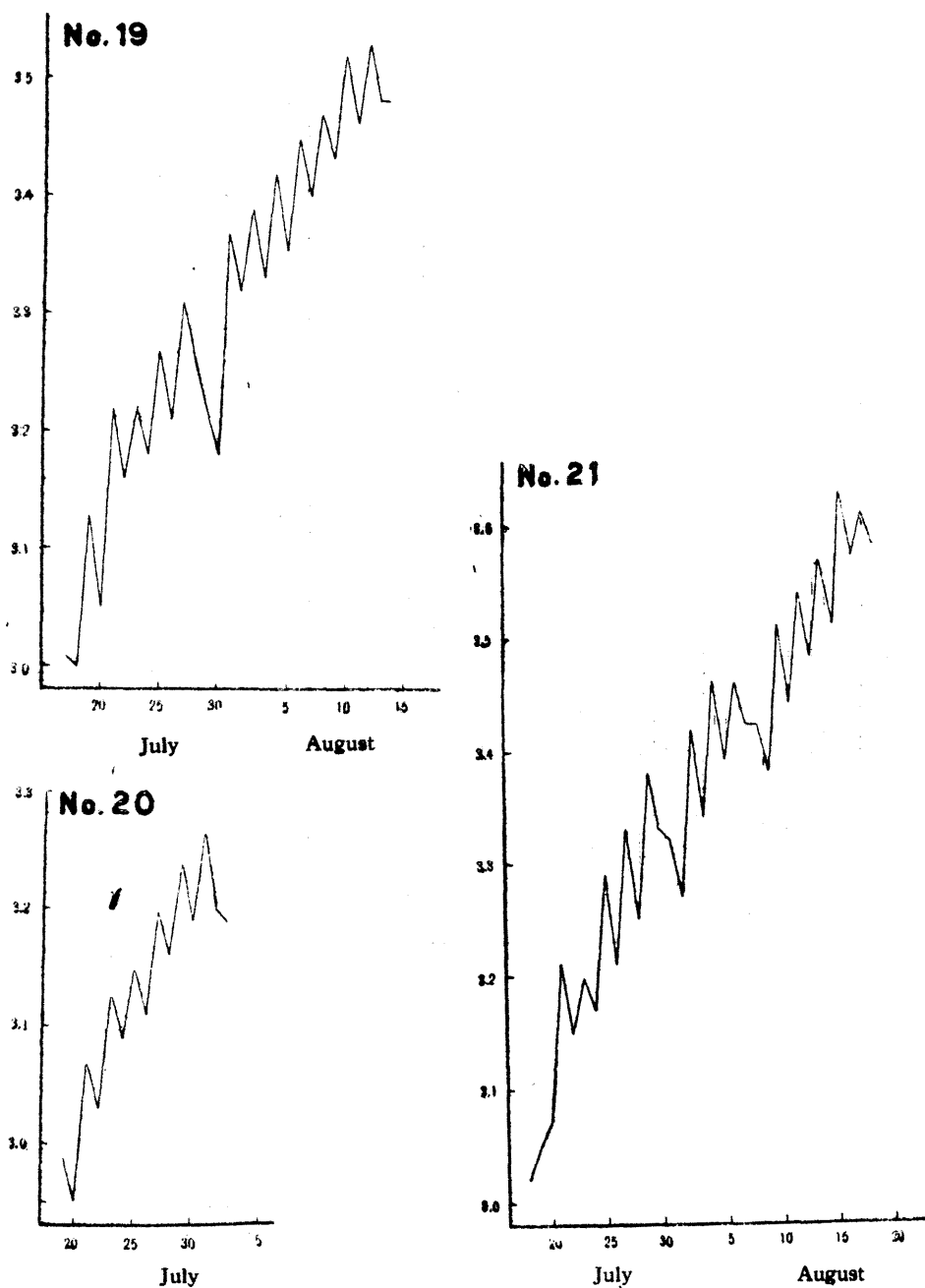
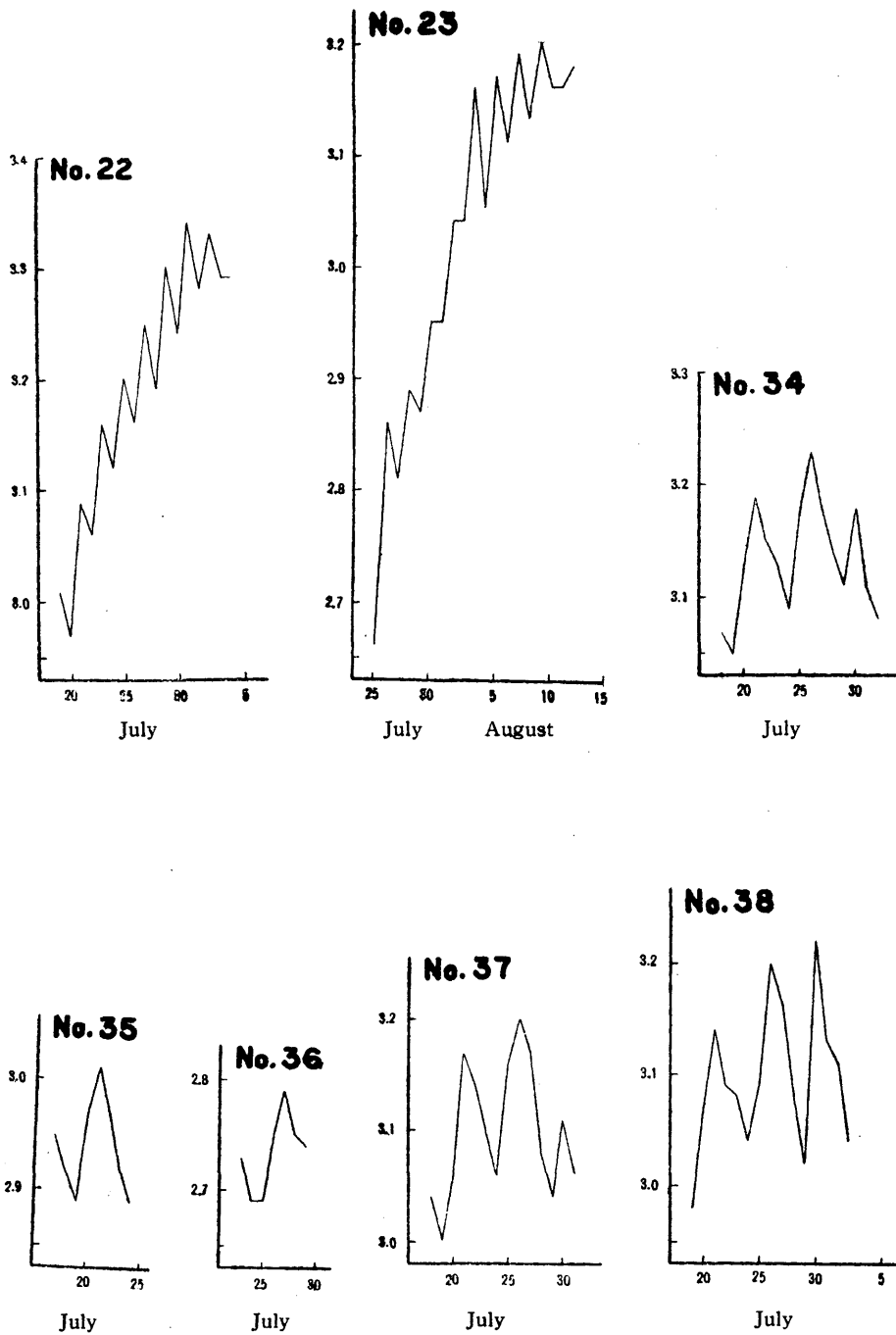
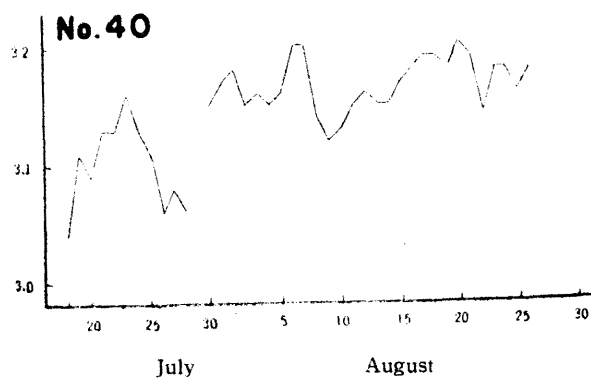
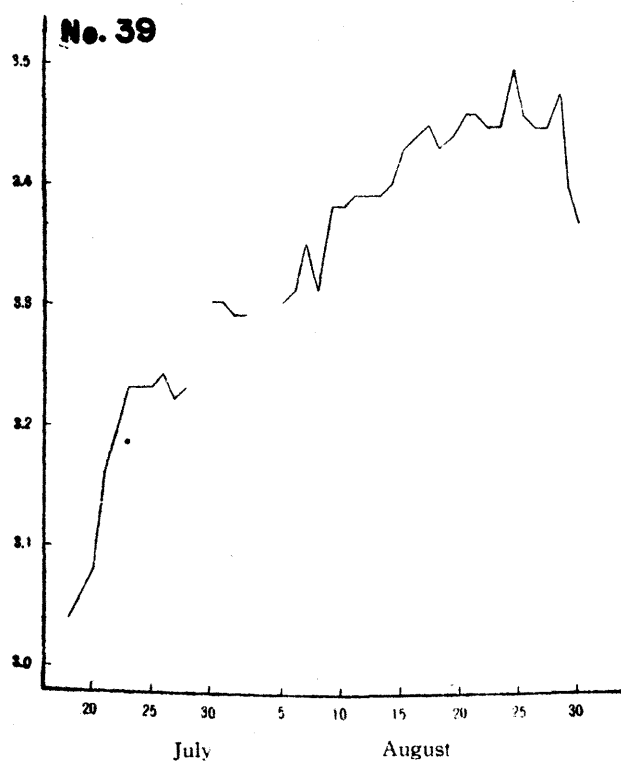
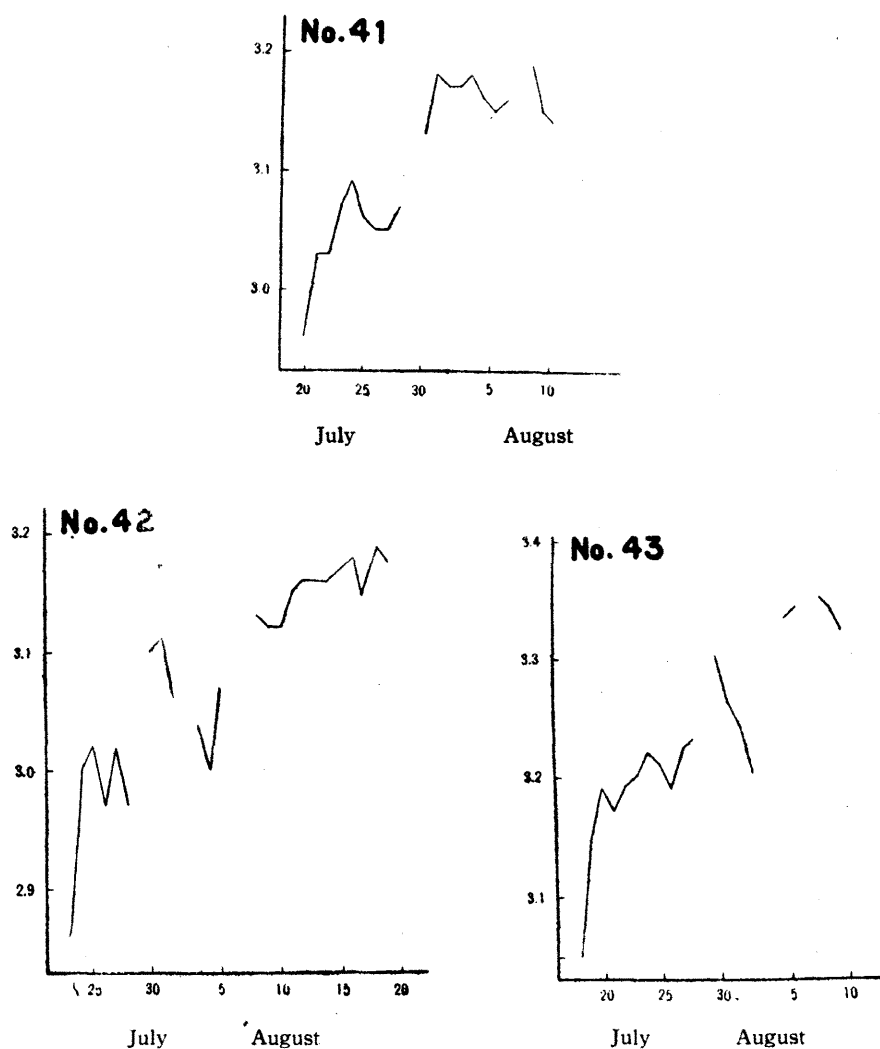


Fig. 35. Change in weight of *Phraortes kumamotoensis* during the larval stadia. Abscissa represents time in days. Ordinate indicates the logarithm of the body weight.







#### 4. Experiments Series 4

In the Experiments Classes 8, 9 and 10, the relation between the food consumption and the oviposition was investigated. The insects belonging to the Class 8 were fed on the foliage of *Lyonia Neziki* on every other day, those belonging to the Class 9 were fed on *Lyonia Neziki* once a day, and the insects Class 10 were

fed on the same plant on every second day. The number and the size of the deposited eggs, the body weight of the insects and the amount of food consumed by the insects were carefully observed every day up to the time of their death.

The general shape of the egg of this Phasmid is somewhat similar to a flattened cask (capsule), flat at one pole and hemispherical at the other, and having an oval cross-section. The flat end is covered by a lid, which consists of a platform or operculum with an encircling ridge, and in the middle of it there is a slight buff-coloured glossy cap or capitulum. On one side of the capsule, there is a mark of ovary attachment.

Concerning the external morphology of the egg of *Phraortes kumamotoensis*, I have already shown the following facts in my previous paper (1931). In that study the following parts of the egg were measured.

- a : Length of the capsule.
- b : Width of the capsule laid in natural condition.
- c : Thickness of the capsule (b is perpendicular to c,  $b > c$ ).
- d : Length of the operculum.
- e : Width of the operculum ( $d > e$ ).
- f : Length of the mark of ovary attachment.
- g : Width of the mark of ovary attachment.
- h : Diameter of the capitulum.
- i : Length (or height) of the capitulum.

The following notations were used in this study.

- : Egg with a capitulum normal.
- △ : Egg with a capitulum moderately deformed.
- × : Egg with a capitulum strongly deformed or without a capitulum.

From the results of these measurements the following relations were obtained.

1.  $a : b = a : f$ .
2.  $b : c = d : e$ .
3. The form of the capitulum shows a comparatively wide range of variation. Among 282 eggs examined ○ was the most predominant type, occupying 68 per cent, △ took the value of 13 per cent, and × occupied 19 per cent.
4. The form of the capitulum or the absence of the capitulum

is independent of the growth of the embryo within the egg, if the egg was laid by a sound female insect.

5. In general the eggs with a deformed capitulum are deposited by ill-fed females.

6. The shape of the capsule has a close connection with the hatching of the egg, even when the embryo within itself has completed its entire development. Indeed no larvae can hatch out from eggs with a deformed capsule.

### Experiments Class 8

No. 44, ♀ An insect, underwent the last moult on July 6th, was taken for experiment immediately after the moult. It was 0.3820 gr. in weight and attained a maximum weight of 0.8055 gr. 22 days later, about 2.1 times its original weight. After a preoviposition period of 12 days the insect dropped a first egg on July 18th, when it weighed 0.5900 gr., about 1.5 times its original weight. As many as 88 eggs were laid by this insect during 64 days, the average number being 1.37 per day. Of these 64 days this insect showed no sign of oviposition on 19 days. The non-ovipositing days were arranged in order as follows: 1-1-1-1-1-1-1-1-2-1-1-1-6. On August 1st the insect dropped 6 eggs, the maximum value of oviposition per day in this female during her life. The shapes of the capitulum of eggs were: ○-4 eggs (4.5%) △-55 eggs (62.5%), ×-29 eggs (33.0%). This insect died 75 days after being placed on this experiment. The length of the mesothorax was 16.6 mm, and the dry weight of the same portion was 0.0150 gr.

No. 45, ♀ An insect, underwent the final moult on July 9th, was put then immediately on this experiment. It was 0.3000 gr. in weight and reached a maximum weight of 0.5460 gr. as late as 48 days after, about 1.5 times its original weight. After a pre-oviposition period of 12 days, this insect laid a first egg on July 21st, when it weighed 0.3800 gr., about 1.3 times its original weight. The total number of eggs laid by this insect was 34 during 45 days, the average number being 0.75 per day. On 20 days this insect laid no eggs. The non-ovipositing days were given in order

as follows: 1-1-2-1-1-1-1-1-3-4-1-2-1. On August 14th the insect exhibited the maximum record of oviposition, laying 3 eggs, during her life. The shapes of the capitulum of eggs showed: ○-8 eggs (23.5%), △-22 eggs (64.7%), ×-4 eggs (11.8%). The duration of life under experimental condition of this insect was 60 days. The length of the mesothorax was 15.0 mm, and the dry weight of the same portion took the value of 0.0100 gr.

No. 46, ♀ An insect, underwent the last moult on July 7th, was used immediately in this experiment. It was 0.5225 gr. in weight and attained a maximum weight of 0.9900 gr., or about 1.8 times its original weight, at an age of 20 days after the last moult, on July 26th. After a preoviposition period of 10 days, this insect dropped a first egg on July 17th, when it weighed 0.7500 gr., about 1.4 times its original weight. This insect laid 84 eggs during 41 days, the average number of eggs being 2.05 per day. On about 5 days this insect laid no eggs. The non-ovipositing days are given in order as follows: 1-1-1-1-1. On August 14th this insect exhibited the highest record of laying 6 eggs during her life. The shapes of the capitulum of eggs presented: ○-17 eggs (20.2%), △-66 eggs (78.6%), ×-1 egg (1.2%). The duration of life in adult insect was 74 days. The mesothorax was 16.7 mm in length and 0.0166 gr. in dry weight.

No. 47, ♀ An insect, underwent the final moult on July 7th, was then immediately transferred to this experiment. It was 0.4225 gr. in weight and attained a maximum weight of 0.7800 gr., or about 1.8 times its original weight, at an age of 20 days after the last moult, on July 26th. After a preoviposition period of 12 days this insect laid a first egg on July 19th, when it weighed 0.6181 gr., about 1.4 times its original weight. This insect deposited 59 eggs during 61 days, the average number of eggs being 0.96 per day. On 25 days this insect laid no eggs. The non-ovipositing days were arranged in order as follows: 1-1-1-1-1-1-1-1-2-1-4-1-3-1-4. On August 7th this insect made the highest record of laying 4 eggs per day during her life. The shapes of the capitulum of eggs were: ○-25 eggs (42.4%), △-26 eggs (44.1%), ×-8 eggs (13.5%). This adult female lived 74 days. The mesothorax was 16.0 mm in length and 0.0126 gr. in dry weight.

No. 48, ♀ An insect, underwent the final moult on July 7th,

was used in this experiment immediately after the moult. It was 0.4890 gr. in weight and attained a maximum weight of 0.8240 gr., or about 1.6 times its initial weight, on July 26th. After a period of 12 days the first oviposition took place on July 19th, when it weighed 0.6337 gr., about 1.2 times its initial weight. This insect dropped as many as 60 eggs in 61 days, the average being 0.98 per day. On 30 days this insect laid no eggs. The non-ovipositing days were given in order as follows: 1-1-2-1-1-1-6-8-1-1-6. On August 4th the insect exhibited the highest record of laying 4 eggs per day during her life. The shapes of the capitulum of eggs were: ○-18 eggs (30.0%), △-41 eggs (68.3%), ×-1 egg (1.7%). The duration of life of this adult insect was 74 days. The mesothorax was 16.9 mm in length and 0.0135 gr. in dry weight.

#### Experiments Class 9

No. 49, ♀ An insect, which underwent the last moult on July 11th, was used immediately after the moult in this experiment. It was 0.4300 gr. in weight and attained a maximum weight of 0.8050 gr., about 1.8 times its original weight, 16 days later. After a pre-oviposition period of 11 days this insect laid a first egg on July 22nd, when it weighed 0.7140 gr., about 1.6 times its initial weight. The duration of life of the adult female was 52 days. The mesothorax was 17.2 mm in length and 0.0150 gr. in dry weight. No further observations were made on this insect.

No. 50, ♀ An insect, underwent the last moult on July 11th, was put then immediately on this experiment. It was then 0.4100 gr. in weight and took a maximum weight of 0.7400 gr., or about 1.8 times its initial weight, as late as 50 days. After a preoviposition period of 16 days, the first oviposition took place on July 27th, when the insect weighed 0.6500 gr., about 1.6 times its initial weight. This insect laid 30 eggs in 55 days, thus the average number of eggs being 0.54 per day. On 34 days this insect laid no eggs. The non-ovipositing days were given in order as follows: 7-3-2-1-5-2-4-1-5-1-1-1-1. On August

24th and September 19th the insect exhibited the maximum record of laying 3 eggs respectively during her life of 70 days. The shapes of the capitulum of eggs were: ○—2 eggs (6.7%), △—28 eggs (93.3%), ×—no eggs. This insect died on September 19th, when its mesothorax was 17.0 mm in length and 0.0145 gr. in dry weight.

No. 51, ♀ An insect, undergone the final moult on July 11th, was put on this experiment immediately after the moult. It was then 0.4570 gr. in weight, and after a very long period of 67 days it attained a maximum weight of 0.8790 gr., or about 1.9 times its original weight. After a long preoviposition period of 16 days this insect laid a first egg on July 27th, when it weighed 0.6500 gr., about 1.4 times its original weight. The total number of eggs dropped by this insect was 43 during 55 days, thus the average being 0.78 eggs per day. On 26 days the insect dropped no eggs. The non-ovipositing days are given in order as follows: 5—7—1—2—1—2—1—1—2—3—1. On September 19th the insect made a highest record of ovipositing 3 eggs during her life of 70 days. The shapes of the capitulum of eggs presented: ○—13 eggs (30.2%), △—22 eggs (51.1%), ×—8 eggs (18.7%). The length of the mesothorax was 17.5 mm and the dry weight of the same portion took the value of 0.0154 gr.

No. 52, ♀ An insect, which underwent the last moult on July 11th, was used then immediately in this experiment. It was at first weighed 0.4338 gr. and attained a maximum weight of 0.7000 gr., or about 1.6 times its original weight, as late as 39 days. After a very long preoviposition period of 18 days this insect laid a first egg, when it weighed 0.5000 gr., about 1.2 times its initial weight. The total number of eggs laid by this insect was 3 during 22 days, thus the average number being 0.14 per day. The first egg with a normal capitulum was dropped on July 29th. The second egg without a capitulum was laid on August 14th. The third egg with a deformed capitulum was dropped on August 19th. The duration of life of this adult female was 54 days. The mesothorax was 17.9 mm in length and 0.0122 gr. in dry weight.

No. 53, ♀ An insect, which underwent the last moult on July 11th, was put then on this experiment. This insect could not withstand hunger longer than 16 days and died on July 27th.

## Experiments Class 10

No. 54, ♀ An insect, which underwent the final ecdysis on July 9th, was used then at once in this experiment. It was then 0.3820 gr. in weight and reached a maximum value of 0.7630 gr., or about twice its initial weight, as late as 19 days. After a comparatively long preoviposition period of 15 days this insect laid a first egg on July 24th, when it weighed 0.6560 gr., about 1.7 times its original weight. The total number of eggs laid by this insect was 50 during 41 days, thus the average number of eggs being 1.21 per day. The non-ovipositing days are given in order as follows: 1-2-2-13 (total 18 days). On August 13th the insect acquired the highest record of laying 4 eggs during her life of 56 days. The shapes of the capitulum of eggs were: ○-6 eggs (12.0%), △-41 eggs (82.0%), ×-3 eggs (6.0%). The mesothorax was 16.9 mm in length and 0.0128 gr. in dry weight.

No. 55, ♀ An insect, undergone the final moult on July 12th, was put then at once on this experiment. It was then 0.3900 gr. in weight and attained a maximum weight of 0.8020 gr., or about twice its initial weight, as late as 16 days. After a comparatively shorter period of 10 days this insect laid a first egg on July 22nd, when it weighed 0.6050 gr., about 1.5 times its original weight. The total number of eggs dropped by this insect was 26 during 14 days, thus the average number representing 1.85 per day. The insect continued to drop eggs every day and exhibited a maximum value of laying 4 eggs during her life of 26 days. The shapes of the capitulum of eggs were: ○-12 eggs (46.2%), △-14 eggs (53.8%). The mesothorax was 15.8 mm in length and 0.0123 gr. in dry weight.

No. 56, ♀ An insect, which underwent the last moult on July 13th, was used then at once on this experiment. It was then 0.3530 gr. in weight and attained a maximum weight of 0.7200 gr., or about twice its initial weight, 14 days later. After a preoviposition period of 13 days this insect laid a first egg on July 26th, when it weighed 0.7200 gr. The total number of eggs laid by this insect was 14 during 13 days, thus the average number being 1.07 per day. The non-ovipositing days are given in order as follows: 1-4-1 (total 6 days). On July 27th and 29th this insect exhibited the maximum record of laying 3 eggs respectively dur-

ing her life. The shapes of the capitulum of eggs were: ○—2 eggs (14.4%), △—8 eggs (57.1%), × 4 eggs (28.5%). The duration of life of this adult female was as short as 30 days. The mesothorax was 15.6 mm in length and 0.0125 gr. in dry weight.

No. 57, ♀ An insect, which underwent the final ecdysis on July 13th, was put then immediately on this experiment. It was then 0.4273 gr. in weight and reached a highest value of weight 0.8280 gr., about twice its original weight, as late as 18 days. After a preoviposition period of 10 days the insect dropped a first egg, when it was 0.6625 gr. in weight, about 1.5 times its initial weight. The total number of eggs laid by this insect was 43 during 33 days, the average number representing 1.30 per day. The non-ovipositing days are given in order as follows: 1—5—1—1 (total 8 days). On July 31st the insect dropped 4 eggs which were the highest record of laying eggs in this female. The shapes of the capitulum of eggs were: ○—28 eggs (65.1%), △—11 eggs (25.6%), ×—4 eggs (9.3%). The duration of life of this adult female was as long as 68 days. The mesothorax was 16.0 mm in length and 0.0126 gr. in dry weight.

No. 58, ♀ An insect, which underwent the last moult on July 17th, was used then at once in this experiment. At first it was 0.3470 gr. in weight and attained a maximum weight of 0.5500 gr., about 1.4 times its original weight, after a long period of 15 days. After a preoviposition period of 9 days this insect dropped a first egg on July 26th, when it weighed 0.4500 gr., about 1.3 times its initial weight. The insect laid only 3 eggs during 13 days, thus the average number being 0.23 per day. The non-ovipositing days are given in order as follows: 5—5 (total 10 days). The first egg with a deformed capitulum was laid on July 26th. The second one with a normal capitulum was dropped on August 1st and the third one with a deformed capitulum was laid on August 7th. The duration of life of this adult female was as short as 23 days. The mesothorax measured 17.2 mm in length and 0.0128 gr. in dry weight.

Table 119. Growth in weight of *Phraortes kumamotoensis* in larval and adult stages. (\* indicates the date of the first egg dropped.)

| Date     | No. 44  | No. 45  | No. 46  | No. 47  | No. 48  |
|----------|---------|---------|---------|---------|---------|
| 6. vii.  | 0.3820  |         |         |         |         |
| 7. vii.  | 0.4520  |         | 0.5225  | 0.4225  | 0.4890  |
| 8. vii.  | 0.4157  |         | 0.6548  | 0.4790  | 0.4820  |
| 9. vii.  | 0.6000  | 0.3000  | 0.5750  | 0.4250  | 0.4221  |
| 10. vii. | 0.5250  | 0.4000  | 0.6960  | 0.4990  | 0.5300  |
| 11. vii. | 0.6500  | 0.3420  | 0.6060  | 0.4455  | 0.4600  |
| 12. vii. | 0.5400  | 0.4100  | 0.7640  | 0.6000  | 0.5700  |
| 13. vii. | 0.6590  | 0.3258  | 0.6595  | 0.5043  | 0.5055  |
| 14. vii. | 0.5700  | 0.4240  | 0.8060  | 0.6448  | 0.6449  |
| 15. vii. | 0.6510  | 0.3548  | 0.7099  | 0.5595  | 0.5532  |
| 16. vii. | 0.5700  | 0.4140  | 0.8583  | 0.6788  | 0.6500  |
| 17. vii. | 0.6650  | 0.3435  | *0.7500 | 0.5890  | 0.6550  |
| 18. vii. | *0.5900 | 0.4600  | 0.9135  | 0.7500  | 0.7135  |
| 19. vii. | 0.7060  | 0.3855  | 0.7716  | *0.6181 | *0.6337 |
| 20. vii. | 0.6200  | 0.4600  | 0.8825  | 0.7128  | 0.7768  |
| 21. vii. | 0.7400  | *0.3800 | 0.7750  | 0.6175  | 0.6674  |
| 22. vii. | 0.6370  | 0.4400  | 0.9200  | 0.7150  | 0.7680  |
| 23. vii. | 0.7825  | 0.3500  | 0.7780  | 0.5953  | 0.6548  |
| 24. vii. | 0.6770  | 0.4568  | 0.8889  | 0.7200  | 0.7800  |
| 25. vii. | 0.7800  | 0.3580  | 0.7880  | 0.6040  | 0.6645  |
| 26. vii. | 0.6860  | 0.5047  | 0.9900  | 0.7800  | 0.8240  |
| 27. vii. | 0.8055  | 0.4000  | 0.7920  | 0.6300  | 0.6980  |
| 28. vii. | 0.6750  | 0.4385  | 0.8570  | 0.7800  | 0.7500  |
| 29. vii. | 0.7300  | 0.3530  | 0.7400  | 0.6530  | 0.6040  |
| 30. vii. | 0.6400  | 0.4598  | 0.7647  | 0.6740  | 0.6595  |
| 31. vii. | 0.7625  | 0.3930  | 0.6875  | 0.5782  | 0.5700  |
| 1. viii. | 0.6400  | 0.4710  | 0.8124  | 0.7100  | 0.7600  |
| 2. viii. | 0.7479  | 0.3849  | 0.7032  | 0.6039  | 0.6278  |
| 3. viii. | 0.6331  | 0.4462  | 0.7883  | 0.7558  | 0.6932  |
| 4. viii. | 0.7785  | 0.3736  | 0.7000  | 0.6204  | 0.6018  |
| 5. viii. | 0.6700  | 0.4271  | 0.8552  | 0.7050  | 0.6789  |
| 6. viii. | 0.7810  | 0.3700  | 0.7500  | 0.6000  | 0.5863  |
| 7. viii. | 0.6368  | 0.5190  | 0.8269  | 0.6790  | 0.6720  |
| 8. viii. | 0.7642  | 0.4465  | 0.7200  | 0.5800  | 0.5858  |

|     |       |        |        |        |        |        |
|-----|-------|--------|--------|--------|--------|--------|
| 9.  | viii. | 0.6440 | 0.5095 | 0.8400 | 0.7300 | 0.6325 |
| 10. | viii. | 0.7827 | 0.4375 | 0.7134 | 0.6200 | 0.5527 |
| 11. | viii. | 0.6538 | 0.5273 | 0.9376 | 0.7182 | 0.6500 |
| 12. | viii. | 0.7447 | 0.4103 | 0.7605 | 0.5703 | 0.5056 |
| 13. | viii. | 0.6395 | 0.4813 | 0.8621 | 0.6869 | 0.6870 |
| 14. | viii. | 0.6925 | 0.3982 | 0.7335 | 0.5892 | 0.5768 |
| 15. | viii. | 0.5898 | 0.4558 | 0.7965 | 0.7384 | 0.6754 |
| 16. | viii. | 0.6878 | 0.3915 | 0.7795 | 0.6380 | 0.5815 |
| 17. | viii. | 0.6855 | 0.4864 |        | 0.7222 | 0.6577 |
| 18. | viii. | 0.7048 | 0.4036 | 0.7400 | 0.5985 | 0.5324 |
| 19. | viii. | 0.6080 | 0.5095 | 0.9282 | 0.7243 | 0.6600 |
| 20. | viii. | 0.7078 | 0.4225 | 0.7600 | 0.6025 | 0.5542 |
| 21. | viii. | 0.5943 | 0.5165 | 0.8823 | 0.7387 | 0.6788 |
| 22. | viii. | 0.6913 | 0.4200 | 0.7658 | 0.6263 | 0.5766 |
| 23. | viii. | 0.5904 | 0.5270 | 0.8857 | 0.6890 | 0.6500 |
| 24. | viii. | 0.7303 | 0.4330 | 0.7437 | 0.5855 | 0.5330 |
| 25. | viii. | 0.6138 | 0.5460 | 0.8800 | 0.6600 | 0.6124 |
| 26. | viii. | 0.7332 | 0.4600 | 0.7500 | 0.5523 | 0.5360 |
| 27. | viii. | 0.6137 | 0.5350 | 0.8744 | 0.7105 | 0.5975 |
| 28. | viii. | 0.6949 | 0.4371 | 0.7400 | 0.5856 | 0.5157 |
| 29. | viii. | 0.5967 | 0.4940 | 0.8420 | 0.7535 | 0.7031 |
| 30. | viii. | 0.7659 | 0.4300 | 0.7455 | 0.6508 | 0.6000 |
| 31. | viii. | 0.6687 | 0.3980 | 0.6625 | 0.5800 | 0.5380 |
| 1.  | ix.   | 0.7138 | 0.4400 | 0.8610 | 0.6825 | 0.6445 |
| 2.  | ix.   | 0.6278 | 0.3860 | 0.7545 | 0.5760 | 0.5465 |
| 3.  | ix.   | 0.6680 | 0.4100 | 0.8700 | 0.5933 | 0.6953 |
| 4.  | ix.   | 0.5880 | 0.3600 | 0.7500 | 0.5000 | 0.5978 |
| 5.  | ix.   | 0.7555 | 0.4000 | 0.8668 | 0.5567 | 0.6996 |
| 6.  | ix.   | 0.6395 | 0.3268 | 0.7470 | 0.4750 | 0.5978 |
| 7.  | ix.   | 0.7000 |        | 0.8995 | 0.7400 | 0.6855 |
| 8.  | ix.   | 0.6228 |        | 0.8000 | 0.6658 | 0.6065 |
| 9.  | ix.   | 0.7140 |        | 0.8870 | 0.7261 | 0.6680 |
| 10. | ix.   | 0.6134 |        | 0.7818 | 0.6323 | 0.5700 |
| 11. | ix.   | 0.7060 |        | 0.8700 | 0.6958 | 0.6289 |
| 12. | ix.   | 0.5190 |        | 0.7623 | 0.6100 | 0.5500 |
| 13. | ix.   | 0.7187 |        | 0.8490 | 0.6564 | 0.6612 |
| 14. | ix.   | 0.6438 |        | 0.7534 | 0.5982 | 0.5850 |
| 15. | ix.   | 0.7313 |        | 0.8532 | 0.6278 | 0.6880 |
| 16. | ix.   | 0.6078 |        | 0.6830 | 0.5160 | 0.5700 |
| 17. | ix.   | 0.7540 |        | 0.7955 | 0.5500 | 0.7460 |
| 18. | ix.   | 0.6460 |        | 0.6644 | 0.4750 | 0.6365 |

Table 120. Growth in weight of *Phraortes kumamotoensis* in larval and adult stages.

| Date      | No. 49  | No. 50  | No. 51  | No. 52  | No. 53 |
|-----------|---------|---------|---------|---------|--------|
| 11. vii.  | 0.4300  | 0.4100  | 0.4570  | 0.4338  | 0.4660 |
| 12. vii.  | 0.4743  | 0.4760  | 0.5268  | 0.4559  | 0.4920 |
| 13. vii.  | 0.5400  | 0.4850  | 0.5780  | 0.4860  | 0.5148 |
| 14. vii.  | 0.5700  | 0.5240  | 0.6139  | 0.5700  |        |
| 15. vii.  | 0.5782  | 0.5065  | 0.6130  | 0.5565  | 0.4665 |
| 16. vii.  | 0.6200  | 0.4955  | 0.5900  | 0.5670  | 0.5000 |
| 17. vii.  | 0.6560  | 0.5058  | 0.5900  | 0.5500  | 0.5300 |
| 18. vii.  | 0.6430  | 0.5320  | 0.5750  | 0.5530  | 0.5100 |
| 19. vii.  | 0.6537  | 0.5420  | 0.5800  | 0.5587  | 0.4975 |
| 20. vii.  | 0.6665  | 0.5289  | 0.5950  | 0.5497  | 0.5080 |
| 21. vii.  | 0.6720  | 0.6070  | 0.5935  | 0.5668  | 0.4959 |
| 22. vii.  | *0.7140 | 0.5885  | 0.6234  | 0.6180  | 0.4400 |
| 23. vii.  | 0.6354  | 0.5668  | 0.5837  | 0.5850  | 0.4700 |
| 24. vii.  | 0.7200  | 0.6110  | 0.6250  | 0.6159  |        |
| 25. vii.  | 0.7250  | 0.6095  | 0.7000  | 0.6200  | 0.4500 |
| 26. vii.  | 0.8050  | 0.6100  | 0.6700  | 0.6020  | 0.4400 |
| 27. vii.  | 0.7000  | *0.6500 | *0.6500 | 0.5960  | 0.4260 |
| 28. vii.  | 0.6800  | 0.6100  | 0.6490  | 0.5568  |        |
| 29. vii.  | 0.7025  | 0.6210  | 0.6275  | *0.5000 |        |
| 30. vii.  | 0.7065  | 0.6140  | 0.6320  | 0.6020  |        |
| 31. vii.  | 0.7400  | 0.6635  | 0.6500  | 0.5440  |        |
| 1. viii.  | 0.7423  | 0.6580  | 0.6860  |         |        |
| 2. viii.  | 0.7459  | 0.6295  | 0.6206  | 0.4786  |        |
| 3. viii.  | 0.7578  | 0.6560  | 0.6850  | 0.5859  |        |
| 4. viii.  | 0.7940  | 0.6431  | 0.7085  | 0.6020  |        |
| 5. viii.  | 0.7762  | 0.6600  | 0.7055  | 0.5834  |        |
| 6. viii.  | 0.7580  | 0.6748  | 0.6900  |         |        |
| 7. viii.  | 0.7780  | 0.6352  | 0.7000  | 0.5700  |        |
| 8. viii.  | 0.7895  | 0.6830  | 0.7000  | 0.6062  |        |
| 9. viii.  | 0.7765  | 0.6722  | 0.7022  | 0.5788  |        |
| 10. viii. | 0.7947  | 0.6843  | 0.7542  | 0.6092  |        |
| 11. viii. | 0.7700  | 0.6828  | 0.7700  | 0.5975  |        |

|      |       |        |        |        |        |
|------|-------|--------|--------|--------|--------|
| 12.. | viii. | 0.7343 | 0.6587 | 0.7085 | 0.5725 |
| 13.  | viii. | 0.7630 |        | 0.7300 | 0.6134 |
| 14.  | viii. | 0.7421 | 0.6394 | 0.7290 | 0.5856 |
| 15.  | viii. | 0.7257 | 0.6492 | 0.6986 | 0.5700 |
| 16.  | viii. | 0.7220 | 0.6780 | 0.7415 | 0.6248 |
| 17.  | viii. | 0.7247 | 0.6760 | 0.7646 | 0.6480 |
| 18.  | viii. | 0.7369 | 0.6797 | 0.7592 | 0.7000 |
| 19.  | viii. | 0.7385 | 0.6547 | 0.7300 | 0.6500 |
| 20.  | viii. | 0.7486 | 0.6514 | 0.7278 | 0.6678 |
| 21.  | viii. | 0.7470 | 0.6200 | 0.7200 |        |
| 22.  | viii. | 0.7550 | 0.6766 | 0.7200 | 0.6347 |
| 23.  | viii. | 0.7625 | 0.7093 | 0.7410 |        |
| 24.  | viii. | 0.7400 | 0.7226 | 0.7332 | 0.5876 |
| 25.  | viii. | 0.7620 | 0.7000 | 0.7300 | 0.6600 |
| 26.  | viii. | 0.6912 | 0.6838 | 0.7577 | 0.6378 |
| 27.  | viii. | 0.6500 | 0.6600 | 0.7300 | 0.6468 |
| 28.  | viii. | 0.6240 | 0.7100 | 0.7200 | 0.6220 |
| 29.  | viii. | 0.5570 | 0.7400 | 0.6980 | 0.5700 |
| 30.  | viii. | 0.5300 | 0.6865 | 0.6710 | 0.5143 |
| 31.  | viii. | 0.4900 | 0.6835 | 0.6786 | 0.5531 |
| 1.   | ix.   |        |        | 0.7787 | 0.6980 |
| 2.   | ix.   |        | 0.6767 | 0.7500 | 0.5132 |
| 3.   | ix.   |        | 0.6372 | 0.7735 |        |
| 4.   | ix.   |        | 0.6240 | 0.7525 |        |
| 5.   | ix.   |        | 0.5800 | 0.7300 |        |
| 6.   | ix.   |        | 0.5510 | 0.7070 |        |
| 7.   | ix.   |        | 0.6700 | 0.6980 |        |
| 8.   | ix.   |        | 0.6852 | 0.7049 |        |
| 9.   | ix.   |        | 0.6737 | 0.7010 |        |
| 10.  | ix.   |        | 0.6880 | 0.7350 |        |
| 11.  | ix.   |        | 0.6844 | 0.7315 |        |
| 12.  | ix.   |        | 0.7375 |        |        |
| 13.  | ix.   |        | 0.6654 | 0.8265 |        |
| 14.  | ix.   |        |        | 0.8300 |        |
| 15.  | ix.   |        | 0.7076 | 0.8790 |        |
| 16.  | ix.   |        | 0.6800 | 0.7500 |        |
| 17.  | ix.   |        | 0.6656 | 0.8067 |        |
| 18.  | ix.   |        | 0.6437 | 0.8137 |        |

Table 121. Growth in weight of *Phraortes kumamotoensis* in larval and adult stages.

