A study of the immature stages of some grasshoppers (Orthoptera:Acridoidea) in Quebec.

## ABSTRACT

The egg pods, eggs and nymphal instars of <u>Melanoplus borealis</u> <u>borealis</u> (Fieber), <u>M. femurrubrum femurrubrum</u> (De Geer), <u>M. sanguinipes</u> <u>sanguinipes</u> (Fabricius), <u>Chortophaga viridifasciata viridifasciata</u> (De Geer) and <u>Encoptolophus sordidus sordidus</u> (Burmeister) are described and illustrated. Keys to species, based upon eggs and upon nymphs and a key to the nymphal instars in all species are presented. Morphological detail, colour pattern and morphometric data are recorded for each species. Studies of growth of parts through the successive nymphal instars, duration of the instars, and notes on the total nymphal development and life history are also included.

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Les masses d'oeufs, les oeufs et les stages nymphaux de <u>Melanoplus borealis borealis</u> (Fieber), <u>M. femurrubrum femurrubrum</u> (De Geer), <u>M. sanguinipes sanguinipes</u> (Fabricius), <u>Chortophaga viridifasciata</u> <u>viridifasciata</u> (De Geer) et <u>Encoptolophus sordidus sordidus</u> (Burmeister) sont décrits et illustrés. Des clefs menant aux espèces, l'une basée sur les oeufs et l'autre sur les nymphes ainsi qu'une clef menant aux stages nymphaux sont présentées. Dans chacune des espèces, des données sur la morphologie, les patrons de coloration et la morphométrie sont notées. Sont aussi incluses des études sur la croissance de certaines stuctures.tout au long du développement nymphal, sur la durée des stages ainsi que des observations sur le développement nymphal entier et le cycle vital.

# A STUDY OF THE IMMATURE STAGES OF SOME GRASSHOPPERS (ORTHOPTERA:ACRIDOIDEA) IN QUEBEC

by

Michel O'connell Guibord

A thesis submitted to the Faculty of Graduate Studies and Research, McGill University, as partial requirement for the degree of Master of Science.

April 1, 1969

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## INTRODUCTION

The need of a better knowledge of the immature stages of grasshoppers, commonly found in Quebec, has been the basic motivation of this study. The eggs and nymphs of grasshoppers have received relatively little attention as is indicated by the literature review. In Quebec and in the adjacent provinces and states nothing had been done prior to the present study.

The species chosen for this study consist of three common species of the genus <u>Melanoplus: femurrubrum femurrubrum</u> (De Geer), the red-legged grasshopper; <u>sanguinipes sanguinipes</u> (Fabricius), the lesser migratory grasshopper; and <u>borealis borealis</u> (Fieber), the northern grasshopper. Two oedipodine species were also studied: <u>Chortophaga viridifasciata</u> <u>viridifasciata</u> (De Geer), the northern green-striped grasshopper; and <u>Encoptolophus sordidus sordidus</u> (Burmeister).

The principal object of the study was to make detailed descriptions of each species, in each nymphal stage, together with photographs, in colour where this was found to be useful, and detailed drawings of the stages and colour patterns. Notes on the life history were also made.

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## REVIEW OF LITERATURE

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The first description of a grasshopper egg pod was undoubtly made by Riley (1877) when he described the egg pod of <u>Melanoplus spretus</u>(Walsh). Waloff (1950) published a description of the eggs of ten British Acrididae and, later, Richards and Waloff (1954) devised a key based upon the eggs of the ten species of British Acrididae. The descriptions of Waloff are very detailed and are accompanied by excellent drawings. No important work was published on the egg pods of the North-American grasshoppers until Onsager and Mulkern (1963) grouped the egg pods into four categories, based mainly on the distribution of the frothy secretions inside the egg pod. The origin and nature of these frothy secretions were discussed by Snodgrass (1935), who stated that they are secreted in special glandular parts of the oviducts. The number of eggs per egg pod, as well as the number of columns in the pod, is reported by Onsager and Mulkern (1953). Blatchley (1920), Criddle (1918 and 1933) and Parker (1957) also give some notes on the number of eggs per pods.

Uvarov (1928) was apparently the first to suggest that the eggs could be identified on the basis of the chorionic sculpturing. Tuck and Smith (1939) published the first extensive work on the description of North-American grasshopper eggs, detailed description of the generallized egg with a key and descriptions of eggs of 48 species of mid-western grasshoppers. Onsager and Mulkern (1963) later published a key and descriptions of eggs of 65 species, together with photographs of the posterior part of the eggs. Roonwal (1954) has shown that while features such as size and weight of eggs vary during development, the chorionic pattern does not change after its formation.

One of the first attempts in North-America to study the changes during the grasshopper development was made by Riley (1877) in his study of <u>M. spretus</u>. Howard (1894) was the first to give a description of each nymphal stage. The species so described was <u>Schistocerca americana</u> (Drury). Herrick and Hadley (1916) published a short description of the nymphal instars of <u>M. s. sanguinipes</u>, accompanied by photographs. Morse (1921)made an attempt at comparative descriptions of nymphs of <u>M. s. sanguinipes</u>, <u>M. spretus</u> and <u>M. bivittatus</u>. Criddle (1924, 1926, 1933) published the first comprehensive papers on immature Orthoptera. His descriptions were based mainly on colour patterns and were often accompanied by excellent drawings. He also pointed out the usefulness of the male genitalia in the later instars.

The most extensive morphological study made on nymphs of a single species was done by White (1926). His work includes detailed drawings of all stages of both sexes of <u>Camnula pellucida</u> (Scudder).

Handford (1946) published a key and a description of 21 <u>Melanoplus</u> species including the three species of this genus studied here. This work served as starting point for the present study.

On the study of growth of parts, Roonwal (1952) showed the general growth pattern and the rate of addition of the number of antennal segments in Acrididae. Dirsh (1950) published a description with drawings to differentiate the two sexes of <u>Locusta migratoria migratorioides</u> (R. and F.). The general pattern of his work has been applied to almost every species studied since then.

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Parker (1930), working on the effects of temperature and moisture on the development of grasshoppers, noticed the occasional occurrence of an extra instar. Shotwell (1930 and 1941) made excellent descriptions of the extra instar together with descriptions of the other nymphal instars. He also included measurements of structures throughout the nymphal development in <u>M. s. sanguinipes</u>, <u>M. f. femurrubrum</u> and other species. He differentiated the six nymphal instar cycle from the regular five instar cycle and discussed the causes governing the number of instars. In laboratory rearings, Shotwell observed that in a strain of <u>M. f. femurrubrum</u> from Montana nearly all passed through five instars while a strain of the same species from Tennessee, which is further south, reared under the same conditions nearly all passed through six nymphal instars. He concluded that the population with six nymphal instars was adapted to a climate having a longer growing season.

Roonwal (1946), worked out rules governing the correlation between the wing pads reversal and the occurrence of the extra instar. Uvarov (1966) reviews the different theories advanced on this subject. The theory of hormonal control of the instar number has recently become generally accepted. (Joly, 1958).

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## MATERIALS AND METHODS

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#### Rearings.

Adults were collected in the field, in the Morgan Arboretum, Macdonald College, Ste.Anne de Bellevue, Quebec, identified and brought to the laboratory. They were placed in wooden cages, 35 cm. deep, 36 cm. wide, 49 cm. high, with a screened false floor placed at 13 cm. from the true floor, a screened air vent on one wall, a .25 watt bulb on the hind wall operated by a time swith set at a 12 hrs daylength, a glass front wall and a 15 X 15 cm. door on the removable top. Jars of sterilised moist sand, at least 5 cm. deep were place on the screened floor, to provide the females with a depositing medium. The insects were fed on lettuce, and during the summer season occasionally on grasses.

After a number of egg pods had been laid, in the jars, the jars were removed and replaced by new ones. Those containing egg pods were placed in an incubator at a temperature of  $27^{\circ} \pm 2^{\circ}$ C. for approximately two months. During the first year nearly all of the eggs were lost through dessication, so that the following year the sand in the jars was kept continuously moist. After the initial two months, the eggs were placed in a cold room at about  $8^{\circ} \pm 2^{\circ}$ C. for at least six weeks.

After six weeks (or more) of cold treatment, the eggs were kept at a temperature varying between 22 and 25<sup>o</sup>C. until they hatched, usually in about 9 days.

The newly hatched nymphs were checked each day and were placed in

small individual rearing cages. These cylindrical cages, 10 cm. in length and 3 cm. in diameter, were made of a celluloid sheeting which was glued along the length of the cylinder. The ends were covered with cheesecloth, the bottom one being retained by an elastic band and the upper one made in a sort of lid by an adhesive cellulose tape bordering the cheesecloth.

The cages were placed in an incubator at a temperature of  $27^{\circ}\pm 2^{\circ}$ C. and a daylength of 12 hrs. A piece of stem was introduced in the cage for the nymph to climb upon and to grasp during the moulting process. The nymphs were fed regurlarly with lettuce.

A complete record of the development of the nymph in each cage was noted as it progressed; the date the eggs were laid, the date the nymph hatched, and the date of each moulting was recorded. Each day the cages were examined for moulted skins, and if there was one in a cage it was removed, the date of moulting was recorded, and the nymph was examined to diagnose the main characteristics of the instar.

Approximately 100 nymphs of each of the species studied, were reared in this way. In each nymphal stage, at least ten individuals were killed for purposes of photography, description and measurement.

#### Photography.

At least one nymph of each instar, of each of the species studied, was killed by short exposure in a cyanide bottle. Immediately, so as to minimize the chances of colour changes, the nymph was laid on the right side in the proper position on a black background to be photographed.

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The photography was made through a Wild M.5 stereomicroscope equipped with a Micro-Photoautomat electronic exposure calculator!. The nymphs of the <u>Melanoplus</u> species and the first instar nymphs of the two oedipodine species were photographed on CN-17 universal outdoor light Agfacolour film. Two lamps were used on a high voltage transformer so as to give the correct wavelength and obtain the colours as accurately as possible. The nymphs of the two oedipodine species where photographed in the same manner, on a white wax background to eliminate shadows. In each case a specimen representative of the species and instar was chosen as carefully as possible. The eggs were photographed through a Nikon compaund microscope equipped of an automatic shutter system<sup>2</sup> and iris diaphragms on the objectives 1.2X, 2X and 3X, so as to augment the depth of field.

## Methods of Study.

Drawings were made with an M 5 stereomicroscope equipped a a Wild M 5 drawing tube. The structures and colour pattern were first drawn with the aid of the drawing tube, after which the details were filled in by direct observation through the M 5 stereomicroscope.

Freshly killed specimens were used for drawings of the lateral views of the whole nymphs, of each instar in each species. Specimens were killed by short exposure to hydro-cyanic acid gas, so as to eliminate possible colour changes caused by killing agents such as alcohol.

- Wild Micro-Photoautomat comprising M Ka4 camera, MEL 13 control unit and Asahi-Pentax SP camera back.
- Nikon compound microscope model FUC-KE and Microflex AFMB automatic unit.

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The male and female genital appendages were drawn from specimens kept in alcohol. For both types of drawing, all specimens of the group were studied so as to choose the most representative specimen for each group. The nymphs and the genital appendages were each drawn to the same scale so as to provide an illustration of size relationship as well as comparison of structure.

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Many structures were investigated but only the pronotum, the wing pads, the metathoracic femur, the female ovipositor valvulae and the male subgenital plate lobe were finally utilised for measurements, together with the number of antennal segments.

The epiphallus was investigated but proved to be of no help since it was unsclerotized.

The length of the antenna was rejected as a possible practical measurement because it is frequently bent in an awkward position and, also because they are sometimes lost in whole or in part through the nymphal stages.

The pronotum was measured along the median carina, as shown in Fig. 1. The wing pads were measured in the instars which had wing pads pointing downward, from the line of junction of the notum and the pad to the furthest point of the margin of the pad in a vertical line, as shown in Fig. 2.

Fig. 3 indicates the measurement which was made of the upturned hind wing pad. The delimiting points were the upper end of the metapleural sulcus, where the hind wing pad originates, and the apical margin.

The metathoracic femur was measured from tip to tip as shown in Fig. 4.

• The lobes of the lower valuale of ovipositor in first and second instar females were measured at the greatest length, as were the upper valvulae (Fig. 5).

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In instars three and later, the lower valuale of the female ovipositor were measured along the greatest length in longitudinal line with the body, as shown in Fig. 6.

The male subgenital plate lobes were measured from a ventral view in the first nymphal instar, along the greatest length of either lobe (Fig. 7), and in the other instars where the two lobes are united, the median length was taken from a line traced between the two lateral incisions, marking the origin point of the lobes, to the median apical margin. (Fig. 8).

# RESULTS

#### THE EGG PODS

Examination of the egg pods deposited by each of the species concerned proved that there were no significant differences between them. However, it was noted that the pods of <u>Melanoplus borealis</u> tended to be somewhat shorter than the average length of the pods of <u>M. sanguinipes</u>, <u>M. femurrubrum and Encoptolophus sordidus sordidus</u>, while those of <u>Chortophaga viridifasciata</u> were generally, although not always, larger than the pods of the above mentioned species. This difference in size is reflected in respective smaller and larger numbers of eggs per pod. Such differences might assist in the identification of eggs of the species studied here.

Other than these differences, the egg pods of the species concerned all have the same basic structure, which is described as follows(Fig. 9):

A mass of eggs (E) deposited in columns, at an angle varying between  $20^{\circ}$  and  $50^{\circ}$  with the cap end downward, is enclosed in a network of lamellae of frothy secretion which also surrounds each individual egg.

The secretions also form an apical pad (P) which closes the pod just below the soil surface.

The secretions form a very loose network between the apical pad and the egg mass as well as in front of the eggs.

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This provides the hatching nymphs with a passage through to the soil surface.

This corresponds to the type two of Onsager and Mulkern(1963). Fig. 10 shows an example of this type of pod.