| Date      | No. 54  | No. 55  | No. 56  | No. 57  | No. 58  |
|-----------|---------|---------|---------|---------|---------|
| 9. vii.   | 0.3820  |         |         |         |         |
| 10. vii.  | 0.5160  |         |         |         |         |
| 11. vii.  | 0.4460  |         |         |         |         |
| 12. vii.  | 0.3960  | 0.3900  |         |         |         |
| 13. vii.  | 0.4973  | 0.4890  | 0.3530  | 0.4273  |         |
| 14. vii.  | 0.4300  | 0.4447  | 0.4150  | 0.4850  |         |
| 15. vii.  | 0.5560  | 0.5755  | 0.3800  | 0.4510  |         |
| 16. vii.  | 0.4800  | 0.5070  | 0.5000  | 0.5689  |         |
| 17. vii.  | 0.6050  | 0.6115  | 0.4500  | 0.5200  | 0.3470  |
| 18. vii.  | 0.5598  | 0.5380  | 0.5290  | 0.7050  | 0.3338  |
| 19. vii.  | 0.6828  | 0.6953  | 0.4700  | 0.5940  | 0.4552  |
| 20. vii.  | 0.5800  | 0.5840  | 0.6335  | 0.7077  | 0.4138  |
| 21. vii.  | 0.6815  | 0.7200  | 0.5300  | 0.6150  | 0.5215  |
| 22. vii.  | 0.6053  | *0.6050 | 0.6000  | 0.7640  | 0.4435  |
| 23. vii.  | 0.7370  | 0.7383  | 0.5290  | *0.6625 | 0.4835  |
| 24. vii.  | *0.6560 | 0.6570  | 0.6700  | 0.7880  | 0.4400  |
| 25. vii.  | 0.8000  | 0.7815  | 0.5700  | 0.6700  | 0.5090  |
| 26. vii.  | 0.6745  | 0.6500  | *0.7200 | 0.8200  | *0.4500 |
| 27. vii.  | 0.7630  | 0.8020  | 0.5980  | 0.7020  | 0.5100  |
| 28. vii.  | 0.6180  | 0.6300  | 0.6580  | 0.7600  | 0.4200  |
| 29. vii.  | 0.7200  | 0.6800  | 0.5495  | 0.6595  | 0.5300  |
| 30. vii.  | 0.6095  | 0.5950  | 0.6000  | 0.8280  | 0.4630  |
| 31. vii.  | 0.7384  | 0.7619  | 0.5400  | 0.6930  | 0.5500  |
| 1. viii.  | 0.6220  | 0.6300  | 0.5000  | 0.6298  | 0.4793  |
| 2. viii.  | 0.5174  | 0.5217  | 0.5793  | 0.7335  | 0.4036  |
| 3. viii.  | 0.6379  | 0.5784  | 0.5348  | 0.6587  | 0.5383  |
| 4. viii.  | 0.5399  | 0.4886  | 0.4890  | 0.6000  | 0.4700  |
| 5. viii.  | 0.4800  | 0.4349  | 0.5473  | 0.8064  | 0.4200  |
| 6. viii.  | 0.6400  | 0.4320  | 0.4565  | 0.6795  | 0.4420  |
| 7. viii.  | 0.5232  |         | 0.4328  | 0.6075  | 0.3875  |
| 8. viii.  | 0.4736  |         | 0.5062  | 0.7467  | 0.3630  |
| 9. viii.  | 0.6288  |         | 0.4615  | 0.6500  |         |
| 10. viii. | 0.5300  |         | 0.4238  | 0.5815  |         |
| 11. viii. | 0.4670  |         | 0.4048  | 0.5335  |         |

|     |       |        |        |
|-----|-------|--------|--------|
| 12. | viii. | 0.5700 | 0.6700 |
| 13. | viii. | 0.5052 | 0.6036 |
| 14. | viii. | 0.4427 | 0.5491 |
| 15. | viii. | 0.5566 | 0.6678 |
| 16. | viii. | 0.4816 | 0.5893 |
| 17. | viii. | 0.4400 | 0.5478 |
| 18. | viii. | 0.5800 | 0.6924 |
| 19. | viii. | 0.4830 | 0.6078 |
| 20. | viii. | 0.4234 | 0.5512 |
| 21. | viii. | 0.5823 | 0.6666 |
| 22. | viii. | 0.5047 | 0.4973 |
| 23. | viii. | 0.4532 | 0.4600 |
| 24. | viii. | 0.5175 | 0.5728 |
| 25. | viii. | 0.4510 | 0.5048 |
| 26. | viii. | 0.4145 | 0.4624 |
| 27. | viii. | 0.5180 | 0.5670 |
| 28. | viii. | 0.4450 | 0.5078 |
| 29. | viii. | 0.4115 | 0.4802 |
| 30. | viii. | 0.5179 | 0.6272 |
| 31. | ix.   | 0.4462 | 0.5578 |
| 1.  | ix.   | 0.4015 | 0.5185 |
| 2.  | ix.   | 0.4328 | 0.5708 |
| 3.  | ix.   |        | 0.5135 |
| 4.  | ix.   |        | 0.4745 |
| 5.  | ix.   |        | 0.5750 |
| 6.  | ix.   |        | 0.5078 |
| 7.  | ix.   |        | 0.4828 |
| 8.  | ix.   |        | 0.5818 |
| 9.  | ix.   |        | 0.5328 |
| 10. | ix.   |        | 0.5026 |
| 11. | ix.   |        | 0.5560 |
| 12. | ix.   |        | 0.5048 |
| 13. | ix.   |        | 0.4930 |
| 14. | ix.   |        | 0.5508 |
| 15. | ix.   |        | 0.5213 |
| 16. | ix.   |        | 0.4706 |
| 17. | ix.   |        | 0.5310 |
| 18. | ix.   |        | 0.4838 |

Table 122. Amount of leaves eaten by *Phraortes kumamotoensis* No. 44 in larval and adult stages.

| Date      | V (average of<br>three days) | V     | O    | W    |
|-----------|------------------------------|-------|------|------|
| 7. vii.   | 449.0                        | 396.0 | 2732 | 3643 |
| 8. vii.   |                              | 246.0 | 1697 | 2263 |
| 9. vii.   | 739.0                        | 528.7 | 3648 | 4864 |
| 10. vii.  |                              | 246.0 | 1697 | 2263 |
| 11. vii.  | 739.0                        | 428.7 | 2706 | 3944 |
| 12. vii.  |                              | 182.3 | 1258 | 1677 |
| 13. vii.  | 547.0                        | 381.0 | 2629 | 3505 |
| 14. vii.  |                              | 198.7 | 1371 | 1828 |
| 15. vii.  | 596.0                        | 349.0 | 2408 | 3211 |
| 16. vii.  |                              | 147.0 | 1026 | 1352 |
| 17. vii.  | 441.0                        | 397.0 | 2760 | 3652 |
| 18. vii.  |                              | 250.0 | 1725 | 2300 |
| 19. vii.  | 750.0                        | 453.0 | 3206 | 4168 |
| 20. vii.  |                              | 203.0 | 1401 | 1868 |
| 21. vii.  | 609.0                        | 490.7 | 3386 | 4514 |
| 22. vii.  |                              | 287.7 | 1985 | 2647 |
| 23. vii.  | 863.0                        | 496.0 | 3422 | 4563 |
| 24. vii.  |                              | 208.3 | 3437 | 1916 |
| 25. vii.  | 625.0                        | 468.7 | 3234 | 4312 |
| 26. vii.  |                              | 260.3 | 1796 | 2395 |
| 27. vii.  | 781.0                        | 505.0 | 3485 | 4646 |
| 28. vii.  |                              | 244.7 | 1688 | 2251 |
| 29. vii.  | 734.0                        | 462.0 | 3188 | 4250 |
| 30. vii.  |                              | 217.3 | 1499 | 1999 |
| 31. vii.  | 652.0                        | 455.3 | 3146 | 4189 |
| 1. viii.  |                              | 238.0 | 1642 | 2190 |
| 2. viii.  | 714.0                        | 451.7 | 3118 | 4156 |
| 3. viii.  |                              | 213.7 | 1474 | 1956 |
| 4. viii.  | 641.0                        | 563.0 | 3885 | 5180 |
| 5. viii.  |                              | 349.3 | 2410 | 3214 |
| 6. viii.  | 1048.0                       | 615.3 | 4246 | 5661 |
| 7. viii.  |                              | 266.0 | 1835 | 2447 |
| 8. viii.  | 798.0                        | 437.7 | 3029 | 4027 |
| 9. viii.  |                              | 171.7 | 1185 | 1580 |
| 10. viii. | 515.0                        | 431.0 | 2974 | 3965 |

|     |       |       |       |      |      |
|-----|-------|-------|-------|------|------|
| 11. | viii. |       | 259.3 | 1789 | 2386 |
| 12. | viii. | 778.9 | 451.7 | 3117 | 4156 |
| 13. | viii. |       | 192.3 | 1327 | 1769 |
| 14. | viii. | 577.0 | 442.0 | 3050 | 4066 |
| 15. | viii. |       | 249.7 | 1724 | 2297 |
| 16. | viii. | 749.0 | 503.3 | 3473 | 4630 |
| 17. | viii. |       | 253.7 | 1751 | 2334 |
| 18. | viii. | 761.0 | 457.3 | 3155 | 4197 |
| 19. | viii. |       | 203.7 | 1406 | 1874 |
| 20. | viii. | 611.0 | 327.7 | 2261 | 3015 |
| 21. | viii. |       | 124.0 | 856  | 1141 |
| 22. | viii. | 372.0 | 321.3 | 2217 | 2956 |
| 23. | viii. |       | 197.3 | 1361 | 1815 |
| 24. | viii. | 592.0 | 410.7 | 2834 | 3778 |
| 25. | viii. |       | 213.3 | 1472 | 1963 |
| 26. | viii. | 640.0 | 394.7 | 2725 | 3631 |
| 27. | viii. |       | 181.3 | 1251 | 1668 |
| 28. | viii. | 544.0 | 470.3 | 3245 | 4327 |
| 29. | viii. |       | 289.0 | 1994 | 2659 |
| 30. | viii. | 867.0 | 401.0 | 2767 | 3689 |
| 31. | viii. |       | 112.0 | 773  | 1030 |
| 1.  | ix.   | 336.0 | 271.3 | 1872 | 2496 |
| 2.  | ix.   |       | 159.3 | 1099 | 1466 |
| 3.  | ix.   | 478.0 | 406.3 | 2803 | 3738 |
| 4.  | ix.   |       | 247.0 | 1704 | 2272 |
| 5.  | ix.   | 741.0 | 415.7 | 2868 | 3824 |
| 6.  | ix.   |       | 168.7 | 1164 | 1552 |
| 7.  | ix.   | 506.0 | 435.7 | 3007 | 4008 |
| 8.  | ix.   |       | 267.0 | 1842 | 2456 |
| 9.  | ix.   | 801.0 | 431.7 | 3324 | 4435 |
| 10. | ix.   |       | 214.7 | 1481 | 1975 |
| 11. | ix.   | 644.0 | 389.0 | 2684 | 3579 |
| 12. | ix.   |       | 174.3 | 1203 | 1604 |
| 13. | ix.   | 523.0 | 345.0 | 2381 | 3174 |
| 14. | ix.   |       | 170.7 | 1178 | 1570 |
| 15. | ix.   | 512.0 | 373.7 | 2580 | 3438 |
| 16. | ix.   |       |       |      |      |
| 17. | ix.   | 609.0 |       |      |      |

Table 1 3. Amount of leaves eaten by *Phraortes kumamotoensis*  
No. 49 in larval and adult stages.

| Date      | V (average of<br>three days) | V     | O    | W    |
|-----------|------------------------------|-------|------|------|
| 11. vii.  | 36.5                         | 115.2 | 795  | 1060 |
| 12. vii.  | 144.0                        | 168.7 | 1164 | 1552 |
| 13. vii.  | 165.0                        | 188.0 | 1297 | 1730 |
| 14. vii.  | 197.0                        | 208.0 | 1435 | 1914 |
| 15. vii.  | 202.0                        | 226.5 | 1569 | 2083 |
| 16. vii.  | 225.0                        | 231.5 | 1597 | 2130 |
| 17. vii.  | 252.5                        | 221.2 | 1526 | 2034 |
| 18. vii.  | 217.0                        | 211.7 | 1461 | 1948 |
| 19. vii.  | 194.0                        | 242.0 | 1670 | 2226 |
| 20. vii.  | 224.0                        | 255.3 | 1764 | 2349 |
| 21. vii.  | 308.0                        | 248.3 | 1713 | 2284 |
| 22. vii.  | 234.0                        | 231.3 | 1596 | 2128 |
| 23. vii.  | 203.0                        | 241.0 | 1663 | 2217 |
| 24. vii.  | 257.0                        | 289.3 | 2056 | 2662 |
| 25. vii.  | 263.0                        | 286.7 | 1979 | 2638 |
| 26. vii.  | 348.0                        | 291.3 | 2010 | 2680 |
| 27. vii.  | 249.0                        | 249.7 | 1723 | 2297 |
| 28. vii.  | 277.0                        | 233.3 | 1610 | 2146 |
| 29. vii.  | 223.0                        | 236.7 | 1633 | 2178 |
| 30. vii.  | 200.0                        | 254.7 | 1755 | 2343 |
| 31. vii.  | 287.0                        | 292.3 | 2017 | 2689 |
| 1. viii.  | 277.0                        | 278.3 | 1920 | 2560 |
| 2. viii.  | 313.0                        | 282.8 | 1951 | 2602 |
| 3. viii.  | 245.0                        | 254.8 | 1758 | 2344 |
| 4. viii.  | 290.5                        | 266.5 | 1839 | 2452 |
| 5. viii.  | 229.0                        | 264.2 | 1823 | 2431 |
| 6. viii.  | 280.0                        | 264.3 | 1824 | 2432 |
| 7. viii.  | 283.0                        | 249.7 | 1723 | 2297 |
| 8. viii.  | 230.0                        | 236.7 | 1633 | 2178 |
| 9. viii.  | 236.0                        | 329.0 | 2270 | 3027 |
| 10. viii. | 244.0                        | 343.0 | 2367 | 3156 |
| 11. viii. | 507.0                        | 362.3 | 2500 | 3333 |
| 12. viii. | 278.0                        | 294.0 | 2029 | 2705 |
| 13. viii. | 302.0                        | 295.7 | 2040 | 2720 |

|     |       |       |       |      |      |
|-----|-------|-------|-------|------|------|
| 14. | viii. | 302.0 | 297.3 | 2051 | 2735 |
| 15. | viii. | 283.0 | 301.3 | 2079 | 2772 |
| 16. | viii. | 307.0 | 308.0 | 2125 | 2834 |
| 17. | viii. | 314.0 | 280.3 | 1934 | 2579 |
| 18. | viii. | 303.0 | 242.7 | 1795 | 2233 |
| 19. | viii. | 224.0 | 276.0 | 1904 | 2539 |
| 20. | viii. | 201.0 | 277.3 | 1913 | 2551 |
| 21. | viii. | 403.0 | 293.3 | 2024 | 2698 |
| 22. | viii. | 228.0 | 242.0 | 1670 | 2226 |
| 23. | viii. | 249.0 | 221.7 | 1530 | 2040 |
| 24. | viii. | 249.0 | 198.7 | 1371 | 1828 |
| 25. | viii. | 167.0 | 187.3 | 1292 | 1723 |
| 26. | viii. | 180.0 | 172.7 | 1192 | 1589 |
| 27. | viii. | 215.0 | 196.7 | 1357 | 1810 |
| 28. | viii. | 123.0 | 156.7 | 1081 | 1432 |
| 29. | viii. | 262.0 | 122.7 | 847  | 1120 |
| 30. | viii. | 85.0  |       |      |      |
| 31. | viii. | 21.0  |       |      |      |

Table 124. Amount of leaves eaten by *Phraortes kumamotoensis*  
No. 54 in larval and adult stages.

| Date     | V (average of<br>three days) | V     | O    | W    |
|----------|------------------------------|-------|------|------|
| 10. vii. | 342.0                        | 114.0 | 787  | 1049 |
| 11. vii. |                              | 143.0 | 987  | 1316 |
| 12. vii. |                              | 143.0 | 987  | 1316 |
| 13. vii. | 429.0                        | 320.0 | 2208 | 2944 |
| 14. vii. |                              | 177.0 | 1221 | 1628 |
| 15. vii. | 531.0                        | 391.3 | 2700 | 3600 |
| 16. vii. |                              | 214.3 | 1479 | 1972 |
| 17. vii. | 643.0                        | 552.7 | 3814 | 5085 |
| 18. vii. |                              | 338.3 | 2334 | 3112 |
| 19. vii. |                              | 706.3 | 4873 | 6498 |
| 20. vii. |                              | 368.0 | 2539 | 3386 |
| 21. vii. | 1104.0                       | 753.7 | 5201 | 6934 |
| 22. vii. |                              | 385.7 | 2661 | 3548 |
| 23. vii. | 1157.0                       | 602.0 | 4154 | 5538 |
| 24. vii. |                              | 216.3 | 1392 | 1990 |

|     |       |        |       |      |      |
|-----|-------|--------|-------|------|------|
| 25. | vii   | 649.0  | 439.7 | 3034 | 4045 |
| 26. | vii.  |        | 223.3 | 1541 | 2054 |
| 27. | vii.  | 670.0  | 551.0 | 3802 | 5069 |
| 28. | vii.  |        | 327.7 | 2261 | 3015 |
| 29. | vii.  | 983.0  | 561.0 | 3871 | 5161 |
| 30. | vii.  |        | 233.3 | 1610 | 2146 |
| 31. | vii.  | 700.0  | 233.3 | 1610 | 2146 |
| 1.  | viii. |        | 234.3 | 1617 | 2156 |
| 2.  | viii. |        | 234.3 | 1617 | 2156 |
| 3.  | viii. | 703.0  | 234.3 | 1617 | 2156 |
| 4.  | viii. |        | 336.0 | 2318 | 3091 |
| 5.  | viii. |        | 336.0 | 2318 | 3091 |
| 6.  | viii. | 1008.0 | 336.0 | 2318 | 3091 |
| 7.  | viii. |        | 248.3 | 1713 | 2284 |
| 8.  | viii. |        | 248.3 | 1713 | 2284 |
| 9.  | viii. | 745.0  | 248.3 | 1713 | 2284 |
| 10. | viii. |        | 274.3 | 1893 | 2524 |
| 11. | viii. |        | 274.3 | 1893 | 2524 |
| 12. | viii. | 823.0  | 274.3 | 1893 | 2524 |
| 13. | viii. |        | 243.3 | 1679 | 2238 |
| 14. | viii. |        | 243.3 | 1679 | 2238 |
| 15. | viii. | 730.0  | 243.3 | 1679 | 2238 |
| 16. | viii. |        | 168.0 | 1159 | 1546 |
| 17. | viii. |        | 168.0 | 1159 | 1546 |
| 18. | viii. | 504.0  | 168.0 | 1159 | 1546 |
| 19. | viii. |        | 207.3 | 1430 | 1907 |
| 20. | viii. |        | 207.3 | 1430 | 1907 |
| 21. | viii. | 622.0  | 207.3 | 1430 | 1907 |
| 22. | viii. |        | 161.3 | 1113 | 1484 |
| 23. | viii. |        | 161.3 | 1113 | 1484 |
| 24. | viii. | 484.0  | 161.3 | 1113 | 1484 |
| 25. | viii. |        | 162.0 | 1118 | 1490 |
| 26. | viii. |        | 162.0 | 1118 | 1490 |
| 27. | viii. | 486.0  | 162.0 | 1118 | 1490 |
| 28. | viii. |        | 155.0 | 1070 | 1426 |
| 29. | viii. |        | 155.0 | 1070 | 1426 |
| 30. | viii. | 465.0  | 155.0 | 1070 | 1426 |
| 31. | viii. |        | 91.7  | 633  | 844  |
| 1.  | ix.   |        |       |      |      |
| 2.  | ix.   | 275.0  |       |      |      |

Table 125. Variation in size of eggs dropped by *Phraortes kumamotoensis* No. 44 during her life.

| Date     | Number | Shape | a     | b     | c     | d     | e     | f     | g     | h     | i     |
|----------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 18. vii. | 1      | △     | 2.500 | 1.500 | 1.200 | 1.000 | 0.750 | 1.500 | 0.500 | 0.250 | 0.250 |
| 20. vii. | 1      | △     | 2.450 | 1.600 | 1.200 | 1.000 | 0.800 | 1.650 | 0.550 | 0.350 | 0.250 |
| 21. vii. | 1      | △     | 2.500 | 1.600 | 1.250 | 1.100 | 0.800 | 1.600 | 0.550 | 0.350 | 0.250 |
| 22. vii. | 5      | △     | 2.550 | 1.600 | 1.250 | 1.100 | 0.750 | 1.650 | 0.550 | 0.250 | 0.250 |
| "        |        | △     | 2.500 | 1.500 | 1.300 | 1.050 | 0.900 | 1.550 | 0.550 | 0.250 | 0.300 |
| "        |        | △     | 2.550 | 1.650 | 1.250 | 1.050 | 0.800 | 1.550 | 0.550 | 0.250 | 0.250 |
| "        |        | △     | 2.500 | 1.500 | 1.200 | 1.000 | 0.750 | 1.700 | 0.550 | 0.300 | 0.300 |
| "        |        | △     | 2.500 | 1.550 | 1.850 | 1.100 | 0.800 | 1.750 | 0.600 | 0.300 | 0.300 |
| 24. vii. | 2      | ○     | 2.600 | 1.500 | 1.250 | 1.050 | 0.800 | 1.500 | 0.550 | 0.450 | 0.300 |
| "        |        | △     | 2.750 | 1.700 | 1.400 | 1.100 | 0.850 | 1.700 | 0.600 | 0.350 | 0.250 |
| 25. vii. | 1      | △     | 2.500 | 1.500 | 1.300 | 1.050 | 0.750 | 1.600 | 0.600 | 0.250 | 0.250 |
| 26. vii. | 2      | △     | 2.750 | 1.900 | 1.500 | 1.100 | 0.900 | 1.750 | 0.550 | 0.250 | 0.250 |
| "        |        | ×     | 2.250 | 1.250 | 1.050 | 0.900 | 0.600 | 1.400 | 0.500 |       |       |
| 28. vii. | 4      | △     | 2.750 | 1.750 | 1.500 | 1.100 | 0.950 | 1.750 | 0.550 | 0.250 | 0.200 |
| "        |        | △     | 2.750 | 1.800 | 1.500 | 1.150 | 0.900 | 1.700 | 0.550 | 0.250 | 0.150 |
| "        |        | △     | 2.750 | 1.800 | 1.500 | 1.250 | 0.950 | 1.650 | 0.550 | 0.200 | 0.150 |
| "        |        | △     | 2.750 | 1.750 | 1.400 | 1.100 | 0.900 | 1.600 | 0.550 | 0.300 | 0.250 |
| 29. vii. | 2      | ○     | 2.750 | 1.750 | 1.500 | 1.100 | 0.800 | 1.750 | 0.550 | 0.350 | 0.250 |
| "        |        | △     | 2.600 | 1.750 | 1.500 | 1.200 | 0.900 | 1.750 | 0.550 | 0.250 | 0.250 |
| 30. vii. | 3      | △     | 2.600 | 1.750 | 1.500 | 1.200 | 1.000 | 1.600 | 0.500 | 0.250 | 0.300 |
| "        |        | △     | 2.500 | 1.800 | 1.500 | 1.250 | 1.000 | 1.600 | 0.600 | 0.300 | 0.250 |
| "        |        | △     | 2.750 | 1.750 | 1.500 | 1.200 | 0.900 | 1.750 | 0.600 | 0.250 | 0.300 |
| 1. viii. | 6      | △     | 2.650 | 1.750 | 1.500 | 1.250 | 0.900 | 1.600 | 0.550 | 0.350 | 0.200 |
| "        |        | △     | 2.500 | 1.700 | 1.500 | 1.150 | 0.900 | 1.600 | 0.550 | 0.200 | 0.200 |
| "        |        | △     | 2.650 | 1.700 | 1.400 | 1.150 | 0.850 | 1.600 | 0.550 | 0.300 | 0.200 |
| "        |        | △     | 2.600 | 1.700 | 1.500 | 1.150 | 0.850 | 1.600 | 0.550 | 0.300 | 0.200 |
| "        |        | △     | 2.500 | 1.700 | 1.500 | 1.200 | 0.850 | 1.600 | 0.550 | 0.200 | 0.200 |
| "        |        | △     | 2.550 | 1.800 | 1.400 | 1.100 | 0.900 | 1.600 | 0.550 | 0.200 | 0.200 |
| 2. viii. | 2      | △     | 2.500 | 1.700 | 1.400 | 1.100 | 0.900 | 1.500 | 0.500 | 0.150 | 0.150 |
| "        |        | △     | 2.500 | 1.650 | 1.500 | 1.100 | 0.850 | 1.600 | 0.550 | 0.250 | 0.200 |
| 3. viii. | 2      | △     | 2.500 | 1.700 | 1.250 | 1.100 | 0.850 | 1.500 | 0.550 | 0.550 | 0.250 |
| "        |        | △     | 2.550 | 1.650 | 1.400 | 1.100 | 0.900 | 1.600 | 0.550 | 0.250 | 0.200 |
| 4. viii. | 1      | △     | 2.650 | 1.700 | 1.400 | 1.150 | 0.950 | 1.700 | 0.550 | 0.200 | 0.250 |
| 5. viii. | 1      | ○     | 2.250 | 1.400 | 1.200 | 1.000 | 0.600 | 1.250 | 0.500 | 0.300 | 0.250 |
| 6. viii. | 1      | ×     | 2.600 | 1.750 | 1.400 | 1.100 | 0.900 | 1.700 | 0.500 |       |       |

|           |   |   |       |       |       |       |       |       |       |       |       |
|-----------|---|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 7. viii.  | 5 | × | 2.650 | 1.700 | 1.500 | 1.100 | 0.900 | 1.750 | 0.550 |       |       |
| ”         |   | △ | 2.750 | 1.750 | 1.500 | 1.150 | 0.950 | 1.700 | 0.550 | 0.300 | 0.200 |
| ”         |   | △ | 2.750 | 1.750 | 1.500 | 1.150 | 0.950 | 1.800 | 0.550 | 0.200 | 0.200 |
| ”         |   | △ | 2.650 | 1.700 | 1.450 | 1.100 | 0.850 | 1.600 | 0.550 | 0.200 | 0.150 |
| 7. viii.  |   | △ | 2.700 | 1.750 | 1.350 | 1.150 | 0.900 | 1.650 | 0.550 | 0.250 | 0.150 |
| 8. viii.  | 1 | △ | 2.750 | 1.750 | 1.400 | 1.100 | 0.800 | 1.650 | 0.550 | 0.200 | 0.100 |
| 9. viii.  | 2 | △ | 2.750 | 1.750 | 1.500 | 1.100 | 0.900 | 1.750 | 0.550 | 0.300 | 0.200 |
| ”         |   | △ | 2.650 | 1.750 | 1.400 | 1.150 | 0.900 | 1.600 | 0.550 | 0.300 | 0.200 |
| 11. viii. | 4 | △ | 2.650 | 1.750 | 1.400 | 1.100 | 0.850 | 1.600 | 0.550 | 0.350 | 0.200 |
| ”         |   | △ | 2.600 | 1.650 | 1.400 | 1.100 | 0.850 | 1.750 | 0.550 | 0.250 | 0.200 |
| ”         |   | △ | 2.500 | 1.650 | 1.500 | 1.050 | 0.900 | 1.500 | 0.600 | 0.300 | 0.200 |
| ”         |   | △ | 2.550 | 1.650 | 1.350 | 1.100 | 0.800 | 1.600 | 0.550 | 0.200 | 0.200 |
| 12. viii. | 1 |   |       |       |       |       |       |       |       |       |       |
| 14. viii. | 1 | △ | 2.400 | 1.500 | 1.250 | 1.000 | 0.750 | 1.500 | 0.550 | 0.200 | 0.200 |
| 15. viii. | 1 | △ | 2.500 | 1.600 | 1.250 | 1.100 | 0.900 | 1.750 | 0.600 | 0.250 | 0.300 |
| 16. viii. | 1 | △ | 2.550 | 1.650 | 1.250 | 1.050 | 0.850 | 1.700 | 0.600 | 0.200 | 0.150 |
| 17. viii. | 1 | △ | 2.250 | 1.500 | 1.200 | 1.050 | 0.750 | 1.400 | 0.550 | 0.350 | 0.200 |
| 18. viii. | 1 | △ | 2.400 | 1.500 | 1.200 | 1.000 | 0.700 | 1.250 | 0.550 | 0.250 | 0.200 |
| 19. viii. | 1 | ○ | 2.750 | 1.700 | 1.200 | 1.050 | 0.850 | 1.700 | 0.550 | 0.350 | 0.200 |
| 21. viii. | 3 |   | 2.600 | 1.750 | 1.300 | 1.200 | 0.850 | 1.700 | 0.550 |       |       |
| ”         |   |   | 2.750 | 1.750 | 1.400 | 1.150 | 0.750 | 1.600 | 0.550 |       |       |
| ”         |   |   | 2.750 | 1.750 | 1.400 | 1.200 | 0.800 | 1.750 | 0.550 |       |       |
| 22. viii. | 1 |   | 2.500 | 1.800 | 1.300 | 1.200 | 0.900 | 1.500 | 0.550 |       |       |
| 24. viii. | 2 | △ | 2.500 | 1.600 | 1.300 | 1.100 | 0.850 | 1.600 | 0.600 | 0.300 | 0.200 |
| ”         |   |   | 2.500 | 1.650 | 1.250 | 1.150 | 0.900 | 1.500 | 0.550 |       |       |
| 25. viii. | 5 | △ | 2.300 | 1.450 | 1.100 | 1.050 | 0.750 | 1.400 |       | 0.250 | 0.150 |
| ”         |   | △ | 2.500 | 1.500 | 1.200 | 1.000 | 0.800 | 1.250 | 0.550 | 0.300 | 0.100 |
| ”         |   | △ | 2.450 | 1.600 | 1.250 | 1.100 | 0.800 | 1.650 | 0.600 | 0.300 | 0.200 |
| ”         |   | △ | 2.400 | 1.500 | 1.300 | 1.000 | 0.800 | 1.500 | 0.550 | 0.300 | 0.250 |
| ”         |   | △ | 2.300 | 1.500 | 1.250 | 1.000 | 0.800 | 1.600 | 0.500 | 0.300 | 0.200 |
| 26. viii. | 1 | △ | 2.400 | 1.500 | 1.200 | 1.000 | 0.750 | 1.750 | 0.550 | 0.200 | 0.200 |
| 29. viii. |   | △ | 2.800 | 1.900 | 1.400 | 1.250 | 0.900 | 1.600 | 0.550 | 0.300 | 0.100 |
| 31. viii. | 2 |   | 2.100 | 1.500 | 1.100 | 0.900 | 0.650 | 1.250 |       |       |       |
| ”         |   |   | 2.500 | 1.750 | 1.400 | 1.150 | 0.900 | 1.600 | 0.550 |       |       |
| 1. ix.    | 2 |   | 2.300 | 1.300 | 1.000 | 0.900 | 0.500 | 1.000 |       |       |       |
| ”         |   |   | 2.750 | 1.750 | 1.500 | 1.200 | 0.900 | 1.600 | 0.600 |       |       |
| 2. ix.    | 1 |   | 2.650 | 1.750 | 1.400 | 1.200 | 0.950 | 1.600 | 0.550 |       |       |
| 4. ix.    | 2 |   | 2.600 | 1.650 | 1.300 | 1.100 | 0.700 | 1.600 | 0.550 |       |       |

|         |     |   |       |       |       |       |       |       |       |       |             |
|---------|-----|---|-------|-------|-------|-------|-------|-------|-------|-------|-------------|
| "       |     |   | 2.500 | 1.750 | 1.400 | 1.100 | 0.900 | 1.700 | 0.550 |       |             |
| 5.      | ix. | 2 | 2.500 | 1.750 | 1.300 | 1.100 | 0.900 | 1.750 | 0.600 |       |             |
| "       |     |   | 2.700 | 1.750 | 1.450 | 1.100 | 0.850 | 1.900 | 0.550 |       |             |
| 6.      | ix. | 1 | 2.550 | 1.650 | 1.250 | 1.100 | 0.750 | 1.600 | 0.550 |       |             |
| 8.      | ix. | 2 | 2.300 | 1.600 | 1.250 | 1.000 | 0.750 | 1.650 | 0.550 |       |             |
| "       |     |   | 2.500 | 1.700 | 1.300 | 1.100 | 0.800 | 1.150 | 0.550 |       |             |
| 9.      | ix. | 1 | △     | 2.500 | 1.650 | 1.250 | 1.050 | 0.750 | 1.900 | 0.550 | 0.300 0.200 |
| 10.     | ix. | 2 |       | 2.550 | 1.700 | 1.400 | 1.100 | 0.750 | 1.750 | 0.600 |             |
| "       |     |   |       | 2.600 | 1.800 | 1.500 | 1.050 | 0.800 | 1.650 | 0.550 |             |
| 17.     | ix. | 2 |       | 2.800 | 1.900 | 1.500 | 1.250 | 0.900 | 1.800 | 0.550 |             |
| "       |     |   |       | 2.750 | 1.750 | 1.500 | 1.100 | 0.800 | 1.600 | 0.550 |             |
| 18.     | ix. | 1 |       | 2.700 | 1.750 | 1.300 | 1.150 | 0.750 | 1.750 | 0.600 |             |
| 19.     | ix. | 3 |       | 2.400 | 1.500 | 1.000 | 1.050 | 0.750 | 1.250 | 0.500 |             |
| "       |     |   |       | 2.750 | 1.900 | 1.300 | 1.200 | 0.750 | 1.600 | 0.600 |             |
| "       |     |   |       | 2.750 | 1.800 | 1.500 | 1.100 | 0.850 | 1.600 | 0.600 |             |
| Maximum |     |   |       | 2.800 | 1.900 | 1.850 | 1.250 | 1.000 | 1.900 | 0.600 | 0.450 0.300 |
| Minimum |     |   |       | 2.100 | 1.250 | 1.000 | 0.900 | 0.500 | 1.000 | 0.500 | 0.150 0.100 |
| Average |     |   |       | 2.556 | 1.668 | 1.354 | 1.102 | 0.832 | 1.609 | 0.554 | 0.275 0.214 |

Table 126. Variation in size of eggs dropped by *Phraortes kumamotoensis* No 45. during her life.

| Date     | Number | Shape | a     | b     | c     | d     | e     | f     | g     | h     | i     |
|----------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 21. vii. | 1      | △     | 2.350 | 1.200 | 1.000 | 0.750 | 0.750 | 1.500 | 0.550 | 0.300 | 0.400 |
| 22. vii. | 1      | ○     | 2.400 | 1.450 | 1.050 | 0.750 | 0.750 | 1.750 | 0.550 | 0.450 | 0.250 |
| 23. vii. | 2      | ○     | 2.500 | 1.500 | 1.200 | 0.800 | 0.800 | 1.800 | 0.550 | 0.500 | 0.350 |
| "        |        | ○     | 2.500 | 1.450 | 1.100 | 0.900 | 0.750 | 1.900 | 0.500 | 0.500 | 0.500 |
| 25. vii. | 1      | ○     | 2.750 | 1.500 | 1.150 | 0.900 | 0.700 | 2.000 | 0.450 | 0.450 | 0.450 |
| 27. vii. | 2      | ○     | 2.500 | 1.500 | 1.150 | 0.900 | 0.750 | 1.900 | 0.550 | 0.500 | 0.500 |
| "        |        | △     | 2.600 | 1.400 | 1.100 | 1.000 | 0.800 | 1.800 | 0.500 | 0.300 | 0.300 |
| 28. vii. | 1      | △     | 2.500 | 1.400 | 1.150 | 1.000 | 0.850 | 1.700 | 0.550 | 0.500 | 0.300 |
| 29. vii. | 1      | ○     | 2.500 | 1.250 | 1.000 | 0.900 | 0.750 | 1.700 | 0.500 | 0.500 | 0.400 |
| 1. viii. | 2      | △     | 2.900 | 1.700 | 1.200 | 1.000 | 0.850 | 1.800 | 0.550 | 0.400 | 0.450 |
| "        |        | △     | 2.800 | 1.650 | 1.250 | 1.000 | 0.900 | 1.700 | 0.600 | 0.350 | 0.400 |
| 3. viii. | 1      | ○     | 2.750 | 1.700 | 1.200 | 1.000 | 0.750 | 2.000 | 0.550 | 0.500 | 0.500 |
| 4. viii. | 1      |       |       |       |       |       |       |       |       |       |       |
| 5. viii. | 1      | △     | 2.600 | 1.500 | 1.200 | 0.900 | 0.750 | 1.700 | 0.600 | 0.500 | 0.300 |
| 7. viii. | 2      | △     | 2.500 | 1.700 | 1.200 | 1.050 | 0.800 | 1.600 | 0.550 | 0.500 | 0.400 |

|           |   |   |       |       |       |       |       |       |       |       |       |
|-----------|---|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| "         |   | △ | 2.500 | 1.700 | 1.150 | 0.750 | 0.650 | 1.750 | 0.550 | 0.500 | 0.200 |
| 9. viii.  | 1 | △ | 2.500 | 1.700 | 1.250 | 1.000 | 0.800 | 1.800 | 0.550 | 0.400 | 0.450 |
| 10. viii. | 1 | △ | 2.700 | 1.650 | 1.400 | 1.000 | 0.800 | 2.000 | 0.600 |       |       |
| 11. viii. | 1 | × | 2.750 | 1.650 | 1.300 | 0.950 | 0.850 | 1.700 | 0.550 |       |       |
| 12. viii. | 1 | ○ | 2.750 | 1.750 | 1.250 | 1.000 | 0.850 | 2.000 | 0.550 | 0.500 | 0.250 |
| 14. viii. | 3 | △ | 2.750 | 1.600 | 1.250 | 0.900 | 0.800 | 1.750 | 0.500 | 0.450 | 0.250 |
| "         |   | △ | 2.700 | 1.650 | 1.000 | 0.900 | 0.700 | 1.900 | 0.500 | 0.450 | 0.450 |
| "         |   | △ | 2.900 | 1.650 | 1.250 | 1.000 | 0.850 | 2.000 | 0.500 | 0.350 | 0.300 |
| 16. viii. | 1 | △ | 2.750 | 1.700 | 1.250 | 1.000 | 0.800 | 1.750 | 0.550 | 0.350 | 0.450 |
| 17. viii. | 1 | △ | 2.650 | 1.500 | 1.250 | 0.750 | 0.750 | 1.750 | 0.550 | 0.450 | 0.150 |
| 18. viii. | 2 | △ | 2.500 | 1.500 | 1.150 | 0.950 | 0.750 | 0.800 | 0.550 | 0.350 | 0.250 |
| "         |   | △ | 2.600 | 1.600 | 1.250 | 0.950 | 0.800 | 1.700 | 0.550 | 0.550 | 0.400 |
| 22. viii. | 1 | △ | 2.900 | 1.750 | 1.500 | 1.050 | 1.000 | 2.150 | 0.550 | 0.300 | 0.200 |
| 27. viii. |   | △ | 2.750 | 1.700 | 1.250 | 1.000 | 0.850 | 1.900 | 0.550 | 0.400 | 0.300 |
| 29. viii. | 1 | △ | 2.900 | 1.800 | 1.300 | 1.050 | 0.800 | 1.850 | 0.550 | 0.250 | 0.150 |
| 1. xi.    | 1 | △ | 2.700 | 1.750 | 1.250 | 1.000 | 0.800 | 1.900 | 0.600 | 0.350 | 0.250 |
| 2. xi.    | 2 | △ | 2.500 | 1.500 | 1.200 | 1.000 | 0.700 | 1.650 | 0.450 | 0.300 | 0.450 |
| "         |   | △ | 2.600 | 1.750 | 1.250 | 0.800 | 0.750 | 1.500 | 0.550 | 0.350 | 0.350 |
| 4. xi.    | 1 |   |       |       |       |       |       |       |       |       |       |
| Maximum   |   |   | 2.900 | 1.800 | 1.500 | 1.050 | 1.000 | 2.150 | 0.600 | 0.550 | 0.500 |
| Minimum   |   |   | 2.350 | 1.200 | 1.000 | 0.750 | 0.650 | 1.500 | 0.450 | 0.250 | 0.150 |
| Average   |   |   | 2.620 | 1.537 | 1.201 | 0.934 | 0.789 | 1.790 | 0.540 | 0.418 | 0.341 |

Table 127. Variation in size of eggs dropped by *Phraortes kumamotoensis* No. 46 during her life.

| Date     | Number | Shape | a     | b     | c     | d     | e     | f     | g     | h     | i     |
|----------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 17. vii. | 4      |       | 2.700 | 1.500 | 1.250 | 1.050 | 0.750 | 1.750 | 0.500 |       |       |
| "        |        | ○     | 2.750 | 1.600 | 1.150 | 1.000 | 0.750 | 1.600 | 0.500 | 0.450 | 0.350 |
| "        |        | ○     | 2.750 | 1.500 | 1.100 | 1.000 | 0.750 | 1.900 | 0.500 | 0.500 | 0.450 |
| "        |        | △     | 2.750 | 1.700 | 1.250 | 1.050 | 0.900 | 1.800 | 0.550 | 0.300 | 0.350 |
| 19. vii. | 2      | △     | 2.600 | 1.600 | 1.250 | 1.000 | 0.900 | 1.750 | 0.500 | 0.200 | 0.300 |
| "        |        | △     | 2.700 | 1.600 | 1.200 | 1.000 | 0.750 | 1.750 | 0.550 | 0.450 | 0.450 |
| 20. vii. | 1      | △     | 2.650 | 1.650 | 1.300 | 1.100 | 0.900 | 1.800 | 0.550 | 0.350 | 0.350 |
| 21. vii. | 2      | △     | 2.650 | 1.600 | 1.250 | 1.100 | 0.900 | 1.900 | 0.550 | 0.250 | 0.450 |
| "        |        | △     | 2.700 | 1.700 | 1.400 | 1.100 | 0.950 | 1.800 | 0.550 | 0.200 | 0.350 |
| 22. vii. | 1      | △     | 2.600 | 1.500 | 1.250 | 1.050 | 0.900 | 1.750 | 0.550 | 0.300 | 0.350 |
| 23. vii. | 4      | △     | 2.650 | 1.600 | 1.250 | 1.100 | 0.900 | 1.750 | 0.600 | 0.350 | 0.350 |

|     |       |   |   |       |       |       |       |       |       |       |       |       |
|-----|-------|---|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| "   |       |   | △ | 2.600 | 1.600 | 1.300 | 1.050 | 0.900 | 1.750 | 0.600 | 0.250 | 0.350 |
| "   |       |   | ○ | 2.700 | 1.800 | 1.500 | 1.050 | 0.900 | 1.900 | 0.550 | 0.500 | 0.450 |
| "   |       |   | ○ | 2.700 | 1.650 | 1.400 | 1.050 | 0.900 | 1.750 | 0.550 | 0.500 | 0.500 |
| 24. | vii.  | 2 | △ | 2.750 | 1.750 | 1.250 | 1.200 | 0.900 | 1.800 | 0.550 | 0.450 | 0.250 |
| "   |       |   | △ | 2.750 | 1.700 | 1.350 | 1.050 | 0.800 | 1.750 | 0.550 | 0.500 | 0.450 |
| 25. | vii.  | 2 | △ | 2.700 | 1.700 | 1.300 | 1.100 | 0.900 | 1.800 | 0.550 | 0.350 | 0.350 |
| "   |       |   | △ | 2.700 | 1.750 | 1.500 | 1.100 | 0.850 | 1.750 | 0.550 | 0.300 | 0.300 |
| 26. | vii.  | 1 | △ | 2.750 | 1.700 | 1.300 | 1.100 | 0.900 | 1.700 | 0.550 | 0.300 | 0.350 |
| 27. | vii.  | 3 | △ | 2.750 | 1.750 | 1.500 | 1.050 | 0.900 | 1.700 | 0.550 | 0.450 | 0.400 |
| "   |       |   | △ | 2.600 | 1.650 | 1.300 | 1.100 | 0.950 | 1.600 | 0.550 | 0.300 | 0.400 |
| "   |       |   | ○ | 2.700 | 1.700 | 1.350 | 1.100 | 0.900 | 1.900 | 0.550 | 0.500 | 0.350 |
| 28. | vii.  | 3 | △ | 2.600 | 1.700 | 1.500 | 1.100 | 0.950 | 1.700 | 0.500 | 0.350 | 0.400 |
| "   |       |   | △ | 2.700 | 1.700 | 1.400 | 1.100 | 0.950 | 1.750 | 0.550 | 0.250 | 0.350 |
| "   |       |   | △ | 2.700 | 1.750 | 1.500 | 1.100 | 0.900 | 1.800 | 0.550 | 0.350 | 0.350 |
| 29. | vii.  | 4 | △ | 2.600 | 1.650 | 1.250 | 1.150 | 0.900 | 1.700 | 0.550 | 0.350 | 0.350 |
| "   |       |   | △ | 2.600 | 1.650 | 1.300 | 1.050 | 0.850 | 1.750 | 0.550 | 0.300 | 0.350 |
| "   |       |   | △ | 2.650 | 1.700 | 1.400 | 1.100 | 0.900 | 1.800 | 0.550 | 0.350 | 0.350 |
| "   |       |   | ○ | 2.700 | 1.650 | 1.500 | 1.100 | 0.900 | 1.750 | 0.600 | 0.500 | 0.400 |
| 30. | vii.  | 2 | △ | 2.500 | 1.600 | 1.300 | 1.050 | 0.900 | 1.700 | 0.550 | 0.500 | 0.500 |
| "   |       |   | △ | 2.550 | 1.500 | 1.300 | 1.100 | 0.900 | 1.600 | 0.550 | 0.400 | 0.400 |
| 31. | vii.  | 3 | ○ | 2.500 | 1.700 | 1.450 | 1.100 | 0.850 | 1.800 | 0.550 | 0.500 | 0.400 |
| "   |       |   | ○ | 2.700 | 1.750 | 1.500 | 1.100 | 0.800 | 1.800 | 0.550 | 0.500 | 0.450 |
| "   |       |   | ○ | 2.500 | 1.750 | 1.300 | 1.100 | 0.750 | 1.600 | 0.550 | 0.500 | 0.500 |
| 2.  | viii. | 5 | △ | 2.600 | 1.750 | 1.300 | 1.100 | 0.800 | 1.700 | 0.550 | 0.350 | 0.350 |
| "   |       |   | △ | 2.650 | 1.700 | 1.300 | 1.100 | 0.900 | 1.600 | 0.550 | 0.300 | 0.350 |
| "   |       |   | △ | 2.800 | 1.750 | 1.550 | 1.100 | 0.950 | 1.750 | 0.550 | 0.200 | 0.350 |
| "   |       |   | ○ | 2.550 | 1.700 | 1.500 | 1.100 | 0.900 | 1.750 | 0.550 | 0.450 | 0.450 |
| "   |       |   | △ | 2.600 | 1.650 | 1.250 | 1.100 | 0.900 | 1.800 | 0.500 | 0.300 | 0.350 |
| 3.  | viii. | 2 | △ | 2.600 | 1.700 | 1.750 | 1.100 | 0.800 | 1.600 | 0.500 | 0.300 | 0.350 |
| "   |       |   | △ | 2.600 | 1.700 | 1.300 | 1.100 | 0.950 | 1.650 | 0.550 | 0.350 | 0.350 |
| 4.  | viii. | 1 | ○ | 2.600 | 1.600 | 1.300 | 1.100 | 0.900 | 1.750 | 0.550 | 0.500 | 0.450 |
| 5.  | viii. | 1 | △ | 2.650 | 1.600 | 1.250 | 1.150 | 0.800 | 1.750 | 0.550 | 0.300 | 0.350 |
| 6.  | viii. | 3 | △ | 2.600 | 1.600 | 1.250 | 1.100 | 0.900 | 1.650 | 0.600 | 0.300 | 0.350 |
| "   |       |   | △ | 2.650 | 1.650 | 1.250 | 1.100 | 0.900 | 1.750 | 0.500 | 0.250 | 0.350 |
| "   |       |   | △ | 2.650 | 1.600 | 1.150 | 1.100 | 0.950 | 1.750 | 0.550 | 0.350 | 0.350 |
| 7.  | viii. | 2 | △ | 2.500 | 1.500 | 1.250 | 1.100 | 0.900 | 1.700 | 0.600 | 0.500 | 0.450 |
| "   |       |   | △ | 2.500 | 1.650 | 1.350 | 1.100 | 0.900 | 1.800 | 0.600 | 0.500 | 0.500 |
| 9.  | viii. | 1 | ○ | 2.600 | 1.600 | 1.300 | 1.000 | 0.850 | 1.850 | 0.600 | 0.500 | 0.500 |

|         |       |   |   |       |       |       |       |       |       |       |       |       |
|---------|-------|---|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 10.     | viii. | 3 | △ | 2.550 | 1.500 | 1.250 | 1.100 | 0.800 | 1.750 | 0.550 | 0.450 | 0.350 |
|         | "     |   | △ | 2.500 | 1.550 | 1.300 | 1.000 | 0.800 | 1.700 | 0.600 | 0.500 | 0.250 |
|         | "     |   | △ | 2.550 | 1.550 | 1.350 | 1.100 | 0.800 | 1.700 | 0.600 | 0.300 | 0.200 |
| 11.     | viii. | 1 | △ | 2.600 | 1.600 | 1.250 | 1.100 | 0.850 | 1.750 | 0.600 | 0.500 | 0.400 |
| 12.     | viii. | 1 |   |       |       |       |       |       |       |       |       |       |
| 13.     | viii. | 1 | △ | 2.300 | 1.500 | 1.200 | 1.050 | 0.900 | 1.400 | 0.550 | 0.500 | 0.300 |
| 14.     | viii. | 6 | ○ | 2.250 | 1.500 | 1.050 | 0.950 | 0.750 | 1.600 | 0.550 | 0.500 | 0.350 |
|         | "     |   | △ | 2.500 | 1.500 | 1.100 | 0.950 | 0.800 | 1.650 | 0.550 | 0.200 | 0.250 |
|         | "     |   | △ | 2.300 | 1.500 | 1.150 | 1.050 | 0.900 | 1.500 | 0.550 | 0.350 | 0.300 |
|         | "     |   | △ | 2.300 | 1.500 | 1.150 | 1.000 | 0.750 | 1.700 | 0.550 | 0.300 | 0.300 |
|         | "     |   | △ | 2.250 | 1.600 | 1.100 | 1.000 | 0.750 | 1.600 | 0.550 | 0.300 | 0.250 |
|         | "     |   | ○ | 2.400 | 1.500 | 1.100 | 1.000 | 0.800 | 1.650 | 0.550 | 0.450 | 0.300 |
| 16.     | viii. | 1 | △ | 2.550 | 1.700 | 1.300 | 1.100 | 0.900 | 1.750 | 0.550 | 0.300 | 0.250 |
| 17.     | viii. | 2 | △ | 2.500 | 1.700 | 1.250 | 1.050 | 0.800 | 1.700 | 0.550 | 0.450 | 0.300 |
|         | "     |   | △ | 2.500 | 1.650 | 1.300 | 1.100 | 0.800 | 1.600 | 0.550 | 0.350 | 0.300 |
| 18.     | viii. | 2 | △ | 2.600 | 1.750 | 1.300 | 1.100 | 0.900 | 1.900 | 0.550 | 0.250 | 0.250 |
|         | "     |   | △ | 2.700 | 1.500 | 1.300 | 1.100 | 0.950 | 1.750 | 0.550 | 0.500 | 0.250 |
| 19.     | viii. | 2 | ○ | 2.500 | 1.600 | 1.300 | 1.100 | 0.900 | 1.750 | 0.600 | 0.500 | 0.350 |
|         | "     |   | △ | 2.550 | 1.600 | 1.400 | 1.100 | 0.900 | 1.700 | 0.600 | 0.250 | 0.200 |
| 20.     | viii. | 3 | △ | 2.600 | 1.550 | 1.350 | 1.100 | 0.950 | 1.650 | 0.550 | 0.300 | 0.250 |
|         | "     |   | △ | 2.350 | 1.550 | 1.250 | 1.100 | 0.800 | 1.600 | 0.550 | 0.350 | 0.350 |
|         | "     |   | △ | 2.500 | 1.650 | 1.200 | 1.100 | 0.750 | 1.750 | 0.550 | 0.350 | 0.300 |
| 21.     | viii. | 2 | △ | 2.650 | 1.650 | 1.250 | 1.100 | 0.900 | 1.800 | 0.550 | 0.350 | 0.350 |
|         | "     |   | △ | 2.500 | 1.500 | 1.250 | 1.050 | 0.950 | 1.650 | 0.550 | 0.350 | 0.300 |
| 22.     | viii. | 3 | △ | 2.500 | 1.600 | 1.250 | 1.100 | 0.800 | 1.750 | 0.600 | 0.400 | 0.300 |
|         | "     |   | △ | 2.500 | 1.500 | 1.200 | 1.550 | 0.850 | 1.800 | 0.550 | 0.250 | 0.200 |
|         | "     |   | △ | 2.450 | 1.600 | 1.250 | 1.000 | 0.800 | 1.750 | 0.550 | 0.300 | 0.300 |
| 23.     | viii. | 1 | △ | 2.200 | 1.500 | 1.100 | 1.050 | 0.800 | 1.650 | 0.550 | 0.300 | 0.300 |
| 24.     | viii. | 2 | △ | 2.300 | 1.500 | 1.200 | 1.050 | 0.900 | 1.800 | 0.550 | 0.350 | 0.350 |
|         | "     |   | △ | 2.450 | 1.500 | 1.250 | 1.050 | 0.850 | 1.800 | 0.550 | 0.300 | 0.250 |
| 26.     | viii. | 5 | △ | 2.350 | 1.500 | 1.150 | 1.000 | 0.900 | 1.900 | 0.550 | 0.350 | 0.300 |
|         | "     |   | △ | 2.500 | 1.700 | 1.300 | 1.150 | 0.900 | 1.950 | 0.600 | 0.450 | 0.400 |
|         | "     |   | △ | 2.300 | 1.500 | 1.250 | 1.100 | 0.900 | 1.750 | 0.600 | 0.350 | 0.350 |
|         | "     |   | △ | 2.500 | 1.600 | 1.250 | 1.100 | 0.900 | 1.950 | 0.600 | 0.350 | 0.300 |
|         | "     |   | ○ | 2.500 | 1.650 | 1.250 | 1.200 | 0.900 | 1.900 | 0.550 | 0.500 | 0.300 |
| Maximum |       |   |   | 2.800 | 1.800 | 1.500 | 1.200 | 0.950 | 1.950 | 0.600 | 0.500 | 0.500 |
| Minimum |       |   |   | 2.200 | 1.500 | 1.050 | 0.950 | 0.750 | 1.400 | 0.500 | 0.200 | 0.200 |
| Average |       |   |   | 2.568 | 1.615 | 1.288 | 1.077 | 0.866 | 1.737 | 0.554 | 0.373 | 0.348 |

Table 128. Variation in size of eggs dropped by *Phraortes kumamotoensis* No. 47 during her life.

| Date      | Number | Shape | a     | b     | c     | d     | e     | f     | g     | h     | i     |
|-----------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 19. vii.  | 1      | ○     | 2.500 | 1.500 | 1.150 | 1.000 | 0.850 | 1.750 | 0.550 | 0.500 | 0.500 |
| 21. vii.  | 2      | △     | 2.600 | 1.650 | 1.300 | 1.050 | 0.950 | 1.900 | 0.600 | 0.250 | 0.500 |
| "         |        | ○     | 2.750 | 1.650 | 1.200 | 1.000 | 0.900 | 1.900 | 0.600 | 0.500 | 0.500 |
| 22. vii.  | 1      | ○     | 2.750 | 1.500 | 1.250 | 1.000 | 0.900 | 2.000 | 0.550 | 0.500 | 0.500 |
| 23. vii.  | 1      | ○     | 2.750 | 1.700 | 1.300 | 1.000 | 0.850 | 2.000 | 0.600 | 0.500 | 0.500 |
| 24. vii.  | 1      | ○     | 2.600 | 1.600 | 1.250 | 1.100 | 0.900 | 1.900 | 0.550 | 0.500 | 0.500 |
| 25. vii.  | 3      | ○     | 2.650 | 1.700 | 1.400 | 1.100 | 0.850 | 1.700 | 0.550 | 0.500 | 0.500 |
| "         |        | ○     | 2.700 | 1.700 | 1.400 | 1.150 | 1.000 | 1.750 | 0.550 | 0.500 | 0.450 |
| "         |        | △     | 2.700 | 1.750 | 1.500 | 1.150 | 0.950 | 1.900 | 0.600 | 0.500 | 0.500 |
| 27. vii.  | 3      | ○     | 2.700 | 1.750 | 1.400 | 1.100 | 0.900 | 1.750 | 0.600 | 0.500 | 0.450 |
| "         |        | ○     | 2.600 | 1.800 | 1.400 | 1.100 | 0.900 | 1.700 | 0.550 | 0.500 | 0.500 |
| "         |        | ○     | 2.700 | 1.650 | 1.400 | 1.050 | 0.900 | 1.900 | 0.550 | 0.500 | 0.400 |
| 29. vii.  | 1      | △     | 2.750 | 1.700 | 1.300 | 1.100 | 0.800 | 1.750 | 0.550 | 0.500 | 0.500 |
| 30. vii.  | 3      | ○     | 2.500 | 1.700 | 1.400 | 1.100 | 0.900 | 1.900 | 0.600 | 0.500 | 0.500 |
| "         |        | ○     | 2.650 | 1.650 | 1.300 | 1.100 | 0.900 | 1.900 | 0.600 | 0.500 | 0.500 |
| "         |        | △     | 2.500 | 1.700 | 1.350 | 1.050 | 1.000 | 1.900 | 0.600 | 0.500 | 0.500 |
| 31. vii.  | 2      | △     | 2.750 | 1.750 | 1.400 | 1.100 | 1.000 | 1.950 | 0.550 | 0.400 | 0.450 |
| "         |        | ○     | 2.650 | 1.700 | 1.300 | 1.100 | 0.950 | 1.800 | 0.600 | 0.500 | 0.500 |
| 1. viii.  | 1      | ○     | 2.650 | 1.700 | 1.400 | 1.050 | 0.950 | 1.700 | 0.600 | 0.500 | 0.500 |
| 2. viii.  | 1      | △     | 2.800 | 1.850 | 1.500 | 1.100 | 0.900 | 2.000 | 0.600 | 0.500 | 0.400 |
| 3. viii.  | 1      |       | 2.500 | 1.700 | 1.400 | 1.100 | 0.900 | 1.600 | 0.550 |       |       |
| 4. viii.  | 3      | △     | 2.750 | 1.750 | 1.300 | 1.100 | 0.900 | 1.900 | 0.550 | 0.500 | 0.400 |
| "         |        | ○     | 2.650 | 1.750 | 1.500 | 1.100 | 0.950 | 1.800 | 0.550 | 0.500 | 0.500 |
| "         |        | ○     | 2.650 | 1.900 | 1.400 | 1.150 | 0.950 | 2.000 | 0.550 | 0.500 | 0.500 |
| 6. viii.  | 2      | ○     | 2.500 | 1.650 | 1.400 | 1.100 | 0.900 | 1.500 | 0.500 | 0.500 | 0.500 |
| "         |        | △     | 2.500 | 1.650 | 1.250 | 1.100 | 0.950 | 1.600 | 0.500 | 0.500 | 0.500 |
| 7. viii.  | 4      | △     | 2.600 | 1.650 | 1.300 | 1.100 | 1.000 | 1.700 | 0.550 | 0.550 | 0.350 |
| "         |        | △     | 2.500 | 1.650 | 1.250 | 1.050 | 0.850 | 1.700 | 0.550 | 0.550 | 0.450 |
| "         |        | ○     | 2.400 | 1.500 | 1.250 | 1.000 | 1.000 | 1.600 | 0.550 | 0.550 | 0.500 |
| "         |        | ○     | 2.550 | 1.600 | 1.400 | 1.100 | 0.900 | 1.750 | 0.500 | 0.550 | 0.500 |
| 8. viii.  | 2      | △     | 2.600 | 1.650 | 1.300 | 1.050 | 0.900 | 1.750 | 0.550 | 0.400 | 0.450 |
| "         |        | ○     | 2.500 | 1.500 | 1.300 | 1.000 | 0.900 | 1.650 | 0.550 | 0.500 | 0.500 |
| 10. viii. | 2      | ○     | 2.700 | 1.700 | 1.500 | 1.200 | 0.800 | 1.900 | 0.600 | 0.500 | 0.500 |
| "         |        | △     | 2.750 | 1.800 | 1.500 | 1.100 | 0.850 | 1.900 | 0.600 | 0.500 | 0.200 |

|         |       |   |   |       |       |       |       |       |       |       |       |       |
|---------|-------|---|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 11.     | viii. | 1 | △ | 2.750 | 1.750 | 1.500 | 1.100 | 0.950 | 1.800 | 0.550 | 0.500 | 0.400 |
| 13.     | viii. | 2 | △ | 2.500 | 1.700 | 1.850 | 1.100 | 0.900 | 1.900 | 0.550 | 0.500 | 0.500 |
|         | 〃     |   | △ | 2.600 | 1.700 | 1.400 | 1.100 | 0.900 | 1.650 | 0.550 | 0.500 | 0.400 |
| 14.     | viii. | 1 | ○ | 2.500 | 1.800 | 1.900 | 1.000 | 0.950 | 1.750 | 0.600 | 0.500 | 0.500 |
| 16.     | viii. | 1 | △ | 2.160 | 1.200 | 1.000 | 0.800 | 0.750 | 1.100 | 0.250 | 0.300 | 0.350 |
| 18.     | viii. | 3 | ○ | 2.700 | 1.900 | 1.400 | 1.150 | 0.950 | 2.000 | 0.550 | 0.500 | 0.500 |
|         | 〃     |   | △ | 2.750 | 1.700 | 1.500 | 1.100 | 0.900 | 1.900 | 0.600 | 0.500 | 0.500 |
|         | 〃     |   | △ | 2.750 | 1.850 | 1.500 | 1.150 | 0.900 | 2.000 | 0.600 | 0.450 | 0.350 |
| 20.     | viii. | 2 | ○ | 2.700 | 1.750 | 1.500 | 1.100 | 0.850 | 2.000 | 0.600 | 0.350 | 0.350 |
|         | 〃     |   | △ | 2.650 | 1.700 | 1.250 | 0.600 | 0.900 | 1.900 | 0.550 | 0.500 | 0.500 |
| 23.     | viii. | 1 | △ | 2.800 | 1.900 | 1.350 | 1.150 | 0.900 | 2.000 | 0.600 | 0.450 | 0.350 |
| 26.     | viii. | 3 | ○ | 2.850 | 1.900 | 1.450 | 1.150 | 1.000 | 2.100 | 0.600 | 0.550 | 0.500 |
|         | 〃     |   | △ | 2.700 | 1.800 | 1.300 | 1.100 | 0.900 | 1.800 | 0.550 | 0.550 | 0.500 |
|         | 〃     |   | △ | 2.850 | 1.750 | 1.350 | 1.200 | 0.850 | 1.900 | 0.550 | 0.250 | 0.350 |
| 28.     | viii. | 2 | △ | 2.800 | 1.750 | 1.500 | 1.200 | 0.950 | 2.100 | 0.650 | 0.250 | 0.450 |
|         | 〃     |   | △ | 2.700 | 1.750 | 1.500 | 1.200 | 0.900 | 2.000 | 0.600 | 0.300 | 0.400 |
| 2.      | ix.   | 1 | △ | 2.700 | 1.700 | 1.250 | 1.100 | 0.950 | 1.750 | 0.550 | 0.200 | 0.250 |
| 4.      | ix.   | 2 |   | 2.500 | 1.500 | 1.250 | 0.900 | 0.900 | 1.000 | 0.500 |       |       |
|         | 〃     |   |   | 2.700 | 1.650 | 1.250 | 1.050 | 0.850 | 1.750 | 0.500 |       |       |
| 8       | ix.   | 2 |   | 2.500 | 1.750 | 1.400 | 1.050 | 0.950 | 1.750 | 0.550 |       |       |
|         | 〃     |   |   | 2.650 | 1.700 | 1.350 | 1.100 | 1.000 | 1.800 | 0.550 |       |       |
| 9.      | ix.   | 1 |   | 2.600 | 1.700 | 1.250 | 1.000 | 0.750 | 1.600 | 0.500 |       |       |
| 10.     | ix.   | 2 |   | 2.500 | 1.700 | 1.250 | 1.050 | 1.000 | 1.800 | 0.550 |       |       |
|         | 〃     |   |   | 2.550 | 1.600 | 1.300 | 1.050 | 0.800 | 2.000 | 0.600 |       |       |
| 12.     | ix.   | 1 | △ | 2.500 | 1.700 | 1.300 | 1.050 | 0.950 | 2.000 | 0.600 | 0.300 | 0.300 |
| 17.     | ix.   | 1 | △ | 2.700 | 1.750 | 1.400 | 1.200 | 0.950 | 1.900 | 0.600 | 0.200 | 0.350 |
| Maximum |       |   |   | 2.850 | 1.900 | 1.900 | 1.200 | 1.000 | 2.100 | 0.650 | 0.500 | 0.500 |
| Minimum |       |   |   | 2.150 | 1.200 | 1.000 | 0.600 | 0.750 | 1.000 | 0.250 | 0.200 | 0.200 |
| Average |       |   |   | 2.625 | 1.696 | 1.365 | 1.075 | 0.909 | 1.810 | 0.561 | 0.453 | 0.448 |

Table 129. Variation in size of eggs dropped by *Phraortes kumamotoensis* No. 48 during her life.

| Date | Number | Shape | a     | b     | c     | d     | e     | f     | g     | h     | i     |       |
|------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 19.  | vii.   | 1     | ○     | 2.650 | 1.750 | 1.350 | 1.150 | 1.000 | 1.900 | 0.550 | 0.500 | 0.500 |
| 20.  | vii.   | 2     | △     | 2.350 | 1.850 | 1.500 | 1.100 | 0.850 | 2.050 | 0.700 | 0.400 | 0.350 |
| 〃    |        | △     | 2.650 | 1.800 | 1.500 | 1.150 | 0.900 | 2.000 | 0.700 | 0.300 | 0.400 |       |
| 21.  | vii.   | 3     | ○     | 2.600 | 1.750 | 1.250 | 1.150 | 1.000 | 1.600 | 0.600 | 0.500 | 0.500 |

|           |   |  |   |       |       |       |       |       |       |       |       |       |
|-----------|---|--|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 〃         |   |  | ○ | 2.800 | 1.750 | 1.500 | 1.150 | 1.000 | 1.900 | 0.600 | 0.500 | 0.500 |
| 〃         |   |  | △ | 2.400 | 1.900 | 1.350 | 1.150 | 0.950 | 2.000 | 0.650 | 0.400 | 0.500 |
| 23. vii.  | 2 |  | ○ | 2.500 | 1.750 | 1.500 | 1.100 | 0.900 | 1.500 | 0.650 | 0.550 | 0.500 |
| 〃         |   |  | △ | 2.650 | 1.700 | 1.500 | 1.100 | 0.950 | 1.600 | 0.600 | 0.350 | 0.500 |
| 24. vii.  | 2 |  | ○ | 2.800 | 1.750 | 1.500 | 1.150 | 0.900 | 2.000 | 0.600 | 0.500 | 0.500 |
| 〃         |   |  | △ | 2.650 | 1.800 | 1.500 | 1.200 | 0.950 | 1.900 | 0.650 | 0.350 | 0.450 |
| 25. vii.  | 2 |  | ○ | 2.600 | 1.800 | 1.500 | 1.150 | 0.800 | 1.800 | 0.700 | 0.500 | 0.500 |
| 〃         |   |  | △ | 2.900 | 1.800 | 1.500 | 1.100 | 0.900 | 1.600 | 0.650 | 0.500 | 0.500 |
| 26. vii.  | 1 |  | △ | 2.750 | 1.900 | 1.500 | 1.100 | 0.900 | 1.900 | 0.650 | 0.250 | 0.350 |
| 27. vii.  | 1 |  | △ | 2.750 | 1.800 | 1.500 | 1.200 | 0.950 | 1.900 | 0.650 | 0.300 | 0.500 |
| 28. vii.  | 3 |  | △ | 2.700 | 1.900 | 1.500 | 1.150 | 0.950 | 1.900 | 0.550 | 0.350 | 0.450 |
| 〃         |   |  | △ | 2.750 | 1.750 | 1.500 | 1.050 | 0.950 | 1.900 | 0.650 | 0.350 | 0.350 |
| 〃         |   |  | △ | 2.800 | 1.900 | 1.500 | 1.150 | 0.950 | 2.000 | 0.600 | 0.500 | 0.500 |
| 29. vii.  | 3 |  | ○ | 2.650 | 1.800 | 1.500 | 1.200 | 0.900 | 1.900 | 0.650 | 0.500 | 0.500 |
| 〃         |   |  | △ | 2.750 | 1.750 | 1.500 | 1.150 | 0.950 | 1.800 | 0.650 | 0.450 | 0.250 |
| 〃         |   |  | ○ | 2.600 | 1.750 | 1.500 | 1.100 | 0.950 | 1.700 | 0.600 | 0.500 | 0.500 |
| 30. vii.  | 1 |  | △ | 2.950 | 1.750 | 1.500 | 1.200 | 0.900 | 2.000 | 0.600 | 0.250 | 0.300 |
| 31. vii.  | 2 |  | ○ | 2.750 | 1.800 | 1.500 | 1.100 | 0.900 | 1.800 | 0.650 | 0.500 | 0.500 |
| 〃         |   |  | ○ | 2.550 | 1.750 | 1.500 | 1.100 | 0.900 | 1.750 | 0.650 | 0.500 | 0.500 |
| 1. viii.  | 2 |  | ○ | 2.800 | 1.850 | 1.500 | 1.150 | 0.950 | 2.000 | 0.650 | 0.500 | 0.450 |
| 〃         |   |  | ○ | 2.650 | 1.750 | 1.500 | 1.100 | 1.000 | 1.900 | 0.600 | 0.500 | 0.500 |
| 2. viii.  | 1 |  | ○ | 2.650 | 1.750 | 1.500 | 1.100 | 0.950 | 1.750 | 0.650 | 0.500 | 0.500 |
| 3. viii.  | 3 |  | △ | 2.500 | 1.600 | 1.300 | 1.050 | 0.900 | 1.600 | 0.650 | 0.450 | 0.450 |
| 〃         |   |  | △ | 2.650 | 1.650 | 1.300 | 1.100 | 0.800 | 1.900 | 0.650 | 0.350 | 0.300 |
| 〃         |   |  | △ | 2.500 | 1.750 | 1.500 | 1.100 | 0.900 | 1.800 | 0.650 | 0.300 | 0.300 |
| 4. viii.  | 4 |  | ○ | 2.500 | 1.700 | 1.300 | 1.100 | 0.850 | 1.700 | 0.650 | 0.500 | 0.500 |
| 〃         |   |  | △ | 2.500 | 1.650 | 1.350 | 1.100 | 0.850 | 1.650 | 0.600 | 0.300 | 0.300 |
| 〃         |   |  | △ | 2.750 | 1.700 | 1.250 | 1.000 | 0.850 | 1.800 | 0.600 | 0.350 | 0.400 |
| 〃         |   |  | △ | 2.600 | 1.600 | 1.300 | 1.050 | 0.800 | 1.900 | 0.600 | 0.450 | 0.350 |
| 5. viii.  | 1 |  | ○ | 2.500 | 1.500 | 1.150 | 1.000 | 0.850 | 1.800 | 0.600 | 0.500 | 0.450 |
| 6. viii.  | 3 |  | △ | 2.500 | 1.500 | 1.250 | 1.100 | 0.900 | 1.850 | 0.700 | 0.500 | 0.300 |
| 〃         |   |  | ○ | 2.650 | 1.600 | 1.250 | 1.050 | 0.850 | 1.850 | 0.600 | 0.500 | 0.350 |
| 〃         |   |  | △ | 2.650 | 1.650 | 1.250 | 1.050 | 0.850 | 1.750 | 0.600 | 0.250 | 0.250 |
| 8. viii.  | 2 |  | △ | 2.600 | 1.700 | 1.250 | 1.100 | 0.950 | 1.900 | 0.650 | 0.250 | 0.350 |
| 〃         |   |  | △ | 2.600 | 1.750 | 1.250 | 1.100 | 0.950 | 1.800 | 0.600 | 0.250 | 0.400 |
| 11. viii. | 1 |  | △ | 2.600 | 1.750 | 1.250 | 1.100 | 0.800 | 1.700 | 0.600 | 0.350 | 0.350 |
| 13. viii. | 3 |  | △ | 2.400 | 1.600 | 1.250 | 1.050 | 0.750 | 1.800 | 0.550 | 0.250 | 0.250 |
| 〃         |   |  | △ | 2.550 | 1.600 | 1.400 | 1.050 | 0.800 | 1.650 | 0.650 | 0.300 | 0.250 |
| 〃         |   |  | ○ | 2.650 | 1.750 | 1.200 | 1.100 | 1.000 | 1.700 | 0.600 | 0.500 | 0.500 |

|         |       |   |   |       |       |       |       |       |       |       |       |       |
|---------|-------|---|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 14.     | viii. | 1 | ○ | 2.500 | 1.700 | 1.300 | 1.100 | 0.750 | 1.850 | 0.600 | 0.500 | 0.450 |
| 16.     | viii. | 1 | △ | 2.650 | 1.800 | 1.500 | 1.100 | 0.900 | 2.000 | 0.700 | 0.350 | 0.250 |
| 18.     | viii. | 1 | △ | 2.750 | 1.800 | 1.500 | 1.100 | 0.900 | 1.900 | 0.700 | 0.200 | 0.250 |
| 24.     | viii. | 3 | △ | 2.750 | 1.750 | 1.300 | 1.100 | 0.800 | 1.900 | 0.600 | 0.350 | 0.100 |
| 〃       |       |   | △ | 2.750 | 1.700 | 1.300 | 1.050 | 0.750 | 2.000 | 0.700 | 0.400 | 0.300 |
| 〃       |       |   | △ | 2.650 | 1.900 | 1.400 | 1.100 | 0.900 | 1.900 | 0.700 | 0.250 | 0.300 |
| 2.      | ix.   | 2 | △ | 2.750 | 1.700 | 1.500 | 1.200 | 0.950 | 2.000 | 0.650 | 0.300 | 0.250 |
| 〃       |       |   | △ | 2.650 | 1.750 | 1.500 | 1.100 | 0.950 | 1.900 | 0.650 | 0.300 | 0.300 |
| 4.      | ix.   | 3 | △ | 2.650 | 1.700 | 1.250 | 1.100 | 0.900 | 1.750 | 0.600 | 0.150 | 0.200 |
| 〃       |       |   | △ | 2.550 | 1.700 | 1.300 | 1.050 | 0.850 | 1.750 | 0.650 | 0.150 | 0.100 |
| 〃       |       |   | △ | 2.550 | 1.600 | 1.250 | 1.100 | 0.900 | 1.750 | 0.600 | 0.150 | 0.200 |
| 6.      | ix.   | 1 | △ | 2.500 | 1.600 | 1.200 | 1.000 | 0.800 | 1.900 | 0.600 | 0.300 | 0.300 |
| 7.      | ix.   | 2 |   | 2.500 | 1.600 | 1.250 | 1.050 | 1.750 | 1.750 | 0.600 |       |       |
| 〃       |       |   | △ | 2.500 | 1.550 | 1.250 | 1.050 | 0.800 | 1.950 | 0.650 | 0.300 | 0.350 |
| 8.      | ix.   | 1 | △ | 2.450 | 1.600 | 1.250 | 0.950 | 0.800 | 1.950 | 0.650 | 0.250 | 0.300 |
| 10.     | ix.   | 1 | △ | 2.650 | 1.500 | 1.300 | 0.950 | 1.050 | 2.000 | 0.700 | 0.250 | 0.200 |
| 17.     | ix.   | 1 | △ | 3.000 | 1.900 | 1.250 | 1.250 | 0.900 | 2.000 | 0.550 | 0.200 | 0.250 |
| Maximum |       |   |   | 3.000 | 1.900 | 1.500 | 1.250 | 1.050 | 2.050 | 0.700 | 0.500 | 0.500 |
| Minimum |       |   |   | 2.400 | 1.500 | 1.150 | 0.950 | 0.750 | 1.500 | 0.550 | 0.150 | 0.100 |
| Average |       |   |   | 2.630 | 1.725 | 1.380 | 1.100 | 0.894 | 1.840 | 0.631 | 0.358 | 0.372 |

Table 130. Variation in size of eggs dropped by *Phraortes kumamotoensis* No. 50 during her life.

| Date      | Number | Shape | a     | b     | c     | d     | e     | f     | g     | h     | i     |
|-----------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 27. vii.  | 1      | △     | 2.500 | 1.600 | 1.150 | 1.000 | 0.750 | 1.850 | 0.500 | 0.350 | 0.300 |
| 4. viii.  | 1      | △     | 2.400 | 1.750 | 1.300 | 1.050 | 0.700 | 1.500 | 0.550 | 0.400 | 0.300 |
| 8. viii.  | 1      | △     | 2.500 | 1.700 | 1.850 | 1.150 | 0.750 | 1.750 | 0.500 | 0.350 | 0.250 |
| 9. viii.  | 2      | △     | 2.650 | 1.750 | 1.250 | 1.200 | 0.300 | 1.800 | 0.550 | 0.250 | 0.350 |
| 〃         |        | △     | 2.600 | 1.700 | 1.250 | 1.150 | 0.800 | 1.600 | 0.550 | 0.300 | 0.250 |
| 11. viii. | 2      | △     | 2.600 | 1.800 | 1.500 | 1.250 | 0.800 | 1.750 | 0.550 | 0.300 | 0.300 |
| 〃         |        | △     | 2.500 | 1.800 | 1.500 | 1.200 | 0.800 | 1.600 | 0.550 | 0.400 | 0.300 |
| 13. viii. | 1      | △     | 2.500 | 1.850 | 1.400 | 1.150 | 0.850 | 1.600 | 0.550 | 0.300 | 0.250 |
| 14. viii. | 1      | △     | 2.600 | 1.750 | 1.300 | 1.500 | 0.900 | 1.850 | 0.500 | 0.500 | 0.350 |
| 15. viii. | 1      | △     | 2.650 | 1.700 | 1.300 | 1.150 | 0.950 | 1.750 | 0.550 | 0.450 | 0.300 |
| 21. viii. | 2      | △     | 2.500 | 1.750 | 1.450 | 1.000 | 0.950 | 1.750 | 0.550 | 0.400 | 0.350 |
| 〃         |        | △     | 2.650 | 1.700 | 1.400 | 1.150 | 0.950 | 1.600 | 0.500 | 0.300 | 0.200 |
| 24. viii. | 3      | △     | 2.500 | 1.700 | 1.250 | 1.050 | 0.900 | 1.850 | 0.500 | 0.450 | 0.150 |

|           |   |   |       |       |       |       |       |       |       |       |       |
|-----------|---|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| ◇         |   | ○ | 2.700 | 1.750 | 1.250 | 1.200 | 0.850 | 1.800 | 0.550 | 0.500 | 0.350 |
| ◇         |   | △ | 2.500 | 1.600 | 1.450 | 1.100 | 0.800 | 1.650 | 0.550 | 0.350 | 0.300 |
| 29. viii. | 1 | △ | 2.600 | 1.600 | 1.400 | 1.200 | 0.900 | 1.750 | 0.500 | 0.300 | 0.350 |
| 30. viii. | 2 | △ | 2.600 | 1.600 | 1.300 | 1.200 | 0.800 | 1.900 | 0.550 | 0.300 | 0.250 |
| ◇         |   | △ | 2.650 | 1.700 | 1.300 | 1.110 | 0.850 | 1.600 | 0.550 | 0.400 | 0.300 |
| 1. ix.    | 1 | △ | 2.600 | 1.750 | 1.400 | 1.150 | 0.900 | 1.650 | 0.550 | 0.350 | 0.300 |
| 2. ix.    | 1 | △ | 2.500 | 1.700 | 1.300 | 1.150 | 0.900 | 1.900 | 0.600 | 0.350 | 0.300 |
| 3. ix.    | 1 | △ | 2.600 | 1.750 | 1.500 | 1.100 | 0.850 | 2.000 | 0.600 | 0.350 | 0.250 |
| 9. ix.    | 1 | ○ | 2.650 | 1.800 | 1.400 | 1.200 | 0.800 | 1.700 | 0.750 | 0.500 | 0.350 |
| 10. ix.   | 1 | △ | 2.700 | 1.750 | 1.400 | 1.250 | 0.800 | 1.850 | 0.550 | 0.350 | 0.200 |
| 12. ix.   | 1 | △ | 2.400 | 1.800 | 1.400 | 1.250 | 0.950 | 1.900 | 0.700 | 0.400 | 0.200 |
| 13. ix.   | 1 | △ | 2.250 | 1.500 | 1.400 | 1.150 | 0.900 | 1.900 | 0.750 | 0.450 | 0.200 |
| 15. ix.   | 1 | △ | 2.750 | 1.850 | 1.500 | 1.200 | 1.000 | 2.000 | 0.550 | 0.350 | 0.200 |
| 17. ix.   | 1 | △ | 2.550 | 1.900 | 1.500 | 1.300 | 1.000 | 1.700 | 0.550 | 0.300 | 0.300 |
| 19. ix.   | 3 | △ | 2.550 | 1.800 | 1.300 | 1.200 | 0.850 | 1.900 | 0.500 | 0.400 | 0.200 |
| ◇         |   | △ | 2.500 | 1.800 | 1.250 | 1.150 | 0.750 | 1.950 | 0.550 | 0.300 | 0.300 |
| ◇         |   | △ | 2.500 | 1.800 | 1.500 | 1.200 | 1.000 | 1.700 | 0.550 | 0.400 | 0.300 |
| Maximum   |   |   | 2.700 | 1.900 | 1.500 | 1.250 | 1.000 | 2.000 | 0.750 | 0.500 | 0.350 |
| Minimum   |   |   | 2.250 | 1.600 | 1.250 | 1.050 | 0.700 | 1.500 | 0.500 | 0.300 | 0.150 |
| Average   |   |   | 2.558 | 1.735 | 1.380 | 1.161 | 0.860 | 1.770 | 0.560 | 0.370 | 0.276 |

Table 131. Variation in size of eggs dropped by *Phraortes kumamotoensis* No. 51 during her life.