# THE EGGS

The grasshopper egg, produced in a panoistic type of ovary, is an oblong, slightly curved cylinder tapering to roundly blunted ends (Fig. The anterior or cephalic end (AE) which is uppermost when in the egg 11). pod exhibits little or no difference in its chorionic sculpturing. It is through this end that the nymph will emerge after development is completed. However, in the Acrididae at least, the posterior or caudal end (PE) forms a characteristic structure named the cap. The cap is anteriorly delimited by the micropyles, which are arranged in a row around the egg, and in the three species of Melanoplus, by an unsculptured band preceding the micropyles. The cap is neither anologous for homologous to the operculum of the eggs of some other insects (Tuck and Smith, 1939), since it is not a lid nor an opening. The micropyles ensure only the penetration of the sperm into the egg, and do not provide for a breaking line, which would permit the cap to open as a lid. These micropylar openings appear as a shallow, V-shaped, depression of the chorion directed posteriorly.

The surface of the eggs of most species show a pattern or sculpturing produced by ridges in the different layers of the chorion. The sculpturing of the cap is often different from that observed on the rest of the egg. Therefore, in the description of sculpturing of the eggs of the species studied two regions will be considered; these are the cap, and the body which covers all the surface of the egg anterior to the cap.

Careful study of the eggs of the five species concerned has shown that they can be identified with *p* relative facility. The most reliable characters lie in the sculpturing of the chorion; other characters, such as the color of the egg, its length and diameter, may prove useful for identification but one has to keep in mind that such characters will vary depending on the stage of embryonic development. (Uvarov, 1966; Roonwal, 1954).

The chorionic sculpturing is molded by the epithelial cells, that secrete the chorion, while the egg is in the oviduct. Therefore the sculpturing is a permanent character which shows no change throughout the development of the egg and could even be utilized after the nymph has hatched.

## Key to eggs

1 a - Body sculptured -----

b - Body unsculptured ----- 2

2 (1b)

a - Cap sculptured on distal half.

Encoptolophus sordidus sordidus

b - Cap unsculptured, found only in summer months.

Chortophaga viridifasciata viridifasciata

a - Cell outlines darker than intrace lular areas, cap region darker than body, cap cell outlines very deep.

Melanoplus borealis borealis

- Cell outlines not darker than intracellular areas, cap region same color as body, cap cell outlines not so deep. ------4

4 (3b)

Micropyles conspicuous as V-shaped brownish depressions, or marks, as brownish row around base of cap; seven or eight rows of wide bordered cap cells.

## Melanoplus femurrubrum femurrubrum

b - Micropyles not apparent; base of cap as pale as rest of body, nine or ten rows of cap cells similar to the body cells; outlines of cap cells not wider or deeper than on body cells.

Melanoplus sanguinipes sanguinipes

## Description of the eggs

A few notes on egg pods have been included so as to assist in identification of the eggs.

## Encoptolophus sordidus sordidus

Colour: light brown

The body is completely devoid of sculpturing. The cap is sculptured,

mostly on the posterior half. The ridges of the hexagonal and pentagonal cap cells are inconspicuous by themselves but they contrast with the granulated intracellular areas. The basal half of the cap, as well as the body of the egg, is smooth. The micropyles are conspicuous, appearing as small V-shaped depressions. The egg pod contains an average of 16 eggs arranged in two columns.

# Chortòphaga viridifasciata viridifasciata

Colour: light brown

Both the cap and the body are devoid of sculpturing. However, numerous small granules are scattered over the two regions, being more numerous on the cap. The micropyles appear as a prominent brownish ring of V-shaped holes at the base of the granulated cap. The granules are very small so that the egg appears as having an overall smooth surface broken only by the micropyles. These eggs are deposited during the month of July and hatch in the end of August and in September, so that one can find an egg of this species only in summer. The egg pod is larger than those of the other species described and usually contains 24 or more eggs which are arranged in two or three columns.

Melanoplus borealis borealis (Fig. 14)

Colour: light-brown

Body covered with hexagonal and pentagonal cells. The ridges of the cells are middle-brown while the intracellular area is much paler (Fig. 15). Micropyles are inconspicuous but their position is indicated

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by an unsculptured band, equivalent to three or four rows of cells, lying just anterior to them. The cap cells have much wider and deeper ridges which confer a darker appearance to this part of the egg. These cells occur in six to eight rows after which are a few rows of shallow bordered cells leading to the apex (Fig. 16). The small egg pod contains an average of 12 eggs arranged in two rows.

<u>Melanoplus femurrubrum</u> femurrubrum (Fig. 17) Colour: tan

Body cells hexagonal and pentagonal but not as regularly shaped as those of <u>borealis</u> and <u>sanguinipes</u>. Ridges and intracellular areas are of the same colour and shade. The cells near the anterior end tend to be smaller than those on the center and posterior part of body (Fig. 18 shows cells photographed on the posterior part of the body).

A band of two to four rows of shallowly outlined cells immediately precedes the conspicuous, brownish, V-shaped micropyles. On the basal half of the cap are seven or eight rows of wide bordered cells (Fig. 19) after which two or three rows of inconspicuous cells converge on the apex. The egg pod contains an average of 18 to 20 eggs arranged in two columns.

<u>Melanoplus sanguinipes sanguinipes</u> (Figs. 20 and 23) Colour: pale tan or whitish

The body is covered with almost regular pentagonal and hexagonal cells (Fig. 21). The ridges and intracellular areas are of the same colour and shade. The two or three rows of cells preceding the inconspicuous micropyles have very shallow outlines. The cap cells are regular and

-15-

resemble the body cells, the only difference being in the ridges which are somewhat higher than on the body cells (Fig. 22). There are nine or ten rows of conspicuous cap cells but the apex is smooth.

The egg pod contains an average of 16 eggs arranged in two columns.

## THE NYMPHAL INSTARS

## Number of instars

Close observation of the nymphs throughout development revealed that they do not always pass through five nymphal instars but may sometimes pass through six instars. In the three species of <u>Melanoplus</u> involved in this study the extra instar appeared after the third moult. It showed a stage of development intermediary between the third and the normal fourth instars. The extra instar (which is called the fourth instar of the six nymphal instar cycle in this text) is differentiated from the normal fourth (the fourth instar of the five instar cycle) mainly by the wing pads, which point downward, and from the third instar by the size, which nearly is as large as that of the fourth instar of the five instar cycle.

In <u>M. f. femurrubrum</u>, the percentage of nymphs which had a cycle of six instars was 31.44%; in <u>M. s. sanguinipes</u> 25.94%; and in <u>M. b</u>. <u>borealis</u> 12.84%. In each of these species, the proportion of males and females of the six nymphal instar cycle nymphs was approximately equal. These results are quite different from those obtained by Shotwell (1941) in the case of <u>M. f. femurrubrum</u>. However, in the case of <u>M. s. sanguinipes</u>, the results agree with those of Shotwell. The fourth instar of the six instar cycle is followed by a fifth and sixth instar which are similar in structure but larger than the fourth instar and the fifth instar of the five instar cycle, respectively.

1

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In the two oedipodine species no extra instar was observed after the third or the fourth moults, but did occur after the fifth moult. All nymphs undergo a normal five nymphal instar cycle but then some moult to a sixth nymphal instar while others moult to the adult stage. In <u>Ch. v. viridifasciata</u>, 44.44% of the nymphs passed through the six instar cycle and these were 100% females. All of the females passed through a cycle of six instars while all of the males passed through a five instar cycle. This suggests that the females require this sixth nymphal instar to enable them to increase in size, since the adult females are larger than the adult males.

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However, this is not the case with <u>E</u>. <u>s</u>. <u>sordidus</u>, in which only 40% of the specimens in the sixth instar were females, while 60% of them were males; in this species the adult females are also larger than the adult males. A total of 33.34% of the nymphs passed through a cycle of six nymphal instars.

## Duration of instars and of nymphal life.

Tables 1 to 5 give the mean duration in days of each nymphal instar and of the average duration of the nymphal development in cycles of five and of six instars for each of the species studied. In each of the three <u>Melanoplus</u> species (Tables 1, 2, and 3), the pattern is the same as follows: in the five instar cycle the duration of each instar averages seven to nine days, with the total duration of nymphal life about 40 days; in the six instar cycle, the first three instars have the same duration as the first three instars of the five instar cycle, while the fourth, fifth and sixth instars are each of slightly shorter duration than the last three instars of the five instar cycle. The total duration of the nymphal life is three to six days longer in the six instar cycle. These results agree with those obtained by Shotwell (1930) for <u>M</u>. <u>s</u>. <u>sanguinipes</u>. However, my results indicate longer average instar duration than found by Shotwell, although rearing conditions appear to be similar.

<u>Ch. v. viridifasciata</u>, Table 4, presents a completely different nymphal developmental duration, mostly in the last three or four instars. The first instar has an average duration of 9.6 days, the second 8.4 days. The third 11 to 20 days, the fourth 15 to 35 days and the fifth 20 to an undetermined maximum in the five instar cycle. In the six instar cycle the fifth instar lasted from 20 to 48 days and the sixth instar from 18 days to an undetermined maximum.

The reason for the extended duration of these instars is that <u>Ch. v. viridifasciata</u> overwinters as a nymph and the diapause takes place during nymphal stages, starting in the third or fourth instar. In the field the eggs are deposited mostly during the month of July, and hatch during late August and early September. When colder temperatures come, around the middle of October, nymphs of this species will be mainly in the third and fourth instars. These enter diapause to pass the winter and resume development as soon as snow is melted in spring. In southwestern Quebec, in April, one can find nymphs of this species in the third, fourth and later instars hopping around in grass just left uncovered by the melting snow. These nymphs then undergo their additional nymphal instars to become adults about the end of May or the beginning of June.

In the laboratory, the long duration of the later instars indicated

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that diapause is an obligate condition in this species. Some adults, matured from nymphs which did not have a cold period. These were never seen mating and the females did not deposit a single egg. <u>E. s. sordidus</u>, which has diapause and overwinters in the egg stage, similar to the <u>Melanoplus</u> species, have a more regular pattern of nymphal development (Table 5). The instars average nine days in duration except for the second and sixth instars for which the duration is 7.4 and 7.7 days respectively. The total duration of nymphal life is evidently longer in the six instar cycle than in the five instar cycle, with the first five instars of the six instar cycle being of the same average duration as in the five instar cycle.

## Study of Growth of Parts

#### Antennae.

The number of antennal segments counted in each nymphal instar of each species is listed on Tables 6 to 10. The general pattern appears to be 13 segments in the first instar, 16 in the second, 19 in the third, 20 in the fourth instar of the five instar cycle, 21 in the fourth instar of the five instar cycle and in the fifth instar of the six instar cycle, 24 in the fifth instar of the five instar cycle and also in the sixth instar of the six instar cycle. In the five nymphal instar cycle these results agree with those of Handford (1946), considering that in the second and third instars one division is often incomplete or in some cases externally difficult to observe. This pattern is seen in the three <u>Melanoplus</u> species, in <u>Ch. v. viridifasciata</u> and in the last instars of <u>E. s. sordidus</u>, but in the second instar of the last mentioned species the number of antennal

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segments is only 14, and in the first and third instars it tends to be one or two segments less than the general number. This is also found in the three first instars of <u>Ch. v. viridifasciata</u> but less often than in <u>E. s.</u> <u>sordidus</u>.

## Pronotum.

Tables 6 to 10 show the increase in length of the pronotum in each species under the appropriate heading. In the <u>Melanoplus</u> species the rate of increase is relatively constant throughout the nymphal development. In the six instar cycle the increase is slower in the last three instars than in the last two instars of the five instar cycle. In the two oedipodine species the increase is approximately constant throughout the five and the six instar cycles.

## Wing pads.

The measurements of the hind wing pad in each instar are listed for each species in tables 6 to 10. In the instars where the wing pads point downward (i.e. the first, second, third instars and in the fourth instar of the six instar cycle). the mean is also applicable to the fore wing pad since it has the same vertical length. In all species, the increase in length of the hind wing pad is greater between the third and the fourth instars and between the fourth and the fifth instars than between the other instars. (Figs. 148 and 149 show the difference in length of the hind wing pad in the IV and the V instar). In the <u>Melanoplus</u> species, this increase is more gradual in the six instar cycle and the final length is greater than in the five instar cycle.

#### Methatoracic femur.

The length of the metathoracic femur proves to be a good measurement of the difference in size between the different instars of a species; there is a constant increase in successive instars and it is easily measured. Shotwell (1941), made studies of correlations between measurements of the length of the metathoracic femur and other structures and came to the conclusion that it was the best measurement of the difference in size between speciments of the same species of grasshopper.

In the <u>Melanoplus</u> species, the six instar cycle shows in its fourth and fifth instars, smaller measurements than in the fourth and the fifth instars of the five instar cycle (Tables 6, 7 and 8).

The metathoracic femur measurements of the two oedipodine species are listed in Tables 9 and 10. The nymphs of <u>Ch. v. viridifasciata</u>(Table 9) show to be much bigger than those of <u>E</u>. <u>s</u>. <u>sordidus</u> (Table 10), mainly in the three last instars.

## Female ovipositor and Male subgenital plate lobe.

Lengths of the lower and upper valvulae of the female ovipositor in the first two instars, together with the length of the male subgenital plate lobe in the different instars, are given on the Tables 6 to 10. They show a continuous size increase, which can be used to determine the instar.

## Ratio of hind wing pad length to pronotal length.

Figs. 173 to 177 show the ratios of the mean length of the hind wing pad to the length of the pronotum for each species studied. In all species, the ratio is very low in the first three instars (of the five instar cycle plus the fourth instar in the six instar cycle, of the <u>Melanoplus</u> species), where it averages 0.3 to 0.4, in the fourth instar (of the five instar cycle and the fifth of the six instar cycle in the <u>Melanoplus</u> species) it averages 0.5 to 0.7, in the fifth instar (of the five instar cycle of the <u>Melanoplus</u> species) and in the sixth instar, it is 1.0 or greater; the ratios show some specific differences, mainly in the last instar of both the five and six instar cycles of the <u>Melanoplus</u> species. <u>M. s. sanguinipes</u> has a greater ratio than <u>M. f. femurrubrum</u>, which in turn has a greater ratio than <u>M. b. borealis</u>.