| Date      | Number | Shape | a     | b     | c     | d     | e     | f     | g     | h     | i     |
|-----------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 27. vii.  | 1      | ○     | 2.400 | 1.250 | 1.000 | 0.800 | 0.700 | 1.750 | 0.500 | 0.500 | 0.500 |
| 2. viii.  | 1      | ○     | 2.350 | 1.400 | 1.000 | 1.000 | 0.800 | 1.650 | 0.550 | 0.500 | 0.400 |
| 10. viii. | 2      | ○     | 2.500 | 1.600 | 1.250 | 1.000 | 0.750 | 1.650 | 0.550 | 0.450 | 0.400 |
| ◇         |        | △     | 2.700 | 1.600 | 1.250 | 1.050 | 0.800 | 1.750 | 0.550 | 0.300 | 0.300 |
| 12. viii. | 2      | △     | 2.550 | 1.500 | 1.100 | 1.000 | 0.750 | 1.800 | 0.500 | 0.300 | 0.350 |
| ◇         |        | ○     | 2.500 | 1.550 | 1.100 | 1.100 | 0.750 | 1.700 | 0.500 | 0.450 | 0.400 |
| 13. viii. | 1      | △     | 2.300 | 1.600 | 1.200 | 1.000 | 0.750 | 1.600 | 0.550 | 0.250 | 0.350 |
| 14. viii. | 2      | ○     | 2.400 | 1.500 | 1.750 | 1.050 | 0.900 | 1.600 | 0.550 | 0.500 | 0.400 |
| ◇         |        | △     | 2.500 | 1.500 | 1.150 | 0.950 | 0.750 | 1.750 | 0.550 | 0.300 | 0.350 |
| 15. viii. | 1      |       |       |       |       |       |       |       |       |       |       |
| 18. viii. | 2      | ○     | 2.600 | 1.650 | 1.800 | 1.150 | 0.800 | 1.700 | 0.550 | 0.350 | 0.350 |
| ◇         |        | ○     | 2.550 | 1.600 | 1.300 | 1.100 | 0.800 | 1.600 | 0.500 | 0.400 | 0.250 |
| 19. viii. | 1      | △     | 2.500 | 1.550 | 1.250 | 1.100 | 0.850 | 1.650 | 0.550 | 0.300 | 0.300 |

|           |   |   |       |       |       |       |       |       |       |       |       |
|-----------|---|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 20. viii. | 2 | ○ | 2.500 | 1.600 | 1.300 | 1.100 | 0.750 | 1.650 | 0.550 | 0.350 | 0.400 |
| 〃         |   | △ | 2.700 | 1.700 | 1.200 | 1.100 | 0.800 | 1.650 | 0.600 | 0.250 | 0.400 |
| 21. viii. | 2 | △ | 2.350 | 1.500 | 1.250 | 1.050 | 0.800 | 1.600 | 0.500 | 0.350 | 0.300 |
| 〃         |   | ○ | 2.500 | 1.500 | 1.250 | 1.050 | 0.800 | 1.750 | 0.550 | 0.500 | 0.500 |
| 22. viii. | 1 | △ | 2.500 | 1.650 | 1.250 | 1.100 | 0.800 | 1.700 | 0.550 | 0.200 | 0.300 |
| 24. viii. | 1 |   |       |       |       |       |       |       |       |       |       |
| 27. viii. | 2 | △ | 2.500 | 1.600 | 1.200 | 1.000 | 0.750 | 1.600 | 0.550 | 0.200 | 0.350 |
| 〃         |   | ○ | 2.500 | 1.600 | 1.250 | 1.150 | 0.700 | 1.700 | 0.500 | 0.400 | 0.450 |
| 29. viii. | 2 |   | 2.500 | 1.500 | 1.200 | 1.050 | 0.750 | 1.700 | 0.550 |       |       |
| 〃         |   |   | 2.350 | 1.500 | 1.650 | 1.000 | 0.750 | 1.600 | 0.550 |       |       |
| 30. viii. | 1 |   | 2.300 | 1.700 | 1.250 | 1.100 | 0.800 | 1.600 | 0.550 |       |       |
| 31. viii. | 1 | △ | 2.500 | 1.650 | 1.200 | 1.050 | 0.800 | 1.900 | 0.550 | 0.200 | 0.300 |
| 1. ix.    | 2 | △ | 2.400 | 1.500 | 1.100 | 1.050 | 0.700 | 1.650 | 0.550 | 0.350 | 0.350 |
| 〃         |   | △ | 2.500 | 1.650 | 1.250 | 1.050 | 0.850 | 1.700 | 0.550 | 0.350 | 0.250 |
| 3. ix.    | 1 | △ | 2.500 | 1.700 | 1.250 | 1.100 | 0.850 | 1.750 | 0.550 | 0.300 | 0.350 |
| 4. ix.    | 1 | △ | 2.550 | 1.700 | 1.250 | 1.100 | 0.750 | 1.700 | 0.550 | 0.200 | 0.250 |
| 7. ix.    | 2 | △ | 2.250 | 1.550 | 1.250 | 1.100 | 0.750 | 1.550 | 0.500 | 0.200 | 0.200 |
| 〃         |   | △ | 2.450 | 1.600 | 1.250 | 1.050 | 0.700 | 1.650 | 0.500 | 0.350 | 0.250 |
| 8. ix.    | 1 | △ | 2.250 | 1.500 | 1.250 | 1.000 | 0.650 | 1.500 | 0.450 | 0.200 | 0.200 |
| 9. ix.    | 1 | ○ | 2.250 | 1.500 | 1.250 | 1.050 | 0.700 | 1.700 | 0.500 | 0.350 | 0.300 |
| 10. ix.   | 1 | △ | 2.250 | 1.500 | 1.150 | 1.050 | 0.750 | 1.600 | 0.550 | 0.300 | 0.250 |
| 11. ix.   | 1 | ○ | 2.250 | 1.500 | 1.100 | 1.000 | 0.700 | 1.500 | 0.500 | 0.350 | 0.300 |
| 12. ix.   | 1 | △ | 2.300 | 1.650 | 1.150 | 1.050 | 0.800 | 1.700 | 0.550 | 0.250 | 0.300 |
| 13. ix.   | 2 | ○ | 2.350 | 1.500 | 1.100 | 1.050 | 0.750 | 1.650 | 0.500 | 0.500 | 0.400 |
| 〃         |   |   | 2.000 | 1.200 | 1.000 | 0.900 | 0.550 | 1.250 | 0.350 |       |       |
| 17. ix.   | 2 |   | 2.250 | 1.600 | 1.300 | 1.200 | 0.800 | 1.600 | 0.500 |       |       |
| 〃         |   |   | 2.300 | 1.500 | 1.200 | 1.100 | 0.800 |       |       |       |       |
| 19. ix.   | 3 | △ | 2.500 | 1.750 | 1.300 | 1.250 | 0.900 | 1.750 | 0.550 | 0.300 | 0.200 |
| 〃         |   | △ | 2.500 | 1.650 | 1.350 | 1.200 | 0.900 | 1.750 | 0.500 | 0.200 | 0.250 |
| 〃         |   | △ | 2.500 | 1.750 | 1.300 | 1.250 | 0.850 | 1.750 | 0.500 | 0.250 | 0.250 |
| Maximum   |   |   | 2.700 | 1.750 | 1.800 | 1.250 | 0.900 | 1.900 | 0.550 | 0.500 | 0.500 |
| Minimum   |   |   | 2.000 | 1.250 | 1.000 | 0.900 | 0.650 | 1.250 | 0.350 | 0.200 | 0.200 |
| Average   |   |   | 2.204 | 1.561 | 1.212 | 1.061 | 0.771 | 1.658 | 0.501 | 0.328 | 0.327 |

Table 132. Variation in size of eggs dropped by *Phraortes kumamotoensis* No. 52 during her life.

| Date      | Number | Shape | a     | b     | c     | d     | e     | f     | g     | h     | i     |
|-----------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 29. vii.  | 1      | ○     | 2.900 | 1.550 | 1.150 | 1.050 | 0.800 | 1.600 | 0.550 | 0.550 | 0.500 |
| 14. viii. | 1      | ×     | 2.900 | 1.750 | .     | 1.100 | 0.800 | 2.000 |       |       |       |
| 19. viii. | 1      | △     | 3.050 | 1.700 | 1.350 | 1.100 | 0.800 | 2.100 | 0.550 | 0.500 | 0.250 |
| Maximum   |        |       | 3.050 | 1.750 | 1.100 | 1.100 | 0.800 | 2.100 | 0.550 | 0.550 | 0.500 |
| Minimum   |        |       | 2.900 | 1.550 | 1.050 | 1.050 | 0.800 | 1.600 | 0.550 | 0.500 | 0.250 |
| Average   |        |       | 2.950 | 1.666 | 1.250 | 1.083 | 0.800 | 1.900 | 0.550 | 0.525 | 0.375 |

Table 133. Variation in size of eggs dropped by *Phraortes kumamotoensis* No. 54 during her life.

| Date     | Number | Shape | a     | b     | c     | d     | e     | f     | g     | h     | i     |
|----------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 24. vii. | 3      | ○     | 2.750 | 1.750 | 1.500 | 1.250 | 1.000 | 2.000 | 0.550 | 0.550 | 0.500 |
| 〃        |        | △     | 2.900 | 1.800 | 1.350 | 1.200 | 0.900 | 1.800 | 0.500 | 0.500 | 0.500 |
| 〃        |        | △     | 3.000 | 1.750 | 1.300 | 1.250 | 0.800 | 2.050 | 0.550 | 0.500 | 0.450 |
| 25. vii. | 1      | △     | 2.800 | 1.800 | 1.500 | 1.250 | 1.000 | 1.900 | 0.550 | 0.500 | 0.350 |
| 26. vii. | 2      | △     | 2.850 | 1.750 | 1.400 | 1.250 | 0.850 | 1.800 | 0.550 | 0.500 | 0.500 |
| 〃        |        | △     | 2.900 | 1.750 | 1.500 | 1.200 | 0.850 | 1.950 | 0.550 | 0.500 | 0.500 |
| 27. vii. | 3      | △     | 2.750 | 1.800 | 1.500 | 1.200 | 0.950 | 1.800 | 0.550 | 0.450 | 0.500 |
| 〃        |        | ○     | 2.750 | 1.750 | 1.500 | 1.200 | 0.750 | 1.800 | 0.550 | 0.500 | 0.450 |
| 〃        |        | △     | 2.800 | 1.750 | 1.300 | 1.200 | 0.950 | 1.800 | 0.550 | 0.350 | 0.450 |
| 28. vii. | 2      | △     | 2.700 | 1.750 | 1.500 | 1.250 | 1.000 | 1.900 | 0.500 | 0.500 | 0.500 |
| 〃        |        | △     | 2.600 | 1.800 | 1.450 | 1.200 | 0.800 | 1.900 | 0.500 |       | 0.450 |
| 29. vii. | 1      | △     | 2.750 | 1.800 | 1.500 | 1.200 | 0.800 | 1.800 | 0.500 | 0.250 | 0.450 |
| 30. vii. | 3      | △     | 2.700 | 1.750 | 1.400 | 1.200 | 0.900 | 1.750 | 0.550 | 0.450 | 0.450 |
| 〃        |        | △     | 2.700 | 1.750 | 1.450 | 1.250 | 0.900 | 1.900 | 0.500 | 0.300 | 0.450 |
| 〃        |        | △     | 2.700 | 1.750 | 1.500 | 1.200 | 1.000 | 1.800 | 0.500 | 0.500 | 0.450 |
| 31. vii. | 2      | △     | 2.800 | 1.750 | 1.400 | 1.200 | 0.900 | 1.800 | 0.550 | 0.250 | 0.400 |
| 〃        |        | △     | 2.800 | 1.700 | 1.400 | 1.100 | 0.950 | 2.000 | 0.500 | 0.350 | 0.450 |
| 1. viii. | 3      | △     | 2.800 | 1.750 | 1.400 | 1.200 | 0.900 | 1.850 | 0.550 | 0.300 | 0.350 |
| 〃        |        | ○     | 2.750 | 1.700 | 1.300 | 1.200 | 1.000 | 1.850 | 0.550 | 0.550 | 0.450 |
| 〃        |        | △     | 2.700 | 1.750 | 1.450 | 1.150 | 1.000 | 1.800 | 0.550 | 0.300 | 0.450 |
| 2. viii. | 3      | △     | 2.700 | 1.650 | 1.400 | 1.100 | 0.800 | 1.800 | 0.550 | 0.500 | 0.500 |
| 〃        |        | △     | 2.750 | 1.750 | 1.500 | 1.150 | 0.900 | 1.800 | 0.500 | 0.450 | 0.400 |

|         |       |   |   |       |       |       |       |       |       |       |       |       |
|---------|-------|---|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 3.      | viii. | 3 | △ | 2.750 | 1.800 | 1.450 | 1.200 | 0.900 | 1.950 | 0.550 | 0.400 | 0.400 |
|         |       |   | ○ | 2.500 | 1.750 | 1.300 | 1.150 | 0.950 | 1.750 | 0.550 | 0.500 | 0.500 |
|         |       |   | △ | 2.650 | 1.750 | 1.450 | 1.250 | 0.850 | 1.800 | 0.550 | 0.500 | 0.450 |
|         |       |   | △ | 2.600 | 1.750 | 1.300 | 1.250 | 0.900 | 1.800 | 0.550 | 0.300 | 0.450 |
| 5.      | viii. | 1 | △ | 2.700 | 1.800 | 1.500 | 1.200 | 0.950 | 1.900 | 0.550 | 0.300 | 0.350 |
| 6.      | viii. | 2 | △ | 2.750 | 1.750 | 1.450 | 1.250 | 0.950 | 1.750 | 0.550 | 0.400 | 0.300 |
|         |       |   | △ | 2.750 | 1.750 | 1.300 | 1.250 | 0.950 | 1.900 | 0.550 | 0.300 | 0.300 |
| 9.      | viii. | 3 | △ | 2.500 | 1.650 | 1.300 | 1.150 | 0.900 | 1.750 | 0.550 | 0.300 | 0.200 |
|         |       |   | △ | 2.450 | 1.550 | 1.200 | 1.200 | 0.900 | 1.700 | 0.550 | 0.300 | 0.350 |
|         |       |   | △ | 2.600 | 1.700 | 1.750 | 1.050 | 0.900 | 1.750 | 0.600 | 0.300 | 0.200 |
| 10.     | viii. | 1 | △ | 2.600 | 1.500 | 1.100 | 1.000 | 0.800 | 1.650 | 0.500 | 0.300 | 0.200 |
| 11.     | viii. | 4 | △ | 2.300 | 1.400 | 1.100 | 1.000 | 0.800 | 1.600 | 0.500 | 0.300 | 0.400 |
|         |       |   | △ | 2.450 | 1.450 | 1.100 | 1.000 | 0.700 | 1.800 | 0.500 | 0.400 | 0.350 |
|         |       |   | △ | 2.400 | 1.400 | 1.250 | 0.950 | 0.750 | 1.750 | 0.500 | 0.300 | 0.300 |
|         |       |   | △ | 2.350 | 1.450 | 1.150 | 1.000 | 0.700 | 1.800 | 0.550 | 0.350 | 0.350 |
| 12.     | viii. | 3 |   |       |       |       |       |       |       |       |       |       |
| 13.     | viii. | 4 | ○ | 2.400 | 1.600 | 1.200 | 1.100 | 0.800 | 1.750 | 0.500 | 0.350 | 0.300 |
|         |       |   | △ | 2.350 | 1.500 | 1.250 | 1.100 | 0.800 | 1.500 | 0.500 | 0.300 | 0.200 |
|         |       |   | △ | 2.250 | 1.500 | 1.200 | 1.050 | 0.750 | 1.500 | 0.550 | 0.300 | 0.200 |
|         |       |   | △ | 2.400 | 1.600 | 1.250 | 1.100 | 0.900 | 1.500 | 0.550 | 0.400 | 0.200 |
| 14.     | viii. | 1 | △ | 2.300 | 1.400 | 1.050 | 1.000 | 0.700 | 1.700 | 0.500 | 0.350 | 0.350 |
| 15.     | viii. | 1 | △ | 2.450 | 1.400 | 1.000 | 1.050 | 0.750 | 1.700 | 0.550 | 0.300 | 0.300 |
| 16.     | viii. | 1 | ○ | 2.250 | 1.250 | 1.000 | 1.000 | 0.700 | 1.650 | 0.500 | 0.500 | 0.400 |
| 19.     | viii. | 2 | △ | 2.100 | 1.400 | 1.000 | 0.750 | 0.600 | 1.500 | 0.500 | 0.500 | 0.150 |
|         |       |   | △ | 2.300 | 1.300 | 1.000 | 0.850 | 0.700 | 1.700 | 0.500 | 0.350 | 0.300 |
| 2.      | ix.   | 1 | △ | 2.250 | 1.250 | 0.900 | 1.000 | 0.650 | 1.700 | 0.500 | 0.300 | 0.250 |
| Maximum |       |   |   | 3.000 | 1.800 | 1.750 | 1.250 | 1.000 | 2.000 | 0.600 | 0.550 | 0.500 |
| Minimum |       |   |   | 2.100 | 1.250 | 0.900 | 0.750 | 0.650 | 1.500 | 0.500 | 0.250 | 0.150 |
| Average |       |   |   | 2.603 | 1.631 | 1.320 | 1.134 | 0.854 | 1.780 | 0.529 | 0.390 | 0.356 |

Table 134. Variations in size of eggs dropped by *Phraortes kumamotoensis* No. 55 during her life.

| Date     | Number | Shape | a     | b     | c     | d     | e     | f     | g     | h     | i     |
|----------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 22. vii. | 1      | ○     | 2.750 | 1.750 | 1.150 | 1.150 | 0.900 | 1.600 | 0.500 | 0.500 | 0.500 |
| 23. vii. | 1      | ○     | 2.600 | 1.750 | 1.300 | 1.050 | 0.800 | 1.800 | 0.500 | 0.450 | 0.500 |
| 24. vii. | 2      | ○     | 2.750 | 1.650 | 1.250 | 1.000 | 0.750 | 1.800 | 0.500 | 0.500 | 0.400 |

|         |       |   |   |       |       |       |       |       |       |       |       |       |
|---------|-------|---|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 25.     | vii.  | 1 | △ | 2.600 | 1.650 | 1.250 | 1.100 | 0.750 | 1.500 | 0.550 | 0.350 | 0.350 |
| 26.     | vii.  | 1 | ○ | 2.550 | 1.750 | 1.300 | 1.000 | 0.650 | 1.600 | 0.500 | 0.500 | 0.450 |
| 27.     | vii.  | 2 | △ | 2.750 | 1.700 | 1.450 | 1.100 | 0.850 | 1.600 | 0.450 | 0.500 | 0.350 |
| 28.     | vii.  | 4 | △ | 2.500 | 1.750 | 1.450 | 1.200 | 0.950 | 1.600 | 0.500 | 0.350 | 0.350 |
|         |       |   | ○ | 2.800 | 1.800 | 1.400 | 1.100 | 1.000 | 1.800 | 0.500 | 0.500 | 0.450 |
|         |       |   | △ | 2.600 | 1.700 | 1.300 | 1.100 | 0.850 | 1.750 | 0.500 | 0.450 | 0.350 |
|         |       |   | △ | 2.700 | 1.750 | 1.500 | 1.100 | 0.950 | 1.800 | 0.500 | 0.350 | 0.350 |
| 29.     | vii.  | 2 | ○ | 2.750 | 1.800 | 1.500 | 1.150 | 1.000 | 1.800 | 0.500 | 0.500 | 0.500 |
|         |       |   | △ | 2.750 | 1.800 | 1.550 | 1.100 | 0.950 | 2.000 | 0.550 | 0.500 | 0.300 |
| 30.     | vii.  | 1 | ○ | 2.700 | 1.800 | 1.500 | 1.150 | 0.900 | 1.800 | 0.500 | 0.500 | 0.500 |
| 31.     | vii.  | 3 | ○ | 2.750 | 1.750 | 1.450 | 1.200 | 0.950 | 1.750 | 0.550 | 0.500 | 0.300 |
|         |       |   | △ | 2.750 | 1.800 | 1.500 | 1.150 | 0.950 | 1.700 | 0.550 | 0.300 | 0.400 |
|         |       |   | △ | 2.850 | 1.800 | 1.450 | 1.100 | 0.900 | 1.750 | 0.500 | 0.350 | 0.500 |
| 1.      | viii. | 3 | △ | 2.500 | 1.800 | 1.450 | 1.200 | 0.900 | 1.700 | 0.500 | 0.400 | 0.450 |
|         |       |   | △ | 2.750 | 1.750 | 1.450 | 1.000 | 0.950 | 1.750 | 0.550 |       | 0.300 |
|         |       |   | △ | 2.700 | 1.750 | 1.350 | 1.150 | 0.750 | 1.500 | 0.500 | 0.500 | 0.350 |
| 2.      | viii. | 2 | ○ | 2.750 | 1.750 | 1.500 | 1.100 | 0.950 | 1.700 | 0.550 | 0.600 | 0.350 |
|         |       |   | △ | 2.650 | 1.800 | 1.500 | 1.100 | 0.900 | 1.600 | 0.550 | 0.500 | 0.450 |
| 3.      | viii. | 2 | △ | 2.750 | 1.750 | 1.300 | 1.100 | 0.900 | 1.600 | 0.550 | 0.300 | 0.350 |
|         |       |   | ○ | 2.600 | 1.700 | 1.350 | 1.100 | 0.950 | 1.750 | 0.500 | 0.650 | 0.350 |
| 4.      | viii. | 1 | ○ | 2.750 | 1.700 | 1.300 | 1.050 | 0.900 | 1.750 | 0.500 | 0.550 | 0.350 |
| Maximum |       |   |   | 2.850 | 1.800 | 1.550 | 1.200 | 1.000 | 2.000 | 0.550 | 0.650 | 0.500 |
| Minimum |       |   |   | 2.500 | 1.650 | 1.250 | 1.000 | 0.650 | 1.500 | 0.450 | 0.300 | 0.300 |
| Average |       |   |   | 2.692 | 1.748 | 1.392 | 1.107 | 0.882 | 1.703 | 0.517 | 0.382 | 0.403 |

Table 135. Variation in size of eggs dropped by *Phraortes kumamotoensis* No. 56 during her life.

| Date     | Number | Shape | a     | b     | c     | d     | e     | f     | g     | h     | i     |
|----------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 26. vii. | 1      | △     | 3.000 | 1.650 | 1.300 | 1.000 | 0.800 | 1.750 | 0.550 | 0.350 | 0.450 |
| 27. vii. | 3      | ○     | 2.900 | 1.750 | 1.500 | 1.000 | 0.800 | 1.800 | 0.500 | 0.490 | 0.400 |
| "        |        | △     | 2.600 | 1.750 | 1.300 | 1.100 | 0.800 | 2.050 | 0.500 |       | 0.350 |
| "        |        | ○     | 3.000 | 1.750 | 1.400 | 1.100 | 0.900 | 1.900 | 0.500 | 0.500 | 0.450 |
| 29. vii. | 3      | ○     | 3.000 | 1.800 | 1.500 | 1.050 | 0.900 | 1.800 | 0.550 | 0.500 | 0.500 |
| "        |        | △     | 3.000 | 1.800 | 1.500 | 1.050 | 0.850 | 1.750 | 0.550 | 0.400 | 0.400 |
| "        |        | △     | 2.650 | 1.800 | 1.500 | 1.250 | 1.000 | 1.850 | 0.550 |       | 0.400 |

|          |   |   |       |       |       |       |       |       |       |       |       |
|----------|---|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 3. viii. | 2 | ○ | 3.000 | 1.900 | 1.500 | 1.100 | 0.850 | 0.900 | 0.550 | 0.450 | 0.500 |
| "        |   | △ | 3.000 | 1.850 | 1.550 | 1.100 | 0.850 | 1.800 | 0.550 |       | 0.450 |
| 5. viii. | 2 | × | 3.000 | 1.700 | 1.450 | 1.000 | 0.800 | 1.800 | 0.500 |       |       |
| "        |   | △ | 3.000 | 1.700 | 1.400 | 1.050 | 0.750 | 1.800 | 0.500 | 0.350 | 0.350 |
| 6. viii. | 2 | × | 2.800 | 1.700 | 1.450 | 1.000 | 0.800 | 1.750 | 0.500 | 0.400 | 0.250 |
| "        |   | △ | 2.900 | 1.500 | 1.250 | 1.000 | 0.800 | 1.800 | 0.500 |       | 0.250 |
| 7. viii. | 1 | △ | 2.500 | 1.500 | 1.200 | 0.900 | 0.750 | 1.550 | 0.450 | 0.500 | 0.250 |
| Maximum  |   |   | 3.000 | 1.900 | 1.550 | 1.250 | 1.000 | 2.050 | 0.550 | 0.500 | 0.500 |
| Minimum  |   |   | 2.500 | 1.500 | 1.200 | 0.900 | 0.750 | 1.550 | 0.450 | 0.350 | 0.250 |
| Average  |   |   | 2.882 | 1.725 | 1.410 | 1.050 | 0.832 | 1.807 | 0.517 | 0.433 | 0.384 |

Table 136. Variation in size of eggs dropped by *Phraortes kumamotoensis* No. 57 during her life.

| Date     | Number | Shape | a     | b     | c     | d     | e     | f     | g     | h     | i     |
|----------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 23. vii. | 1      | ○     | 2.500 | 1.650 | 1.250 | 1.050 | 0.800 | 1.750 | 0.550 | 0.500 | 0.450 |
| 24. vii. | 1      | ○     | 2.500 | 1.900 | 1.250 | 1.100 | 0.900 | 1.700 | 0.600 | 0.500 | 0.400 |
| 25. vii. | 3      | ○     | 2.750 | 1.750 | 1.350 | 1.050 | 1.300 | 1.750 | 0.550 | 0.450 | 0.300 |
| "        |        | ○     | 2.700 | 1.500 | 1.300 | 1.100 | 0.800 | 1.500 | 0.550 | 0.500 | 0.350 |
| "        |        | ○     | 2.500 | 1.650 | 1.400 | 1.050 | 0.850 | 1.700 | 0.550 | 0.400 | 0.300 |
| 26. vii. | 2      | ○     | 2.700 | 1.700 | 1.300 | 1.100 | 0.850 | 1.700 | 0.600 | 0.500 | 0.350 |
| "        |        | ○     | 2.650 | 1.650 | 1.400 | 1.050 | 0.850 | 1.700 | 0.600 | 0.450 | 0.350 |
| 27. vii. | 2      | ○     | 2.700 | 1.750 | 1.300 | 1.100 | 0.900 | 1.650 | 0.550 | 0.450 | 0.300 |
| "        |        |       | 2.600 | 1.650 | 1.400 | 1.050 | 0.850 | 1.700 | 0.550 |       |       |
| 28. vii. | 2      | ○     | 2.750 | 1.800 | 1.300 | 1.100 | 0.750 | 1.800 | 0.600 | 0.500 | 0.350 |
| "        |        | ○     | 2.700 | 1.750 | 1.500 | 1.050 | 0.800 | 1.800 | 0.550 | 0.450 | 0.350 |
| 29. vii. | 1      | ○     | 2.650 | 1.800 | 1.500 | 1.100 | 0.900 | 1.750 | 0.600 | 0.500 | 0.450 |
| 30. vii. | 2      | ○     | 2.750 | 1.750 | 1.500 | 1.100 | 0.900 | 1.700 | 0.550 | 0.450 | 0.300 |
| "        |        | △     | 2.750 | 1.850 | 1.450 | 1.150 | 0.900 | 1.750 | 0.550 | 0.450 | 0.350 |
| 31. vii. | 4      | ○     | 2.700 | 1.700 | 1.400 | 1.100 | 0.950 | 1.650 | 0.500 | 0.450 | 0.350 |
| "        |        | △     | 2.650 | 1.800 | 1.500 | 1.100 | 0.900 | 1.650 | 0.550 | 0.350 | 0.350 |
| "        |        | ○     | 2.750 | 1.800 | 1.500 | 1.100 | 0.850 | 1.750 | 0.550 | 0.450 | 0.350 |
| "        |        | ○     | 2.700 | 1.800 | 1.500 | 1.100 | 0.900 | 1.750 | 0.550 | 0.400 | 0.350 |
| 2. viii. | 1      | ○     | 2.750 | 1.800 | 1.500 | 1.050 | 0.850 | 1.750 | 0.550 | 0.400 | 0.350 |
| 3. viii. | 3      | ○     | 2.750 | 1.750 | 1.500 | 1.100 | 0.900 | 1.900 | 0.550 | 0.450 | 0.400 |
| "        |        | △     | 2.750 | 1.750 | 1.500 | 1.100 | 0.900 | 1.700 | 0.600 | 0.300 | 0.250 |
| "        |        |       | 2.700 | 1.750 | 1.300 | 1.050 | 0.850 | 1.750 | 0.550 |       |       |
| 4. viii. | 1      | ○     | 2.700 | 1.750 | 1.500 | 1.050 | 0.800 | 1.850 | 0.600 | 0.500 | 0.450 |

|           |   |   |       |       |       |       |       |       |       |       |       |
|-----------|---|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 5. viii.  | 1 | △ | 2.700 | 1.700 | 1.250 | 1.100 | 0.850 | 1.750 | 0.550 | 0.350 | 0.250 |
| 6. viii.  | 1 | ○ | 2.600 | 1.600 | 1.400 | 1.050 | 0.900 | 1.750 | 0.600 | 0.350 | 0.300 |
| 7. viii.  | 3 | △ | 2.500 | 1.600 | 1.300 | 1.100 | 0.950 | 1.700 | 0.550 | 0.350 | 0.250 |
| "         |   | △ | 2.600 | 1.650 | 1.300 | 1.050 | 0.900 | 1.600 | 0.550 | 0.350 | 0.250 |
| "         |   | △ | 2.500 | 1.650 | 1.300 | 1.000 | 0.850 | 1.650 | 0.550 | 0.300 | 0.250 |
| 8. viii.  | 3 | ○ | 2.450 | 1.650 | 1.250 | 1.000 | 0.800 | 1.650 | 0.550 | 0.400 | 0.400 |
| "         |   | △ | 2.600 | 1.650 | 1.300 | 1.000 | 0.850 | 1.750 | 0.550 | 0.500 | 0.350 |
| "         |   | △ | 2.500 | 1.700 | 1.300 | 1.050 | 0.900 | 1.050 | 0.550 | 0.350 | 0.250 |
| 9. viii.  | 2 | ○ | 2.600 | 1.600 | 1.300 | 1.000 | 0.800 | 1.750 | 0.550 | 0.450 | 0.450 |
| "         |   | ○ | 2.650 | 1.700 | 1.400 | 1.050 | 0.800 | 1.700 | 0.600 | 0.500 | 0.400 |
| 10. viii. | 1 | ○ | 2.500 | 1.700 | 1.400 | 1.050 | 0.850 | 1.700 | 0.600 | 0.500 | 0.350 |
| 11. viii. | 2 | ○ | 2.500 | 1.700 | 1.300 | 1.050 | 0.900 | 1.700 | 0.600 | 0.450 | 0.350 |
| "         |   | ○ | 2.500 | 1.700 | 1.350 | 1.050 | 0.900 | 1.700 | 0.600 | 0.500 | 0.400 |
| 17. viii. | 1 | ○ | 2.400 | 1.600 | 1.100 | 1.000 | 0.700 | 1.500 | 0.500 | 0.350 | 0.350 |
| 18. viii. | 1 | △ | 2.300 | 1.400 | 1.200 | 1.050 | 0.750 | 1.500 | 0.550 | 0.250 | 0.250 |
| 20. viii. | 1 |   | 2.900 | 1.750 | 1.500 | 1.250 | 0.900 | 2.000 | 0.550 |       |       |
| 22. viii. | 2 | △ | 2.500 | 1.500 | 1.150 | 1.000 | 0.750 | 1.500 | 0.500 | 0.450 | 0.250 |
| "         |   | ○ | 2.500 | 1.550 | 1.200 | 1.000 | 0.750 | 1.550 | 0.550 | 0.450 | 0.300 |
| 23. viii. | 1 | △ | 2.500 | 1.550 | 1.050 | 1.000 | 0.700 | 1.500 | 0.550 | 0.500 | 0.200 |
| 24. viii. | 1 |   | 2.150 | 1.500 | 1.100 | 1.000 | 0.750 | 1.600 | 0.550 |       |       |
| Maximum   |   |   | 2.750 | 1.900 | 1.500 | 1.250 | 1.300 | 2.000 | 0.600 | 0.500 | 0.450 |
| Minimum   |   |   | 2.150 | 1.400 | 1.050 | 1.000 | 0.700 | 1.500 | 0.500 | 0.250 | 0.200 |
| Average   |   |   | 2.593 | 1.686 | 1.345 | 1.063 | 0.855 | 1.640 | 0.564 | 0.429 | 0.334 |

Table 137. Variation in size of eggs dropped by *Phraortes kumamotoensis* No. 58 during her life.

| Date     | Number | Shape | a     | b     | c     | d     | e     | f     | g     | h     | i     |
|----------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 26. vii. | 1      | △     | 2.650 | 1.700 | 1.400 | 1.200 | 0.950 | 1.750 | 0.550 |       | 0.450 |
| 1. viii. | 1      | ○     | 2.700 | 1.800 | 1.500 | 1.050 | 0.900 | 1.700 | 0.500 | 0.550 | 0.400 |
| 7. viii. | 1      | △     | 2.700 | 1.600 | 1.200 | 1.200 | 0.650 | 1.800 | 0.500 |       | 0.250 |
| Maximum  |        |       | 2.700 | 1.800 | 1.500 | 1.200 | 0.950 | 1.800 | 0.550 |       | 0.450 |
| Minimum  |        |       | 2.650 | 1.600 | 1.200 | 1.050 | 0.650 | 1.700 | 0.500 |       | 0.250 |
| Average  |        |       | 2.683 | 1.700 | 1.386 | 1.150 | 0.833 | 1.750 | 0.518 | 0.550 | 0.363 |

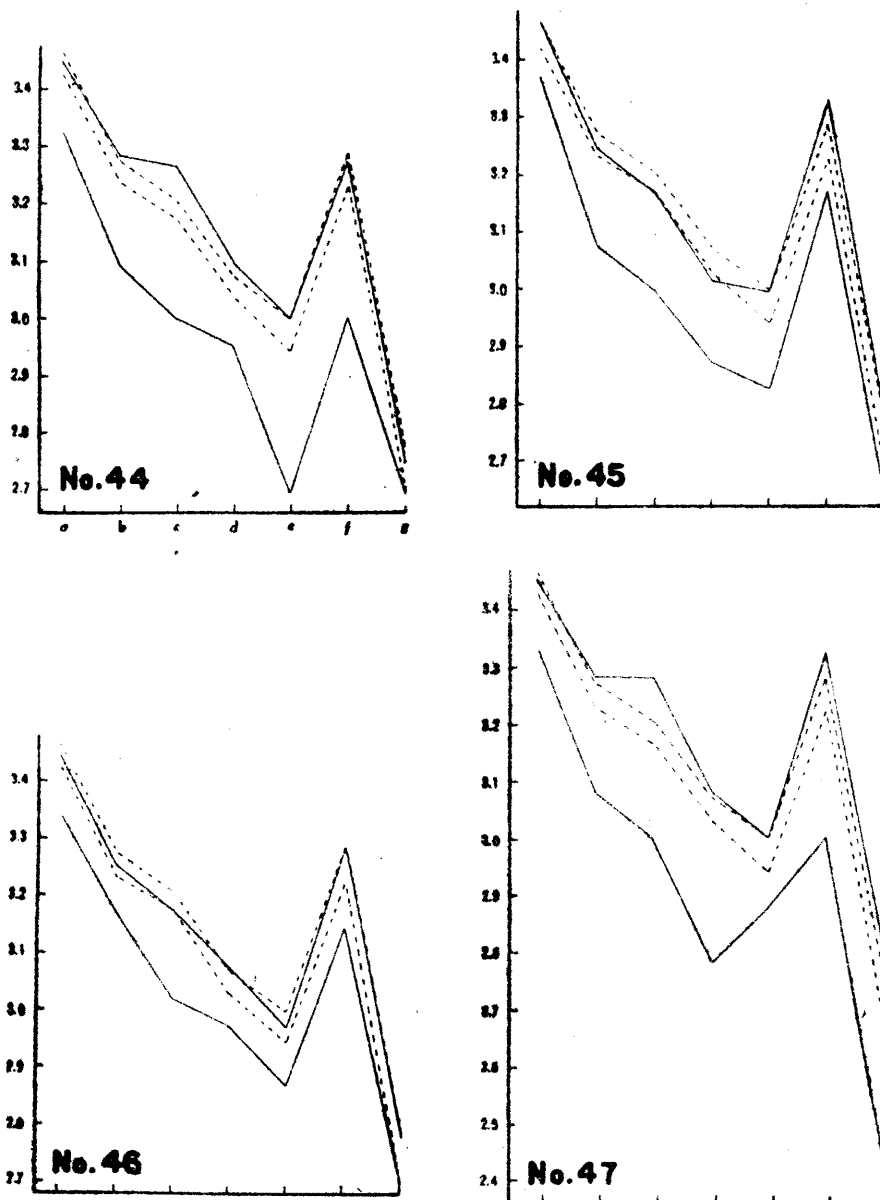
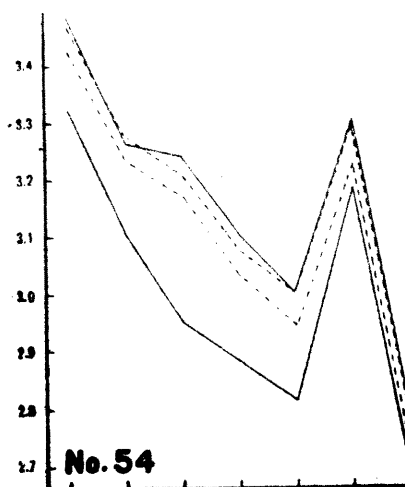
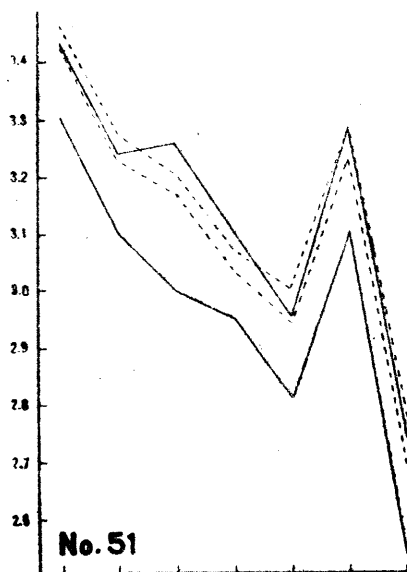
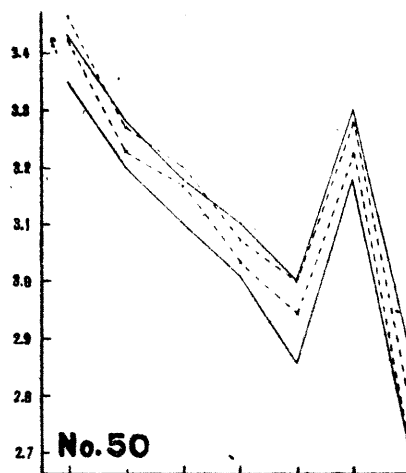
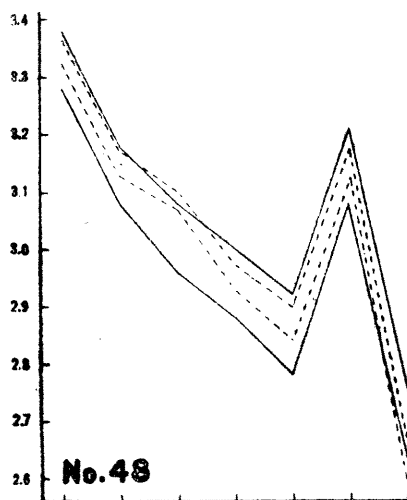
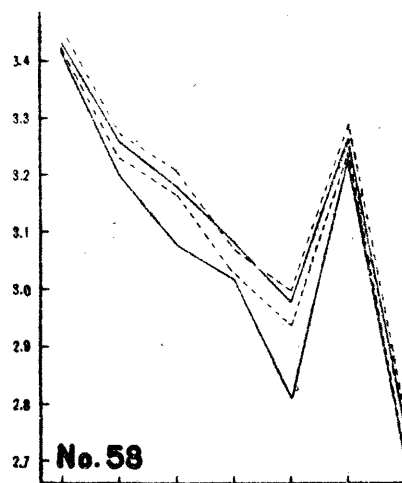
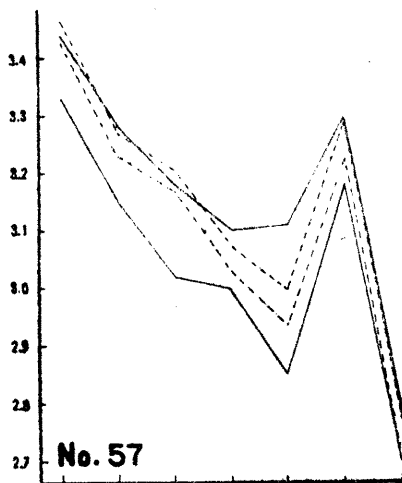
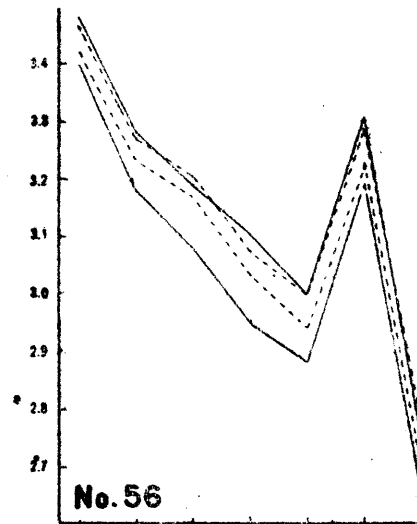
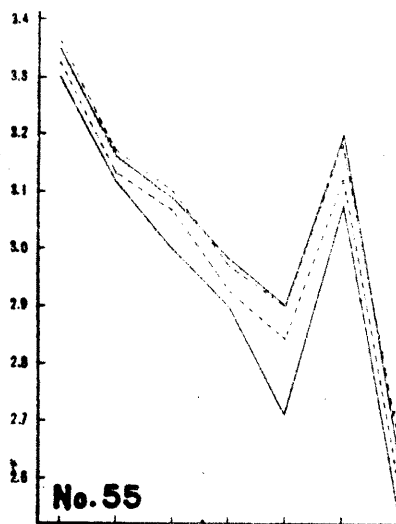


Fig. 36. Variation in size of eggs dropped by experimental and standard insects. Broken lines indicate the variation area of the standard insect. Full lines indicate the variation area of experimental insects. Abscissa represents the measured parts as given in Fig. No. 44. Ordinate represents the logarithms of  $\{(\text{values of the measured parts}) \times 100\}$ .





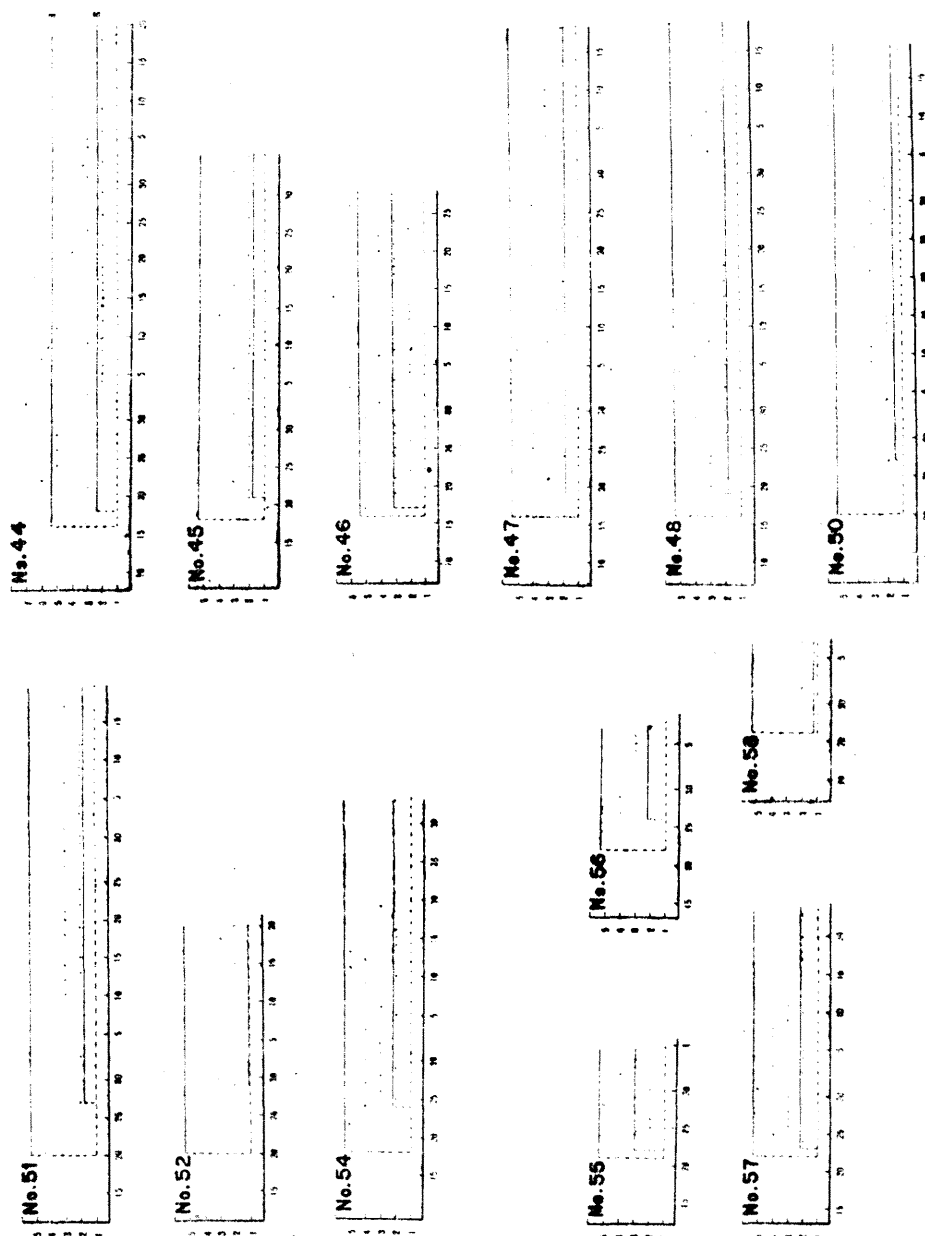


Fig. 37. Comparison of the number of eggs produced by experimental and standard insects in their oviposition period. Abscissa represents the time. Ordinate represents the number of eggs produced per day. S: Standard line of egg-production per day. E: Average line of egg-production per day in experiments. Dots represent the actual number of eggs.

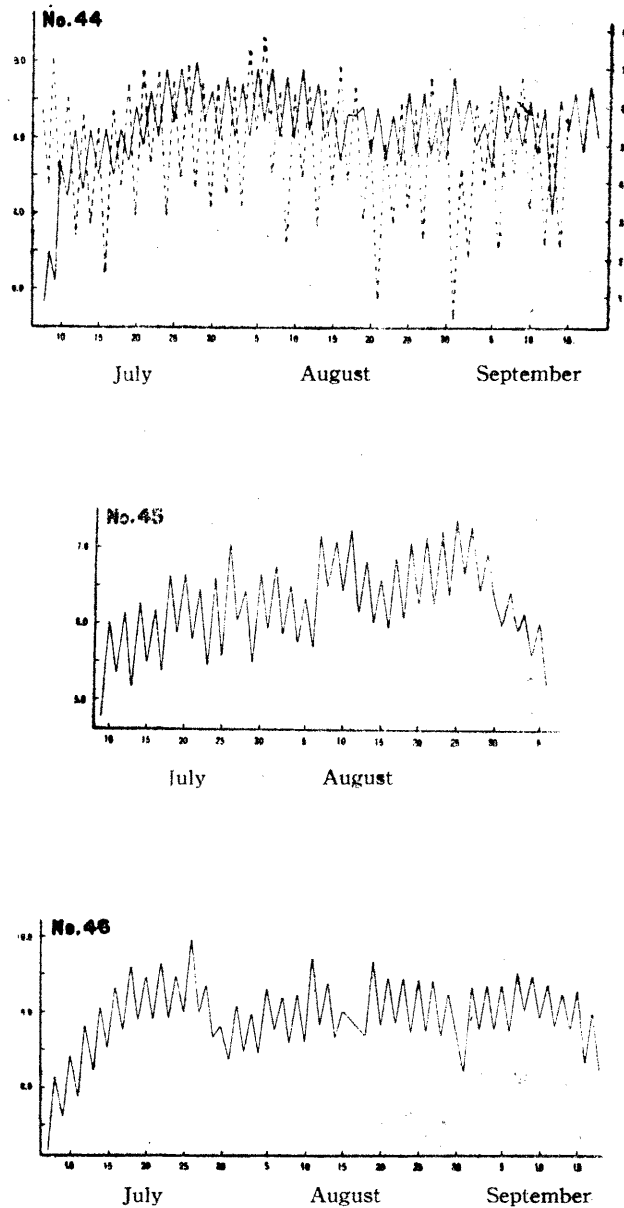
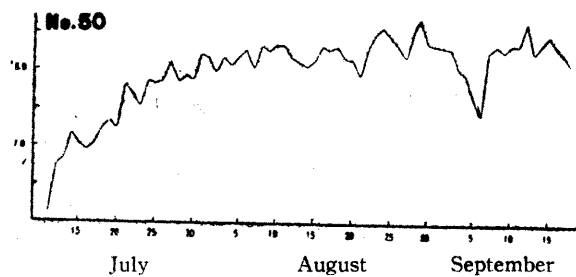
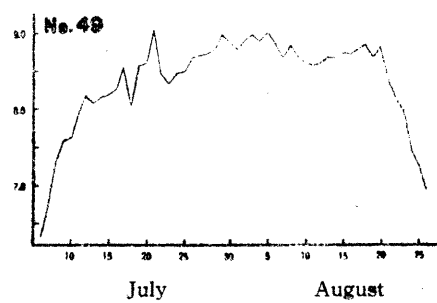
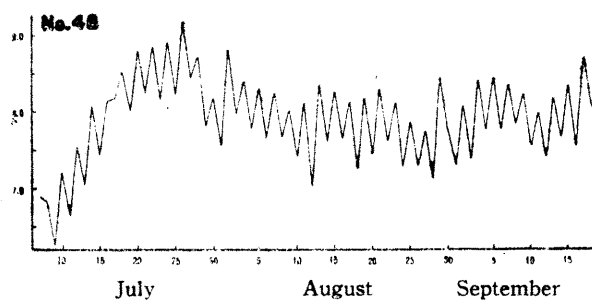
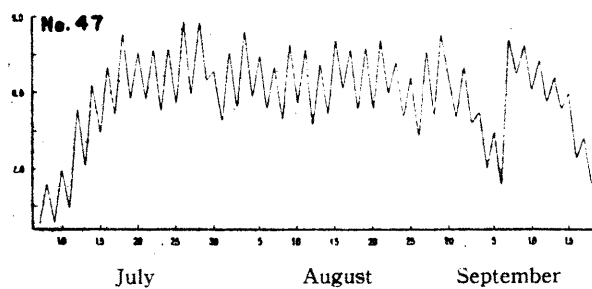
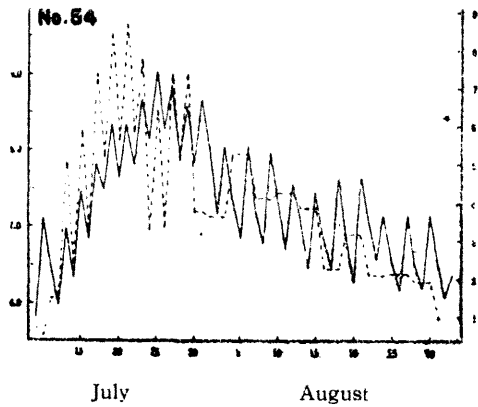
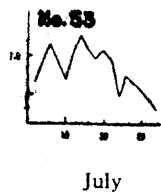
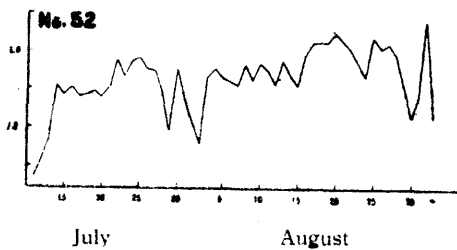
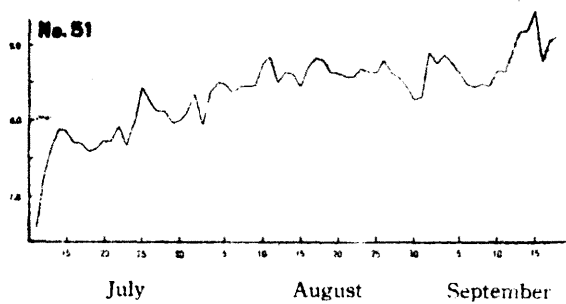
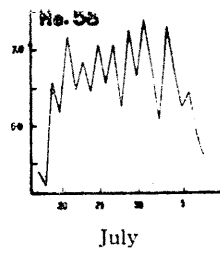
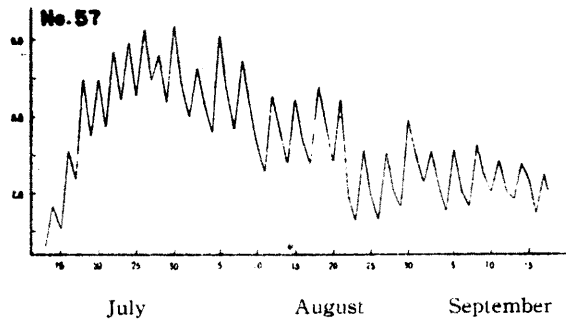
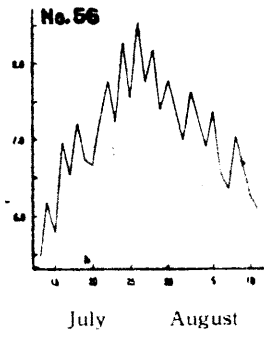
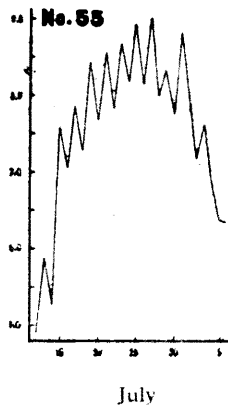


Fig. 38. Change in weight of (full line) and the volume of leaves eaten by (broken line) *Phraortes kumamotoensis* during larval and adult stadia. Abscissa represents the date. Ordinate indicates the logarithm of the body weight or the logarithm of the volume of leaves.







## Observations

From the three series of feeding experiments mentioned above, we can safely derive the following results concerning the ability of oviposition of the female sex. First of all the influence of feeding with insufficient diet upon the length of the preoviposition period must be considered. The comparatively long preoviposition period of more than 15 days appears to show that the development of the genital organs in the female sex is apparently dependent on the amount of food which will be consumed during that period. However, the preoviposition period of less than 13 days more abundant in my experiments and this may be regarded as normal as compared with that of insects reared with normal food, or in such cases the insufficient nutrition, as being fed every other day, every second days or once a day, did not influence the preoviposition period of the insects in any way without affecting the characteristic velocity of sexual maturity. In the case of the experimental insect No. 58 which was fed once a day the preoviposition period lasted only 9 days, even one day shorter than the average 10 days. Thus it is clear that the relation between the food consumption (in the cases of my experiments) and the oviposition cannot be adequately expressed by measuring the length of the preoviposition period.

Table 138. Preoviposition period and the duration of life of the experimental insects.

| No. | Preoviposition period |                   | Duration of life in the adult stage |
|-----|-----------------------|-------------------|-------------------------------------|
|     | Experimental          | Control (Average) |                                     |
| 44  | 12 days               | 10 days           | 75 days                             |
| 45  | 12 days               | 10 days           | 60 days                             |
| 46  | 10 days               | 10 days           | 74 days                             |
| 47  | 12 days               | 10 days           | 74 days                             |
| 48  | 12 days               | 10 days           | 74 days                             |
| 49  | 11 days               | 10 days           | 52 days                             |
| 50  | 16 days               | 10 days           | 70 days                             |
| 51  | 16 days               | 10 days           | 70 days                             |
| 52  | 18 days               | 10 days           | 54 days                             |

|    |             |         |         |
|----|-------------|---------|---------|
| 53 | Over 6 days | 10 days | 16 days |
| 54 | 15 days     | 10 days | 56 days |
| 55 | 10 days     | 10 days | 26 days |
| 56 | 13 days     | 10 days | 30 days |
| 57 | 10 days     | 10 days | 18 days |
| 58 | 9 days      | 10 days | 23 days |

Next it is of interest to ascertain whether insects which have been fed on an insufficient diet after the last moult are able to produce a normal number of eggs or eggs with normal shape. It has already been shown that the normal female deposits the average number of 4.5 eggs a day. The results of my experiments are clearly shown in the following table.

Table 139. Average number of eggs deposited per day by experimental insects.  $R = C - E$ .

| No. | E (Experimental) | C (Control or normal average) | R     |
|-----|------------------|-------------------------------|-------|
| 44  | 1.37             | 4.5                           | 3.28  |
| 45  | 0.75             | 4.5                           | 6.00  |
| 46  | 2.05             | 4.5                           | 2.19  |
| 47  | 0.96             | 4.5                           | 4.68  |
| 48  | 0.98             | 4.5                           | 4.59  |
| 50  | 0.54             | 4.5                           | 8.33  |
| 51  | 0.78             | 4.5                           | 5.76  |
| 52  | 0.14             | 4.5                           | 32.14 |
| 54  | 1.21             | 4.5                           | 3.71  |
| 55  | 1.85             | 4.5                           | 2.43  |
| 56  | 1.07             | 4.5                           | 4.20  |
| 57  | 1.30             | 4.5                           | 3.46  |
| 58  | 0.23             | 4.5                           | 19.56 |

The total number of eggs produced by each of the experimental insects was not more than 100 during her life and apparently very small as compared with the case of those fed on normal diet. This result supports the fact that the insufficient nutrition of the experiments arrests the normal development of

the genital organs, especially of ovaries, from the continuous production of eggs during her life. This is also in close connection with the comparatively shorter duration of life of the adult stage. As is seen in the table given above, the average number of eggs produced per day by experimental insects is conspicuously small without exceptions. In the experiment insect No. 52 the average number of eggs produced per day was only one thirty-second of the average number in normal individuals. There were no experimental insects which could produce eggs more than a half the number of eggs of normal individuals.

Apart from the number of eggs the shape of eggs produced by experimental insects fed on an insufficient diet is to be examined. From the morphological point of view I classified the shape of the capitulum in three categories: 1—egg with a capitulum normal (○), 2—egg with a capitulum moderately deformed (△), 3—egg with a capitulum strongly deformed or without a capitulum (×). Following this classification the shapes of the capitulum of eggs deposited by experimental insects were summarized as in the following table.

Table 140. The shapes of the capitulum of eggs in experimental insects (figures in %).

| Type<br>No. | ○    |         | △    |         | ×    |         |
|-------------|------|---------|------|---------|------|---------|
|             | Exp. | Control | Exp. | Control | Exp. | Control |
| 44          | 4.5  | 68.0    | 62.5 | 13.0    | 33.0 | 19.0    |
| 45          | 23.5 | 68.0    | 64.7 | 13.0    | 11.8 | 19.0    |
| 46          | 20.2 | 68.0    | 78.6 | 13.0    | 1.2  | 19.0    |
| 47          | 42.4 | 68.0    | 44.1 | 13.0    | 13.5 | 19.0    |
| 48          | 30.0 | 68.0    | 68.3 | 13.0    | 1.7  | 19.0    |
| 50          | 6.7  | 68.0    | 93.3 | 13.0    | 0.0  | 19.0    |
| 51          | 30.2 | 68.0    | 51.1 | 13.0    | 18.7 | 19.0    |
| 52          | 33.3 | 68.0    | 33.3 | 13.0    | 33.3 | 19.0    |
| 54          | 12.0 | 68.0    | 82.0 | 13.0    | 6.0  | 19.0    |
| 55          | 46.2 | 68.0    | 53.8 | 13.0    | 0.0  | 19.0    |
| 56          | 14.4 | 68.0    | 57.1 | 13.0    | 28.5 | 19.0    |
| 57          | 65.1 | 68.0    | 25.6 | 13.0    | 9.3  | 19.0    |
| 58          | 33.3 | 68.0    | 66.6 | 13.0    | 0.0  | 19.0    |

The above observations show that the percentage of the eggs with a normal capitulum in experimental insects is always and definitely lower than that of normal individuals, and that of the eggs with a moderately deformed capitulum is always and definitely higher than that of normal ones. The physiological nature of the process producing eggs with a strongly or moderately deformed capitulum or without a capitulum could be definitely shown only by actual analyses of several series of my experiments. In general a normally fed insect always produces eggs with a complete capitulum without exceptions. The maximum case of the production of deformed eggs was exhibited by the experimental insect No. 44, of which about 95.5 per cent of the eggs produced were with a deformed capitulum. Thus it is quite evident that the insufficient diet during the oviposition period exhibits a great effect in producing perfect eggs. Though the shape of the capitulum is independent of the hatching of eggs, it is frequently closely correlated with the shape of the capsule, a main part of the egg, and provides a good criterion in determining the adequate amount of food to produce perfect eggs. It must not be forgotten that an egg with a deformed capsule always has a deformed capitulum. The shape of the capsule is also strikingly influenced by the insufficient nutrition and those the measurements of the same in the experimental insects are given in the following table.

Table 141. The shape of the capsule of eggs produced by experimental insects.

| No. | a : b | a : f | b : c | d : e |
|-----|-------|-------|-------|-------|
| 44  | 1.53  | 1.58  | 1.23  | 1.32  |
| 45  | 1.65  | 1.46  | 1.32  | 1.18  |
| 46  | 1.59  | 1.45  | 1.25  | 1.24  |
| 47  | 1.54  | 1.45  | 1.24  | 1.18  |
| 48  | 1.52  | 1.42  | 1.25  | 1.23  |
| 50  | 1.47  | 1.44  | 1.25  | 1.35  |
| 51  | 1.41  | 1.32  | 1.28  | 1.37  |
| 52  | 1.77  | 1.55  | 1.33  | 1.35  |
| 54  | 1.59  | 1.45  | 1.23  | 1.32  |
| 55  | 1.54  | 1.58  | 1.25  | 1.25  |
| 56  | 1.67  | 1.59  | 1.22  | 1.26  |
| 57  | 1.53  | 1.58  | 1.25  | 1.24  |
| 58  | 1.58  | 1.53  | 1.22  | 1.38  |

As shown in the text-figures, the width of the variation in the shape of eggs dropped by experimental insects fed on insufficient diet is very much larger than that in normal individuals. The value  $a : b$  fluctuates between 1.41 and 1.77. In case that the value  $a : b$  is small, the egg has a comparatively short capsule. The value  $a : f$  fluctuates between 1.32 and 1.59. In case that the value  $a : f$  is large, then the egg has a comparatively short ovary attachment. The value  $a : b$  is not equal to that of  $a : f$  in experimental insects, while it is not the case in normal insects. The value  $b : c$  varies between 1.22 and 1.33. In case that the value  $b : c$  is large, then the transverse section of the egg takes the form of a compressed ellipse. The value  $d : e$  varies between 1.18 and 1.38. In case that the value  $d : e$  is small, then the shape of the platform of the egg becomes semicircular in outline. In the perfect egg the values  $b : c$  and  $d : e$  are equal to each other. But this relation cannot be applicable to the eggs produced in my experiment. These observations allow to consider the insufficient diet experimented as being extremely resistant to the production of perfect or normally shaped eggs. Finally, in order to ascertain, if the shape of eggs dropped by experimental insects has any relationship with the age of insects, the whole oviposition period was divided into several intervals in order and the average value of eggs dropped in each division was calculated. The results of the experimental insect No. 44 are shown in the following tables. The negative result, however, that the shape of eggs dropped by ill-fed insects was independent of the age of the material, was obtained in all the cases.

Table 142. The measurements of eggs laid by experimental insect No. 44 in 7 divisions. I (Average value)

| Divisions                 | a     | b     | c     | d     | e     | f     |
|---------------------------|-------|-------|-------|-------|-------|-------|
| I (18. vii - 27. vii)     | 2.530 | 1.488 | 1.307 | 1.046 | 0.788 | 1.607 |
| II (28. vii - 6. viii)    | 2.600 | 1.720 | 1.443 | 1.145 | 0.886 | 1.618 |
| III ( 7. viii - 16. viii) | 2.606 | 1.690 | 1.400 | 1.100 | 0.870 | 1.600 |
| IV (17. viii - 26. viii)  | 2.490 | 1.603 | 1.256 | 1.083 | 0.803 | 1.543 |
| V (27. viii - 5. ix)      | 2.540 | 1.685 | 1.326 | 1.100 | 0.815 | 1.560 |
| VI ( 6. ix - 15. ix)      | 2.500 | 1.683 | 1.350 | 1.066 | 0.766 | 1.716 |
| VII (16. ix - 19. ix)     | 2.691 | 1.600 | 1.350 | 1.141 | 0.800 | 1.600 |

Table 143. The measurements of eggs laid by experimental insect No. 44 in 7 divisions. II

| Divisions | a : b | a : f | b : c | d : e |
|-----------|-------|-------|-------|-------|
| I         | 1.70  | 1.57  | 1.13  | 1.32  |
| II        | 1.51  | 1.60  | 1.19  | 1.29  |
| III       | 1.54  | 1.62  | 1.20  | 1.26  |
| IV        | 1.55  | 1.67  | 1.27  | 1.34  |
| V         | 1.50  | 1.69  | 1.27  | 1.34  |
| VI        | 1.48  | 1.45  | 1.24  | 1.39  |
| VII       | 1.68  | 1.48  | 1.18  | 1.42  |

## 5. Experiments Series 5

### Experiments Class 11

No. 59, ♀ An insect, underwent the fourth moult on June 9th, was then put immediately on this experiment. This insect underwent the fifth and sixth moults on June 19th and on July 3rd respectively. The food consumed by this insect in the sixth stadium was about twice as much as that in the fifth one. After a preoviposition period of 10 days, the first oviposition took place on July 13th. After 128 days the insect died on November 17th. Thus the duration of adult life of this female was 138 days.

No. 60, ♀ An insect, underwent the fourth moult on June 9th, was used in this experiment immediately after the moult. This insect underwent the fifth and sixth moults on June 20th and on July 4th respectively. The food taken by this insect in the sixth stadium was approximately twice as much as that in the fifth one. After a preoviposition period of 11 days, the insect laid a first egg on July 15th. After 103 days later this insect died on October 25th. Thus the duration of adult life of this female was 114 days.

No. 61, ♀ An insect, underwent the fifth moult on June 15th, was then used immediately in this experiment. After 13 days the sixth moult took place on June 28th. The preoviposition period of this female was 10 days. On September 26th the insect died 90 days after the last moult.

No. 62, ♀ An insect, underwent the fourth moult on June 21st, was used at once in this experiment. This insect underwent the

fifth and sixth moults on July 2nd and on July 13th respectively. The food consumed by this insect in the sixth stadium was exactly twice as much as that in the fifth one. After a preoviposition period of 7 days, the first oviposition took place on July 21st. After 117 days this insect died on November 14. Thus the duration of adult life of this female was 124 days.

No. 63, ♀ An insect, underwent the fourth moult on June 14th, was put immediately on this experiment. On July 25th it died during the succeeding moult.

#### Experiments Class 12

No. 64, ♂ An insect, underwent the fourth moult on June 11th, was used at once in this experiment. The fifth or the last moult took place on June 23rd. The duration of adult life of this male was 147 days. It died on November 17th.

No. 65, ♂ An insect, underwent the fourth moult on June 11th, was put at once on this experiment. It died on June 22nd during the final moult.

No. 66, ♂ An insect, underwent the fourth moult on June 13th, was then used immediately in this experiment. After 9 days the last moult took place on June 21st. After a long period of 141 days this male died on November 9th.

No. 67, ♂ An insect, underwent the fourth moult on June 11th, was then put immediately on this experiment. After 11 days this insect underwent the last moult on June 21st. The duration of adult life of this male was comparatively short. Thus it died on August 26th or 66 days after the final moult.

No. 68, ♂ An insect, underwent the fourth moult on June 11th, was put at once on this experiment. After 13 days this insect underwent the fifth moult. The duration of adult life of this male was very long. Thus it died on November 30th, 160 days after the last moult.

Table 144. Amount of leaves eaten by *Phragortes kumamotoensis* No. 59 in larval and adult stages.

| Date   | V    | O   | W   | Date      | V     | O    | W    |
|--------|------|-----|-----|-----------|-------|------|------|
| 9. vi. | 80.0 | 568 | 920 | 29. viii. | 344.0 | 2442 | 3956 |

|          |        |      |       |           |       |      |      |
|----------|--------|------|-------|-----------|-------|------|------|
| 10. vi.  | 150.0  | 1065 | 1725  | 30. viii. | 174.6 | 1240 | 2008 |
| 11. vi.  | 188.7  | 1340 | 2170  | 31. viii. | 362.0 | 2570 | 4163 |
| 12. vi.  | 293.0  | 2080 | 3370  | 1. ix.    | 550.0 | 3905 | 6325 |
| 13. vi.  | 183.4  | 1302 | 2109  | 2. ix.    | 613.7 | 4357 | 7058 |
| 14. vi.  | 272.5  | 1935 | 3134  | 3. ix.    | 503.0 | 3571 | 5785 |
| 15. vi.  | 228.0  | 1619 | 2622  | 4. ix.    | 325.0 | 2308 | 3738 |
| 16. vi.  | 290.5  | 2063 | 3341  | 5. ix.    | 278.0 | 1974 | 3197 |
| 17. vi.  | 0.0    | 0    | 0     | 6. ix.    | 324.5 | 2304 | 3732 |
| 18. vi.  | 0.0    | 0    | 0     | 7. ix.    | 174.8 | 1241 | 2010 |
| 19. vi.  | 0.0    | 0    | 0     | 8. ix.    | 668.0 | 4743 | 7682 |
| 20. vi.  | 186.4  | 1323 | 2144  | 9. ix.    | 438.5 | 3113 | 5043 |
| 21. vi.  | 357.6  | 2539 | 4112  | 10. ix.   | 334.0 | 2371 | 3841 |
| 22. vi.  | 283.0  | 2009 | 3255  | 11. ix.   | 427.2 | 3033 | 4913 |
| 23. vi.  | 427.0  | 3032 | 4911  | 12. ix.   | 226.0 | 1605 | 2599 |
| 24. vi.  | 250.0  | 1775 | 2875  | 13. ix.   | 492.0 | 3493 | 5658 |
| 25. vi.  | 438.6  | 3114 | 5044  | 14. ix.   | 276.5 | 1963 | 3180 |
| 26. vi.  | 494.3  | 3510 | 5684  | 15. ix.   | 285.2 | 2025 | 3280 |
| 27. vi.  | 295.2  | 2096 | 3395  | 16. ix.   | 190.0 | 1349 | 2185 |
| 28. vi.  | 352.0  | 2499 | 4048  | 17. ix.   | 390.0 | 2769 | 4485 |
| 29. vi.  | 441.5  | 3135 | 5077  | 18. ix.   | 387.6 | 2751 | 4457 |
| 30. vi.  | 97.0   | 689  | 1161  | 9. ix.    | 529.0 | 3756 | 6084 |
| 1. vii.  | 130.0  | 923  | 1495  | 20. ix.   | 409.4 | 2907 | 4708 |
| 2. vii.  | 0.0    | 0    | 0     | 21. ix.   | 479.0 | 3401 | 5509 |
| 3. vii.  | 0.0    | 0    | 0     | 22. ix.   | 251.5 | 1786 | 2892 |
| 4. vii.  | 201.5  | 1431 | 2317  | 23. ix.   | 419.3 | 2977 | 4922 |
| 5. vii.  | 396.0  | 2812 | 4554  | 24. ix.   | 264.0 | 2584 | 4181 |
| 6. vii.  | 708.2  | 5028 | 8144  | 25. ix.   | 113.7 | 807  | 1308 |
| 7. vii.  | 421.0  | 2989 | 4842  | 26. ix.   | 198.4 | 1409 | 2281 |
| 8. vii.  | 338.5  | 2403 | 3893  | 27. ix.   | 177.8 | 1262 | 2045 |
| 9. vii.  | 930.0  | 6603 | 10695 | 28. ix.   | 428.0 | 3039 | 4922 |
| 10. vii. | 563.6  | 4002 | 6481  | 29. ix.   | 182.5 | 1296 | 2099 |
| 11. vii. | 442.0  | 3138 | 5083  | 30. ix.   | 322.2 | 2288 | 3705 |
| 12. vii. | 616.0  | 4374 | 7084  | 1. x.     | 354.0 | 2513 | 4071 |
| 13. vii. | 705.0  | 5006 | 8108  | 2. x.     | 434.6 | 3086 | 4998 |
| 14. vii. | 974.7  | 6920 | 11209 | 3. x.     | 222.0 | 1576 | 2553 |
| 15. vii. | 1028.0 | 7299 | 11822 | 4. x.     | 133.4 | 947  | 1534 |
| 16. vii. | 709.8  | 5040 | 8163  | 5. x.     | 0.0   | 0    | 0    |
| 17. vii. | 867.5  | 6159 | 9976  | 6. x.     | 154.0 | 1093 | 1771 |
| 18. vii. | 781.0  | 5545 | 8982  | 7. x.     | 271.5 | 1928 | 3122 |

|           |       |      |       |         |       |      |      |
|-----------|-------|------|-------|---------|-------|------|------|
| 19. vii.  | 608.0 | 4317 | 6992  | 8. x.   | 85.0  | 604  | 978  |
| 20. vii.  | 208.5 | 1480 | 2398  | 9. x.   | 230.0 | 1633 | 2645 |
| 21. vii.  | 535.6 | 3803 | 6159  | 10. x.  | 0.0   | 0    | 0    |
| 22. vii.  | 548.7 | 3896 | 6310  | 11. x.  | 294.0 | 2087 | 3381 |
| 23. vii.  | 302.0 | 2144 | 3473  | 12. x.  | 147.8 | 1049 | 1700 |
| 24. vii.  | 788.0 | 5595 | 9062  | 13. x.  | 222.0 | 1576 | 2553 |
| 25. vii.  | 409.5 | 2907 | 4709  | 14. x.  | 265.9 | 1888 | 3058 |
| 26. vii.  | 597.2 | 4240 | 6868  | 15. x.  | 244.0 | 1732 | 2806 |
| 27. vii.  | 706.0 | 5012 | 8119  | 16. x.  | 180.4 | 1281 | 2075 |
| 28. vii.  | 434.6 | 3086 | 4498  | 17. x.  | 145.6 | 1034 | 1674 |
| 29. vii.  | 650.0 | 4615 | 7475  | 18. x.  | 123.0 | 873  | 1415 |
| 30. vii.  | 349.7 | 2483 | 4022  | 19. x.  | 198.5 | 1409 | 2283 |
| 31. vii.  | 893.0 | 6340 | 10269 | 20. x.  | 361.0 | 2563 | 4152 |
| 1. viii.  | 517.4 | 3674 | 5950  | 21. x.  | 194.0 | 1377 | 2231 |
| 2. viii.  | 397.0 | 2819 | 4566  | 22. x.  | 405.6 | 2880 | 4664 |
| 3. viii.  | 666.5 | 4732 | 7665  | 23. x.  | 0.0   | 0    | 0    |
| 4. viii.  | 221.8 | 1575 | 2551  | 24. x.  | 216.0 | 1534 | 2484 |
| 5. viii.  | 338.0 | 2400 | 3887  | 25. x.  | 229.7 | 1631 | 2641 |
| 6. viii.  | 331.5 | 2354 | 3812  | 26. x.  | 94.0  | 667  | 1081 |
| 7. viii.  | 315.0 | 2237 | 3623  | 27. x.  | 0.0   | 0    | 0    |
| 8. viii.  | 781.4 | 5548 | 8986  | 28. x.  | 260.0 | 1846 | 2990 |
| 9. viii.  | 298.6 | 2120 | 3434  | 29. x.  | 0.0   | 0    | 0    |
| 10. viii. | 369.0 | 2620 | 4244  | 30. x.  | 429.8 | 3052 | 4943 |
| 11. viii. | 137.0 | 972  | 1575  | 31. x.  | 0.0   | 0    | 0    |
| 12. viii. | 637.0 | 4523 | 7326  | 1. xi.  | 550.0 | 355  | 575  |
| 13. viii. | 339.0 | 2407 | 2899  | 2. xi.  | 36.4  | 258  | 419  |
| 14. viii. | 464.0 | 3294 | 5336  | 3. xi.  | 0.0   | 0    | 0    |
| 15. viii. | 427.8 | 3038 | 4920  | 4. xi.  | 78.0  | 554  | 897  |
| 16. viii. | 757.0 | 5375 | 8706  | 5. xi.  | 115.9 | 823  | 1323 |
| 17. viii. | 407.5 | 2893 | 4686  | 6. xi.  | 100.0 | 710  | 1150 |
| 18. viii. | 0.0   | 0    | 0     | 7. xi.  | 109.4 | 777  | 1258 |
| 19. viii. | 591.0 | 4196 | 6797  | 8. xi.  | 52.3  | 371  | 601  |
| 20. viii. | 513.6 | 3647 | 5906  | 9. xi.  | 53.5  | 380  | 615  |
| 21. viii. | 314.0 | 2229 | 3611  | 10. xi. | 104.0 | 738  | 1196 |
| 22. viii. | 228.0 | 1619 | 2622  | 11. xi. | 168.8 | 1198 | 1941 |
| 23. viii. | 90.5  | 643  | 1041  | 12. xi. | 41.0  | 291  | 472  |
| 24. viii. | 700.0 | 4970 | 8050  | 13. xi. | 45.7  | 324  | 526  |
| 25. viii. | 943.0 | 6695 | 10845 | 14. xi. | 69.0  | 490  | 794  |
| 26. viii. | 377.3 | 2679 | 4339  | 15. xi. | 112.0 | 795  | 1288 |
| 27. viii. | 233.0 | 1654 | 2680  | 16. xi. | 87.5  | 621  | 1006 |
| 28. viii. | 347.5 | 2467 | 3996  | 17. xi. | 93.4  | 663  | 1074 |

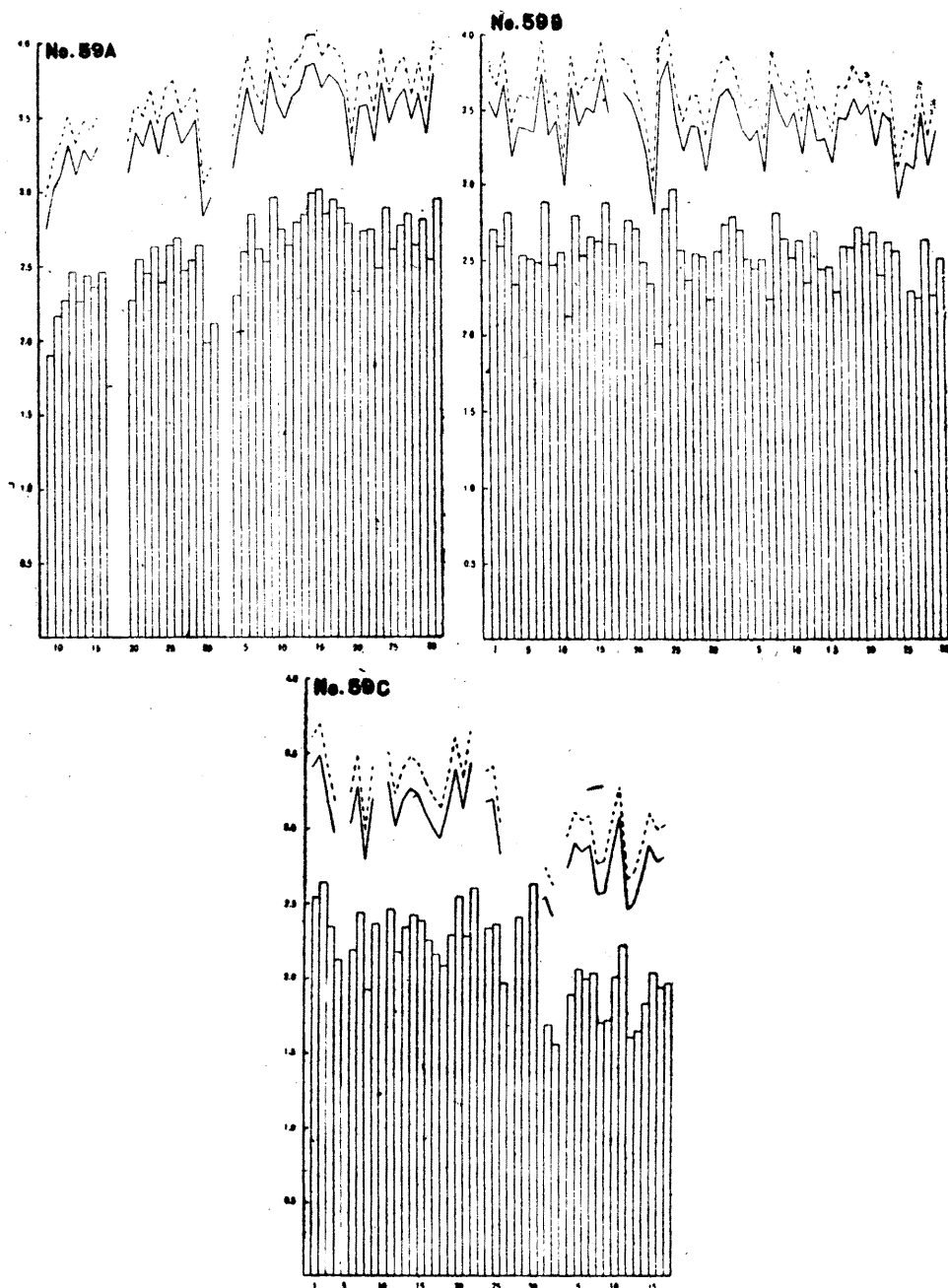


Fig. 39. Amount of leaves eaten by *Phraortes kumamotoensis*, No. 59, during the later larval and adult stadia. Abscissa represents time in date from June to November.

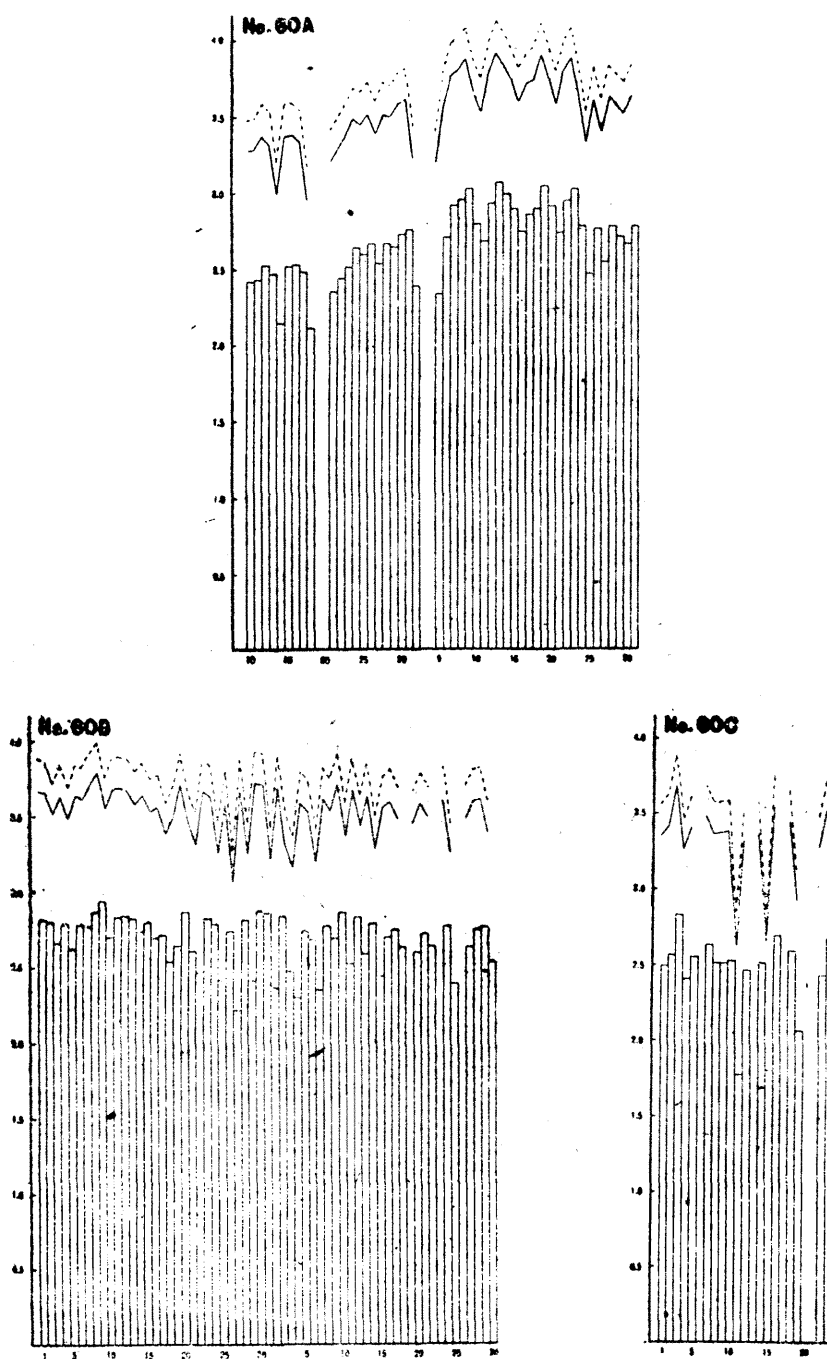


Fig. 40. Amount of leaves eaten by *Phraortes kumamotoensis*, No. 60, during the later larval and adult stadia. Abscissa represents time in date from June to October.