The fifth instar of the two oedipodine species show no significant differences but the ratio in the sixth instar is slightly under 1.0 in <u>Ch. v. viridifasciata</u> and slightly over 1.0 in <u>E. s. sordidus</u>. However this difference is not significant as the number of sixth instar specimens in <u>E. s. sordidus</u> was much smaller than in <u>Ch. v. viridifasciata</u>.

## Colour and Colour Pattern

In newly hatched nymphs the colour is whitish all over with reddish eyes, the colour pattern appears in about three to five minutes after hatching. An experiment was conducted to see if the late embryo or larva showed the specific colour pattern. The chorionic coverings were peeled off. an egg of <u>M. b. borealis</u>, which was nearly ready to hatch. Air could reach the larva through the serosal cuticle. After a few minutes the embryo showed the characteristic colour pattern of the species (Fig. 150). The serosal cuticle was then removed to show a larva coloured in

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in the same pattern as the first nymphal instar, Fig. 151. This shows that, despite the variation, the colour pattern of a species is quite a reliable criterion.

## Keys and Descriptions

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The following keys, mainly the key to the species, are presented primarily as guides to the descriptions. The descriptions must be used together with the colour photographs (or black and white photographs of the oedipodines), the drawings of the instars, the drawings of the genital appendages of both males and females, and the tables and figures of ratios.

The colour tints and shades mentioned in the descriptions are so used mainly to show the relation between the shades or tints of different areas.

## Key to the nymphal instars

1	a -	Wing pads pointing downward2
	b -	Wing pads pointing upward5
2	(1a)	
	a -	No sign of venation on the wing pads, length of the wing pads
		0.30 mm. or less; number of antennal segments not more than
		16; length of the metathoracic femur under 3.50 mm3

b - Signs of venation present as grooves and ridges on the surface;
 wing pad length more than 0.40 mm., length of metathoracic femur
 more than 4.00 mm.

3 (2a)

a,

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j.

a - Number of antennal segments not greater than 13; wing pads very short, not more than 0.10 mm. in vertical length; length of the methathoracic femur not more than 2.70 mm.

First instar.

 b - Number of antennal segments usually 16, sometimes 14, but not less (<u>Encoptolophus sordidus sordidus</u>); wing pads evident, 0.20 to 0.30 mm. in length; metathoracic femur length from 2.95 to 3.50 mm.

Second instar.

- 4 (2b)
  - a Number of antennal segments usually 19, sometimes 18; in the <u>Melanoplus</u> species - wing pads length, 0.40 to 0.50 mm.; metathoracic femur length, 4.00 to 4.50 mm.; in the two oedipodine species - wing pads length, 0.56 to 0.85 mm.; metathoracic femur length, 4.65 to 5.20 mm.

Third instar.

b - In the <u>Melanoplus</u> species - the number of antennal segments,
20; length of the wing pads, 0.58 to 0.84 mm.; metathoracic femur
length, 4.90 to 5.5 mm.

Fourth instar of the six nymphal instar cycle, or extra instar.

5 (1a)

a - Ratio of hind wing pad length to pronotum length (hwp/pron.)
 approximately 0.5, not over 0.7; number of antennal segments, 21
 or 22.

Fourth instar of the five nymphal instar cycle and fifth instar of the six nymphal instar cycle of the <u>Melanoplus</u> species.

b - Ratio of the hing wing pad length to the pronotum length (hwp/pron.)
 approximately 1.0 or slightly more; number of antennal segments,
 24.

Fifth instar of the five nymphal instar cycle and sixth instar of the six nymphal instar cycle of the <u>Melanoplus</u> species. Key to the species - First instar nymphs only

- 1 a General body colour uniform dark-brown, shiny, with no markings on the head, pronotum or abdomen; pleural area and sternum white, contrasting with the dark brown. ------2
  - b Body colour, including pleural area and sternum brown; markings occur on the head, pronotum and abdomen.-----3
- 2 (la)
  - a Yellowish, dark to middle-brown.

## Encoptolophus sordidus sordidus

b - Reddish-brown

# Chortophaga viridifasciata viridifasciata

3 (1b)

- a Very dark-reddish-brown; a conspicuous large white crescent on gena and pronotum; dorsal median white band along the thorax and abdomen, conspicuous; no other markings on pronotum; metathoracic femur with outer and inner faces completely dark-brown. Melanoplus borealis borealis

3 (2b)

- a Body colour rather yellowish middle-brown; white area behind the eye and below the dark band posterior to the eye; dark streak on outer face of metathoracic femur not even partly broken by a pale spot; two bands on the top of the metathoracic femur pale or inconspicuous; on the inner side the dark streak is continuous. Melanoplus femurrubrum femurrubrum
- b No white area behind eye and below the dark band posterior to the eye, but a pale background area maculated with dark-brown spots; outer face of metathoracic femur with a dark streak which is either completely broken or broken only on the upper row of chevrons by a pale spot, two large conspicuous bands on the top contrast with the pale to whitish areas between them; the inner face of the metathoracic femur with two dark bands contrasting with the white bands.

## Melanoplus sanguinipes sanguinipes

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#### Key to species - All instars other than the first

- 1 a Body colour entirely grey, greyish brown or green; antenna short and dorso-ventrally flattened.
  - b Body colour brown with dark, pale, whitish or greenish markings;
    antenna longer and segments mostly circular in cross section.---3
- 2 (la)

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 Body colour pale grey but densely maculated with dark-grey to black markings; pronotum with a pale X-pattern dorsally.

#### Encoptolophus sordidus sordidus

- b Body colour uniform, either middle-grey, greyish brown or pale green with very few markings; top of pronotum without X-pattern. <u>Chortophaga viridifasciata viridifasciata</u>
- 3 (1b)
  - a Conspicuous white crescent on gena and pronotum, and no other white spot on pronotum; eye banded, lower half much darker than the maculated upper half (Fig.145); dark streaks on inner and outer faces of metathoracic femur continuous and covering all, or almost all, of the chevrons area; no particular marking on top of femur; no dark bands or dark spots just above the leg sockets on the mesopleuron and metapleuron; posterior margin of male subgenital plate

not grooved; cerci slender, upper margin deeply concave and lower margin convex, apical width less than median width.

#### Melanoplus borealis borealis

3 a - White crescent not so conspicuous, often incomplete; pronotum always with whitish spots at least on the margins if not also on the lobe as well as the white crescent and on the median carina; mesopleuron and metapleuron with conspicuous dark markings just above the leg sockets; streak on outer and inner faces of the femur does not cover the whole chevron area, the inside streak never being complete and the outside streak convering not more than the whole surface of the upper chevrons plus the upper third of the lower row of chevrons. ------4

#### 4 (3b)

a - White area on the gena always present; subocular sulcus region dark; pronotum evenly coloured dark brown, punctuated only by the clear white markings (Fig.146); median carina of pronotum whitish and contrasting with the colour of adjacent regions; no white spot in the axillary sclerites region of the upturned hind wing pad; fuscous streak on outer face of metathoracic femur continuous over the upper row of chevrons; in the last instars male subgenital plate not grooved on the apical margin; cerci with upper and lower margins concave so that apical width is more than the median width.

#### Melanoplus femurrubrum femurrubrum

4 b - White area on the gena absent; white crescent on the pronotum very small, often reduced to a narrow elongated white spot in the center of the pronotum; remainder of pronotum pale and covered with middle and dark brown maculations, no contrasting white median carina (Fig.147); conspicuous and contrasting white spot on the axillary sclerites region of the upturned hind wing pad; subocular sulcus region not darker than adjacent areas; metathoracic femur marked with two conspicuous dark bands on the inner face, the top and the outer face where they may or may not be united on the upper third of the lower row of chevrons but are never united on the upper row of chevrons; in the last instars, male subgenital plate grooved medially on the apical margin and cerci with a slightly concave upper margin and convex lower margin, apical width less than median width and cerci short and stout in appearance.

#### Melanoplus sanguinipes sanguinipes

#### Descriptions of the nymphal stages of the species

#### Melanoplus femurrubrum femurrubrum (De Geer)

The measurements for all instars of this species are listed in Table 6.

## First instar (Figs. 24, 122 and 123)

Antenna with 13 segments, those of the base of the flagellum, the scape and pedicel nearly circular in cross section while the six or eight terminal segments form a slightly pronounced club; scape, pedicel, and sometimes also the first segment of the flagellum, bearing a dark-brown marking on the ventral side, the three or four following segments very pale and with little or no markings; the six or seven terminal roundish segments are coloured middle-brown and bear no marking.

The head is covered with brown dots on a whitish background; maculations are more dense around the base of the antennae; on the lower labrum, below the eyes, surrounding the subocular sulcus, and in the postero-ventral corner of the gena; behind the eye is a dark fuscous marking running posteriorly to the hind margin of the head; immediately above this fuscous marking is a small whitish narrow streak which lies just posterior to the eye; below the fuscous marking lies a large whitish band which begins below the eye, runs along the lower posterior edge of the eye posteriorly and upward toward the hind margin of the head (this whitish marking is quite important as it varies from one species to another); eye with a middle-brown background, maculated with pale dots which tend to be more numerous on the anterior upper half.

The posterior margin of the pronotum shows an inflection inwardly at the middle; the whitish median carina averages 0.75 mm. in length; area lateral to the carina coloured pale to middle-brown, and on the anterior border a whitish spot and dark fuscous markings continue the corresponding markings of the head; the main marking of the pronotum is the pronotal crescent, which in the species extends from the anterior margin backward for two-thirds of the pronotum from whence it continues as a thin, interrupted band; anterior part of the crescent often interrupted by brown dots; below the crescent, the pronotum is dark-brown, except for the region adjacent to the postero-ventral corner; both fore and hind margins are ornamented with eight to ten fuscous spots; the pre-episternum is dark on its anterior part and whitish posteriorly.

The mesonotum and metanotum appear as narrow transverse scierites which are coloured middle-brown, except for a median whitish or pale carina and a dark fuscous spot near the anterior border at lateral edge of the scierites, this spot marking the line of hinging of the wing pad on the notum; wing pads are very short and show as laterally-downward projecting lobes about 0.1 mm. in length.

The metathoracic femur measures about 2.26 mm. in length; chevrons on the outer face are covered with a continuous fuscous streak; this marking is more pronounced along the median separation line of chevron rows; on the top of the femur are two large brown markings on either side of the carina; a third marking occurs near the distal end, mostly

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inside the carina; the inner face bears a continuous fuscous streak which covers all of the chevrons.

The abdominal tergites bear a median whitish line which narrows posteriorly; they are coloured middle-brown with a few dark-brown markings in rows along the posterior margins on each side of the carina and around the lateral edges; sternites are pale (as is the whole ventral region of the thorax); genital appendages appear on the eighth and ninth sternites on a female nymph and on the ninth sternite on a male nymph.

In the female (Fig. 53), the lower ovipositor values appear as two small lobes projecting from the hind margin of the eighth sternite, forming a transverse fold in the hind part of the sternite; the lobes measure about 0.08 mm. in length; the upper values, measuring about 1.40 mm. in length are a pair of lobes of the ninth sternite, nearly twice as long as the lobes of the lower values, and about one-third of the length of the underlying paraprocts; these upper values have rounded apices and are completely, or nearly separated by a deep incision.

The male (Fig. 54) shows no appendage on the eighth segment but only on the ninth segment; at the posterior edge of the ninth sternite is a projection consisting of two short obtuse lobes which are joined medially by a semi-circularly excised apex; they cover only one-fourth to onethird of the underlying paraprocts and measure about 0.10 mm. in length.

#### Second instar (Figs. 25 and 124)

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The antennae have 16 segments, the proximal six being pale and the remainder dark-brown.

The head is covered with brown maculations which gives it a middlebrown appearance; the subocular sulcus region is darker; a fuscous band posterior to the eye lies just above a white band covering the upper part of the gena; the postero-ventral region of the head is maculated with brown spots; a small white spot lies just above the fuscous band and adjacent to the posterior margin of the eye; the eye bears numerous whitish maculations evenly scattered over the entire reddish-brown background.

The pronotum measures 1.11 mm. in length; the median carina is whitish followed laterally by a middle-brown area lying above the white crescent; the crescent runs across two-thirds of the pronotum and continues as a pale brown band to the hind margin; near the anterior margin the crescent is attenuated by brown maculations, it is not as white as shown in Fig. 124. (the white patches on the gena, the anterior part of the crescent, and the femur, the postero-ventral area, are emphasized by light reflection); beneath the crescent are two short, dark-brown bands, one adjacent to the crescent and following posteriorly and upward to the middle of the pronotum, the other one beginning on the pre-episternum and running parallel to the first; between and behind these markings the pronotum is maculated pale-brown; the pre-episternum is fuscous except for its posterior third.

The mesonotum and the metanotum are similar in colour to the hind part of the pronotum, a whitish median carina below which is a middlebrown area with dark spots on the hind border, and with a pale band below across both segments, a continuation of the pale band of the pronotum; a dark fuscous spot, below the pale band, indicates the separation line between the notum and the wing pad; this spot is usually seen only on the metanotum as that of the mesonotum is usually concealed under the pronotum; wing pads show as lobes extending downward, with a very slight curve backward, approximately 0.20 mm. in length with no signs of venation; the tip pale-brown to whitish.

The pleuron is marked with fuscous just over the mesothoracic and the metathoracic leg sockets. The metathoracic femur averages 3.02 mm. in length; the outer face is marked with a continuous fuscous streak covering the center line on the proximal third and then extending over the upper row of chevrons and just covering the upper third of the lower row of chevrons; two faint marks appear above, inside and outside the carina; the inner face is marked by fuscous spots on the first distal chevrons.