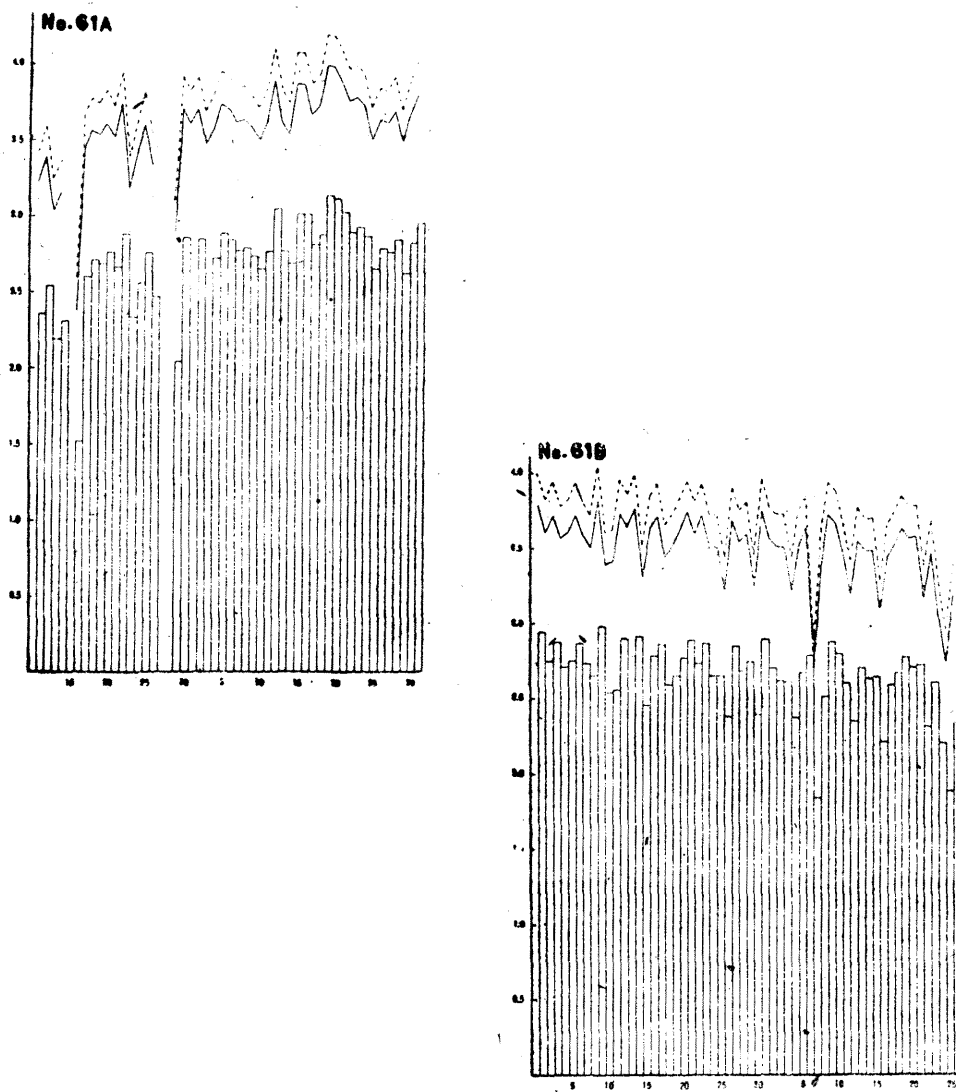


Fig. 41. Amount of leaves eaten by *Phraortes kumamotoensis*, No. 61, during the later larval and adult stadia. Abscissa represents time in date from June to September.

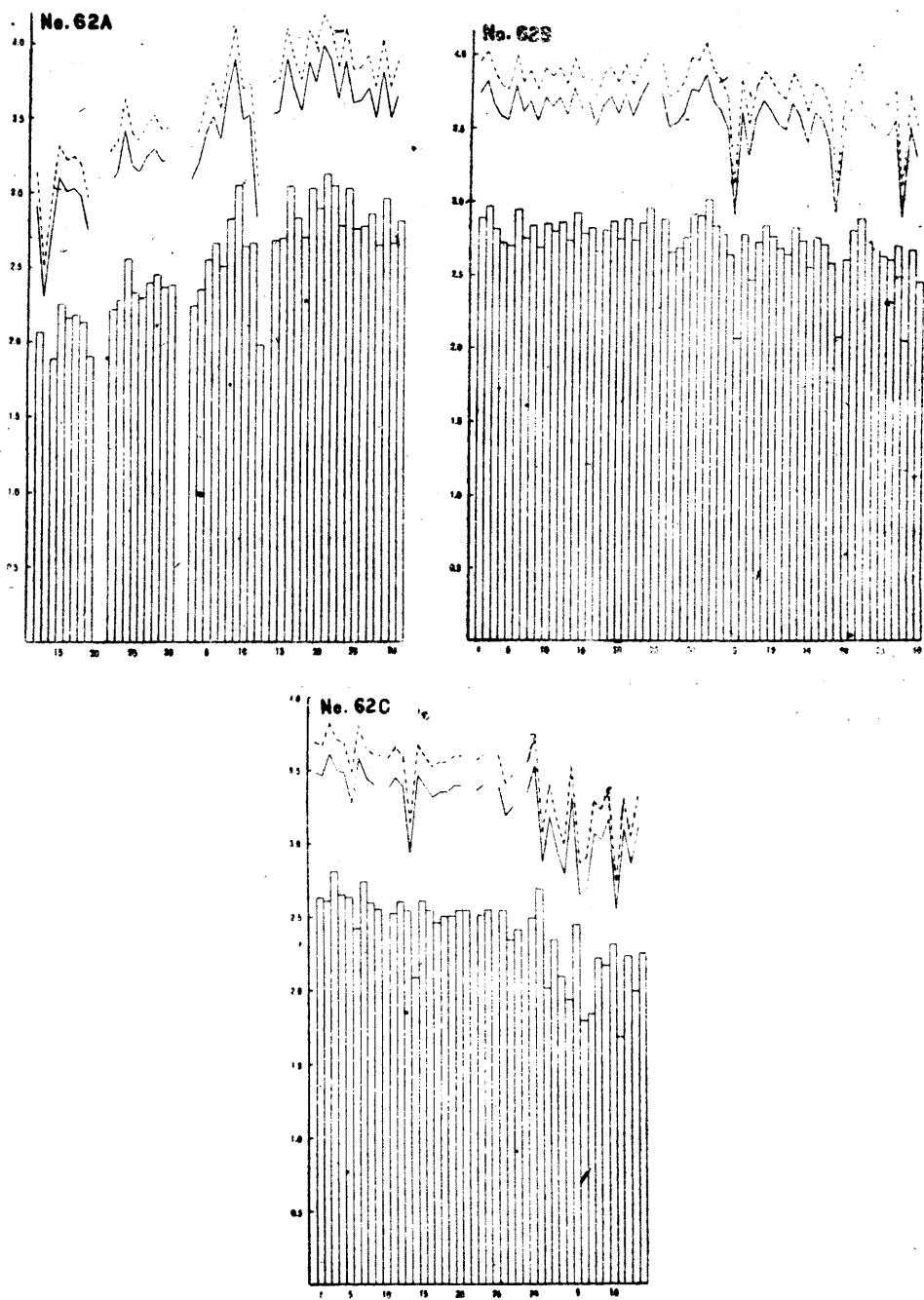


Fig. 42. Amount of leaves eaten by *Phraortes kumamotoensis*, No. 62, during the later larval and adult stadia. Abscissa represents time in date from June to November.

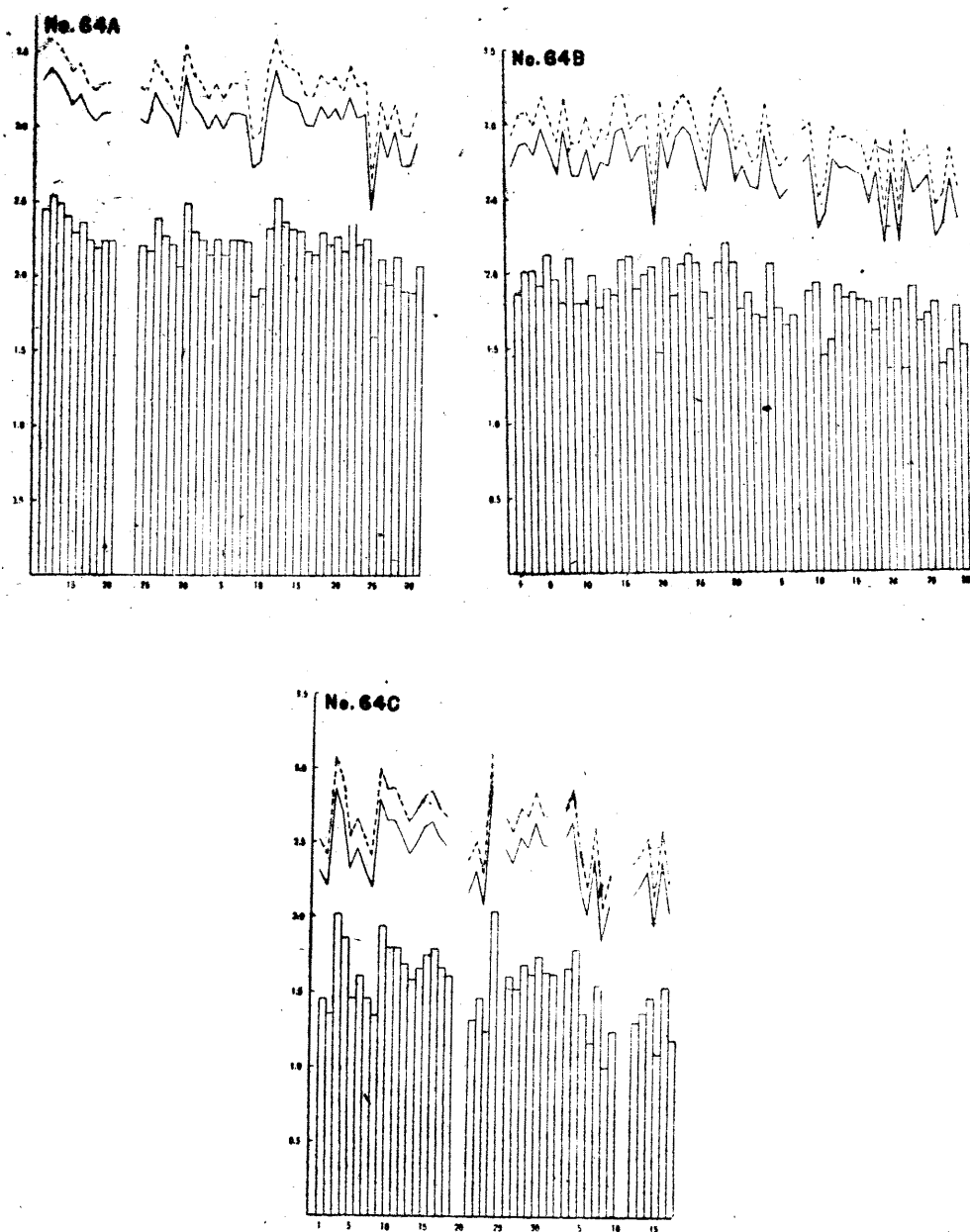


Fig. 43. Amount of leaves eaten by *Phraortes kunamotoensis*, No. 64, during the later larval and adult stadia. Abscissa represents time in date from June to November.

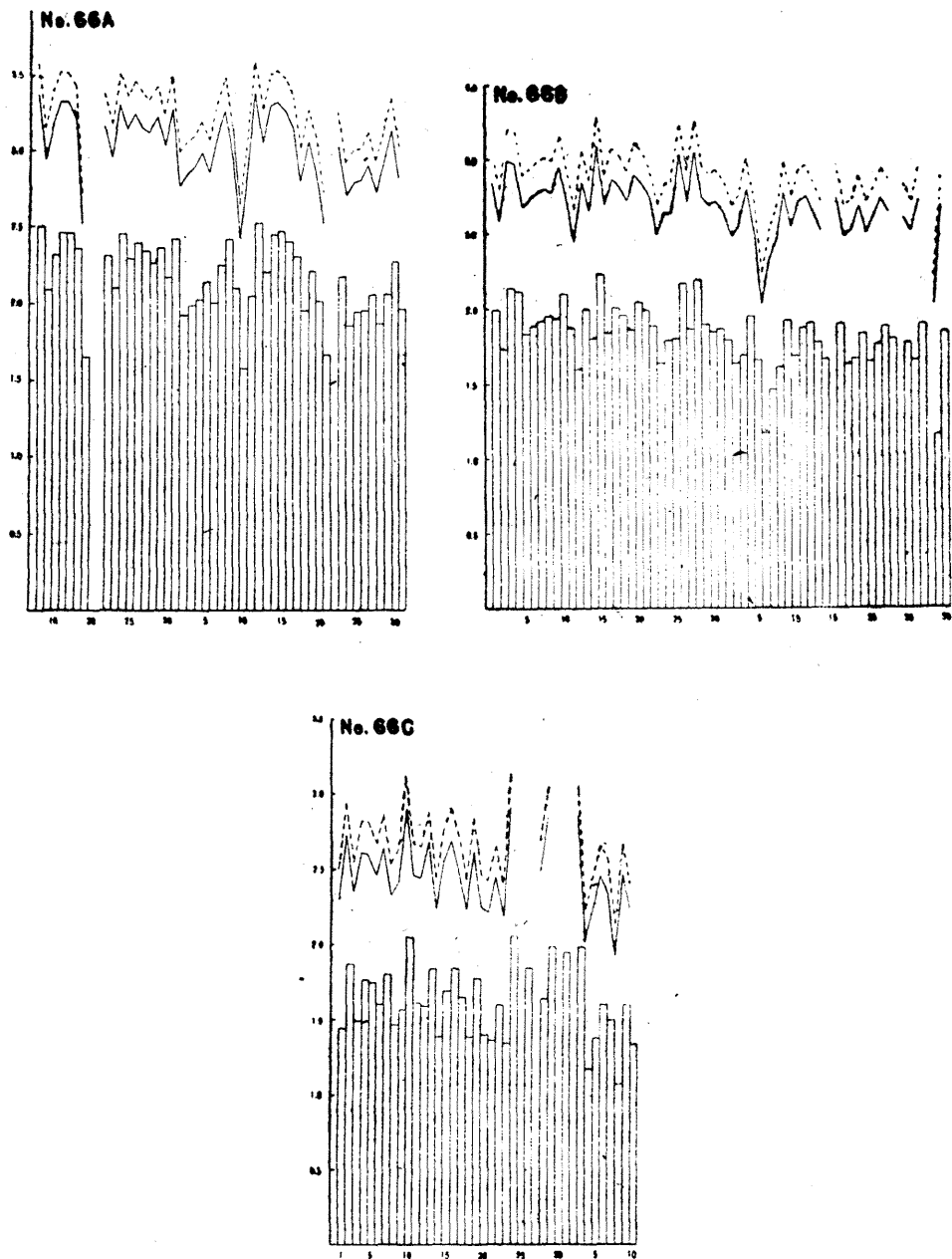


Fig. 44. Amount of leaves eaten by *Phraortes kumamotoensis*, No. 66, during the later larval and adult stadia. Abscissa represents time in date from June to November.

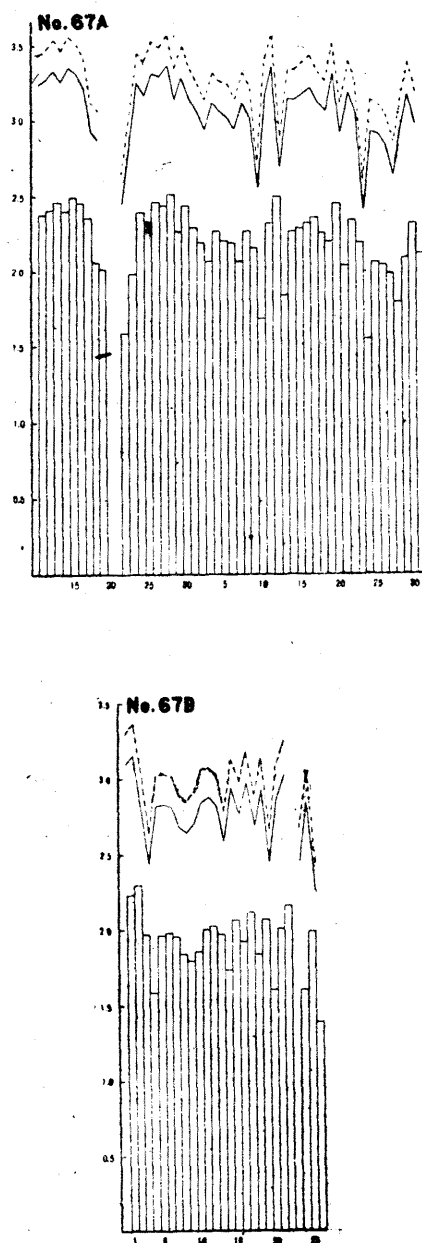


Fig. 45. Amount of leaves eaten by *Phraortes kumamotoensis*, No. 67, during the larval and adult stadia. Abscissa represents time in date from June to August.

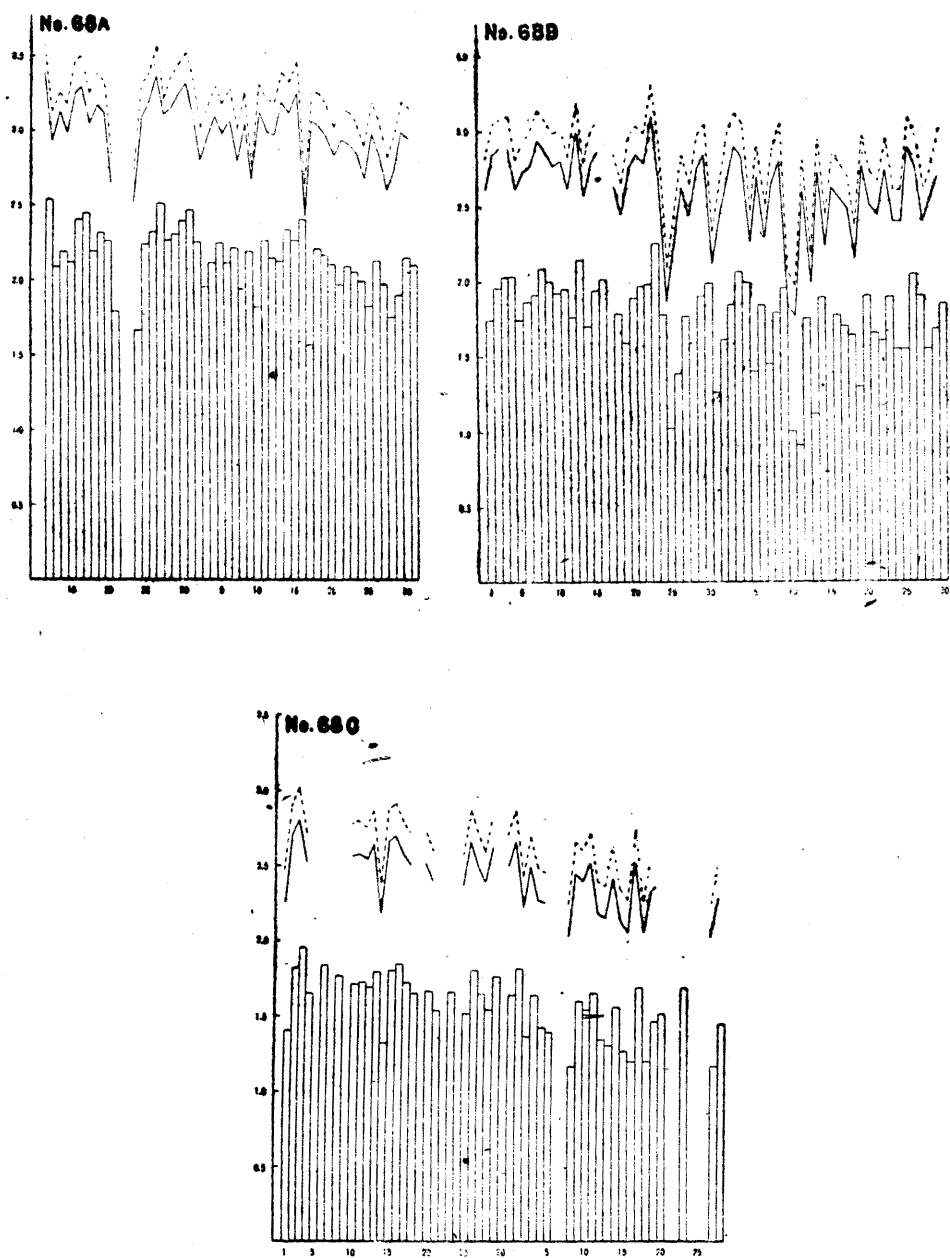


Fig. 46. Amount of leaves eaten by *Phraortes kumamotoensis*, No. 68, during the later larval and adult stadia. Abscissa represents time in date from June to November.

Table 145. Amount of leaves eaten by *Phraortes kumamotoensis* No. 60 in larval and adult stages

| Date     | V      | O    | W     | Date      | V     | O    | W    |
|----------|--------|------|-------|-----------|-------|------|------|
| 9. vi.   | 0.0    | 0    | 0     | 18. viii. | 340.1 | 2415 | 3911 |
| 10. vi.  | 266.0  | 1889 | 3059  | 19. viii. | 443.0 | 3145 | 5095 |
| 11. vi.  | 267.0  | 1896 | 3071  | 20. viii. | 728.5 | 5172 | 8378 |
| 12. vi.  | 333.0  | 2364 | 3830  | 21. viii. | 410.0 | 2911 | 4715 |
| 13. vi.  | 292.5  | 2077 | 3364  | 22. viii. | 296.0 | 2102 | 3404 |
| 14. vi.  | 139.7  | 992  | 1607  | 23. viii. | 666.0 | 4729 | 7659 |
| 15. vi.  | 329.4  | 2339 | 3788  | 24. viii. | 606.3 | 4303 | 6969 |
| 16. vi.  | 335.2  | 2380 | 3855  | 25. viii. | 256.0 | 1818 | 2944 |
| 17. vi.  | 299.6  | 2127 | 3445  | 26. viii. | 548.0 | 3891 | 6302 |
| 18. vi.  | 128.5  | 912  | 1478  | 27. viii. | 162.2 | 1152 | 1865 |
| 19. vi.  | 0.0    | 0    | 0     | 28. viii. | 652.3 | 4631 | 7501 |
| 20. vi.  | 0.0    | 0    | 0     | 29. viii. | 258.0 | 1832 | 2967 |
| 21. vi.  | 226.0  | 1605 | 2599  | 30. viii. | 748.0 | 5311 | 8602 |
| 22. vi.  | 276.0  | 1960 | 3174  | 31. viii. | 729.5 | 5179 | 8389 |
| 23. vi.  | 327.8  | 2324 | 2764  | 1. ix.    | 233.0 | 1654 | 2680 |
| 24. vi.  | 434.0  | 3081 | 4991  | 2. ix.    | 683.4 | 4852 | 7859 |
| 25. vi.  | 397.5  | 2822 | 4571  | 3. ix.    | 297.2 | 2110 | 3418 |
| 26. vi.  | 471.0  | 3344 | 5417  | 4. ix.    | 200.5 | 1424 | 2306 |
| 27. vi.  | 346.0  | 2457 | 3979  | 5. ix.    | 545.0 | 3870 | 6268 |
| 28. vi.  | 469.3  | 3332 | 5397  | 6. ix.    | 479.5 | 3404 | 5514 |
| 29. vi.  | 446.5  | 3170 | 5135  | 7. ix.    | 222.0 | 1576 | 2553 |
| 30. vi.  | 543.0  | 3855 | 6245  | 8. ix.    | 581.5 | 4129 | 6687 |
| 1. vii.  | 573.0  | 4068 | 6490  | 9. ix.    | 491.3 | 3488 | 5650 |
| 2. vii.  | 238.0  | 1690 | 2737  | 10. ix.   | 719.8 | 5111 | 8278 |
| 3. vii.  | 0.0    | 0    | 0     | 11. ix.   | 328.9 | 2335 | 3782 |
| 4. vii.  | 0.0    | 0    | 0     | 12. ix.   | 674.4 | 4788 | 7756 |
| 5. vii.  | 221.0  | 1569 | 2542  | 13. ix.   | 381.3 | 2707 | 4385 |
| 6. vii.  | 521.0  | 3699 | 5992  | 14. ix.   | 612.1 | 4346 | 7039 |
| 7. vii.  | 837.0  | 5943 | 9726  | 15. ix.   | 272.8 | 1937 | 3137 |
| 8. vii.  | 919.3  | 6527 | 10572 | 16. ix.   | 508.1 | 3608 | 5843 |
| 9. vii.  | 1078.4 | 7657 | 12402 | 17. ix.   | 562.5 | 3994 | 6469 |
| 10. vii. | 632.0  | 4487 | 7268  | 18. ix.   | 422.8 | 3002 | 4862 |
| 11. vii. | 484.0  | 3436 | 5566  | 19. ix.   | 0.0   | 0    | 0    |
| 12. vii. | 849.0  | 6028 | 9763  | 20. ix.   | 398.3 | 2828 | 4580 |
| 13. vii. | 1180.2 | 8379 | 13572 | 21. ix.   | 530.4 | 3766 | 6100 |

|                       |        |      |       |         |       |      |      |
|-----------------------|--------|------|-------|---------|-------|------|------|
| 14. vii.              | 974.0  | 6915 | 11201 | 22. ix. | 441.5 | 3135 | 5077 |
| 15. vii.              | 786.6  | 5585 | 9046  | 23. ix. | 0.0   | 0    | 0    |
| 16. vii.              | 568.0  | 4032 | 6532  | 24. ix. | 592.6 | 4207 | 6812 |
| 17. <sup>3</sup> vii. | 731.4  | 5193 | 8411  | 25. ix. | 247.5 | 1757 | 2846 |
| 18. vii.              | 789.5  | 5605 | 9079  | 26. ix. | 0.0   | 0    | 0    |
| 19. vii.              | 1122.0 | 7966 | 12903 | 27. ix. | 436.5 | 3099 | 5020 |
| 20. vii.              | 809.8  | 5750 | 9313  | 28. ix. | 557.2 | 3956 | 6408 |
| 21. vii.              | 554.3  | 3936 | 6374  | 29. ix. | 576.4 | 4092 | 6629 |
| 22. vii.              | 881.8  | 6261 | 10141 | 30. ix. | 349.7 | 2483 | 4022 |
| 23. vii.              | 1065.4 | 7564 | 12252 | 1. x.   | 317.5 | 2254 | 3651 |
| 24. vii.              | 604.0  | 4288 | 6946  | 2. xi   | 274.8 | 2661 | 4310 |
| 25. vii.              | 298.5  | 2119 | 3433  | 3. x.   | 684.0 | 4856 | 7866 |
| 26. vii.              | 582.5  | 4136 | 6699  | 4. x.   | 256.0 | 1818 | 2944 |
| 27. vii.              | 357.2  | 2536 | 4108  | 5. x.   | 363.7 | 2582 | 4182 |
| 28. vii.              | 601.0  | 4267 | 6912  | 6. x.   | 0.0   | 0    | 0    |
| 29. vii.              | 525.0  | 3728 | 6038  | 7. x.   | 425.0 | 3018 | 4888 |
| 30. vii.              | 470.3  | 3339 | 5408  | 8. x.   | 330.5 | 2347 | 3801 |
| 31. vii.              | 600.6  | 4264 | 6907  | 9. x.   | 334.0 | 2371 | 3841 |
| 1. viii.              | 662.4  | 4703 | 7618  | 10. x.  | 345.0 | 2450 | 3967 |
| 2. viii.              | 632.0  | 4487 | 7268  | 11. x.  | 61.0  | 433  | 702  |
| 3. viii.              | 458.5  | 3255 | 5273  | 12. x.  | 296.0 | 2102 | 3404 |
| 4. viii.              | 606.0  | 4303 | 6969  | 13. x.  | 0.0   | 0    | 0    |
| 5. viii.              | 423.0  | 3003 | 4864  | 14. x.  | 329.5 | 2339 | 3879 |
| 6. viii.              | 596.7  | 4237 | 6862  | 15. x.  | 64.8  | 460  | 745  |
| 7. viii.              | 584.0  | 4146 | 6716  | 16. x.  | 504.8 | 3584 | 5805 |
| 8. viii.              | 720.5  | 5116 | 8286  | 17. x.  | 0.0   | 0    | 0    |
| 9. viii.              | 852.0  | 6049 | 9798  | 18. x.  | 401.8 | 2853 | 4621 |
| 10. viii.             | 500.5  | 3554 | 5756  | 19. x.  | 119.0 | 845  | 1369 |
| 11. viii.             | 678.0  | 4814 | 7797  | 20. x.  | 0.0   | 0    | 0    |
| 12. viii.             | 696.0  | 4942 | 8004  | 21. x.  | 0.0   | 0    | 0    |
| 13. viii.             | 661.5  | 4697 | 7507  | 22. x.  | 271.4 | 1927 | 3121 |
| 14. viii.             | 553.7  | 3931 | 6368  | 23. x.  | 474.5 | 3369 | 5457 |
| 15. viii.             | 627.0  | 4452 | 7211  | 24. x.  | 0.0   | 0    | 0    |
| 16. viii.             | 491.2  | 3488 | 5649  | 25. x.  | 0.0   | 0    | 0    |
| 17. viii.             | 512.0  | 3635 | 5888  |         |       |      |      |

Table 146. Amount of leaves eaten by *Phraortes kumamotoensis* No. 61 in larval and adult stages.

| Date     | V      | O    | W     | Date      | V     | O    | W     |
|----------|--------|------|-------|-----------|-------|------|-------|
| 11. vi.  | 232.0  | 1647 | 2668  | 4. viii.  | 511.0 | 3628 | 5877  |
| 12. vi.  | 349.0  | 2477 | 4014  | 5. viii.  | 564.0 | 4004 | 6486  |
| 13. vi.  | 154.0  | 1093 | 1771  | 6. viii.  | 740.6 | 5258 | 8517  |
| 14. vi.  | 204.5  | 1452 | 2352  | 7. viii.  | 554.0 | 3933 | 6371  |
| 15. vi.  | 0.0    | 0    | 0     | 8. viii.  | 448.7 | 3186 | 5160  |
| 16. vi.  | 33.3   | 236  | 388   | 9. viii.  | 936.0 | 6446 | 10764 |
| 17. vi.  | 402.0  | 2854 | 4623  | 10. viii. | 345.6 | 2454 | 3974  |
| 18. vi.  | 511.0  | 3628 | 5877  | 11. viii. | 359.5 | 2552 | 4134  |
| 19. vi.  | 480.5  | 3412 | 5526  | 12. viii. | 782.0 | 5552 | 8993  |
| 20. vi.  | 581.0  | 4125 | 6682  | 13. viii. | 610.0 | 4331 | 7015  |
| 21. vi.  | 461.5  | 3277 | 5307  | 14. viii. | 821.5 | 5833 | 9447  |
| 22. vi.  | 761.8  | 5409 | 8761  | 15. viii. | 284.0 | 2016 | 3266  |
| 23. vi.  | 215.0  | 1527 | 2473  | 16. viii. | 605.4 | 4298 | 6962  |
| 24. vi.  | 365.4  | 2594 | 4202  | 17. viii. | 726.6 | 5159 | 8356  |
| 25. vi.  | 569.3  | 4042 | 6547  | 18. viii. | 389.0 | 2762 | 4474  |
| 26. vi.  | 296.0  | 2102 | 3404  | 19. viii. | 456.0 | 3238 | 5244  |
| 27. vi.  | 0.0    | 0    | 0     | 20. viii. | 585.0 | 4154 | 6728  |
| 28. vi.  | 0.0    | 0    | 0     | 21. viii. | 768.7 | 5458 | 8840  |
| 29. vi.  | 110.0  | 781  | 1265  | 22. viii. | 547.5 | 3887 | 6296  |
| 30. vi.  | 724.6  | 5145 | 8333  | 23. viii. | 731.0 | 5190 | 8407  |
| 1. vii.  | 569.5  | 4043 | 6549  | 24. viii. | 452.0 | 3209 | 5198  |
| 2. vii.  | 709.0  | 5034 | 8154  | 25. viii. | 454.8 | 3229 | 5230  |
| 3. vii.  | 419.2  | 2976 | 4821  | 26. viii. | 236.0 | 1676 | 2714  |
| 4. vii.  | 531.0  | 3770 | 6107  | 27. viii. | 690.0 | 4899 | 7935  |
| 5. vii.  | 767.7  | 5451 | 8829  | 28. viii. | 484.4 | 3439 | 5571  |
| 6. vii.  | 702.5  | 4988 | 8079  | 29. viii. | 550.6 | 3909 | 6332  |
| 7. vii.  | 588.8  | 4180 | 6771  | 30. viii. | 246.0 | 1747 | 2829  |
| 8. vii.  | 612.7  | 4350 | 7046  | 31. viii. | 784.0 | 5566 | 9016  |
| 9. vii.  | 535.2  | 3800 | 6155  | 1. ix.    | 511.5 | 3652 | 5882  |
| 10. vii. | 445.0  | 3160 | 5118  | 2. ix.    | 460.0 | 3266 | 5290  |
| 11. vii. | 591.0  | 4196 | 6797  | 3. ix.    | 456.0 | 3238 | 5244  |
| 12. vii. | 1120.0 | 7952 | 12880 | 4. ix.    | 234.8 | 1667 | 2700  |
| 13. vii. | 587.6  | 4172 | 6757  | 5. ix.    | 469.2 | 3331 | 5396  |
| 14. vii. | 478.5  | 3397 | 5503  | 6. ix.    | 601.0 | 4267 | 6912  |
| 15. vii. | 1024.0 | 7270 | 11776 | 7. ix.    | 69.5  | 493  | 799   |

|          |        |      |       |         |       |      |      |
|----------|--------|------|-------|---------|-------|------|------|
| 16. vii. | 1028.1 | 7300 | 11823 | 8. ix.  | 328.5 | 2332 | 3778 |
| 17. vii. | 644.7  | 4577 | 4714  | 9. ix.  | 747.0 | 5304 | 8591 |
| 18. vii. | 741.0  | 5261 | 8522  | 10. ix. | 624.0 | 4558 | 7383 |
| 19. vii. | 1360.4 | 9659 | 15645 | 11. ix. | 400.8 | 2846 | 4609 |
| 20. vii. | 1307.5 | 9283 | 15036 | 12. ix. | 221.5 | 1573 | 2547 |
| 21. vii. | 1046.0 | 7427 | 12029 | 13. ix. | 501.0 | 3557 | 5762 |
| 22. vii. | 792.0  | 5623 | 9108  | 14. ix. | 423.3 | 3005 | 4868 |
| 23. vii. | 842.8  | 5984 | 9692  | 15. ix. | 432.7 | 3072 | 4976 |
| 24. vii. | 747.0  | 5304 | 8591  | 16. ix. | 164.0 | 1164 | 1886 |
| 25. vii. | 444.7  | 3157 | 5114  | 17. ix. | 388.8 | 2760 | 4471 |
| 26. vii. | 605.3  | 4298 | 6961  | 18. ix. | 469.0 | 3330 | 5394 |
| 27. vii. | 577.0  | 4097 | 6636  | 19. ix. | 587.0 | 4168 | 6751 |
| 28. vii. | 700.5  | 4974 | 8056  | 20. ix. | 510.0 | 3621 | 5865 |
| 29. vii. | 422.0  | 2996 | 4853  | 21. ix. | 523.4 | 3716 | 6019 |
| 30. vii. | 654.7  | 4648 | 7529  | 22. ix. | 205.5 | 1459 | 2363 |
| 31. vii. | 891.6  | 6330 | 10253 | 23. ix. | 406.0 | 2883 | 4669 |
| 1. viii. | 869.0  | 6170 | 9994  | 24. ix. | 159.2 | 1130 | 1831 |
| 2. viii. | 561.0  | 3983 | 6452  | 25. ix. | 76.0  | 540  | 874  |
| 3. viii. | 741.4  | 5264 | 8526  | 26. ix. | 215.0 | 1527 | 2473 |

Table 147. Amount of leaves eaten by *Phraortes kumamotoensis* No. 62 in larval and adult stages.

| Date    | V     | O    | W    | Date      | V      | O    | W     |
|---------|-------|------|------|-----------|--------|------|-------|
| 12. vi. | 115.0 | 817  | 1323 | 29. viii. | 580.0  | 4118 | 6670  |
| 13. vi. | 28.4  | 202  | 327  | 30. viii. | 836.0  | 5936 | 9614  |
| 14. vi. | 77.0  | 547  | 886  | 31. viii. | 825.8  | 5863 | 9496  |
| 15. vi. | 178.2 | 1265 | 2049 | 1. ix.    | 1054.6 | 7488 | 12127 |
| 16. vi. | 146.0 | 1037 | 1679 | 2. ix.    | 697.0  | 4949 | 8016  |
| 17. vi. | 149.5 | 1061 | 1719 | 3. ix.    | 609.2  | 4325 | 7006  |
| 18. vi. | 132.5 | 941  | 1524 | 4. ix.    | 447.4  | 3177 | 5145  |
| 19. vi. | 80.0  | 568  | 920  | 5. ix.    | 119.0  | 845  | 1369  |
| 20. vi. | 0.0   | 0    | 0    | 6. ix.    | 602.0  | 4274 | 6923  |
| 21. vi. | 0.0   | 0    | 0    | 7. ix.    | 298.0  | 2116 | 3427  |
| 22. vi. | 161.4 | 1146 | 1856 | 8. ix.    | 544.5  | 3866 | 6262  |
| 23. vi. | 189.0 | 1342 | 2174 | 9. ix.    | 693.5  | 4924 | 7975  |
| 24. vi. | 359.6 | 2553 | 4135 | 10. ix.   | 601.6  | 4271 | 6918  |
| 25. vi. | 211.5 | 1502 | 2432 | 11. ix.   | 489.3  | 3474 | 5627  |

|          |        |      |       |         |       |      |      |
|----------|--------|------|-------|---------|-------|------|------|
| 26. vi.  | 195.0  | 1385 | 2243  | 12. ix. | 445.0 | 3160 | 5118 |
| 27. vi.  | 248.8  | 1766 | 2861  | 13. ix. | 674.0 | 4785 | 7751 |
| 28. vi.  | 278.8  | 1979 | 3206  | 14. ix. | 547.1 | 3884 | 6292 |
| 29. vi.  | 231.0  | 1640 | 2657  | 15. ix. | 365.2 | 2593 | 4200 |
| 30. vi.  | 233.0  | 1654 | 2680  | 16. ix. | 576.0 | 4090 | 6624 |
| 1. vii.  | 0.0    | 0    | 0     | 17. ix. | 529.4 | 3759 | 6088 |
| 2. vii.  | 0.0    | 0    | 0     | 18. ix. | 382.3 | 2714 | 4396 |
| 3. vii.  | 170.6  | 1211 | 1962  | 19. ix. | 120.5 | 856  | 1386 |
| 4. vii.  | 221.5  | 1573 | 2547  | 20. ix. | 405.7 | 2880 | 4666 |
| 5. vii.  | 350.6  | 2489 | 4032  | 21. ix. | 641.0 | 4551 | 7372 |
| 6. vii.  | 462.0  | 3280 | 5313  | 22. ix. | 788.2 | 5596 | 9064 |
| 7. vii.  | 316.0  | 2244 | 3634  | 23. ix. | 537.4 | 3816 | 6180 |
| 8. vii.  | 652.4  | 4632 | 7503  | 24. ix. | 482.1 | 3423 | 5544 |
| 9. vii.  | 1108.2 | 7868 | 12744 | 25. ix. | 434.0 | 3081 | 4991 |
| 10. vii. | 424.0  | 3010 | 4876  | 26. ix. | 415.6 | 2951 | 4779 |
| 11. vii. | 452.8  | 3215 | 5207  | 27. ix. | 511.0 | 3628 | 5877 |
| 12. vii. | 93.3   | 662  | 1073  | 28. ix. | 116.0 | 824  | 1334 |
| 13. vii. | 0.0    | 0    | 0     | 29. ix. | 473.8 | 3364 | 5449 |
| 14. vii. | 471.2  | 3346 | 5419  | 30. ix. | 296.0 | 2102 | 3404 |
| 15. vii. | 487.0  | 3458 | 5600  | 1. x.   | 431.5 | 3064 | 4962 |
| 16. vii. | 1098.7 | 7801 | 12635 | 2. x.   | 410.4 | 2914 | 4720 |
| 17. vii. | 670.0  | 4757 | 7705  | 3. x.   | 580.6 | 4122 | 6677 |
| 18. vii. | 488.0  | 3465 | 5612  | 4. x.   | 450.3 | 3197 | 5178 |
| 19. vii. | 1039.5 | 7380 | 11954 | 5. x.   | 429.7 | 3051 | 4942 |
| 20. vii. | 759.5  | 5392 | 8734  | 6. x.   | 261.2 | 1855 | 3004 |
| 21. vii. | 1325.6 | 9412 | 15244 | 7. x.   | 554.0 | 3933 | 6371 |
| 22. vii. | 1081.4 | 7678 | 12436 | 8. x.   | 391.4 | 2779 | 4501 |
| 23. vii. | 591.0  | 4196 | 6797  | 9. x.   | 357.0 | 2535 | 4106 |
| 24. vii. | 1054.7 | 7488 | 12129 | 10. x.  | 0.0   | 0    | 0    |
| 25. vii. | 558.8  | 3967 | 6426  | 11. x.  | 331.0 | 2350 | 3807 |
| 26. vii. | 575.8  | 4088 | 6622  | 12. x.  | 397.0 | 2819 | 4566 |
| 27. vii. | 702.0  | 4984 | 8073  | 13. x.  | 344.5 | 2446 | 3962 |
| 28. vii. | 438.0  | 3110 | 5037  | 14. x.  | 121.5 | 863  | 1397 |
| 29. vii. | 895.0  | 6354 | 10292 | 15. x.  | 405.5 | 2879 | 4663 |
| 30. vii. | 442.4  | 3141 | 5088  | 16. x.  | 346.4 | 2459 | 3984 |
| 31. vii. | 638.0  | 4530 | 7337  | 17. x.  | 289.0 | 2052 | 3324 |
| 1. viii. | 770.5  | 5471 | 8861  | 18. x.  | 314.3 | 2232 | 3614 |
| 2. viii. | 928.2  | 6590 | 10664 | 19. x.  | 316.2 | 2245 | 3636 |
| 3. viii. | 644.0  | 4572 | 7406  | 20. x.  | 348.0 | 2471 | 4002 |

|           |       |      |       |         |       |      |      |
|-----------|-------|------|-------|---------|-------|------|------|
| 4. viii.  | 532.0 | 3777 | 6118  | 21. x.  | 349.0 | 2478 | 4014 |
| 5. viii.  | 502.7 | 3669 | 5781  | 22. x.  | 0.0   | 0    | 0    |
| 6. viii.  | 877.3 | 6229 | 10089 | 23. x.  | 321.6 | 2283 | 3698 |
| 7. viii.  | 565.0 | 4112 | 6497  | 24. x.  | 350.7 | 2490 | 4033 |
| 8. viii.  | 676.0 | 4800 | 7774  | 25. x.  | 0.0   | 0    | 0    |
| 9. viii.  | 500.0 | 3550 | 5750  | 26. x.  | 350.0 | 2485 | 4025 |
| 10. viii. | 700.4 | 4973 | 8055  | 27. x.  | 217.8 | 1546 | 2505 |
| 11. viii. | 624.3 | 4433 | 7179  | 28. x.  | 257.2 | 1826 | 2958 |
| 12. viii. | 720.0 | 5112 | 8280  | 29. x.  | 0.0   | 0    | 0    |
| 13. viii. | 551.2 | 3914 | 6339  | 30. x.  | 312.0 | 2215 | 3588 |
| 14. viii. | 834.0 | 5921 | 9591  | 31. x.  | 474.4 | 3368 | 5456 |
| 15. viii. | 605.5 | 4299 | 6963  | 1. xi.  | 103.0 | 731  | 1186 |
| 16. viii. | 665.0 | 4722 | 7648  | 2. xi.  | 220.3 | 1564 | 2533 |
| 17. viii. | 458.3 | 3254 | 5270  | 3. xi.  | 123.9 | 880  | 1425 |
| 18. viii. | 642.0 | 4558 | 7383  | 4. xi.  | 85.6  | 608  | 984  |
| 19. viii. | 728.2 | 5170 | 8374  | 5. xi.  | 286.0 | 2031 | 3289 |
| 20. viii. | 568.0 | 4033 | 6533  | 6. xi.  | 63.0  | 447  | 725  |
| 21. viii. | 761.5 | 5407 | 8757  | 7. xi.  | 69.4  | 492  | 798  |
| 22. viii. | 546.0 | 3877 | 6279  | 8. xi.  | 165.0 | 1172 | 1898 |
| 23. viii. | 732.0 | 5197 | 8418  | 9. xi.  | 149.0 | 1058 | 1714 |
| 24. viii. | 906.0 | 6433 | 10419 | 10. xi. | 204.0 | 1448 | 2346 |
| 25. viii. | 0.0   | 0    | 0     | 11. xi. | 48.6  | 345  | 559  |
| 26. viii. | 766.4 | 5441 | 8814  | 12. xi. | 172.0 | 1221 | 1978 |
| 27. viii. | 459.7 | 3264 | 5287  | 13. xi. | 98.5  | 709  | 1133 |
| 28. viii. | 489.3 | 3474 | 5629  | 14. xi. | 179.4 | 1274 | 2063 |