The ventral view of the terminal abdominal segments of the female nymph (Fig. 55) shows lower valvulae of 0.31 mm. projecting out of a semi-circularly excised posterior margin of the eighth segment; the lower valvulae are triangular, with rounded apices and with outer margins showing depression; the upper valvulae are elongated(0.45 mm.) covering two-thirds of the paraprocts, with bluntly pointed apices, and are separated by a deep acute excision;

The male subgenital plate (Fig. 56) covers about two-thirds of the paraprocts; length 0.32 mm.; the apex is in the form of a V-shaped excision, the sides showing light inflexions; the line of separation between the ninth sternum itself and the subgenital plate is indicated by two lateral incisions.

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#### Third instar(Figs. 26 and 125)

The antennae have 19 segments, dark-brown on the distal half and paler toward the base.

The head is maculated with middle to dark-brown spots, more dense below the antennal bases and around the subocular sulcus, forming darker areas; a dark fuscous band behind the eye extends backward to the posterior margin of the head; below this is a white spot starting just below the eye and extending backward and upward so as to cut the posterior end of the fuscous band; the rest of the gena is coloured light to middlebrown.

The pronotum has two large middle to dark-brown coloured areas, the upper one just lateral of the whitish median carina and above the whitish crescent which extends across, or nearly across, the side of the pronotum; the lower dark area is pierced by three white spots, from the lower part of the anterior margin to the center of this lower dark area; the postero-ventral area is also whitish; (the specimen shown in Fig. 125 is relatively dark coloured, nymphs of <u>M</u>. <u>femurrubrum</u> are often found which are much paler than that shown in Fig. 125). The pre-episternum is fuscus, except for the posterior third which is whitish; the pronotum measures 1.69 mm. along its median carina.

The mesonotum and the metanotum bear the same colours as found on the pronotum, and in the same order; a few dark spots marks the posterior border of the sclerites as on the pronotum; the white pronotal band continues through these two nota but in general is more attenuated, than shown in the photograph (Fig. 125); the lower dark spot indicates the region of the line of separation of the notum and the wing pad; wing pads average 0.43 mm. in vertical length; the fore wing pad tends to be more pointed than the hind wing pad which presents a circular margin; both point downward and backward and show a few grooves pointing in the same direction which are indications of venation; the mesopleuron and metapleuron have fuscous markings just above the leg sockets and those spots contrast with the whitish upper part of the pleuron; the metathoracic femur is 4.36 mm. in length; its outer face is marked with a continuous fuscous streak which covers the upper third of the lower row of chevrons and the whole surface of the upper row of chevrons except the region adjacent to the proximal upper corner; on the top of the femur are two pale markings inside and outside the carina; the inner face of the femur bears a fuscous streak which is broken by white coloured chevrons in the proximal third.

The abdomen is coloured middle-brown on the dorsum and paler on the venter; from ventral view, the terminal abdominal segments show, in the female (Fig. 57) triangular lower valvulae of 0.40 mm. in length, bluntly pointed and showing a depression on the outer margin.

The upper valvulae cover three-fourths of the paraprocts and are half covered by the lower valvulae. They appear as elongated and bent inward.

The male subgenital plate (Fig. 58) measures about 0.42 mm. in length; the apex is trilobed, covering two-thirds of the paraprocts.

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region of the line of separation of the notum and the wing pad; wing pads average 0.43 mm. in vertical length; the fore wing pad tends to be more pointed than the hind wing pad which presents a circular margin; both point downward and backward and show a few grooves pointing in the same direction which are indications of venation; the mesopleuron and metapleuron have fuscous markings just above the leg sockets and those spots contrast with the whitish upper part of the pleuron; the metathoracic femur is 4.36 mm. in length; its outer face is marked with a continuous fuscous streak which covers the upper third of the lower row of chevrons and the whole surface of the upper row of chevrons except the region adjacent to the proximal upper corner; on the top of the femur are two pale markings inside and outside the carina; the inner face of the femur bears a fuscous streak which is broken by white coloured chevrons in the proximal third.

The abdomen is coloured middle-brown on the dorsum and paler on the venter; from ventral view, the terminal abdominal segments show, in the female (Fig. 57) triangular lower valvulae of 0.40 mm. in length, bluntly pointed and showing a depression on the outer margin.

The upper valvulae cover three-fourths of the paraprocts and are half covered by the lower valvulae. They appear as elongated and bent inward.

The male subgenital plate (Fig. 58) measures about 0.42 mm. in length; the apex is trilobed, covering two-thirds of the paraprocts.

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# Fourth instar of the six nymphal instar cycle, or extra or intermediary instar. (Fig. 126)

The dark antennae have 20 segments.

The head is maculated middle-brown except around the subocular sulcus and in the band posterior to the eye which like the mandibles are dark fuscous; below the dark eye-band and posterior to the eye is a white mark covering the upper half of the gena; the eye is maculated with light spots on a middle-brown background.

The pronotum measures 1.92 mm., is ornamented with two middle to dark-brown patches above and below the whitish crescent; the upper patch lies just below the whitish median carina, the lower patch is partly separated by a broken whitish streak originating in the antero-ventral corner of the pronotum; the anterior thirds of the two patches are somewhat darker; the white crescent is attenuated toward the posterior third of the pronotum and on the posterior margin is covered with brown spots; the pale or whitish postero-ventral region may be very small so as to cover only the border of the adjacent corner or may be large as that shown in Fig.126; the pre-episternum is dark fuscous except on the pale posterior third.

The mesonotum and metanotum show a narrow pale band which is the continuation of the white pronotal crescent; below this band lies a black spot marking the future point of inflexion of the wing pad; the wing bads are largely pale coloured with dark bases, pointing downward with a pronounced angle backward; the fore wing pad is a narrow elongated lobe while the hind wing pad is triangular in shape and measures 0.71 mm. in vertical length; both fore and hind wing pads bear numerous veins parallel to the direction of the pad.

The metathoracic femur is 5.06 mm. long; its outer face is marked with a continuous fuscous streak covering the upper third of the lower chevrons and the whole of the upper chevrons except in the region adjacent to the proximal upper corner; the top is marked with two pale bands; the inner face is covered with dark to fuscous spots on the distal third and near the proximal end they correspond more or less to the position of the marks on the top.

The abdomen is middle-brown coloured bearing ventrally the genital appendages in a stage of growth similar to those of the regular fourth instar, but tending to be a little bit shorter; the lower valvulae of the female ovipositor, measure 0.61 mm. and the male subgenital plate lobe measures 0.57 mm.

#### Fourth instar of the five nymphal instar cycle (Figs. 27 and 127)

The antennae have 21 segments, those on the distal half being dark and the proximal ones gradually becoming paler near the base.

The head is covered with middle-brown maculations except in the region of the dark subocular sulcus, the fuscous band, posterior to the eye and a whitish area, covering the upper part of the gena; eye with a middle to dark background maculated with pale spots which are more or less evenly scattered cover the whole area.

The pronotum is 2.68 mm. long; two large brown areas colour the side; the upper area, just below the whitish median carina, forms a large middle to dark-brown band continuing the fuscous band of the head; below it lies the whitish crescent which continues across the pronotum

(the photograph (Fig. 127) shows some light reflections in this region, as well as in some others, which should not be misinterpreted as markings, since the crescent appears more clearly than it really is); the lower brown patch is punctured with pale areas on its antero-ventral corner, near its center and, along the ventral and posterior margins; the pre-episternum is fuscous, except for its posterior third which is pale.

The mesonotum and metanotum are concealed behind the upturned wing pads; the fore wing pad appears as an elongated lobe pointing backward and angled upward, its distal half hidden behind the triangular hind wing pad; the hind wing pad, which is 1.6 mm. long, converges with the one of the other side so that at the tip, and only at the tip the two hind wing pads meet or nearly meet; the hind wing pad is mainly dark-brown, except that on the upper margin there is a pale band which broadens toward the tip; both the fore wing pad and the hind wing pad show distinct venation network and a basal axillary region (Figs.127& 148); the mesopleuron and metapleuron are pale coloured, cream or pale-brown, on their upper two-thirds while the lower third is coloured dark-brown to fuscous.

The metathoracic femur, 6.18 mm. in length, bears a continuous fuscous streak on the outer face covering the upper third of the lower chevrons and the whole of the upper chevrons, except an area adjacent to the upper proximal corner; light-brown above with two slightly darker bands running across it; the inner face is marked with fuscous spots on distal chevrons down for about two-thirds of the length; the underside of the femur is pale-brown to whitish as in the other nymphal stages.

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In the female (Fig. 59), the lower valvulae are elongated structures, 0.72 mm. long, their outer margins depressed on the distal half; they are bluntly pointed and show no or little sign of formation of teeth at the tip; the posterior margin of the eighth segment has a median projection between the bases of the valvulae; the upper valvulae, which cover almost the whole length of the paraprocts have rounded tips. The male subgenital plate lobe (Fig. 60) measures approximately 0.60 mm. in length and covers more than half of the paraprocts; the posterior margin shows two rounded lobes, separated by a semicircular depression.

#### Fifth instar of the six nymphal instar cycle (Figs.28 and 128)

The antenna has 21 segments, those of the distal half being dark and the proximal ones being paler.

The head is maculated middle-brown except on the following areas: around the subocular sulcus and on the band posterior to the eye, which are dark fuscous; on the upper half of the gena, which is pale to white. The eye is middle-brown and densely maculated with evenly scattered pale spots.

The pronotum, which measures 2.96 mm. in length, is coloured by two large middle to dark-brown patches separated by the white crescent which crosses or almost crosses the pronotum; the lower patch is broken on its anterior half by two or three pale, whitish spots and the posteroventral corner region is also very pale or white; the pre-episternum bears a fuscous to dark-brown spot covering approximately the anterior two-thirds, the rest being very pale.

The wing pads are oriented upward and backward, dark-brown, except

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for the upper third, which is pale brown to white; the hind wing pad concealing the forewing pad is triangular in form but more elongated than in the normal fourth instar, (fourth instar of the five nymphal instar cycle) although it is not much longer, measuring 1.74 mm. in length.

The mesopleuron and metapleuron are pale to white on their upper two-thirds while the lower part is coloured with fuscous.

The metathoracic femur, 7.0 mm. in length, bears a continuous fuscous to dark-brown streak along the outer face, covering the upper third of the lower row of chevrons and the whole upper row of chevrons except for a region adjacent to the upper proximal corner; the dorsal area is crossed by two pale to middle-brown marks, these marks are continued by fuscous spots, in line with them, on the chevrons of the inner face, mostly at the distal end.

The female has ventrally, well developed ventral ovipositor valvulae (Fig. 61); the lower valvulae measure 1.0 mm. in length, bearing sclerotized, tooth-like structures and with their outer margins presenting a shoulder-like projection near the tooth; the upper valvulae, which are longer than the paraprocts, terminate in tooth-like apices.

The male subgenital plate lobe (Fig. 62) is much elongated, about 0.80 mm. and nearly covers the whole length of the paraprocts; the posterior margin appears slightly depressed at the center between the two raised sides.

#### Fifth instar of the five nymphal instar cycle (Figs. 29 and 129)

The antennae have 24 segments, the distal ones being dark-brown or fuscous and the basal ones paler.

The head is coloured for the most part with middle-brown maculations, except for the dark region of the subocular sulcus and the fuscous band posterior to the eye, and the gena, which is whitish on the upper half and middle to pale-brown below.

The pronotum bears two large middle-brown to fuscous markings, separated by a neat white crescent; the lower marking is pierced by white spots on the anterior half; the region near the postero-ventral corner is spotted with white; the pre-episternum is partly dark coloured, the posterior third being whitish; the length of the pronotum is 3.59 mm.

The hind wing pad is very much elongated (Fig. 149), measuring 3.73 mm.; it is always longer or at least as long as the pronotum; fuscous to dark-brown except for an upper white band broadening toward apex; both wing pads are a definitely pointing backward, touching those of the other side along their entire length; venation is developed.

The mesopleuron and the metapleuron are mainly pale coloured except near the leg sockets where they are middle-brown to fuscous.

The metathoracic femur, 7.97 mm. in length, bears a continuous fuscous streak on its outer face covering the upper third of the lower row of chevrons and the whole of the upper row of chevrons except for a small patch in the upper proximal corner; the dorsum is crossed by two markings while on the inner face fuscous marks cover the chevrons of the distal half. The female shows, ventrally (Fig. 63) ovipositor valualae which are nearly grown to the adult shape. The lower valualae measure 1.0 mm., have a sclerotized pointed apex, and bear two basivalular sclerites which cover about half their length; they cover more than threequarters of the upper valuale, also pointed with a heavily sclerotized apex (the lateral view is shown in Fig. 64); the upper valual is bent upward, but less so than in <u>Melanoplus sanguinipes</u>, and is bluntly tipped; the lower valuae shows basally the upper and lower basivalular sclerites, following the upward bend of the upper valual with its apex on the underside.

The male subgenital plate lobe measures about 1.2 mm.; its posterior margin, in ventral view, presents a more or less rounded appearance (Fig. 65); in lateral view (Fig. 66) it appears as a lateral elevated rounded lobe which then lowers posteriorly to a semi circular apex as shows in posterior view (Fig. 67); there is no path or groove in the middle; cerci shows with the distal part larger than the middle portion; both upper and lower sides are concave, a feature which can also be seen to some extent in the fourth instar.

#### Sixth instar of six nymphal instar cycle

The antenna, head, pronotum, and metathoracic femur show the same colouration pattern as the fifth instar of the five nymphal instar cycle. The genital appendages also shown the same developmental stage as the later mentioned instar: The lower valvulae measures 1.16 mm., and the male subgenital plate lobe is 1.27 mm.; the pronotum is 3.81 mm., the femur 8.71 mm., and the wing pad is 4.11 mm. in length. The antenna has 24 segments, as in the fifth instar of the five instar cycle.

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#### Melanoplus sanguinipes sanguinipes (Fabr.)

The measurements for all instars of this species are listed on Table 7.

First instar (Figs. 30, 130 and 131)

The antenna is composed of 13 segments which are dark coloured.

The head is maculated dark-brown to fuscous, with dark areas at the base of the front, on the lower part of the gena and behind the eye; posterior to the eye margin is a small white spot lying just above a large fuscous band; upper and lower parts of the gena are patched with dark-brown to fuscous; there is no white or pale streak; the eye is dark to reddish-brown and covered with pale spots which are larger on the upper half of the eye.

The pronotum is 0.67 mm. in length along the whitish median carina, coloured middle-brown with darker regions near the anterior margin, at the level of the dark band of the head and, near the antero-ventral corner; the whitish crescent is greatly reduced and broken by dark-brown spots, consisting only of two or three whitish spots, one at the anterior margin followed by a few brown maculations before the second white spot in the middle, thus it does not proceed further than two-thirds or less of the length of the pronotum; two narrow white bands are found on the anterior margin is pale, maculated with dark spots; the pre-episternum is dark on the anterior third and pale on the posterior two-thirds.

The mesonotum and metanotum are coloured middle-brown with a pale median carina, posterior margin pale and maculated with dark spots and a dark marking on their anterior two-thirds which marks the line where the notum and the wing pad join; wing pads are mainly dark coloured, measuring about 0.10 mm. in length and show no sign of venation.

The mesopleuron and metapleuron are dark, more so near the leg sockets.

The metathoracic femur is 2.14 mm. long, its outer face coloured with a dark-brown streak broken for all its width or only in half its width by a pale spot; the dark streak covers nearly all of the lower row of chevrons, when it is not cut by the light marking, and the three or four chevrons anterior to the pale spot together with the chevrons distal to the pale spot; the dorsum of the femur presents four dark-brown markings, the proximal one being small, and two larger ones which are more constant, all crossing the carina and can be seen on the inner side of the top; the distal end also has a dark spot seen from above (Fig. 131), showing as three white spots between the four dark markings along the top of the femur; the inner face is crossed by two dark-brown to fuscous bands in line with those on the top; the distal end of the femur is also dark corresponding to the top and the outer face; the underside of the femur is completely dark.

The abdomen is marked by a pale line on the median carina and is maculated all over the sides with small and large spots of dark-brown colour, while the underside is paler.

On the ventral side, the female presents appendages on its eighth

and ninth segments, which are respectively the lobes of the lower and upper valvulae (Fig. 69); the lower valvulae appear as small lobes posterior to a fold in the eighth sclerite; the upper valvulae are a pair of triangular lobes separated by a large inflexion, their inner sides concave and the tips quite tapering; the lower valvulae measure 0.08 mm. while the upper valvulae measure 0.18 mm. in length and the latter are equal to about half the length of the paraprocts.

The ninth sternite of the male (Fig. 70) is prolongated by two short obtuse lobes separated by a semicircular median inflexion; the lobes measure about 0.08 mm. in length and cover less than one-third of the length of the paraproct.

#### Second instar (Figs. 31 and 132)

The antenna is dark and consists of 16 segments.

The head is pale, as is the rest of the body, the only dark marking being the fuscous band behind the eye which runs horizontally from the posterior margin of the eye to the posterior margin of the head; the rest of the head is maculated with light- brown spots, more or less evenly scattered; the whole area below the dark band on the upper part of the gena is maculated and without a white patch; the eye is of a middle-reddish-brown background colour maculated with pale spots which are more numerous on the upper half.

The pronotum which is 1.04 mm. in length bears small middle to dark markings; in line with the fuscous band of the head are three to four spots on the anterior margin of the pronotum and posterior to them is a small area, coloured middle brown and bordered with a dark-brown

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band on its lower border; a few dark markings lie in the center of the pronotum side; separated from the upper set of dark markings by the white crescent, which is a narrow band running from the anterior margin for the two-thirds of the pronotal length, irregular and interrupted by dark spots on its anterior part so that often it appears as a white longitudinally elongated spot in the middle of the side of the pronotum; the upper third of the lateral area of the pronotum is coloured light to middle brown, maculated with dark spots, while the lower part is very pale and marked by a very few dark spots mainly along the posterior margin.

The mesonotum and metanotum are pale-brown in colour with a few dark maculations; toward their lower margins is an anterior fuscous marking, which delimits the line of origin of the wing pad; both wing pads appear as lobes pointing downward and very slightly posteriorly, pale with a few middle -brown spots on the posterior parts, behind a fuscous marking; they measure about 0.30 mm. in length and show no sign of venation; the mesopleuron and metapleuron are pale above but bear large fuscous bands just above the leg sockets.

The metathoracic femur measures 3.13 mm.; its outer face bears a fuscous streak which is sometimes completely divided by the white area, as shown in Fig. 132, or may be broken only on the upper row of chevrons so that a narrow fuscous band joins the two spots through the upper third of the lower row of chevrons; the proximal part of the streak begins on the median line and on the upper third of the lower chevrons and then extends over the whole surface of two or three

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chevrons just anterior to the white patch; the distal part covers both the upper and lower rows of chevrons; distally is a pale transverse band, anterior to the dark coloured distal end; the dorsum of the femur bears two dark bands in line with the two parts of the streak on the outer face, also a small band on the proximal part and a dark region at the distal end; the inner face bears three large dark bands corresponding to the three main bands on the dorsum and on the outer face.

In the female (Fig. 71), the lower valuale show as triangular lobes, 0.21 mm. in length, with rounded apices and concave outer margins; the upper valuale are elongated structures showing a cylindrical distal half, their bases not completely separated; on each side, the beginning of differentiation of basivalualar sclerites can be seen, they are 0.32 mm. long, and cover slightly less than half of the paraprocts.

In the male (Fig. 72), the lobes of the ninth sternite are quadrangular structures separated in the middle by a suture or a depression; the apical margin appears as a concave obtuse angle; the lobes measure 0.25 mm. in length and cover half of the paraprocts.

#### Third instar (Figs. 32, 133 and 134)

The antennae consist of 19 segments and are coloured dark to middle-brown.

The head is nearly evenly maculated with pale to middle-brown spots, the only exceptions being a small white area above the dark band posterior to the eye; the eye is middle-brown and maculated with pale spots which are more numerous in the upper portion (Fig. 134); the colour of the eye in Fig. 133 is a result of change after death.

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The pronotum bears a narrow whitish band from its anterior margin to the middle of its length, the posterior part being attenuated with pale brown and darker spots; above this is a middle-brown coloured area covered with darker maculations and below is a small dark marking bordering the whitish band in the center, and middle-brown maculations dispersed over the pale lower half; the pre-episternum is coloured middlebrown on the anterior half and is pale posteriorly; pronotal length is 1.64 mm.

The mesonotum and metanotum show the same colouration as the upper part of the pronotum, with the dark fuscous spot on the anterior part of each notum delimiting the wing pad, generally pale coloured with some darker maculations; the fore wing pad is tapered with a rounded apex pointing downward and backward, while the hind wing pad, pointing in the same direction, has convex margins and is roundish overall; both wing pads show signs of venation as longitudinal ridges and grooves; they measure about 0.45 mm. in length; the mesopleuron and metapleuron are pale on the upper part but bear dark spots or bands just above the leg sockets.

The metathoracic femur is 4.33 mm. long; its outer face bears two large dark bands, either joined or not joined through the upper third of the lower row of chevrons but always separated in the upper row by a whitish area; the dorsum of the femur bears two dark bands in line with those of the outer face; at the distal end is a dark region which is also found on the outer and inner face; the inner face is crossed by two large dark bands corresponding in position with those on the

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dorsum.

In the female (Fig. 73), the lower valuale have elongated to 0.40 mm. and conceal most of the second valuale, of which only the tip is visible; the upper valuale are long tapering structures, but still with rounded tips, covering about two-thirds of the paraprocts.

In the male (Fig. 74), the lobes have united to form a large plate, 0.53 mm. long, on which the apical margin shows two prolongations separated by an inflexion or groove; the subgenital plate lobe covers nearly the entire length of the paraprocts.

#### Fourth instar of the six nymphal instar cycle (Figs. 33, 135 and 136)

The dark antenna consists of 20 segments.

The head is maculated all over with pale to middle-brown spots, except for the dark band posterior to the eye and a small whitish area above it; the maculations on the eye are somewhat more numerous on the upper half, making the lower part appear a bit darker.

The pronotum, 1.95 mm. long; laterally, with an almost centrally situated elongated white spot surrounded with dark markings, mainly above.

The mesonotum and metanotum have the same colouration as the upper part of the pronotum which is pale to middle-brown with dark maculations; the wing pads still point downward but also definitely backward; the wing pads have a pale background with middle-brown marks along the veins, and a dark spot at their upper anterior corner; the hind wing pad measures 0.80 mm.; the mesopleuron and metapleuron are pale above but bear dark bands just above the leg sockets.

The metathoracic femur, 5.40 mm. in length, is marked by two fuscous bands on the outer face, the top and inner face.

The genital appendages show development similar to those of the fourth instar of the five nymphal instar cycle; the female lower valvulae measure 0.61 mm. in length and the male subgenital plate lobe measures 0.85 mm. in length.

### Fourth instar of the five nymphal instar cycle (Figs. 34 and 137)

The antenna is composed of 21 segments, the proximal ones having a pale colour dorsally and a dark colour ventrally, the distal ones being dark-brown.

The head is entirely maculated with middle-brown spots, plus a few small dark ones on the front, except for the dark band posterior to the eye and the small whitish region above it; the eye is reddishbrown in colour and maculated with paler spots which are somewhat more numerous on the upper half, tending to be banded as in Fig. 137.

The pronotum, 2.58 mm. in length, has a dark band in line with that of the head posterior to the eye which does not always extend completely along the length of the pronotum; just below it is a narrow whitish band, often reduced to a central longitudinally elongated spot, the anterior and posterior regions often being coloured and maculated; below the white central spot is an irregular dark marking which always lies just at the lower border of the central white spot; the lower half of the pronotum is pale coloured sometimes with dark irregular maculations. The wing pads are reversed, pointing upward, appearing as triangular lobes, 1.68 mm. in length; a white spot occurs in the region of the axillary sclerites, and is surrounded by a fuscous region, of variable width, to a maximum as shown in Fig. 137; the upper margin and the tips are pale; distinct venation can be seen on both of the wing pads; the fore wing pads are elongated lobes directed backward and concealed under the hind wing pads which nearly touch the one of the other side at the tip.

The mesopleuron and metapleuron are pale-brown with dark spots just above the leg sockets.

The metathoracic leg is marked with two large bands on the outer face, the top and the innerface; on the outer face, the proximal band is extended along the middle line and on the lower part of the upper row of chevrons then expands covering two or three entire chevrons of the upper row; the second band covers all of the last upper chevrons and part or all of the last lower chevrons, the two bands may or may not be united by a dark band on the upper row of the lower chevrons below the whitish patch; the distal end of the femur is ringed by dark-brown colour.

In the female (Fig. 75), the lower valuation have elongated to 0.70 mm., with the tip heavily sclerotized, still rounded; the basivaluation valuation of the sclerites begin to differentiate; the upper valuation which cover more than the three-fourths of the paraprocts, are heavily sclerotized at the tips.

In the male (Fig. 76), the subgenital plate lobe is elongated to 1.00 mm. and straight lateral margins lead to an apical margin

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which is incised with a central groove which runs upon the posterior part of the lobe; the lobe is now much longer than the paraprocts.

#### Fifth instar of the six nymphal instar cycle

This instar is very similar to the fourth instar of the five nymphal instar cycle, except as follows: the pronotum measures 2.92, the wing pad 1.86, the femur 6.82, the lower valvulae of the female ovipositor 1.05, and the male subgenital plate lobe 1.21 mm. in length.

#### Fifth instar of the five nymphal instar cycle (Figs. 35 and 138)

The antenna, which has 24 segments, is dark on the distal part and becomes paler toward the base.

The head is entirely maculated with pale to middle-brown spots except on the dark band and on the narrow white band posterior to the eye; the eye is dark reddish-brown, maculated with pale spots which are more numerous on the upper half; banding across the eye is evident (Fig. 138) at the level of the white and dark levels posterior to the eye.

The pronotum bears laterally a longitudinally elongated white spot which is the remnant of the white crescent, this may on some specimens be more complete and appearing as a narrow white band starting at or near the anterior margin and extending to the middle of the pronotum; in each case, the central white spot is bordered above and below by a dark spot, the remainder of the pronotum being maculated pale to middlebrown; pronotal length is 7.82 mm.

The hind wing pad is a large, fan like, elongated lobe 4.15 mm. in length, venation is elaborate and is covered in part on in whole by dark patches; a white spot surrounded by dark markings is present at the base of the veins; the hind wing pads meet along nearly their whole length; the fore wing pad is a narrow elongated lobe concealed behind the pronotum and the hind wing pad a part, of its veined surface can be seen above the anterior part of the hind wing pad.

The mesopleuron and metapleuron are maculated light-brown, except just above the leg sockets, where they are slightly darker to much darker.

The metathoracic femur, 7.82 mm. in length, is marked by two large bands running across the outer face, the top and the inner face; on the outer face the two bands may be united on the lower row of chevrons below the pale patch (Fig. 138), or be completely separated by the white patch.

In the female (Fig. 77), the lower ovipositor valuale measure 1.23 mm. in length; they show distinct basivalualar sclerites and the outer margin curves abruptly so that the narrow tip appears as a toothlike process; the upper valuale curve upward (Fig. 78)more than those of <u>M. femurrubrum</u>, and are about of the same length. The tip is more acute than in M. femurrubrum.

The male subgenital plate lobe is 1.41 mm. long; it has an elongated apical part with the apical margin depressed in the middle by a groove which runs in the external surface of the apical part (Figs. 79, 80 and 81). In lateral view, the prolonged apical portion appears as two digit-like structures separated by a groove; the cerci have the upper margin concave but the lower margin is convex; the apical width is much smaller than the median width.

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#### Sixth instar of the six nymphal instar cycle

The antenna has 24 segments, the eye, the head, the pronotum, the wing pads, the femur and the genital appendages correspond to the description of the fifth instar of the five nymphal instar cycle, except for some differences in size, as follows: pronotum 3.82; hind wing pad 4.76, hind femur 8.58 mm., lower valvula of the female ovipositor 1.35, and the male subgenital plate lobe is 1.52 mm. in length.