Table 148. Amount of leaves eaten by *Phraortes kumamotoensis* No. 64 in larval and adult stages.

| Date    | V     | O    | W    | Date      | V     | O   | W    |
|---------|-------|------|------|-----------|-------|-----|------|
| 11. vi. | 286.0 | 2031 | 3288 | 30. viii. | 116.4 | 826 | 1339 |
| 12. vi. | 345.2 | 2451 | 3970 | 31. viii. | 57.0  | 405 | 656  |
| 13. vi. | 308.5 | 2190 | 3548 | 1. ix.    | 72.5  | 515 | 834  |
| 14. vi. | 255.3 | 1813 | 2936 | 2. ix.    | 51.3  | 364 | 590  |
| 15. vi. | 198.0 | 1406 | 2277 | 3. ix.    | 50.0  | 355 | 575  |
| 16. vi. | 231.0 | 1640 | 2657 | 4. ix.    | 113.4 | 805 | 1303 |
| 17. vi. | 171.3 | 1216 | 1970 | 5. ix.    | 56.6  | 402 | 651  |
| 18. vi. | 152.0 | 1079 | 1748 | 6. ix.    | 43.7  | 310 | 503  |

|          |       |      |      |         |       |     |      |
|----------|-------|------|------|---------|-------|-----|------|
| 19. vi.  | 170.5 | 1211 | 1961 | 7. ix.  | 50.2  | 356 | 577  |
| 20. vi.  | 173.0 | 1228 | 1990 | 8. ix.  | 0.0   | 0   | 0    |
| 21. vi.  | 0.0   | 0    | 0    | 9. ix.  | 75.5  | 536 | 868  |
| 22. vi.  | 0.0   | 0    | 0    | 10. ix. | 85.0  | 604 | 978  |
| 23. vi.  | 0.0   | 0    | 0    | 11. ix. | 27.0  | 192 | 310  |
| 24. vi.  | 159.4 | 1132 | 1833 | 12. ix. | 35.0  | 249 | 403  |
| 25. vi.  | 148.0 | 1051 | 1702 | 13. ix. | 79.5  | 563 | 914  |
| 26. vi.  | 243.2 | 1727 | 2797 | 14. ix. | 67.4  | 479 | 775  |
| 27. vi.  | 189.5 | 1345 | 2179 | 15. ix. | 70.0  | 497 | 805  |
| 28. vi.  | 162.0 | 1150 | 1863 | 16. ix. | 64.5  | 458 | 742  |
| 29. vi.  | 116.0 | 814  | 1334 | 17. ix. | 62.0  | 433 | 702  |
| 30. vi.  | 310.5 | 2205 | 3571 | 18. ix. | 40.0  | 284 | 460  |
| 1. vii.  | 199.2 | 1414 | 2291 | 19. ix. | 65.5  | 465 | 753  |
| 2. vii.  | 172.0 | 1221 | 1978 | 20. ix. | 22.2  | 158 | 255  |
| 3. vii.  | 137.0 | 973  | 1576 | 21. xi. | 64.0  | 454 | 736  |
| 4. vii.  | 174.4 | 1238 | 1906 | 22. ix. | 22.0  | 156 | 253  |
| 5. vii.  | 137.0 | 973  | 1576 | 23. ix. | 76.4  | 542 | 879  |
| 6. vii.  | 168.5 | 1196 | 1938 | 24. ix. | 46.0  | 327 | 529  |
| 7. vii.  | 172.0 | 1221 | 1978 | 25. ix. | 51.3  | 364 | 590  |
| 8. vii.  | 166.5 | 1182 | 1915 | 26. ix. | 61.0  | 433 | 702  |
| 9. vii.  | 74.0  | 525  | 851  | 27. ix. | 23.5  | 167 | 270  |
| 10. vii. | 82.6  | 586  | 950  | 28. ix. | 29.0  | 206 | 334  |
| 11. vii. | 212.0 | 1505 | 2438 | 29. ix. | 56.5  | 401 | 650  |
| 12. vii. | 336.5 | 2389 | 3870 | 30. ix. | 31.0  | 220 | 357  |
| 13. vii. | 232.0 | 1647 | 2668 | 1. x.   | 29.0  | 206 | 334  |
| 14. vii. | 213.4 | 1515 | 2454 | 2. x.   | 23.0  | 163 | 265  |
| 15. vii. | 200.0 | 1420 | 2300 | 3. x.   | 105.0 | 746 | 1208 |
| 16. vii. | 146.5 | 1040 | 1685 | 4. x.   | 74.0  | 525 | 851  |
| 17. vii. | 141.0 | 1001 | 1622 | 5. x.   | 29.5  | 209 | 339  |
| 18. vii. | 194.6 | 1382 | 2238 | 6. x.   | 41.0  | 291 | 472  |
| 19. vii. | 163.0 | 1157 | 1875 | 7. x.   | 29.0  | 206 | 334  |
| 20. vii. | 189.0 | 1342 | 2174 | 8. x.   | 22.5  | 160 | 259  |
| 21. vii. | 150.6 | 1069 | 1732 | 9. x.   | 88.6  | 629 | 1019 |
| 22. vii. | 225.4 | 1600 | 2592 | 10. x.  | 64.0  | 454 | 736  |
| 23. vii. | 165.2 | 1173 | 1900 | 11. x.  | 63.7  | 452 | 733  |
| 24. vii. | 174.0 | 1235 | 2001 | 12. x.  | 50.0  | 355 | 575  |
| 25. vii. | 39.0  | 277  | 449  | 13. x.  | 38.6  | 274 | 444  |
| 26. vii. | 131.5 | 934  | 1512 | 14. x.  | 46.5  | 330 | 535  |
| 27. vii. | 86.0  | 611  | 989  | 15. x.  | 57.4  | 408 | 660  |

|           |       |      |      |         |       |     |      |
|-----------|-------|------|------|---------|-------|-----|------|
| 28. vii.  | 134.0 | 951  | 1441 | 16. x.  | 62.0  | 440 | 713  |
| 29. vii.  | 79.0  | 561  | 908  | 17. x.  | 47.8  | 339 | 550  |
| 30. vii.  | 77.5  | 550  | 891  | 18. x.  | 42.5  | 302 | 489  |
| 31. vii.  | 113.6 | 807  | 1306 | 19. x.  | 0.0   | 0   | 0    |
| 1. viii.  | 73.0  | 518  | 840  | 20. x.  | 0.0   | 0   | 0    |
| 2. viii.  | 102.5 | 728  | 1179 | 21. x.  | 21.0  | 149 | 242  |
| 3. viii.  | 104.0 | 738  | 1196 | 22. x.  | 29.0  | 206 | 334  |
| 4. viii.  | 85.0  | 604  | 978  | 23. x.  | 17.5  | 124 | 202  |
| 5. viii.  | 133.5 | 948  | 1535 | 24. x.  | 111.4 | 791 | 1281 |
| 6. viii.  | 93.0  | 660  | 1070 | 25. x.  | 0.0   | 0   | 0    |
| 7. viii.  | 63.5  | 451  | 730  | 26. x.  | 41.0  | 291 | 472  |
| 8. viii.  | 126.0 | 895  | 1449 | 27. x.  | 33.5  | 238 | 385  |
| 9. viii.  | 64.0  | 454  | 736  | 28. x.  | 48.0  | 341 | 552  |
| 10. viii. | 63.4  | 450  | 729  | 29. x.  | 42.0  | 298 | 483  |
| 11. viii. | 96.0  | 671  | 1104 | 30. x.  | 62.0  | 440 | 713  |
| 12. viii. | 59.0  | 419  | 679  | 31. x.  | 43.5  | 309 | 500  |
| 13. viii. | 79.0  | 561  | 909  | 1. xi.  | 42.5  | 302 | 489  |
| 14. viii. | 72.5  | 515  | 834  | 2. xi.  | 0.0   | 0   | 0    |
| 15. viii. | 122.0 | 866  | 1403 | 3. xi.  | 47.4  | 337 | 545  |
| 16. viii. | 131.0 | 930  | 1507 | 4. xi.  | 63.0  | 447 | 725  |
| 17. viii. | 78.7  | 559  | 905  | 5. xi.  | 23.0  | 163 | 265  |
| 18. viii. | 96.0  | 682  | 1104 | 6. xi.  | 14.5  | 103 | 167  |
| 19. viii. | 100.8 | 716  | 1159 | 7. xi.  | 35.6  | 253 | 409  |
| 20. viii. | 29.0  | 206  | 334  | 8. xi.  | 10.0  | 71  | 115  |
| 21. viii. | 123.6 | 878  | 1421 | 9. xi.  | 17.6  | 125 | 202  |
| 22. viii. | 70.0  | 497  | 805  | 10. xi. | 0.0   | 0   | 0    |
| 23. viii. | 113.5 | 806  | 1305 | 11. xi. | 0.0   | 0   | 0    |
| 24. viii. | 132.4 | 940  | 1523 | 12. xi. | 20.0  | 142 | 230  |
| 25. viii. | 115.0 | 817  | 1323 | 13. xi. | 23.5  | 167 | 270  |
| 26. viii. | 74.0  | 525  | 851  | 14. xi. | 29.6  | 210 | 340  |
| 27. viii. | 49.5  | 351  | 569  | 15. xi. | 12.4  | 88  | 143  |
| 28. viii. | 117.0 | 831  | 1346 | 16. xi. | 34.0  | 241 | 391  |
| 29. viii. | 152.0 | 1079 | 1748 | 17. xi. | 15.4  | 109 | 177  |

Table 149. Amount of leaves eaten by *Phraortes kumamotoensis* No. 66 in larval and adult stages.

| Date    | V     | O    | W    | Date      | V     | O    | W    |
|---------|-------|------|------|-----------|-------|------|------|
| 13. vi. | 323.0 | 2293 | 3715 | 27. viii. | 73.5  | 522  | 845  |
| 14. vi. | 122.5 | 870  | 1409 | 28. viii. | 157.0 | 1115 | 1806 |

|          |       |      |      |           |      |     |      |
|----------|-------|------|------|-----------|------|-----|------|
| 15. vi.  | 210.4 | 1494 | 2420 | 29. viii. | 78.0 | 554 | 897  |
| 16. vi.  | 290.0 | 2059 | 3335 | 30. viii. | 70.5 | 501 | 811  |
| 17. vi.  | 288.6 | 2049 | 3319 | 31. viii. | 72.6 | 515 | 835  |
| 18. vi.  | 228.5 | 1622 | 2628 | 1. ix.    | 62.4 | 443 | 718  |
| 19. vi.  | 45.7  | 324  | 526  | 2. ix.    | 43.0 | 305 | 495  |
| 20. vi.  | 0.0   | 0    | 0    | 3. ix.    | 50.1 | 356 | 576  |
| 21. vi.  | 0.0   | 0    | 0    | 4. ix.    | 90.0 | 639 | 1035 |
| 22. vi.  | 206.0 | 1463 | 2369 | 5. ix.    | 46.5 | 330 | 535  |
| 23. vi.  | 126.5 | 898  | 1455 | 6. ix.    | 15.0 | 107 | 173  |
| 24. vi.  | 287.0 | 2038 | 3301 | 7. ix.    | 29.4 | 209 | 338  |
| 25. vi.  | 194.5 | 1381 | 2237 | 8. ix.    | 41.0 | 291 | 472  |
| 26. vi.  | 247.3 | 1756 | 2844 | 9. ix.    | 84.3 | 599 | 969  |
| 27. vi.  | 214.5 | 1423 | 2467 | 10. ix.   | 50.0 | 355 | 575  |
| 28. vi.  | 185.6 | 1318 | 2134 | 11. ix.   | 74.6 | 530 | 858  |
| 29. vi.  | 231.5 | 1644 | 2662 | 12. ix.   | 80.3 | 570 | 923  |
| 30. vi.  | 151.0 | 1072 | 1737 | 13. ix.   | 60.0 | 426 | 690  |
| 1. vii.  | 265.0 | 1882 | 3048 | 14. ix.   | 46.5 | 330 | 535  |
| 2. vii.  | 83.4  | 592  | 959  | 15. ix.   | 0.0  | 0   | 0    |
| 3. vii.  | 97.6  | 693  | 1122 | 16. ix.   | 80.5 | 572 | 926  |
| 4. vii.  | 107.0 | 760  | 1231 | 17. xi.   | 42.8 | 304 | 492  |
| 5. vii.  | 135.5 | 962  | 1558 | 18. ix.   | 47.5 | 337 | 546  |
| 6. vii.  | 100.8 | 716  | 1159 | 19. ix.   | 69.0 | 490 | 794  |
| 7. vii.  | 175.0 | 1243 | 2013 | 20. ix.   | 45.7 | 324 | 526  |
| 8. vii.  | 260.0 | 1846 | 2990 | 21. ix.   | 58.0 | 412 | 668  |
| 9. vii.  | 124.3 | 883  | 1429 | 22. ix.   | 76.0 | 540 | 874  |
| 10. vii. | 37.6  | 267  | 432  | 23. ix.   | 63.5 | 451 | 730  |
| 11. vii. | 110.2 | 782  | 1267 | 24. ix.   | 0.0  | 0   | 0    |
| 12. vii. | 334.5 | 2375 | 3847 | 25. ix.   | 60.0 | 426 | 690  |
| 13. vii. | 160.0 | 1136 | 1840 | 26. ix.   | 46.0 | 327 | 529  |
| 14. vii. | 277.2 | 1968 | 3188 | 27. ix.   | 80.5 | 572 | 926  |
| 15. vii. | 294.0 | 2087 | 3381 | 28. ix.   | 0.0  | 0   | 0    |
| 16. vii. | 250.6 | 1779 | 2882 | 29. ix.   | 14.5 | 103 | 167  |
| 17. vii. | 202.8 | 1440 | 2332 | 30. ix.   | 71.0 | 504 | 817  |
| 18. vii. | 90.6  | 643  | 1042 | 1. x.     | 27.8 | 197 | 330  |
| 19. vii. | 162.4 | 1158 | 1868 | 2. x.     | 75.5 | 536 | 868  |
| 20. vii. | 103.0 | 731  | 1185 | 3. x.     | 31.6 | 224 | 363  |
| 21. vii. | 46.5  | 330  | 535  | 4. x.     | 58.0 | 412 | 668  |
| 22. vii. | 0.0   | 0    | 0    | 5. x.     | 56.7 | 403 | 662  |
| 23. vii. | 148.9 | 1057 | 1712 | 6. x.     | 40.0 | 284 | 460  |

|           |       |      |      |        |       |     |      |
|-----------|-------|------|------|--------|-------|-----|------|
| 24. vii.  | 71.0  | 504  | 817  | 7. x.  | 63.6  | 452 | 731  |
| 25. vii.  | 87.5  | 621  | 1006 | 8. x.  | 30.0  | 213 | 345  |
| 26. vii.  | 90.0  | 639  | 1035 | 9. x.  | 36.7  | 261 | 432  |
| 27. vii.  | 112.6 | 799  | 1295 | 10. x. | 112.4 | 798 | 1293 |
| 28. vii.  | 75.5  | 536  | 868  | 11. x. | 41.0  | 261 | 472  |
| 29. vii.  | 116.0 | 823  | 1334 | 12. x. | 39.5  | 280 | 454  |
| 30. vii.  | 188.0 | 1335 | 2162 | 13. x. | 68.5  | 486 | 788  |
| 31. vii.  | 93.0  | 660  | 1070 | 14. x. | 24.0  | 170 | 276  |
| 1. viii.  | 100.8 | 716  | 1159 | 15. x. | 50.0  | 355 | 575  |
| 2. viii.  | 54.9  | 390  | 631  | 16. x. | 70.0  | 497 | 805  |
| 3. viii.  | 141.0 | 1001 | 1622 | 17. x. | 45.0  | 320 | 518  |
| 4. viii.  | 131.5 | 934  | 1512 | 18. x. | 24.0  | 170 | 276  |
| 5. viii.  | 68.7  | 488  | 790  | 19. x. | 60.0  | 426 | 690  |
| 6. viii.  | 76.0  | 540  | 874  | 20. x. | 25.5  | 181 | 293  |
| 7. viii.  | 83.8  | 595  | 964  | 21. x. | 23.0  | 163 | 265  |
| 8. viii.  | 90.0  | 639  | 1035 | 22. x. | 40.0  | 284 | 460  |
| 9. viii.  | 86.5  | 614  | 995  | 23. x. | 22.0  | 156 | 253  |
| 10. viii. | 126.2 | 896  | 1451 | 24. x. | 114.5 | 813 | 1317 |
| 11. viii. | 75.1  | 533  | 864  | 25. x. | 0.0   | 0   | 0    |
| 12. viii. | 40.4  | 287  | 465  | 26. x. | 70.0  | 497 | 805  |
| 13. viii. | 101.0 | 717  | 1162 | 27. x. | 0.0   | 0   | 0    |
| 14. viii. | 63.2  | 499  | 727  | 28. x. | 43.0  | 305 | 495  |
| 15. viii. | 173.0 | 1228 | 1990 | 29. x. | 96.5  | 685 | 1110 |
| 16. viii. | 69.0  | 490  | 794  | 30. x. | 0.0   | 0   | 0    |
| 17. viii. | 104.5 | 742  | 1202 | 31. x. | 88.4  | 628 | 1017 |
| 18. viii. | 92.4  | 656  | 1063 | 1. xi. | 0.0   | 0   | 0    |
| 19. viii. | 74.0  | 525  | 851  | 2. xi. | 97.6  | 693 | 1122 |
| 20. viii. | 113.5 | 806  | 1305 | 3. xi. | 15.0  | 107 | 173  |
| 21. viii. | 98.2  | 697  | 1129 | 4. xi. | 23.7  | 168 | 273  |
| 22. viii. | 76.0  | 540  | 874  | 5. xi. | 40.5  | 288 | 466  |
| 23. viii. | 43.7  | 310  | 503  | 6. xi. | 32.0  | 227 | 368  |
| 24. viii. | 60.8  | 432  | 699  | 7. xi. | 12.0  | 85  | 138  |
| 25. viii. | 62.0  | 440  | 713  | 8. xi. | 40.7  | 289 | 468  |
| 26. viii. | 150.6 | 1069 | 1732 | 9. xi. | 22.0  | 156 | 253  |

Table 150. Amount of leaves eaten by *Phraortes kumamotoensis* No. 67 on larval and adult stages.

| Date     | V     | O    | W    | Date      | V     | O    | W    |
|----------|-------|------|------|-----------|-------|------|------|
| 11. vi.  | 242.0 | 1718 | 2783 | 20. vii.  | 282.0 | 2002 | 3243 |
| 12. vi.  | 259.5 | 1842 | 2984 | 21. vii.  | 112.0 | 795  | 1288 |
| 13. vi.  | 300.0 | 2130 | 3450 | 22. vii.  | 223.4 | 1586 | 2569 |
| 14. vi.  | 254.6 | 1807 | 2928 | 23. vii.  | 156.0 | 1108 | 1794 |
| 15. vi.  | 317.4 | 2254 | 3650 | 24. vii.  | 36.0  | 256  | 414  |
| 16. vi.  | 289.5 | 2055 | 3329 | 25. vii.  | 119.0 | 844  | 1368 |
| 17. vi.  | 232.0 | 1647 | 2668 | 26. vii.  | 112.3 | 797  | 1281 |
| 18. vi.  | 115.0 | 817  | 1323 | 27. vii.  | 96.0  | 682  | 1104 |
| 19. vi.  | 104.5 | 741  | 1201 | 28. vii.  | 62.8  | 446  | 722  |
| 20. vi.  | 0.0   | 0    | 0    | 29. vii.  | 123.0 | 873  | 1414 |
| 21. vi.  | 0.0   | 0    | 0    | 30. vii.  | 210.0 | 1491 | 2415 |
| 22. vi.  | 39.4  | 280  | 453  | 31. vii.  | 132.4 | 940  | 1523 |
| 23. vi.  | 96.0  | 693  | 1104 | 1. viii.  | 171.0 | 1214 | 1967 |
| 24. vi.  | 248.5 | 1764 | 2858 | 2. viii.  | 200.0 | 1420 | 2300 |
| 25. vi.  | 212.0 | 1505 | 2438 | 3. viii.  | 95.2  | 671  | 1095 |
| 26. vi.  | 299.0 | 2133 | 3439 | 4. viii.  | 38.2  | 271  | 439  |
| 27. vi.  | 271.3 | 1926 | 3120 | 5. viii.  | 92.0  | 653  | 1058 |
| 28. vi.  | 330.0 | 2343 | 3795 | 6. viii.  | 94.0  | 667  | 1081 |
| 29. vi.  | 189.7 | 1347 | 2182 | 7. viii.  | 91.5  | 650  | 1052 |
| 30. vi.  | 278.2 | 1975 | 3198 | 8. viii.  | 68.4  | 486  | 787  |
| 1. vii.  | 196.0 | 1392 | 2254 | 9. viii.  | 63.0  | 447  | 724  |
| 2. vii.  | 157.0 | 1114 | 1806 | 10. viii. | 71.5  | 508  | 822  |
| 3. vii.  | 120.0 | 852  | 1385 | 11. viii. | 100.6 | 704  | 1157 |
| 4. vii.  | 183.5 | 1303 | 2110 | 12. viii. | 106.0 | 752  | 1219 |
| 5. vii.  | 162.5 | 1154 | 1869 | 13. viii. | 95.2  | 676  | 1095 |
| 6. vii.  | 152.0 | 1079 | 1748 | 14. viii. | 54.0  | 383  | 621  |
| 7. vii.  | 120.0 | 852  | 1385 | 15. viii. | 120.0 | 852  | 1380 |
| 8. vii.  | 185.0 | 1314 | 2128 | 16. viii. | 84.0  | 596  | 966  |
| 9. vii.  | 142.2 | 1010 | 1635 | 17. viii. | 133.5 | 948  | 1535 |
| 10. vii. | 48.0  | 341  | 552  | 18. viii. | 68.0  | 483  | 782  |
| 11. vii. | 211.5 | 1502 | 2432 | 19. viii. | 118.0 | 838  | 1357 |
| 12. vii. | 323.0 | 2293 | 3715 | 20. viii. | 40.5  | 288  | 466  |
| 13. vii. | 70.0  | 497  | 805  | 21. viii. | 104.0 | 738  | 1196 |
| 14. vii. | 188.0 | 1335 | 2162 | 22. viii. | 146.0 | 1036 | 1779 |
| 15. vii. | 193.3 | 1372 | 2213 | 23. viii. | 0.0   | 0    | 0    |
| 16. vii. | 210.0 | 1491 | 2415 | 24. viii. | 40.0  | 284  | 460  |
| 17. vii. | 233.1 | 1655 | 2680 | 25. viii. | 98.5  | 699  | 1133 |
| 18. vii. | 185.0 | 1313 | 2127 | 26. viii. | 24.2  | 172  | 278  |
| 19. vii. | 161.0 | 1143 | 1852 |           |       |      |      |

Table 151. Amount of leaves eaten by *Phraortes kumamotoensis* No. 68 in larval and adult stages.

| Date     | V     | O    | W    | Date    | V     | O   | W    |
|----------|-------|------|------|---------|-------|-----|------|
| 11. vi.  | 0.0   | 0    | 0    | 5. ix.  | 25.4  | 180 | 292  |
| 12. vi.  | 346.1 | 2457 | 3980 | 6. ix.  | 68.3  | 485 | 785  |
| 13. vi.  | 119.2 | 846  | 1371 | 7. ix.  | 28.0  | 199 | 322  |
| 14. vi.  | 155.3 | 1316 | 1797 | 8. ix.  | 63.0  | 447 | 723  |
| 15. vi.  | 132.0 | 937  | 1518 | 9. ix.  | 88.5  | 628 | 1118 |
| 16. vi.  | 251.0 | 1782 | 2887 | 10. ix. | 10.0  | 71  | 115  |
| 17. vi.  | 275.4 | 1955 | 3167 | 11. ix. | 8.2   | 58  | 94   |
| 18. vi.  | 155.0 | 1100 | 1783 | 12. ix. | 56.0  | 398 | 644  |
| 19. vi.  | 210.2 | 1492 | 2417 | 13. ix. | 13.4  | 95  | 154  |
| 20. vi.  | 180.0 | 1278 | 2070 | 14. ix. | 75.5  | 536 | 868  |
| 21. vi.  | 61.0  | 433  | 702  | 15. ix. | 24.0  | 170 | 276  |
| 22. vi.  | 0.0   | 0    | 0    | 16. ix. | 60.0  | 426 | 690  |
| 23. vi.  | 0.0   | 0    | 0    | 17. ix. | 50.5  | 359 | 581  |
| 24. vi.  | 46.5  | 330  | 535  | 18. ix. | 42.7  | 303 | 491  |
| 25. vi.  | 170.3 | 1209 | 1958 | 19. ix. | 20.0  | 142 | 230  |
| 26. vi.  | 211.0 | 1498 | 2427 | 20. ix. | 81.0  | 575 | 931  |
| 27. vi.  | 325.3 | 2310 | 3741 | 21. ix. | 45.0  | 319 | 518  |
| 28. vi.  | 182.0 | 1292 | 2093 | 22. ix. | 39.5  | 280 | 454  |
| 29. vi.  | 200.0 | 1420 | 2300 | 23. ix. | 76.0  | 540 | 874  |
| 30. vi.  | 244.0 | 1732 | 2706 | 24. ix. | 34.6  | 246 | 398  |
| 1. vii.  | 288.5 | 2049 | 3318 | 25. ix. | 35.0  | 249 | 403  |
| 2. vii.  | 179.0 | 1271 | 2059 | 26. ix. | 107.5 | 763 | 1236 |
| 3. vii.  | 90.0  | 639  | 1035 | 27. ix. | 76.0  | 540 | 874  |
| 4. vii.  | 127.7 | 907  | 1469 | 28. ix. | 35.0  | 249 | 403  |
| 5. vii.  | 173.5 | 1232 | 1995 | 29. ix. | 47.7  | 339 | 549  |
| 6. vii.  | 130.0 | 923  | 1495 | 30. ix. | 70.0  | 497 | 1005 |
| 7. vii.  | 164.0 | 1164 | 1886 | 1. x.   | 25.5  | 181 | 293  |
| 8. vii.  | 87.4  | 621  | 1005 | 2. x.   | 67.4  | 479 | 775  |
| 9. vii.  | 153.0 | 1086 | 1759 | 3. x.   | 90.0  | 639 | 1035 |
| 10. vii. | 66.0  | 469  | 559  | 4. x.   | 45.7  | 324 | 525  |
| 11. vii. | 186.0 | 1320 | 2119 | 5. x.   | 0.0   | 0   | 0    |
| 12. vii. | 139.7 | 992  | 1599 | 6. x.   | 68.5  | 486 | 787  |
| 13. vii. | 131.6 | 934  | 1513 | 7. x.   | 0.0   | 0   | 0    |
| 14. vii. | 215.0 | 1527 | 2473 | 8. x.   | 59.0  | 419 | 679  |
| 15. vii. | 183.6 | 1304 | 2111 | 9. x.   | 0.0   | 0   | 0    |

|           |       |      |      |         |      |     |     |
|-----------|-------|------|------|---------|------|-----|-----|
| 16. vii.  | 253.0 | 1796 | 2909 | 10. x.  | 52.0 | 369 | 598 |
| 17. vii.  | 37.4  | 266  | 430  | 11. x.  | 53.2 | 378 | 612 |
| 18. vii.  | 160.0 | 1136 | 1340 | 12. x.  | 49.5 | 351 | 569 |
| 19. vii.  | 148.0 | 1051 | 1702 | 13. x.  | 62.4 | 442 | 728 |
| 20. vii.  | 126.0 | 894  | 1450 | 14. x.  | 21.0 | 149 | 242 |
| 21. vii.  | 93.5  | 664  | 1075 | 15. x.  | 64.0 | 454 | 736 |
| 22. vii.  | 119.8 | 852  | 1378 | 16. x.  | 70.0 | 497 | 805 |
| 23. vii.  | 112.0 | 795  | 1288 | 17. x.  | 53.0 | 376 | 610 |
| 24. vii.  | 98.0  | 696  | 1127 | 18. x.  | 45.0 | 320 | 518 |
| 25. vii.  | 65.5  | 465  | 753  | 19. x.  | 0.0  | 0   | 0   |
| 26. vii.  | 131.0 | 930  | 1507 | 20. x.  | 46.0 | 327 | 529 |
| 27. vii.  | 92.6  | 657  | 1065 | 21. x.  | 34.0 | 241 | 391 |
| 28. vii.  | 56.5  | 401  | 650  | 22. x.  | 0.0  | 0   | 0   |
| 29. vii.  | 78.0  | 554  | 897  | 23. x.  | 46.5 | 330 | 535 |
| 30. vii.  | 135.5 | 962  | 1558 | 24. x.  | 0.0  | 0   | 0   |
| 31. vii.  | 121.0 | 859  | 1392 | 25. x.  | 33.0 | 234 | 380 |
| 1. viii.  | 57.0  | 405  | 656  | 26. x.  | 64.5 | 458 | 742 |
| 2. viii.  | 94.5  | 671  | 1087 | 27. x.  | 45.3 | 321 | 521 |
| 3. viii.  | 108.0 | 767  | 1242 | 28. x.  | 34.0 | 241 | 391 |
| 4. viii.  | 109.8 | 780  | 1263 | 29. x.  | 59.5 | 422 | 684 |
| 5. viii.  | 56.8  | 403  | 653  | 30. x.  | 0.0  | 0   | 0   |
| 6. viii.  | 75.0  | 533  | 863  | 31. x.  | 0.0  | 0   | 0   |
| 7. viii.  | 83.0  | 589  | 955  | 1. xi.  | 44.0 | 312 | 506 |
| 8. viii.  | 119.5 | 848  | 1374 | 2. xi.  | 65.5 | 465 | 753 |
| 9. viii.  | 100.0 | 710  | 1150 | 3. xi.  | 23.0 | 163 | 265 |
| 10. viii. | 84.0  | 596  | 966  | 4. xi.  | 44.0 | 312 | 506 |
| 11. viii. | 89.6  | 636  | 1030 | 5. xi.  | 26.5 | 188 | 305 |
| 12. viii. | 58.0  | 412  | 667  | 6. xi.  | 25.0 | 178 | 288 |
| 13. viii. | 137.5 | 976  | 1581 | 7. xi.  | 0.0  | 0   | 0   |
| 14. viii. | 51.0  | 362  | 587  | 8. xi.  | 0.0  | 0   | 0   |
| 15. viii. | 87.0  | 618  | 1001 | 9. xi.  | 15.0 | 107 | 173 |
| 16. viii. | 104.0 | 738  | 1196 | 10. xi. | 40.5 | 288 | 466 |
| 17. viii. | 0.0   | 0    | 0    | 11. xi. | 35.0 | 249 | 403 |
| 18. viii. | 61.5  | 437  | 707  | 12. xi. | 46.0 | 327 | 529 |
| 19. viii. | 39.0  | 277  | 448  | 13. xi. | 22.0 | 156 | 253 |
| 20. viii. | 79.0  | 561  | 909  | 14. xi. | 20.0 | 142 | 230 |
| 21. viii. | 94.5  | 671  | 1087 | 15. xi. | 37.5 | 266 | 431 |
| 22. viii. | 86.3  | 613  | 882  | 16. xi. | 19.0 | 135 | 219 |
| 23. viii. | 178.0 | 1264 | 2047 | 17. xi. | 16.0 | 114 | 184 |

|           |       |     |      |         |      |     |     |
|-----------|-------|-----|------|---------|------|-----|-----|
| 24. viii. | 60.0  | 426 | 690  | 18. xi. | 50.0 | 355 | 575 |
| 25. viii. | 10.5  | 75  | 121  | 19. xi. | 16.0 | 114 | 184 |
| 26. viii. | 25.0  | 178 | 288  | 20. xi. | 30.0 | 213 | 345 |
| 27. viii. | 59.2  | 420 | 681  | 21. xi. | 32.6 | 231 | 375 |
| 28. viii. | 37.7  | 268 | 434  | 22. xi. | 0.0  | 0   | 0   |
| 29. viii. | 80.0  | 568 | 920  | 23. xi. | 0.0  | 0   | 0   |
| 30. viii. | 95.2  | 676 | 1095 | 24. xi. | 50.0 | 355 | 575 |
| 31. viii. | 18.4  | 131 | 212  | 25. x.  | 0.0  | 0   | 0   |
| 1. ix.    | 41.0  | 291 | 472  | 26. xi. | 0.0  | 0   | 0   |
| 2. ix.    | 70.0  | 497 | 1005 | 27. xi. | 0.0  | 0   | 0   |
| 3. ix.    | 111.5 | 792 | 1282 | 28. xi. | 15.0 | 107 | 173 |
| 4. ix.    | 96.0  | 682 | 1104 | 29. xi. | 28.5 | 202 | 327 |

## Observations

The data derived from the two series of experiments may be classified as in the following tables. In these tables the following new abbreviations are added.

Va : Average volume of the leaf in mm<sup>3</sup> eaten per day by an insect.

Oa : (Organic matter contents in mg in Va)  $\times 10^6$ .

Wa : (Water contents in mg in Va)  $\times 10^6$ .

Table 152. Food consumption of the experimental insect No. 59, ♀.

| Instar or division    | $\Sigma V$ | Va    | $\Sigma O$ | Oa     | $\Sigma W$ | Wa     |
|-----------------------|------------|-------|------------|--------|------------|--------|
| Instar V              | 1686.1     | 210.7 | 11972      | 1496.5 | 19391      | 2423.7 |
| VI                    | 3752.6     | 312.7 | 26644      | 2223.0 | 43156      | 3596.3 |
| Adult                 | 45594.7    | 353.4 | 385793     | 2990.6 | 543649     | 4214.3 |
| Preoviposition period | 4616.8     | 512.9 | 32780      | 3643.3 | 53093      | 5899.2 |
| Division I (20 days)  |            | 630.7 |            | 4477.8 |            | 7228.2 |
| II (20 days)          |            | 415.3 |            | 2948.9 |            | 4776.5 |
| III (20 days)         |            | 400.5 |            | 2861.3 |            | 4608.6 |
| IV (20 days)          |            | 327.4 |            | 2325.0 |            | 3771.0 |
| V (20 days)           |            | 203.3 |            | 1043.3 |            | 2393.4 |
| VI (20 days)          |            | 146.1 |            | 860.7  |            | 1393.6 |
| VII ( 8 days)         |            | 90.2  |            | 640.0  |            | 1037.1 |

Table 153. Food consumption of the experimental insect No. 60, ♀.

| Instar or division    | $\Sigma V$ | Va    | $\Sigma O$ | Oa     | $\Sigma W$ | Wa     |
|-----------------------|------------|-------|------------|--------|------------|--------|
| Instar V              | 2390.9     | 265.7 | 16976      | 1886.2 | 27497      | 3055.2 |
| VI                    | 4747.6     | 395.6 | 33708      | 2809.0 | 54499      | 4541.5 |
| Adult                 | 54442.2    | 481.7 | 286557     | 2358.9 | 625784     | 5537.9 |
| Preoviposition period | 7695.9     | 769.6 | 54640      | 5464.0 | 88604      | 8860.4 |
| Division I (20 days)  |            | 655.0 |            | 4660.7 |            | 7538.0 |
| II (20 days)          |            | 569.3 |            | 4042.5 |            | 6516.8 |
| III (20 days)         |            | 470.8 |            | 3342.9 |            | 5414.5 |
| IV (20 days)          |            | 379.1 |            | 2682.5 |            | 4364.5 |
| V (23 days)           |            | 224.3 |            | 1624.0 |            | 2630.4 |

Table 154. Food consumption of the experimental insect No. 61, ♀.

| Instar or division    | $\Sigma V$ | Va    | $\Sigma O$ | Oa     | $\Sigma W$ | Wa     |
|-----------------------|------------|-------|------------|--------|------------|--------|
| Instar VI             | 4676.8     | 425.2 | 32936      | 2994.1 | 53790      | 4890.0 |
| Adult                 | 51337.6    | 570.4 | 369430     | 4104.7 | 585643     | 6507.1 |
| Preoviposition period | 5735.0     | 573.5 | 40718      | 4071.8 | 65954      | 6595.4 |
| Division I (20 days)  |            | 780.9 |            | 5799.5 |            | 8980.6 |
| II (20 days)          |            | 621.2 |            | 4402.0 |            | 7146.4 |
| III (20 days)         |            | 505.4 |            | 3589.3 |            | 5561.9 |
| IV (20 days)          |            | 372.6 |            | 2649.6 |            | 4295.4 |

Table 155. Food consumption of the experimental insect No. 62, ♀.

| Instar or division    | $\Sigma V$ | Va    | $\Sigma O$ | Oa     | $\Sigma W$ | Wa     |
|-----------------------|------------|-------|------------|--------|------------|--------|
| Instar V              | 2108.1     | 234.2 | 14967      | 1663.0 | 24244      | 2693.7 |
| VI                    | 4251.4     | 425.1 | 30234      | 3023.4 | 48893      | 4889.3 |
| Adult                 | 59887.8    | 482.9 | 425424     | 3430.8 | 683097     | 5508.8 |
| Preoviposition period | 5013.9     | 716.2 | 35599      | 5085.5 | 57659      | 8237.0 |
| Division I (20 days)  |            | 714.9 |            | 5085.9 |            | 8221.1 |
| II (20 days)          |            | 616.9 |            | 4380.0 |            | 6812.9 |
| III (20 days)         |            | 566.8 |            | 4021.9 |            | 6519.2 |
| IV (20 days)          |            | 436.5 |            | 3099.3 |            | 5020.0 |
| V (20 days)           |            | 270.8 |            | 1922.9 |            | 3114.9 |
| VI (17 days)          |            | 161.9 |            | 1150.7 |            | 1863.5 |

Table 156. Food consumption of the experimental insect No. 64, ♂.

| Instar or division   | $\Sigma V$ | Va    | $\Sigma O$ | Oa     | $\Sigma W$ | Wa     |
|----------------------|------------|-------|------------|--------|------------|--------|
| Instar V             | 2290.8     | 229.1 | 16265      | 1626.5 | 26346      | 2634.6 |
| Adult                | 12450.4    | 84.7  | 92374      | 628.5  | 143070     | 973.2  |
| Division I (20 days) |            | 178.6 |            | 1274.7 |            | 2060.7 |
| II (20 days)         |            | 139.9 |            | 993.5  |            | 1604.4 |
| III (20 days)        |            | 89.5  |            | 835.0  |            | 1029.3 |
| IV (20 days)         |            | 77.6  |            | 550.9  |            | 892.4  |
| V (20 days)          |            | 49.8  |            | 353.1  |            | 575.9  |
| VI (20 days)         |            | 45.3  |            | 321.6  |            | 521.2  |
| VII (20 days)        |            | 34.7  |            | 241.9  |            | 391.9  |
| VIII ( 7 days)       |            | 19.3  |            | 136.7  |            | 221.5  |

Table 157. Food consumption of the experimental insect No. 66, ♂.

| Instar or division   | $\Sigma V$ | Va    | $\Sigma O$ | Oa     | $\Sigma W$ | Wa      |
|----------------------|------------|-------|------------|--------|------------|---------|
| Instar V             | 1218.0     | 174.0 | 10711      | 1530.1 | 17352      | 2478.8  |
| Adult                | 12310.6    | 87.3  | 87528      | 620.7  | 142920     | 11013.6 |
| Division I (20 days) |            | 166.5 |            | 1180.9 |            | 1920.7  |
| II (20 days)         |            | 145.2 |            | 1030.8 |            | 1669.9  |
| III (20 days)        |            | 93.3  |            | 662.3  |            | 1072.8  |
| IV (20 days)         |            | 70.2  |            | 498.7  |            | 807.7   |
| V (20 days)          |            | 49.7  |            | 353.4  |            | 572.4   |
| VI (20 days)         |            | 51.3  |            | 363.9  |            | 590.9   |
| VII (21 days)        |            | 39.3  |            | 281.2  |            | 511.4   |

Table 158. Food consumption of the experimental insect No. 67, ♂.

| Instar or division   | $\Sigma V$ | Va    | $\Sigma O$ | Oa     | $\Sigma W$ | Wa     |
|----------------------|------------|-------|------------|--------|------------|--------|
| Instar V             | 2114.5     | 234.9 | 15011      | 1667.8 | 24316      | 2701.7 |
| Adult                | 9187.4     | 139.2 | 65234      | 988.3  | 104744     | 1587.0 |
| Division I (20 days) |            | 182.1 |            | 1293.9 |            | 2044.5 |
| II (20 days)         |            | 161.4 |            | 1145.9 |            | 1855.2 |
| III (20 days)        |            | 95.2  |            | 675.3  |            | 1905.1 |
| IV ( 6 days)         |            | 68.7  |            | 488.1  |            | 807.6  |

Table 159. Food consumption of the experimental insect No. 68, ♂.

| Instar or division   | $\Sigma V$ | Va    | $\Sigma O$ | Oa     | $\Sigma W$ | Wa     |
|----------------------|------------|-------|------------|--------|------------|--------|
| Instar V             | 1886.2     | 188.6 | 13593      | 1359.3 | 21692      | 2169.2 |
| Adult                | 11664.0    | 72.9  | 80589      | 500.9  | 130718     | 817.0  |
| Division I (20 days) |            | 164.8 |            | 1169.9 |            | 1878.5 |
| II (20 days)         |            | 118.9 |            | 841.2  |            | 1367.4 |
| III (20 days)        |            | 81.2  |            | 576.3  |            | 933.5  |
| IV (20 days)         |            | 67.7  |            | 416.8  |            | 690.0  |
| V (20 days)          |            | 50.7  |            | 360.3  |            | 593.6  |
| VI (20 days)         |            | 44.0  |            | 312.6  |            | 506.9  |
| VI (20 days)         |            | 34.9  |            | 209.9  |            | 325.7  |
| VII (20 days)        |            | 20.9  |            | 148.3  |            | 240.1  |

In the experiments the duration of adult life was divided into several periods in order to investigate the change in nature of food consumption with the age. Each period consisted of 20 days except the last one and noted as the first division, second division, etc. In the case of the females the preoviposition period was excluded from such divisions, *i.e.* the date of the first oviposition was the start of the first division.

As is seen from the above tables it is clear that after the preoviposition period the amount of food eaten by each female has the tendency of decreasing towards the end of life. In the case of the males the same tendency was also clearly observed with the age after the emergence. This means that the longer is the life of the adult, the smaller is the average amount of food consumed per day. The percentage decrease of the food consumption with the age is summarized in the following table.

Table 160. Percentage decrease of the food consumption in the experimental insects with the age.

| No. | Sex | Ma (Maximum)          | Mi (Minimum)           | Decrease or<br>Ma-Mi(%) | Mean decrease<br>per period or<br>$\frac{Ma-Mi}{t.n.p.}$ |
|-----|-----|-----------------------|------------------------|-------------------------|----------------------------------------------------------|
| 59  | ♀   | 100 (P <sub>1</sub> ) | 14.6 (P <sub>7</sub> ) | 85.4                    | 12.2                                                     |
| 60  | ♀   | 100 (Pr)              | 29.1 (P <sub>5</sub> ) | 70.9                    | 14.1                                                     |
| 61  | ♀   | 100 (P <sub>1</sub> ) | 48.1 (P <sub>4</sub> ) | 51.1                    | 12.7                                                     |
| 62  | ♀   | 100 (Pr)              | 22.7 (P <sub>8</sub> ) | 77.3                    | 11.0                                                     |
| 64  | ♂   | 100 (P <sub>1</sub> ) | 10.8 (P <sub>3</sub> ) | 89.2                    | 11.1                                                     |
| 66  | ♂   | 100 (P <sub>1</sub> ) | 23.6 (P <sub>7</sub> ) | 76.4                    | 10.9                                                     |
| 67  | ♂   | 100 (P <sub>1</sub> ) | 37.7 (P <sub>4</sub> ) | 62.3                    | 15.5                                                     |
| 68  | ♂   | 100 (P <sub>1</sub> ) | 12.6 (P <sub>8</sub> ) | 87.4                    | 10.9                                                     |

P<sub>1</sub> : Period I Pr : Preoviposition period

t.n.p. : Total number of the periods.

This table indicates that the amount of food consumed by the insects was decreasing with successive periods at the rate of 10.9—15.5 per cent with an average of 12.3 per cent. Further the foregoing tables may suggest some important conclusions as given in the following lines. The amount of food eaten per day by a female in her preoviposition period is almost equal to, or slightly larger than, the total amount of food consumed in the third stadium of her larval life, and distinctly smaller than the same in the fourth stadium. In the male sex the amount of food consumed per day in his first period of adult life is almost equal to the total amount of food eaten in the first stadium of his larval life and is about one-fourth or one-fifth the average amount of food consumed per day during the preoviposition period of the female. The value  $\sum V$  in the preoviposition period is always larger than that in the last larval stage and approximately equal to the value of  $\sum V_5$  and  $\sum V_6$  taken together. This fact would indicate that an extremely large amount of food is necessary for the female during the preoviposition period in order to become mature and contrasts sharply with that obtained in the male. In the male the

value  $\Sigma V$  in the first period of adult life immediately after the last moult is always smaller than that of the preceding larval stage.

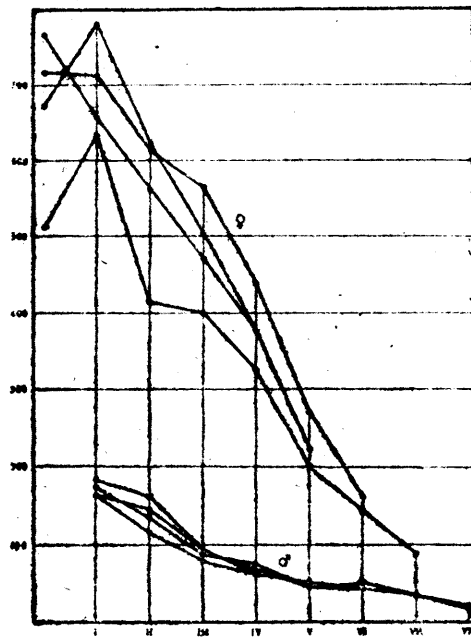


Fig. 47. Amount of leaves eaten by *Phraortes kumamotoensis* in the adult period.

## D. Discussions

### 1. Historical

In his excellent review of insect nutrition and metabolism UVAROV (1928) called attention to the fact that a very few points on these problems have been touched and the results achieved were but a drop compared with the ocean of unknown phenomena. Although the voluminous bibliography concerning nutrition tells us upon what plants or in what media insects may be found, with the assumption that these plants and media constitute food of them, very little is said of what actually is used by the insect for

food or the amount of food consumed by the insect for the completion of the post-embryonic growth, the maintenance of its metabolism and for the reproduction. As is well known, the works made by UVAROV (1928), CHAPMAN (1931) and HODGE IV (1933) cover the literature on the problem in question. Among Orthoptera the contributions of ZABINSKI (1928, 1929) and HODGE IV (1933) are excellent. The first author used *Periplaneta orientalis* and *Blattella germanica* (Blattidae) in his experiment, feeding them with such artificial foodstuffs as ovalbumin, gelatin, glycocoll, starch, saccharose, agar-agar and mineral salt (MCCOLLUM and SIMONDS) and reported the following conclusions. During approximately the first one-third of the post-embryonic period they grew equally rapidly on synthetic as on normal diets. The entire development cycle of the blackbeetle (*Periplaneta orientalis*) could not be completed on a synthetic diet. Blackbeetle larvae put on synthetic diets half-way through the growth period could attain sexual maturity. The cockroach (*Blattella germanica*) was able to complete its entire development cycle on a synthetic diet, even when the only nitrogenous constituent was glycine. The symptoms of avitaminosis, which appeared after the above-stated time, were lack of mobility and the appearance of a matt surface of the chitin envelope; should sexual maturity be attained, small dimensions and infertility were characteristic symptoms. Ovalbumine might be replaced by biologically deficient proteins such as gelatin, or even by glycine, without in any way affecting the character of growth. By diminishing the percentage nitrogen content in diets the rate of growth was distinctly diminished, but at the same time the period of its duration was prolonged. Blackbeetles and cockroaches were exceptionally resistant to the absence of nitrogenous constituents in their food, being able to maintain their body-weight over periods of time equal in length to that of the entire normal post-embryonic cycle. Even after prolonged inhibition of growth, the administration of a normal diet allowed these animals to resume growth and attain sexual maturity, including the production of normal young. The rate of growth of insects which had been given normal food after long periods of inhibition of growth was independent of the actual age of the insect, and corresponded to that which the animal had possessed at the commencement of the period of inhibition. These insects did not

survive long if fed upon exclusively protein diets, in the absence of carbohydrates. The addition of small quantity of butter, yeast, or vitamin B extracts to synthetic and complete diets did not lead to any enhancement of growth. The second author, HODGE IV, used *Melanoplus differentialis* (Acrididae). The preferences of the insect have been determined in the field, under natural conditions, to be tall ragweed, smartweed, corn, the clovers, etc., and he fed them with such plants as plantain, dandelion, wheat, rye, barley, oats and lettuce, either alone or as a mixtures of these and other leafy plants and got the following results. The relatively poor development, irregular growth, susceptibility to pathological conditions, and higher mortality of the insect on such restricted diets as lettuce or oat leaves alone indicated that such criteria can be used as indications of dietary deficiency in further experiments with various insufficient diets. The better development of the insect, as shown by general vigor, longevity, and fertility, on the diets of wheat, barley, or rye leaves alone, showed that such single plant diets were clearly sufficient and satisfactory diets for this species. The growth curves for the insects on four different satisfactory diets were all of the type similar to one another. The variation of the weight of the insects was apparently not correlated with any particular diet,

In 1938, J. K. DE JONG published the study of influence of the quality of the food on the egg production in *Helopeltis theivora*, *Epilachna* sp., *Tinolius eburneigutta* and *Diacrisia strigatula*. The differences of food in quality were obtained by taking leaves of different age, by selecting plants of the same species and by technical methods. Thus the foods were classified into five kinds, and the experiments were carried out. From his experiments the following results were obtained. When the quantity of the carbohydrates in the food diminished the fertility of the insects: 1) decreased in *Epilachna*, *Tinolius*, *Toxoptera*, 2) increased in *Diacrisia*, 3) increased, at first, then decreased in *Helopeltis* and *Diacrisia*. In this connection experiments of K. H. HEIL (1936) on *Carausius morosus* called attention to the fact that it is necessary to use standard test plants for the different standard test insects to ascertain average values for all the customary test plants in feeding experiments or in testing the action of some insecticides.

The separate nutritional studies of hormones, vitamins, other

similar chemical compounds or yeasts for insects constitute a great and important field of biological science from the viewpoint of biochemistry and physiology. But there is no reason to say that the study of total amount of food consumed by insects or of the cumulative effect of the above mentioned nutritional components, is of less important. DAVIS and SATTERTHWAIT (1916) made an excellent work on the American army worm, *Cirphis unipuncta*, to determine the total amount of food eaten by healthy larvae under different feeding conditions. Their feeding experiments, where exact records of the amount of corn foliage eaten in each instar were kept, are especially interesting and instructive, for it will be noticed that more than 80 per cent of all the foliage eaten during the entire life of the larva was consumed during the last larval instar, which corroborates previous field observations to the effect that army worms rarely become evident and destructive until they are nearly fullgrown. In their experiments three types of rearing cages, tin boxes, glass test tubes and lantern globes, were used. The tin-box cages were kept indoors, and the other two kinds of apparatus were kept on a latticed porch and were therefore under more nearly normal outdoor conditions. The average lengths of the different stages for individuals in the lantern-globe cages and in glass vials were noticeably longer than for individuals reared in the tin boxes. The length of the first five larval instars did not vary greatly one from the other, although the amount of the foliage eaten in each of these instars was a gradual increase from nearly 0.03 of a square inch for the first instar to over 5 square inches for the fifth instar. The period for the six larval instar was noticeably longer than in any of the previous instars, being approximately two and one-half times as long; and the amount of foliage eaten in this instar was nearly seven times as much as in the fifth instar, and more than 80 per cent of all of the foliage eaten during the entire larval period. This remarkable voracity of the army worm during its last larval instar explains its sudden appearance in such enormous and destructive numbers only when it is nearly fullgrown. From these observations, they made the following interesting considerations. At the time of the outbreak of this army worm the corn is 2 feet in height. MONTGOMERY has shown that mature corn plants have a foliage area of 927.8 to 1912.9 square inches. Corn

plants 2 feet in height would have at the most not more than one-twelfth the foliage area of a mature plant; hence, it can be said with comparative assurance that a corn plant such as was found in Michigan during the 1914 outbreak would have no more than 100 square inches of foliage. Since one larva would eat 41.4 square inches, it would require five larvae to devour two corn plants. With 8890 corn plants to an acre ( $2\frac{1}{2}$  plants to a hill and  $3\frac{1}{2}$  feet each way), it would require 21473 worms to destroy an acre of corn 2 feet in height. Although seemingly a large number of worms, this number represents only the progeny of probably not more than 40 females.

Table 161. Corn foliage eaten by the army worm in different instars (unit in square inches) (after DAVIS and SATTERTHWAIT, 1916).

| Instar | Foliage eaten | Rate of increase |
|--------|---------------|------------------|
| I      | 0.0294        | } 3.5            |
| II     | 0.103         |                  |
| III    | 0.338         | } 3.3            |
| IV     | 1.204         |                  |
| V      | 5.364         | } 3.6            |
| VI     | 34.128        |                  |
|        |               | } 4.6            |
|        |               |                  |
|        |               | } 6.3            |
|        |               |                  |

In this connection TOWER (1916) published a very interesting comparative study of the amount of food eaten by parasitised and non-parasitised larvae of *Cirphus unipuncta*. From his experiments it will be seen that parasitised larvae ate approximately half as much as unparasitised larvae during the same periods, and it seems conclusive, even from these few records, that parasitism by *Apanteles militaris* is directly beneficial in the generation attacked. In the stick insect ROTH (1916) also made some experiments on the feeding habit. His conclusions were as follows. *Carausius morosus* is an irregular feeder, eating much on one day, little on the other day, and so on, but the amount of food is always more immediately after a moult than in later part of the same stadium. Their feeding generally takes place in the evening and in the

morning. The food consumption doubles with each successive stadium, the quantity consumed per mm length of the insect increases at the same time, thus; in the first stadium the consumption per mm length of the insect is 7 sq. mm, in the second 17.5 sq. mm, in the third 36, in the fourth 79.6, in the fifth 140, in the sixth 295, and after the sixth 597, and these figures are near to the series, 9, 18, 36, 72, 144, 288 and 576, respectively. For the two or three weeks immediately following the last ecdysis the insects eat enormously, but afterwards, generally speaking, they eat gradually less and less. There is a remarkable correspondence between the quantity of food consumed and the number of eggs produced. As with the egg-dropping, so too with the food consumption, the size of the insect appears to have nothing to do with the results, and a shorter insect may eat more than a longer one.

TITSCHACK's experiments on the growth and the food consumption of *Carausius morosus* (1924), *Tineola biselliella* (1926) and *Cimex lectularius* (1930) are extremely excellent. A long series of literature with regard to such problems was referred to his papers. Among these the study on the stick insect, *Carausius morosus*, is of interest for the present investigation. The following results derived from his elaborate work were based upon the observations of five individuals. The amount of food eaten by the insect became larger instar by instar, and that of the five examples were tabulated as follows.

Table 162. Foliage eaten by *Carausius morosus*  
in different instars (unit in mm<sup>2</sup>) (After  
TITSCHACK, 1924).

| No.<br>Instar | 1       | 2       | 3       | 4       | 5       |
|---------------|---------|---------|---------|---------|---------|
| I             | 248.25  | 245.25  | 215.63  | 163.00  | 251.63  |
| II            | 441.88  | 552.25  | 422.37  | 382.50  | 332.87  |
| III           | 1112.87 | 1113.13 | 860.25  | 415.00  | 595.13  |
| IV            | 1393.50 | 1376.12 | 1509.50 | 2005.25 | 2020.37 |
| V             | 2364.00 | 2697.25 | 2615.75 | 2791.63 | 2967.88 |
| VI            | 4266.75 | 4578.50 | 5908.00 | 5732.62 | 6069.25 |

The maximum record of the amount of food eaten by an insect (No. 4) during its life was 1078.4 cm<sup>2</sup> and 22.8 gr. of leaves. To produce 1 mgr. unit of the insect, nutrient of 4.0 mgr. was needed during the first 150 days and of 8.5 mg during the entire life. The ratio of the amount of food eaten per day in each instar to the body weight was calculated, giving the following values. First instar—27.7~29.0 %, second instar—19.2~19.9 %, third instar—15.5~17.5 %, fourth instar—15.3~17.6 %, fifth instar—14.6 %, sixth instar—11.5 %, adult stage—10.4 %. The fact would be explained by the relative decrease in diameter of the intestine of the insect during post-embryonic developmental period. The maximum amount of food eaten by an insect during the entire life was 18.6 times as much as the body weight. To produce 1 mgr. weight of eggs 7.8~10.4 mgr. of nutrient is necessary. Of the 100 units of food eaten by the insect 35.8 are excreted as excrement.

In order to make the present discussions easy, the present experiments fertile for investigation of insect nutrition, and the conclusion to be derived useful in economic entomology, it may be of some advantages to consider the general feature of the feeding habits of the insect and the nature of the food plants used in my experiments.

The physiological conditions represented by various environments differ greatly even within a single plant, and the nutritive value of the different parts of the leaf may vary greatly. Further the nutrients within the leaves varies from one time of day to another, depending upon the higher or lower contents of protein as shown in the extensive works done upon the nutrition of silkworms. It seems possible, therefore, that the nutritive value of the leaves of three different plants used, viz. *Lyonia Neziki*, *Prunus subhirtella* and *Amelanchier asiatica*, should vary very much not only in the different parts within the leaves but also in time of the day. In this connection it must be noted that the plants used in my experiments are not the "apparent" food but "actual" food for this insect (UVAROV, 1928). Nevertheless the stick insect, being strictly herbivorous according to the categories of HANDLIRSCH (1926), as in many cases of phytophagous insects, feeds upon any parts of leaves at any time. Actually the insects feed independently of the nutritive value of the leaves, as shown

in the organic matter contents, water contents, etc. in different plants or at different time. It is often experimentally demonstrated in certain groups of insects that when insects reared in isolation are compared with others from the same litter which have been reared in groups, a longer time elapses before the isolated insects accomplish equivalent moults and the longer stadia of the isolated insects delay the attainment of maturity. There seems to be no doubt that this slower growth of isolated insects may be ascribed to the absence of jostling and mutual stimulation. FAURE (1932) and others have noted differences between migratory locusts reared under crowded conditions and those reared in isolation. In FAURE's experiments the increased activity gave rise to structural and colorational differences. For instance, locusts of the phase *solitaria*, if taken off the veld early enough in their development as hoppers and crowded together in cages, would acquire the coloration of the phase *gregaria* before they reached the final moult. PETTIT (1940) reared *Blattella germanica* in similar conditions and recorded that such differences as structural and colorational have not been detected, the altered metabolism, under conditions of crowding and resulting stimulation, appeared merely to affect the time required to reach maturity, and such differences in growth rate were detectable at the temperature of 23° to 25°C, but were less noticeable as the temperature increased, because the duration of the nymphal period and the differences in rate were similarly reduced. In the present experiments, the material was all reared in isolation, and the results showed that the colour and structure of the stick insects were not at all influenced by the isolated condition in comparison with those reared in crowded condition. The total amount of food taken by each individual in a rearing box should express the value almost equal to that of an insect in the field, as the stick insect is exclusively solitary in habit. Moreover, the total length of the post-embryonic growth period in each experimental insect showed a very close value to the mean taken from a number of individuals. Thus all of the above mentioned conditions of the material are ideal enough as to regard the results before me to be most accurate and satisfactory in determining the total amount of food eaten by the insects for the completion of the post-embryonic growth, the maintenance of their metabolism and for the continuation of the reproduction.

Attention may now be turned to the consideration of the amount of food eaten by the material used in my experiments. In the following discussions some particular expressions are used as below :

1. Insect fed three times a day→Insect fed with 3A units of food a day, where A denotes one meal (unit).
2. Insect fed three times every other day→Insect fed with 3A units of food every other day.
3. Insect fed three times every third day→Insect fed with 3A units of food every third day.
4. Insect fed three times every fourth day→Insect fed with 3A units of food every fourth day.
5. Insect fed once a day→Insect fed with an A unit of food a day.

In other words, the experimental insects 1-5 as shown above were equivalent to those fed with 3A, 2A, 1.5A, 1.2A and 1A units of food every day respectively. However, we must not forget to remember the fact that 1.2 unit of food is actually of less value than 1A biologically, though theoretically larger, so far as the cases of No. 4 and 5 are concerned.

## 2. Number of Instars as a Criterion of Growth

Generally the stick insect, *Phraortes kumamotoensis*, moults six times in the female and five in the male, and this seems to be a universal rule of this insect. Thus the number of instars may be accepted as a criterion of the normal growth. Owing to the object of my rearing experiments, however, it is impossible to find examples showing any relation to this problem excepting the following unique case. Among many experimental material besides those not given in the present paper, I found a single male insect which underwent only four moults instead of five, characteristic of the species. The elimination of the fifth instar in this male may be ascribed to the unsatisfactory diet taken during the post-embryonic developmental period (fed once a day). The irregularity of the number of instars under the same environmental conditions is a well-known phenomenon among many species of insects, and in such cases the number of instars is not altogether a perfect criterion of the biologic age. For instance (HONGE

IV, 1933), *Melanoplus differentialis* usually passes six instars; but 13 of the insects used in nutritional experiments exhibited an extra instar apiece, making their total seven instead of six, and two males moulted eight times each. Of these insects exhibiting extra instars, 6 were males, consisting of 2 on the mixed diet, 2 on rye, 1 on barley, and 1 on wheat. The other 7 were females; of which 2 on the mixed diet, 1 on barley, 1 on lettuce, and 3 on wheat.

### 3. Length of Instars as a Criterion of Growth

It is well known that temperature, food, and other environmental factors affect the length of instars. In my material the effect of insufficient diet upon the length of instars was exceedingly evident. In feeding experiments of 2A units of food consumption per day, the length of the instars was strongly lengthened in comparison with those fed normally. In feeding experiments of 1.5A units of food consumption per day, the duration of the instars was very much influenced and much more lengthened than that of normally fed individuals, and sometimes the insects could not undergo the next moult. Feeding of 1.2A unit of food per day strongly affected the growth of insects and no insects could not only undergo the next moult but also maintain their metabolism. The effect of feeding of exactly 1A of food per day upon the duration of the instars was almost similar to that of the experiments classes 3 and 4; the length of the instars was very much lengthened or sometimes the insects could not undergo the next moult. Feeding of 2A, 1.5A, 1.2A or 1A seems to indicate that such a quantity of food was insufficient to initiate the activity or to obtain the necessary amount of moulting hormone regularly. Thus feeding of 3A units of food per day regularly would satisfy the requirement of the sufficient diet for this insect to complete the normal post-embryonic developmental period.

### 4. Increase in Weight in each Instar as a Criterion of Growth

In feeding experiments, increase or decrease in weight of the insects may afford a very recommendable criterion, and it is not

less important than the length of the instars. In all cases of my respective experiments of feeding of 2A, 1.5A or 1A, the material secured the dry weight of their mesothorax exclusively small in comparison with that of those fed normally. Thus it may be clear that each of feeding of 2A, 1.5A or 1A unit of food per day is insufficient for the insects to complete the normal post-embryonic developmental growth.

#### 5. Linear Growth in each Instar as a Criterion of Growth

In feeding experiments, the linear growth of the insects in each instar may become a fairly good criterion of growth. In feeding experiments of 2A units of food per day, the length of the mesothorax was not apparently influenced by the insufficient diet. In feeding experiments of 1.5A unit of food per day, the length of the mesothorax was strikingly influenced by the insufficient diet, and became shorter than that of normally fed individuals. In feeding experiments of 1A unit of food per day, the length of the mesothorax was either shorter than or as long as that of normally fed individuals. In other words, the influence of unsatisfactory diet was either evident or indistinct.

#### 6. Necessary Amount of Food for the Completion of the Normal Post-embryonic Growth

As determined in my feeding experiments, 3A units of food per day may be regarded as the necessary and optimum amount of food for the insects to complete the normal post-embryonic developmental period. The total amount of food eaten by an individual insect during its larval instars was 8024.5 mm<sup>3</sup> (7299.1~9101.5 mm<sup>3</sup>) in volume in the female and 4536.5 mm<sup>3</sup> (3969.5~5350.9 mm<sup>3</sup>) in volume in the male. The total amount of organic matter eaten by an individual insect during its larval period was 65.59 gr. (61.68~69.50 gr.) in weight in the female and 31.76 gr. (30.17~33.14 gr.) in weight in the male. Comparisons of food quantity eaten in each larval instar with that in another made by several authors mentioned above were all carried out by a super-

ficial method, measuring only the total area of the leaves eaten. Even if the results derived from experiments by such a simple method and those obtained by my elaborate method are not much different in some cases, it appears that the method to show the quantity of food only by the area of leaves consumed is not accurate enough. In my column of experiments the amount of food (volume, organic matter and water) taken by the insects during their larval period was compared carefully with the weight of the mesothorax (exoskeleton) of the adult after the last moult. Thus the amount of food components to produce unit weight of the mesothorax of the adult was calculated separately in each instar. Since the insects used in the present investigation were selected at random, and further, I observed the food consumption of each individual separately by using the careful method, it seems probable that the results may represent the general features exhibited by phytophagous Orthoptera, including the Phasmidae and other related groups. The result was an astonishingly simple one, showing that the total amount of food eaten in each instar was doubled in the following one. The law may be expressed in the form of an equation:  $V_n = 2^{n-1} V_1$ , where  $V_n$  is the quantity of food taken in the stadium  $n$ , and  $V_1$  is the same taken in the first stadium. Although this result resembles the so-called PRZIBRAM's principle for the growth process among the insect world in some respects, my law concerning the food requirement of the larval insects of Orthoptera has not been derived from, or has no direct relation with, the principle of PRZIBRAM, which is even not universally applicable to the increase in weight or in length of insects. Further it must be noted that the amount of food taken by the male in its larval period was approximately 50 per cent of that by the female in its larval period.

## 7. Necessary Amount of Food for Reproduction

The nutrients consumed by the female insect may apparently partly for the maintenance of metabolism and partly for the source of the development of the ovaries. The development of the ovaries is not entirely dependent upon the nutrient, but there is an evident, close correlation between the amount of food eaten and the forma-

tion of eggs. The feeding experiments of 2A, 1A and 1.5A units of food per day were carried out to determine the necessary and optimum amount of food for the continuation of reproduction. The results obtained indicated that 3A units of food per day were essentially necessary for a female insect to continue the normal and ideal oviposition during her life. According to the feeding experiments of 2A, 1A and 1.5A units of food per day, the relation between the food consumption and the oviposition could not be exclusively expressed by measuring the length of the preoviposition period. On the other hand the eggs produced by females fed with such units of food were all deformed and very few in number. From the observation given in detail in my previous paper (YASUMATSU, 1931), it is not difficult to understand the impossibility of hatching of larvae from these eggs. Thus it is evident that 2A, 1.5A and 1A unit of food may be insufficient for the female to continue the normal reproduction. At the same time this evidence would indicate that the reproduction is not exclusively due to the nutrition, but is influenced by many other factors. Next, it is of great interest that the amount of food taken by the adult insects (both sexes) decreases at the rate of about 12.3 per cent with successive periods of twenty days, and this phenomenon implies that the absolute quantity of 3A for each period decreases successively, taking the figures of  $3A_1$ ,  $2.6A_1$ ,  $2.3A_1$ ,  $2.0A_1$ ,  $1.8A_1$ ,  $1.6A_1$ ,  $1.4A_1$  and  $1.2A_1$  in successive periods, where  $A_1$  means the absolute quantity of 3A in the first period of adult life. Though such figures as  $2.0A_1$ ,  $1.8A_1$ ,  $1.6A_1$ ,  $1.4A_1$  and  $1.2A_1$  per day are biologically different from those of the same notations for those fed every other day, every third day, etc., this phenomenon seems to indicate the fact that the female insects are apt to deposit irregularly shaped eggs at the later period of their lives. The amount of food eaten per day by a female during the preoviposition period is about 3.7 times as much as that by a male during the first period after the final moult. That of the female during the first period is about 4 times as much as that of the male during the same period. In the second period that of the female is about 3.3 times as much as that of the male. In the third period that of the female is about 5.2 times as much as that of the male. In the fourth period that of the female is about 4.8 times as much as that of the male. In

the fifth period that of the female is about 4.7 times as much as that of the male. In the sixth period that of the female is about 3.4 times as much as that of the male. In the seventh period that of the female is about 2.5 times as much as of the male. The amount of food eaten per day by the female during the sixth period may be comparable to, or is almost equivalent to, that of the male during the second period, and that of the female during the seventh period is almost equivalent to that of the male during the third period. The average of the total cases of both sexes demonstrates that the amount of food eaten per day by the female is about 4 times as much as that of the male. On the other hand the amount of food eaten per day or per instar by the female is as much as that by the male during the larval stages. These facts contrast sharply with each other and are considered a strongly affirmative evidence for the existence of the distinct physiological differences between the sexes in the adult stage.

#### 7. Attempt at the Application of the Results to the Practical Cases

It is desirable to apply the results obtained to the practical cases in economic entomology. Generally speaking, defoliating or phytophagous insects of mandibulate type may be classified into three different categories, according to their habits. Some species, called "leaf miners", feed upon the succulent interior leaf tissues while tunneling between the upper and lower cuticula. Others, "skeletonisers", eat all of the leaf except the vascular portions, thus skeletonising the leaf, leaving only the veins. Insects of the third category, "leaf chewers", eat all the leaf tissues. Almost all members of Orthoptera are skeletonisers during earlier parts of their developmental period and become leaf chewers during later stages. Regardless of the manner of their works, all of the defoliators have essentially the same effect upon the life process of the plant. The severity of the injury or damage is directly proportional to the amount of chlorophyll-bearing tissues destroyed. In accordance with the observations before us, it may be defined without difficulties that the damage caused by such defoliators as the larvae of sawflies, beetles as well as of butterflies and moths

(all are the holometabolous type of the insects) is essentially larger and stronger than that caused by the larvae of the Orthopterous defoliators (paurometabolous type of the insects). In the latter case, in which the adult insects are of the same feeding habit as the larvae, the injury caused by the female insect is always heavier than that of the male insect. In the Order Orthoptera the most famous and enormous is the damage caused by the migratory locusts. The damage caused by the Phasmidae is generally not severe and scatteredly observed throughout the world. But in Pagan Island, the Mariannas, Micronesia, the plantation of *Cocos nucifera* has been heavily damaged by a Phasmid, *Acanthograeffea denticulata*, in recent years. In the spring of 1940 I have had a good opportunity to visit the island and observed the injury. The damage was astonishingly severe, and in some places all the leaves were skeletonised completely by this large Phasmid. On a single coconut tree I was able to find no less than sixty or seventy individuals. Thus the economic loss due to this stick insect seemed to be comparable to that of an injurious Hispid beetle, *Planispa mariana* SPAETH, in Micronesia. But in all cases accurate estimate of economic loss due to such injurious insects is very difficult, and no recommendable methods of such estimations upon definite scientific basis have been established so far, though various methods were proposed. In some cases the estimations become too high, while in other occasions they are too low. It must be, therefore, very necessary, to find some bases for the estimation of economic loss. The so-called damage is not a simple phenomenon but a total result of many factors. The damage caused by defoliators may be divided into two parts, *i.e.* the mechanical and the physiological. The mechanical damage represents the amount of the leaves eaten directly by injurious insects and may be measured comparatively easily. The physiological damage may be said as the after-effect of the mechanical damage due to injurious insects, and its measurements are much more difficult than that of the former. In the phytophagous Orthopterous insects, especially in the Phasmidae, the mechanical damage will be calculated or estimated by the application of the law derived from my feeding experiments. If we admit the definition of the mechanical damage as mentioned above, in which the damage is expressed by the amount of food taken,

we shall have  $D_n = 2^{n-1} D_1$ , where  $D_n$  denotes the damage caused in the instar  $n$ , and  $D_1$  is the damage caused in the first instar. By using this equation we can state the following suppositions. The mechanical damage caused in the sixth instar is 32 times as heavy as that of the same number of insects in the first instar. The mechanical damage caused in the fifth instar is 16 times as heavy as that of the first. The same caused in the fourth instar is 8 times as heavy as that of the first. The same caused in the third instar is 4 times as severe as that of the first. The same caused in the second is twice as heavy as that of the first. In the adult stage the mechanical damage has the tendency of decreasing towards the end of life at a certain definite rate. The mechanical damage caused by the adult female per day in the preoviposition period is almost as severe as, or slightly more than, the damage caused in the third larval stadium. The mechanical damage caused by the adult male per day in the first period is as severe as that of the first larval instar and about one-fourth or one-fifth the damage by the adult female per day in the preoviposition period. The damage caused by the adult female in the preoviposition period is always heavier than that of the last larval stage and almost as heavy as that caused in the first period is always lighter than that of the preadult instar. Thus the damage seems to be heaviest in the last larval stage in the male insect and in the preoviposition period in the female insect. If we calculate the population of the injurious insect in a given area and apply the law of the mechanical damage given above to the result, we can estimate the actual mechanical damage occurred or occurring at a given time in a given area, and moreover the amount of possible loss in the future time.

#### E. Summary

1. The growth of larvae and the oviposition of the females of *Phraortes kumamotoensis* were investigated with regard to the food consumption.
2. The following plants were proved to be adequate food for complete development and metamorphosis of *Phraortes kumamotoensis*. *Rosa multiflora*, *Prunus Persica*, *Prunus subhirtella*,

*Amelanchier asiatica* (Rosaceae); *Lespedeza bicolor* (Papilionaceae); *Viburnum japonicum* (Caprifoliaceae); *Lyonia Neziki* (Ericaceae); *Celastrus articulatus* (Celastraceae); *Castanea crenata* (Fagaceae).

3. The time of feeding in one day is independent of the chemical change of fluid in the leaves of the plants.
4. In general the insects feeds three or four times a day.
5. In the experiments special attentions were concentrated into such physiological properties of the leaves eaten by insects as the thickness, the live weight, the dry weight, the water contents, the organic matter contents as well as the ash contents per unit volume. Three physiologically different types of plants of two different families were used in rearing the material for satisfactory comparisons.
6. In a normal and ideal development, a general trend, indicating a similarity in food consumption, is to be noted in all individuals reared with different plants. Thus under standardised conditions, the relation of food consumption with age is best defined by the formula  $V_n = 2^{n-1} V_1$  for both sexes, where  $V_n$  is either the volume of food or the contents of organic matter consumed in the stadium  $n$ , and  $V_1$  is either the volume of food or the contents of organic matter consumed in the first instar.
7. The actual amount of organic matter eaten by insects during the post-embryonic developmental period to produce the unit weight (1 gram) of the mesothorax of the adult was calculated, an average for several individuals showed the following values: 2.12~2.76 grams in the first instar, 4.52~6.06 in the second instar, 8.62~8.65 in the third instar, 14.91~15.89 in the fourth instar, 31.51~36.14 in the fifth instar and 67.53 in the sixth instar.
8. The actual amount of organic matter eaten by a female insect during the larval stadia was about twice as much as that by the male insect.
9. The experiments indicate the existence of the fundamental differences in the requirement of nourishment between the sexes. In connection with this fact it may be reasonable that the duration of the fifth instar was already slightly lengthened in the female sex as compared with that in the male.

10. The feeding on every other day affects the normal growth both in the duration of larval life and the dry weight of the mesothorax. The duration of the instars is strongly lengthened, and the dry weight of the mesothorax becomes exclusively lighter than that of the normally fed individuals.
11. The feeding of three times every third day or even every second day affects the normal growth very much. The duration of larval life is highly influenced and very much lengthened, or sometimes the insects cannot undergo the moulting and die. In this experiment the length of the mesothorax was also extremely influenced besides the weight.
12. The feeding of three times every fourth day causes the fatal influence upon the insects. No individuals can undergo the moulting. In this connection it is interesting to note that the insects which were obliged to remain hungry over two days could not respond quickly to food unless they drank water.
13. The feeding of once a day is also insufficient to complete the normal development. The duration of larval life is strongly lengthened, and the dry weight of the mesothorax becomes lighter than that of the normally fed individuals.
14. In the experiments with regard to the relation between the food consumption and the oviposition, special attention was made upon the external morphology of the eggs. In general the egg with a normal capitulum is the most predominant form occupying 68 per cent, the egg with a moderately deformed capitulum takes the value 13 per cent, and the egg with a strongly deformed capitulum or without capitulum occupies 19 per cent. The form of the capitulum or the absence of the capitulum is independent of the growth of the embryo within the egg, if the egg has been laid by a sound female. In general the eggs with a deformed capitulum are deposited by ill-fed females. The shape of the capsule has close connection with the hatching of the embryo.
15. It is apparent that the relation between the food consumption and the oviposition cannot be exclusively expressed by measuring the length of the preoviposition period.
16. The insufficient nutrition (fed three times every other day, fed once a day, or fed three times every third day) arrests the normal development of the female genital organs, especial-

ly of ovaries, from the continuous production of eggs during her life. It is also in close connection with the relatively shorter duration of life in the adult stage. The average number of eggs produced per day by the experimental insects with insufficient nutrition was prominently small without any exceptions, and the total number of eggs produced by them was about one half of that deposited by normal insects.

17. The percentage of the eggs with a normal capitulum produced by insects with insufficient nutrition was always lower than that of normal individuals, and the same of the eggs with a moderately deformed capitulum was always higher than that of normal ones. It is evident that the insufficient diet taken during the oviposition period exhibits a great influence on the inhibition in producing perfect eggs.
18. The egg with a deformed capsule has always a deformed capitulum. Thus the shape of the capsule becomes a good criterion in determining the adequate amount of food to produce perfect eggs. The variation in the shape of eggs deposited by insects fed on insufficient diet is very much larger than that of normal individuals.
19. In all cases the shape of eggs dropped by ill-fed insects was independent of the age of the insects.
20. After the preoviposition period the amount of food eaten by the insects has the tendency of decreasing towards the end of life. This means that the longer the life of the adult, the fewer is the average amount of food consumed per day. The amount of food consumed by the adult insects decreased at the rate of about 12.3 per cent with successive periods, each consisting of 20 days.
21. The amount of food eaten per day by a female in the preoviposition period is almost equal to, or slightly larger than, the total amount of food taken in the third instar or her life, and distinctly smaller than the same of the fourth one. In the male the amount of food consumed per day in its first period of adult life is almost equal to the total amount of food eaten in the first stadium of his larval life and is about one-fourth or one-fifth the average amount of food consumed per day during the preoviposition period of the female.

22. The feeding of three times a day would represent the satisfactory and sufficient diet for this insect to complete the normal post-embryonic developmental period. The feeding of less amount of diet per day seems to be insufficient to initiate the activity or to obtain the necessary amount of moulting hormone regularly.
23. The amount of food eaten per day by an adult female is about 4 times as much as that of the male. This fact contrasts sharply with that seen during the post-embryonic developmental period up to the fifth instar in both sexes and is a strong, affirmative evidence for the existence of the distinct physiological differences between the sexes in adult stage. In the larval period the amount of food eaten per day or per instar by a female is as much as that of the male up to the fifth instar.
24. The value  $\sum V$  in the preoviposition period of the female is always larger than that of the last larval stage and approximately equal to the value of  $\sum V_5$  and  $\sum V_6$  taken together. From this fact it is clear that an extremely larger amount of food is necessary for the female during the preoviposition period and it contrasts sharply with the amount consumed by the male during the first period of twenty days in adult life. In the male sex the value  $\sum V$  in the first period immediately after the last ecdysis is smaller than that in the last larval stage.
25. *Phraortes kumamotoensis* moults six times in the female and five in the male, and this may be regarded as a universal rule in this insect. This character seems to be unaffected by the effect of an unsatisfactory diet taken during the larval stadia. Only a single exception was found among hundreds of rearing experiments. This male insect (fed once a day) underwent only four moults instead of five, characteristic of the species.
26. In the case of injurious insects of the order Orthoptera, we may be able to estimate the actual mechanical damages occurred or occurring at a given time and in a given area, as well as the amount of possible loss in the future in application of the law of mechanical damage here proposed,  $D_n = 2^{n-1} D_1$ , where  $D_n$  denotes the damage caused in the instar  $n$  and  $D_1$  is the damage caused in the first instar.

## VII. GENERAL RÉSUMÉ

1. The growth of larvae of *Phraortes kumamotoensis* was analysed with regard to the length, regeneration, weight and the food consumption experimentally in full detail.
2. The previous works relating to the problem in question were reviewed.
3. The growth rate both in length and weight, and further the amount of food consumption must be correlated with one another in the larval stadia.
4. The interpretation of the linear growth of the appendages in insects can be safely undertaken by the idea of the growth-promoting and growth-inhibiting factors analysed in my experiments.
5. To decide the existence or absence of two or more growth phases is the primary and fundamental process in the study of the growth in insects. Bearing this fact in mind it is enabled to select suitable organs for the comparison of the growth, to derive the equation of the growth curve, if needed, and to calculate the growth coefficient or growth constant, if present, from the data accumulated by the experiments.
6. The mode of change in the amount of food eaten by insects during their larval period may be classified into several types in terms of their increasing or decreasing rate.
7. *Phraortes kumamotoensis* is a representative of one type in which the amount of food eaten in successive instars follows fairly well after the fashion of a geometrical progression whose exponent is 2 and differs entirely from that of the Lepidopterous insects.
8. For the estimation of losses by injurious insects a part of answers can be given by determining the type of the larval development of the insects in question.
9. The results of the present study would throw some light upon the future investigation of the growth of injurious or non-injurious insects.

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