#### Melanoplus borealis borealis (Fieber)

The measurements of all instars are shown in Table 8. <u>First instar</u> (Figs. 36 and 139)

The antenna is dark-brown and is composed of 13 segments.

The head is very dark-brown all over even on the front (it is not pale as the light reflection on Fig. 139 may suggest); exceptions to the dark colour are the large well defined white crescent from the antero-ventral corner of the gena to its upper posterior margin, passing by the lower posterior margin of the eye, and a narrow white band dorsal to, and separated from the crescent by a dark band, just above and posterior to the eye; the eye is reddish-brown colour with pale maculations on the upper half, banding is evident at the level of the upper border of the dark band posterior to the eye, this banding turns ventrally toward the anterior edge of the eye. The pronotum, 0.78 mm. in length, has a white median carina but laterally is very dark-brown except for a large, clearly defined white area, a continuation of the crescent of the gena, which crosses the pronotum from the anterior margin for three-fourths of the length; on the posterior fourth, it still can be seen but is tinted lightbrown.

The mesonotum and the metanotum are very dark-brown except for the white median carina; the line of origin of the wing pads on the nota is indicated by a darker fuscous spot on the anterior part of each notum; the wing pads are entirely very dark brown and show as short downward-pointing lobes about 0.10 mm. in length; the mesopleuron and metapleuron are entirely dark.

The metathoracic femur measures about 2.24 mm. in length; the outer face is completely covered, chevrons and distal end, by a dark fuscous streak; the dorsum is irregularly coloured pale or middlebrown inside and outside of the carina; the chevrons of inner face and the distal end are completely covered by a dark fuscous streak; the femur is also dark fuscous beneath.

The abdomen is entirely very dark-brown except for a contrasting median carina and some pale areas lateral to the median carina on the caudal abdominal segments;

In the female (Fig. 82), the lower valuale of the ovipositor appear as short lobes of 0.10 mm. in length, posterior to a fold in the eighth sternite; the upper valuale are distally tapering lobes with round tips and are separated by a deep incision; they measure 0.18 mm. in length and cover less than half the length of the paraprocts. The male bears two pointed lobes 0.10 mm. long, as projections of the ninth sternite (Fig. 83), separated by an acute incision; they cover less than half the length of the paraprocts.

#### Second instar (Figs. 37 and 140)

The antenna is composed of 16 segments, coloured middle-brown, paler near the base.

The head is middle-brown on the front and on the vertex; on the gena a clear, well defined, large, white crescent occurs from the anteroventral corner to the upper posterior margin; a dark band borders the white crescent anteriorly, on the subocular sulcus region, and passing through the eye and posterior to the eye as a dark fuscous band; the genal portion posterior and below the white crescent is also coloured very dark-brown; the eye is banded, the upper half being maculated with numerous pale spots and the lower part, with very few pale spots, appears darker.

The pronotum, 1.17 mm. in length, is crossed by a large well defined white crescent from the anterior border reaching or nearly reaching the posterior margin; above and below this white crescent is a dark-brown to fuscous region as wide or wider than the white band itself, the rest of the pronotum is coloured pale to middle-brown with dark-brown maculations scattered about.

The mesonotum and metanotum show a whitish median carina and a pale-brown to whitish band continuing the pronotal crescent; dark areas above and below the pale band are similar to those on the pronotum; the lower dark region corresponds with the dark spot marking the line of origin of the wing pad; the remainder of these segments, and the wing pads, are coloured middle-brown; the wing pads are 0.25 mm. long, show no sign of venation, point downward, and have rounded margins; the mesopleuron and metapleuron are of the same colour, entirely middle-brown.

The metathoracic femur is 3.16 mm. long; its outer face is covered by a continuous unbroken fuscous streak which completely covers the chevrons; the inner face bears the same kind of streak covering all of the chevrons area; dorsally, there are some pale and middlebrown areas irregularly distributed.

The abdomen is middle-brown with darker markings on the sides, the underside is middle to pale brown.

In the female (Fig. 84), the lower ovipositor valvulae, which are 0.20 mm. long, have grown as two triangular lobes joined at the median margins; the upper valvulae are more pointed than the lower ones and their distal parts are largely separated; they measure 0.31 mm. in length and cover more than half of the paraprocts.

The male subgenital plate lobe (Fig. 85) measures 0.32 mm. in length and its apical margin has two rounded projections separated by an uniformly incised median border; the lobe covers about the twothirds of the paraprocts.

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#### Third instar (Figs. 38 and 141)

The antenna is composed of 19 segments.

The head is coloured middle-brown on the front and vertex and the postero-ventral region of the gena; the white crescent is large and well defined from the antero-ventral corner of the gena to its upper posterior margin; the subocular sulcus, the lower half of the eye, and the dark band posterior to the eye border the white crescent anteriorly.

The pronotum, 1.68 mm. long, is crossed by the large, well defined, white crescent from the anterior to the posterior margin; a dark region lies just above the crescent and also below it in the anterior part; the rest of the pronotum is pale to middle-brown.

The mesonotum and metanotum are pale to middle-brown and bear a whitish band, a continuation of the pronotal crescent; below the band, anteriorly, is a dark spot marking the line of origin of the wing pad; the middle-brown coloured pads point downward but show a definite angle backward, and rudiments of venation; they measure 0.40 mm. in length; the mesopleuron and metapleuron are pale to middle-brown; even near the leg sockets they bear no dark marks.

The metathoracic femur, 4.34 mm. in length, is covered on the whole chevrons area of the outer and the inner faces by a dark fuscous streak; there is no particular marking dorsally.

The abdomen is pale brown with large band of middle to dark-brown markings on the side.

In the female (Fig. 86), the lower ovipositor valvulae, 0.41 mm. in length, are long triangular lobes with large bluntly rounded apices, basivalvular sclerites have begun to differentiate; the upper valvulae, covering about three-fourths of the paraprocts, are long, bluntly pointed and have basivalvular sclerites.

In the male (Fig. 87), the subgenital plate lobe has a slightly concave distal margin and covers nearly the whole length of the paraprocts; it measures 0.41 mm. in length.

# Fourth instar of the six nymphal instar\_cycle, (or the extra instar) (Figs. 39 and 142)

The antenna is composed of 20 segments.

The head is coloured middle-brown on the front, vertex and on the postero-ventral region of the gena; a large white, well defined crescent runs from the antero-ventral corner of the gena to its upper posterior margin; the subocular sulcus, the lower half of the eye and the dark band posterior to the eye border the upper margin of the white crescent; the eye is banded, the upper half being maculated with pale spots which render it paler than the lower half.

The pronotum, 2.21 mm. long, bears a large, well defined white crescent from the anterior to the posterior margin; a few dark markings border the crescent anteriorly but the rest of the pronotum is pale to middle-brown.

The mesonotum and metanotum are middle-brown and bear a pale narrow band, a continuing of the white pronotal crescent; the pale coloured wing pads are delimited by a dark spot below the anterior part of the pale band; the narrow fore wing pad is pointing downward, and is marked by ridges and grooves which are the indications of venation; the hind wing pad which is larger, also points downward and also bears signs of a definite venation pattern; both measure about 0.62 mm. in vertical length; the mesopleuron and metapleuron are middle-brown coloured and bear no dark markings above the leg sockets.

The metathoracic femur which is 5.10 mm. long, bears a continuous dark streak covering the whole chevrons area on the outer and inner faces; dorsally, the femur bears no characteristic marking and is coloured pale-brown.

The abdomen bears dark-brown bands on the sides along each of its tergites, the ventral area is paler.

In the female, the lower valuale have grown to 0.56 mm. and their apices begin to exhibit a heavily sclerotized structure; the upper valuale are elongated structures, barely shorter than the paraprocts.

The male has a large subgenital plate lobe nearly as long as the paraprocts, about 0.51 mm., and having the apical margin slightly con-cave.

Fourth instar of the five nymphal instar cycle (Figs. 40 and 143)

•

The antenna is composed of 21 segments, the distal ones being dark brown and the proximal ones paler.

The head is coloured middle-brown on the front, the vertex and on the postero-ventral region of the gena; the well defined white crescent runs from the antero-ventral region of the gena to its upper posterior margin; the subocular sulcus region, the lower half of the eye and the band posterior to the eye make a dark anterior border to the white crescent; the eye is banded, the lower part being dark and the upper part covered with pale maculations.
The pronotum, 2.38 mm. in length, bears a large well defined white crescent from the anterior to the posterior margin; the rest of the pronotum is middle-brown, except for a few dark spots above and below the anterior part of the crescent.

The wing pads are turned upward; the fore wing pad is an elongated, veined lobe, concealed under the pronotum and the hind wing pad; the hind wing pads are rather triangular, dark-brown, except for the upper margins and the apices, which are pale, meeting only at the tips; 1.39 mm. long; venation is distinct and axillary sclerites rudiments are visible.

The mesopleuron and metapleuron are entirely maculated middlebrown and do not bear dark markings near the leg sockets.

The metathoracic femur, 5.44 mm. in length, bears a continuous dark fuscous streak covering the whole, or nearly the whole of the chevrons areas on both outer and inner faces; no particular markings appear on the dorsum.

The abdomen is marked by a broad dark band on each side, the rest being pale and maculated with middle-brown spots.

in the female (Fig. 88), the lower ovipositor valualae measure 0.71 mm. in length; their apices are heavily sclerotized in the form of tooth-like process; the upper valualae are slightly longer than the paraprocts and are heavily sclerotized at the tips; basivalualar sclerites are distinct on the lateral side of the upper valualae.

In the male, the subgenital plate lobe is extended to a length of 0.59 mm.; the apex is very slightly concave in ventral view (Fig.89),

in posterior view the apical margin shows a median semicircular inflec-

#### Fifth instar of the six nymphal instar cycle

The description is the same as that of the fourth instar of the five nymphal instar cycle, except for the size of certain structures, which are as follows: pronotum 2.60, hind wing pad 1.55, hind femur 5.94, female lower valuale 0.89, and the male subgenital plate lobe is 0.85 mm. in length.

#### Fifth instar of the five nymphal instar cycle (Figs. 41 and 144)

The antenna is composed of 24 segments, the distal ones being dark-brown and the proximal ones paler.

The head is coloured middle-brown on the front, the vertex and the postero-ventral region of the gena; a large, well defined white crescent runs from the antero-ventral region of the gena to its upper posterior margin; the subocular sulcus, the lower half of the eye and a band posterior to the eye make a dark border anterior to the crescent; the eye is banded, the upper part being maculated with pale spots and thus appearing paler than the dark lower part.

The pronotum, 3.11 mm. in length, is crossed by a large, well defined, white crescent from the anterior to the posterior margin; dark markings border the white band above and below its anterior half, the rest of the pronotum being coloured middle-brown.

The hind wing pads show as large, elongated triangular lobes, upturned and pointing backward; they meet, or nearly meet, for nearly their whole length; venation is elaborate and originates from a well defined axillary sclerite region; it is completely dark-brown except for the distal half of the upper fourth; the hind wing pad is 3.28 mm. long, and conceals the distal part of the long, narrow-shaped fore wing pad; the mesopleuron and metapleuron are maculated middlebrown and do not bear dark markings near the leg sockets.

The metathoracic femur is 7.26 mm. long; its outer and inner faces are nearly or entirely covered by a continuous dark fuscous streak on the chevrons area; dorsally, it does not bear any particular marking and is coloured pale to middle-brown.

The abdomen bears a very broad dark band on each side, the rest being pale with middle-brown maculations.

In the female, (Fig. 90)the lower ovipositor valuale show distinct basivalular sclerites and tooth-like apices; they measure 1.10 mm. in length; the upper valuale appear in lateral view (Fig. 91) to be bent upward, but not to the extent as in <u>M. sanguinipes</u>, and have acute apices; the upper valuale are shorter than those of <u>M.femurrubrum</u> and <u>M. sanguinipes</u>.

In the male, the lobe of the subgenital plate, in ventral view (Fig. 92), appears as long, narrowing toward the apex with a slightly convex apical margin; it measures 1.0 mm. in length; in lateral view (Fig. 93), the apex is somewhat elevated and shows a very shallow median depression which is more obvious in the posterior view (Fig. 94); the cerci (in side view (Fig. 93)) are narrower apically than at the middle, with the lower margin convex and the upper margin much more concave than in M. sanguinipes.

## Sixth instar of the six nymphal instar. cycle

This instar is essentially the same in appearance as the fifth instar of the five nymphal instar cycle except for the following measurements: pronotum 3.5, hind wing pad 3.62, hind femur 7.87 mm., lower valvulae of the female ovipositor 1.22, and the male subgenital plate lobe 1.18 mm. in length.

## <u>Chortophaga viridifasciata viridifasciata</u> (De Geer)

Measurements for all nymphal instars are listed in Table 9. First instar (Figs. 42 and 152)

The clubbed antenna is composed of 13 segments, maculated with dark-brown spots and is flattened dorso-ventrally.

The head is completely coloured dark-reddish-brown (which is also found on the dorsal parts of the thorax and abdomen); the eye is uniformly a clear reddish-brown in colour.

The pronotum, 0.89 mm. in length, is dark reddish-brown without any other markings; the mesonotum and metanotum are also completely dark-reddish-brown; wing pads are not delimited by a darker spot; wing pads measure approximately 0.10 mm. or less; the pleural and sternal areas are whitish.

The metathoracic femur is 2.46 mm. in length; its outer face marked by two diffuse middle-brown areas on the center and distal part of the chevrons, and with a dark fuscous distal end; above are two dark bands corresponding to the positions of the diffuse marks on the outer face, and a series of dark spots on the carina; the inner side shows a dark fuscous apical end and two coloured areas corresponding to those on the outer-face and on the dorsum.

The abdomen is coloured dark reddish brown on its dorsum, the ventral side being whitish.

The female shows ventrally (Fig. 95) appendages on the eighth and ninth sternites, the lobes of the lower and upper valvulae, respectively; the lower valvulae are small lobes, about 0.10 mm. long, seen posterior to the fold of the eighth sternite; the upper valvulae, about 0.21 mm. long, are lobes on which the distal halves diverge toward the apex due to a large incision between them; they cover nearly half the length of the paraprocts. In the male (Fig. 96) small lobes, 0.11 mm. in length, occur either side of the apical margin of the ninth sternite, covering one-third of the length of the paraprocts.

## Second instar (Figs. 43 and 153)

The antennae have 16 segments, but often only 15 can be seen readily; the segments are dorso-ventrally flattened and are grey in colour.

The head is pale-grey, with markings of scattered darker grey spots, as on the rest of the body; the colour may also be completely dark beige or brown all over the body or, mostly in females, may be completely pale green.

The eye is banded by a white streak from the base of the antenna to the anterior part of the pronotum; the darker maculations are more

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numerous in the region below the white streak.

The pronotum is 1.54 mm. in length and on its upper anterior part bears a banding under which is a denser maculated region. The wing pads are 0.25 mm. long; point downward, show no venation and are coloured grey, as are the nota to which they are attached.

The metathoracic femur is 3.42 mm. long; its outer face bears no marking; the top is marked by two small dark spots inside and outside the carina; the inner face is marked with dark bands crossing the chevrons, one near the end of the chevrons and the other covering the chevrons from the middle to the proximal end.

In the female (Fig. 97), the lower valuale of the ovipositor are 0.18 mm. long, appearing as lobes with small apical points; the upper valuale are 0.32 mm. long, pointed, and are separated by an acute incision; they cover a bit less than half the length of the paraprocts.

The male subgenital plate lobes (Fig. 98) have united to form a single lobe, 0.20 mm. in length, the apical margin of which is medially depressed or concave, and which covers about half the length of the paraprocts.

#### Third instar (Figs. 44 and 154)

The short antenna has 19 segments, but often only 18 can be seen; the segments are dorso-ventrally flattened and are very short.

The head is uniformly coloured grey with slightly darker spots; the only other marking is banding from the base of the antenna to the anterior part of the pronotum, passing on the eye; the region just below the pale banding is densely maculated with dark-grey spots, thus

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the lower half of the eye is dark-grey and the upper half has a pale band.

The pronotum is 2.71 mm. long; the median carina is elevated and the median posterior region is prolonged over the mesonotum; the colour of the pronotum, as on the whole body, is pale-grey with slightly darker scattered maculations.

The wing pads point downward but also with a clear tendency to grow backward; they show signs of venation by parallel longitudinal grooves and ridges; the wing pads measure 0.81 mm. in vertical length.

The metathoracic femur, 5.06 mm. in length, is not marked on its outer face but dorsally bears two small dark spots which correspond to two bands on the inner face, of which the distal one is narrow and crosses the chevrons while the other covers the proximal half of the chevrons area.

In the female (Fig. 99), the lower valualae of the ovipositor measure 0.52 mm. in length and have tooth-like sclerotized apices; the upper valuale still cover about half of the length of the paraprocts.

In the male (Fig. 100), the subgenital plate lobe is 0.32 mm. in length; its narrow apical margin is concave; the lateral margins converging sharply.

#### Fourth instar (Figs.45 and 155

The short, dorso-ventrally, flattened antennae have 21 segments, although often only 20 can be counted.

The head is marked by banding from the base of the antenna to the anterior upper part of the pronotum, colouring the eye dark on the lower half, while the upper half is maculated middle-grey near the top and very pale just above the dark-grey.

The banded pattern of the head is also found on the anterior part of the pronotum; the pronotum is 4.32 mm. long; the median carina is crested and the upper median region is prolonged posteriorly over the mesonotum and the metanotum; the elongated fore wing pad is concealed under the pronotum and the hind wing pad; both wing pads are upturned and bear complex venation; the hind wing pads are large triangular lobes, 2.47 mm. long, and meet only at tips.

The metathoracic leg, 6.98 mm. long, bears markings only on the dorsum and on the inner face; dorsally there are two or three narrow dark bands and the inner face is marked by a band corresponding in position with the most distal dorsal band, and also a large dark patch covering the chevrons from the proximal end to the second dorsal band.

In the female (Fig. 101), the lower ovipositor valvulae are 0.81 mm. long, and the distal part is narrow and heavily sclerotized; the upper valvulae show distinct basivalvular sclerites, have heavily sclerotized apices, and cover nearly the whole length of the paraprocts.

In the male (Fig. 102), the subgenital plate lobe is 0.73 mm. long and is nearly semicircularly shaped except for a small, slightly concave apical margin; it covers about four-fifths of the paraprocts.

## Fifth Instar (Figs. 46 and 156)

The short dorso-ventrally flattened antennae are composed of 24 segments, although often only 23 segments can be distinguished.

The vertex of the head is crested; the head is crossed from the base of the antenna to the pronotum by a narrow pale band bordered below by a dark region; the eye is coloured in the same way, the upper half being maculated at the top, pale near the center and darker below.

The pronotum, 4.93 mm. in length, has a crested carina, which extends posteriorly in an acute lobe, covering the mesonotum and metanotum; on the anterior half the pronotum bears a continuation of the banding of the head.

The hind wing pads are large, upturned and backward oriented lobes which meet along nearly all of their length; the pads show definite venation with an axillary sclerite region and are middle to dark coloured; the length is 4.97 mm.

The metathoracic femur, 8.15 mm. in length, bears two dark bands dorsally and on the inner face; on the inner face the more proximal band extends over the whole proximal half of the chevrons area.

In the female (Figs. 103 and 104), the lower ovipositor valvulae are 1.22 mm. long and show clearly defined basivalvular sclerites and have large sclerotized tooth-like apical processes; the upper valvulae are bent upward (Fig. 104) and the lower margins are angulate at the apices.

In the male (Figs. 105,106 and 107), the subgenital plate lobe is 0.96 mm. long, convex all around its margins and has no notch, groove or concave curve on the apical margin in posterior view (Fig. 107); in lateral view (Fig. 1060, the apical portion is bent away and the apical margin lies anterior to the most posterior point of the lobe.

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Sixth instar (Fig. 47)

The short antennae are composed of 24 dorso-ventrally flattened segments.

The head is banded from the base of the antenna to the pronotum by adjacent white bands above, and a dark region below; the eye is similarly coloured, the upper half being crossed by the pale band and the lower half is dark; the head has a high crested vertex.

The pronotum is 5.93 mm. long and its posterior lobe is prolonged over the mesonotum and the metanotum; the median carina is crested and slightly cut by a sulcus; the hind wing pads, 5.82 mm. long, are large triangular veined lobes which meet for nearly their entire length.

The metathoracic femur bears small dark marks dorsally which correspond in position with large dark bands on the inner face; the proximal band covers the proximal half of the chevrons area.

The lower ovipositor valvulae of females are 1.53 mm. long (Fig. 108); both lower and upper valvulae being like those of the fifth instar except for the increase in size.

## Encoptolophus sordidus sordidus (Burmeister)

#### Measurements for all instars are given in Table 10.

First instar (Figs. 48 and 157)

The clubbed antennae are composed of 13 segments, which are coloured pale-brown.

The head is coloured middle-brown laterally but becomes dark fuscous dorsally; the eye is middle-brown without markings.

The pronotum, 0.82 mm. in length, is dark fuscous dorsally becoming gradually yellowish middle-brown laterally; the mesonotum and metanotum are similarly coloured; the wing pads are short brown lobes, 0.10 mm. in length, attached to the ventral margins of the nota; the pleural areas and the prothoracic and mesothoracic legs are white.

The metathoracic leg is 2.31 mm. long; the outer face is marked with two diffuse light-brown spots on the chevrons; apically it is spotted dark brown and fuscous; there are several small dark spots on the dorsal carina, two of which are enlarged and cover the inside and outside face of the carina; the inner face is marked by three large dark-brown bands and the apical end is also dark.

The abdomen is dark fuscous above and gradually becomes yellowishmiddle-brown laterally; both the thorax and the abdomen are whitish ventrally.

In the female (Fig. 109), the lower ovipositor valvulae appear as short lobes, 0.07 mm. in length, posterior to a fold in the eighth sternite; the upper valvulae are lobes of the ninth sternite, 0.13 mm. in length, and are separated by a semicircular inflexion; they cover about one third of the paraprocts.

In the male (Fig. 110), the ninth sternite bears two short rounded lobes separated by a V-shaped inflexion; the lobes measure 0.10 mm. and cover less than one third of the paraproct.

## Second instar (Figs. 49 and 158)

The short antenna is composed of only 14 visible segments.

The head is covered by dark grey or blackish maculations over a pale grey background; the eye is grey and crossed by the pale band extending from the base of the antenna to the pronotum; posterior to the eye, dark regions border the pale band above and below.

The pronotum, 1.25 mm. in length, is marked with grey maculations and a pale band extends from the anterior margin, a continuation of that of the head, to the middle of the carina and then downward toward the posterior margin. As seen from above (Fig. 172), this pale marking is X-shaped; the rest is grey.

The mesonotum and metanotum are coloured grey and each bears a dark spot on the median carina; the wing pads are short lobes, 0.22 mm. long, and show no signs of venation.

The metathoracic femur is 3.16 mm. long and the outer face is marked by two pale bands on the whitish chevrons and darker markings at the distal end; dorsally, there are three or four small dark bands mainly toward the apex; the inner face bears no particular markings.

The abdomen is grey with a dark spot on the dorsal median carina

of each segment.

In the female (Fig. 111), the lower ovipositor valvulae are short lobes, 0.12 mm. in length; the upper valvulae are pointed lobes, 0.22 mm. in length, separated by an acute inflexion, and covering less than one-third of the paraprocts.

In the male (Fig. 112), the two lobes of the subgenital plate of the first instar are united into one large lobe with a concave apical margin; it measures 0.21 mm. and covers about half of the length of the paraprocts.

### Third instar (Figs. 50 and 159)

The antennae are short, dorso-ventrally flattened, and are composed of 19 segments, although often only 18 segments are distinguishable.

The head is grey, maculated with dark spots on the lower part and banded laterally with a white band on the upper part, passing through the eye, so that the upper part of the head and the eye appear paler.

The pronotum is 2.22 mm. long and shows the pale X dorsally; apart from this marking the entire pronotum is maculated with grey spots.

The mesonotum and metanotum are grey, with dark spots on their median carinae, and bear the wing pads which point downward and backward; some venation is indicated: the wing pads are 0.60 mm. in length.

The metathoracic femur is 4.71 mm. long and is diffusely marked on the outer face by three dark bands the dorsum is marked by numerous dark spots, but three of these corresponding to those of the outer and inner faces, are larger; the inner face is banded in three places and at the apex. The abdomen is grey; and each segment bears a dark spot on the median carina.

In the female (Fig. 113), the lower valvulae of the ovipositor are triangular lobes, 0.26 mm. long, and the upper valvulae are elongated lobes, 0.36 mm. long, covering about half of the paraprocts.

In the male, (Fig. 114), the lobe of the subgenital plate is 0.38 mm. long and the converging sides lead to a narrow transverse apical margin.

### Fourth instar (Figs. 51 and 160)

The antenna is composed of 21 segments, dorso-ventrally flattened, and grey in colour.

The head is pale above, becoming darker below a band extending from the base of the antenna to the pronotum passing by the eye.

The promotum is 3.14 mm. long and bears the white X dorsally; the rest is maculated grey.

The hind wing pads are 1.89 mm. long, upturned, bear elaborate venation and an axillary sclerite region; they meet only at tip; the fore wing pad is also an elongated veined lobe, upturned and pointing backwards, but it is concealed under the pronotum and the hind wing pad.

The metathoracic femur is marked by two or three dark bands on all sides, darker on the inner side, on the proximal half of the chevrons area which are completely dark; the femur measures 6.08 mm. in length.

The abdomen is covered by grey maculations and the median carina

of each segment bears a dark spot.

In the female (Fig. 115), the lower ovipositor valvulae have highly sclerotized apices: they measure 0.80 mm. in length; the upper valvulae are elongated structures with bluntly rounded apices and nearly cover the paraprocts.

In the male (Fig. 116), the subgenital plate lobe is 0.66 mm. long, and its converging lateral margins are united by a convex apical margin; it almost completely covers the paraproct.

## Fifth instar (Figs. 52 and 161)

The grey antennae are composed of 24 segments.

The head is banded from the base of the antenna to the pronotum by a pale band delimiting a dark coloured region just below; the rest is maculated with middle to dark-grey spots.

The pronotum, 3.72 mm. in length, is marked dorsally by the Xshaped pale bands; the remainder is grey, becoming darker grey laterally; the median carina is crested and is cut by a sulcus.

The hind wing pads are long triangular lobes, upturned, veined, meeting for nearly their entire length, grey in colour, and 3.93 mm. in length.

The metathoracic femur is marked by two or three dark bands on all aspects; the bands are darker dorsally and on the inner face, where the proximal half of the chevrons face is entirely dark; the length is 7.33 mm.

The abdomen is grey, with each segment bearing a dark spot on the median carina.

In the female (Fig. 117) the lower ovipositor valuale are 1.32 mm. long and show distinct basivalular scierites; each bears a large flat tooth-like scierotized process at the apex; the upper valuale are much longer than the paraprocts and, in lateral view (Fig. 118), are bent upward and have pointed apices; the lower margins of the upper valuale are bent in a circular way and show no angle near the apex of the lower valuale.

In the male, (Fig. 119), the subgenital plate lobe is 0.89 mm. in length, longer than the paraprocts; in lateral and posterior views (Figs. 120 and 121) appears as an emarginate spoon; in which the apical margin presents no points, depressions or processes; the cerci (Fig. 120) are long tapering structures, with the upper margin bending downward near the tip to converge more steeply toward the nearly straight lower margin.

## <u>Sixth instar</u>

The description of the fifth instar applies in every detail except for the size of structures as follows: pronotum 4.56, hind wing pad 4.72, hind femur 8.78, lower ovipositor valvulae of females 1.53, and the male subgenital plate 1.16 mm., in length.

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## THE ADULTS

As the subject of this work is on the immature stages the adults have not been closely studied. However, so as to have the series of each species complete and to provide a supplementary basis for the comparison of the studied species, colour photographs of the female and the male of each species are included as follows:

<u>M. f</u> .	femurrub	rum -	Femal	e	Fig.	162
11	11	~	Male		Fig.	163
<u>M. s</u> .	<u>sanguini</u>	oès -	Femal	e	Fig.	164
11	II.		Male		Fig.	165
<u>M. b</u> .	<u>borealis</u>		Female	8	Fig.	166
11	11	-	Male		Fig.	167
<u>Ch</u> . <u>v</u> .	viridifa	<u>asciata</u> -	Female	2	Fig.	168
11	If	-	Male		Fig.	169
<u>E. s</u> .	<u>sordidus</u>		Femalo	<b>.</b>	Fig.	170
EI	Ħ	-	Male		Fig.	171
18	11		11			
<b>II</b>	t t	Dorsal	Vi <del>c</del> w.of	Pronotum	Fig.	172

Descriptions of adults of these species, have been given by Blatchley (1920), Brooks (1958) and Vickery (1961).

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### NOTE REGARDING TABLES 1-10, FIGURES 173-177.

It should be noted that, in Tables 1 to 3, 6 to 8, and in Figs. 173 to 175, the data for the five and the six nymphal instar cycles were taken from the same group of specimens in each of the first three instars, since it was impossible to tell before the fourth instar whether any particular nymph would undergo a five nymphal instar cycle or a six nymphal instar cycle.

In Tables 5, 6, 9 and 10 and in Figs. 176 and 177, the data for the five and the six nymphal instar cycles were taken from the same group of specimens in each of the first five instars, since it was impossible to tell if any particular nymph would undergo a five nymphal instar cycle or a six nymphal instar cycle.

In all cases, the nymphs were killed in order to take the necessary data, so no further progress of these specimens could be studied.

Mean duration of instars in days and nymphal life duration, in the five and the six instar cycles in <u>M</u>. <u>f</u>. <u>femurrubrum</u>.

Instars:	-	1	11	111	· 1V ···	V	V1 ·	Total nymphal life duration
Five instar	•	8.2	7.6	7.9	9.1	8.7		41.5 days
Six instar cycle :		8.2	7.6	7.9	7.1	6.8	6.5	44.1 days

### TABLE 2

Mean duration of instars in days and nymphal lifé duration, in the five and the six instar cycles in <u>M. s. sanguinipés</u>.

Five inst cycle	ar :	8.6	7.3	8.1	8.2	7.5		39.7 days
Six insta cycle	r ;:	8.6	7.3	8.1	7.8	6.9	7.1	45.8 days

## TABLE 3

Mean duration of instars in days and nymphal life duration, in the fivesand the six instar cycles in <u>M. b. borealis</u>.

Five insta cycle	ər :	7.0	8.5	9.1	8.2	7.8		40.6 days
Six instar cycle	•	7.0	8.5	9.1	7.9	6.8	7.5	46.8 days

Mean duration of instars in days and nymphal life duration, in the five and the six instar cycles in <u>Ch</u>. v. viridifasciata.

Instars:	1		11 111		10	۷	V1	Total nymphal life duration		
Five instar cycle	• •	9.6	8.4	11-20	15-35	20-?		64.2 to 7 days		
Six instar cycle	:	9.6	8.4	11-20	15-35	20 <b>-</b> 48	18-?	82.2 to ? days		

## TABLE 5

Mean duration of instars in days and nymphal life duration, in the five and the six instar cycles in <u>E</u>. <u>s</u>. <u>sordidus</u>.

Five instar 8.8 7.4 9.1 8.7 43.3 days cycle 9.3 : --Six instar 8.8 7.4 8.7 51.0 days cycle : 9.1 9.3 7.7

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Measurements of structures of <u>M</u>. <u>f</u>. <u>femurrubrum</u> nymphs. ( n = 10 )

<b>0</b> .					<u>1</u> 1	<u>nstars</u>		
Structure	instars in cycle	ł	1	11	111	۱V	v	VI
Number of	5		13	16	. 19	21	24	. = =
segments	6		13	16	19	20	22	24
Length of:		••						
Pronotum	5	Mean St.D.	0.75 0.06	1.11 0.10	1.69 , 0.21	2.68 0.23	3.59 0.25	
	6	Mean St.D.	0.75 0.06	1.11 0.10	1.69 0.21	1.92 0.24	2.96 0.26	3.81 0.31
Hind wing pad	5	Mean St.D.	0.10 0.01	0.20 0.02	0.43 0.05	1.61 0.10	3.73 0.30	
	6	Mean St.D.	0.10 0.01	0.20 0.02	0.43 0.05	0.71 0.06	1.74 0.19	4.11 0.30
Metathoracic femur	5	Mean St.D.	2.26 0.40	3.02 0.26	4.36 0.35	6.18 0.26	7•97 0•59	488 488 488 489
	6	Mean St.D.	2.26 0.40	3.02 0.26	4.36	5.06 0.43	7.00 0.68	8.71 0.52
우 Lower Valvulae	5	li. Mean-	0.08	0.31	0.40	0.72	1.00	
	6	Mean	0.08	0.31	0.40	0.61	1.00	1.16
우 Upper Valvulae	5	Mean	0.14	0.45	**	* = ~ =	·	
	6	Mean	0.14	0.45				
Subgenital	_							
plate lobe	5	Mean	0.10	0.32	0.42	0.60	1.20	aha ana ana ana
	6	Mean	0.10	0.32	0.42	0.57	0.80	1.27

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Measurements of structure of <u>M</u>. <u>s</u>. <u>sanguinipes</u> nymphs. (h = 10)

C	No -f				<u>1</u>	nstars;;	•	
Structure	instars		1	11	111	1 V	V	VI
Number of	5		13	16	. 19	21	24	
segments	6		13	. 16	19	20	21	24
Length of:								
Pronotum	5	Mean St.D.	0.67 0.03	1.04 0.17	1.64 0.08	2.58 0.18	3.4 <u>2</u> 0.28	
	6	Mean St.D.	0.67 0.03	1.04 0.17	1.64 0.08	1.95 0.11	2.92 0.20	3.82 0.29
Hind wing pad	5	Mean St.D.	0.10 0.01	0.30	0.45 0.04	1.68 0.15	4.15 0.48	
	6	Mean St.D.	0.10 0.01	0.30	0.45 0.04	0.80 0.07	1.86 0.16	4.76 0.49
Metathoracic femur	5	Mean St.D.	2.14 0.06	3.13 0.17	4.33 0.23	6.24 0.50	7.82 0.57	
	6	Mean St.D.	2.14	3.13 0.17	4.33 0.23	5.40 0.44	6.82 0.61	8.58 0.69
9 Lower	E	Мара	0.08	0.21	0 /10	0 70	1 22	
Valvulae	2	nean	0.00	0.21	0.40	0.70	1.23	
	6	Mean	0.08	0.21	0.40	0.61	1.05	1.35
♀Upper Valvulae	5	Mean	0.18	0.32				
	6	Mean	0.18	0.32				
Subgenital								
platelobe	5	Mean	0.08	0.25	0.53	1.00	1.41	
	6	Mean	0.08	0.25	0.53	0.85	1.21	1.52

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Measurements of structure of <u>M</u>. <u>b</u>. <u>borealis</u> nymphs. (n=10)

		Instars							
Structure	NO. of instars in cycle		1	11	- 111	IV.	V	VI	
Number of	5		13	16	19	21	24		
segments	6		-13	. 16	19	20	- 21	24	
Length of:									
Pronotum	5	Mean St.D.	0.78 0.10	1.17 0.05	1.68 0.13	2.38 0.22	3.11 0.25	** ** **	
	6	Mean St.D.	0.78 0.10	1.17 0.05	1.68 0.13	2.21 0.06	2.60 0.18	3.51 0.29	
Hind wing pad	5	Mean St.D.	0.10 0.01	0.25 0.02	0.40 0.03	1.39 0.12	3.28 0.19		
	6	Mean St.D.	0.10 0.01	0.25 0.02	0.40 0.03	0.62	1.55 0.14	3.62 0.22	
Metathoracic femur	5	Mean St.D.	2.24 0.19	3.16 0.11	4.34 0.20	5.44 0.46	7.26 0.41	****	
·	6	Mean St.D.	2.24 0.19	3.16 0.11	4.34 0.20	5.10 0.09	5.94 0.12	7.84 0.49	
♀ Lower									
Valvulae	5	Mean	0.10	0.20	0.41	0.71	1.10		
	6	Mean	0.10	0.20	0.41	0.56	0.89	1.22	
♀ Upper Valvulae	5	Mean	0.18	0.31			· ••• والع والع الع		
	6	Mean	0.18	0.31					
Subgenital									
plate lobe	5	Mean	0.10	0.32	0.41	0.59	1.00		
	6	Mean	0.10	0.32	0.41	0.51	0.85	1.18	

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Measurements of structure of <u>Ch</u>. <u>v</u>. <u>viridifasciata</u> nymphs.  $(h = 1^{\circ})$ 

Instars

<b>C</b>	No - 5				1113 C			
Structure	nu, or instars in cycle	9	1	11	111	17	V	V1
Number of antennal	5	· · ·	13	. 16	19	21	24	. <b></b>
segments	6		13	16	19	21	24	24
Length of:								
Pronotum	5	Mean St.D.	0.89 0.10	1.54 0.15	2.71 0.21	4.32 0.28	4.93 0.35	
	6	Mean St.D.	0.89 0.10	1.54 0.15	2.71 0.21	4.32 0.28	4.93 0.35	5.93 0.19
Hind wing pad	5	Mean St.D.	0.10 0.01	0.25 0.02	0.81 0.05	2.47 0.17	4.97 0.37	
	6	Mean St.D.	0.10 0.01	0.25 0.02	0.81 0.05	2.47 0.17	4.97 0.37	5.82 0.16
Metathoracic femur	5	Mean. St.D	2.46 0.20	3.42 0.18	5.06 0.32	6.98 0.28	8.15 0.58	
	6	Mean St.D.	2.46 0.20	3.42 0.18	5.06 0.32	6.98 0.28	8.15 0.58	9.18 0.38
♀ Lower Valvulae	5	Mean	0.10	0.18	0.52	0.81	1.22	
	6	Mean	0.10	0.18	0.52	0.81	1.22	1.53
ç Upper Valvulae	5	Mean	0.21	0.32				
	6	Mean	0.21	0.32		· •••		
d <sup>3</sup> Subgenital plate lobe	5	Mean	0.11	0.20	0.32	0.73	0.96	
	6	Mean	0.11	0.20	0.32	0.73	0.96	

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Structure	N <b>d.</b> of instars in cycle		< 1 <sup>11</sup>	. 11	111	٧ĭ	V V	VI
Number of	5		13	14	18	21	24	
segments	6		13	14	18	21	24	24
Length: of:								
Pronotum	5	Mean St.D.	0.82 0.08	1.25	2.22	3.14 0.22	3.72 0.33	
	6	Mean St.D.	0.82 0.08	1.25	2.22	3.14 0.22	3.72 0.33	4.56 0.32
Hind wing pac	15	Mean St.D.	0.10 0.01	0.22 0.02	0.60 0.04	1.89 0.17	3.93 0.27	
	6	Mean St.D.	0.10 0.01	0.22 0.02	0.60 0.04	1.89 0.17	3.93 0.27	4.72 0.36
Metathoracic								
femur	5	Mean St.D.	2.31 0.13	3.16 0.18	4.71 0.37	6.08 0.49	7.33 0.31	
	6	Mean St.D.	2.31 0.13	3.16 0.18	4.71 0.37	6.08 0.49	7.33 0.31	8.78 0.73
<b>q</b> Lower								
Valvulae	5	Mean	0.07	0.12	0.26	0.80	1.32	
	6	Mean	0.07	0.12	0.26	0.80	1.32	1.53
♀ Upper								
Valvulae	-5	Mean	0.13	0.22				
	6	Mean	0.13	0.22				
<sup>8</sup> Subgenital plate lobe	5	Mean	0.10	0.21	0.38	0.66	0.89	
-	6	Maan	0 10	0.21	0.20	0.66	0 00	1 16
	0	nean	0.10	0+41	0.30	0.00	0.07	1.10

Measurements of structure of <u>E. s. sordidus</u> nymphs. (n = 10)

Fig. 1 - Measurement of pronotum length (P.L.)

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Fig. 2 - Measurement of hind wing pad length (h.w.p.l.)

in the instars where the wing pads point downward.

Fig. 3 - Measurement of hind wing pad length (h.w.p.l.) where the wing pads point upward.

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Fig. 4 - Measurement of metathoracic femur length (M.F.L.)









Fig. 3

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Fig. 4

- Fig. 5 Measurement of the length of the lower valvulae (L.V.L.) and of the upper valvulae (U.V.L.) in the first two instars.
- Fig. 6 Measurement of the lower valvulae (L.V.L.).
  - U.V.: upper valvula
  - P. : paraproct

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Fig. 7 - Measurement of the subgenital plate lobe (S.G.P.L.L.) in the first instar.

Fig. 8 - Measurement of the subgenital plate lobe length (S.G.P.P.L.) in all instars except the first.







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Fig. 6



Fig. 7

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Fig. 9 - Schematic drawing of egg pod, longitudinal section.

Fig. 10 - Egg pods of  $\underline{M}$ . <u>b</u>. <u>borealis</u>. (Scale = 1 cm.)






Fig. 11 - Drawing of a grasshopper egg.

Fig. 14 - <u>M. b. borealis</u> egg. (20X)





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Fig. 15 - Sculpturing of <u>M</u>. <u>b</u>. <u>borealis</u> egg.  $(12 \circ X)$ 

Fig. 16 - Cap region of <u>M</u>. <u>b</u>. <u>borealis</u> egg. (35火)





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Fig. 17 - M. f. femurrubrum egg. (20x)

Fig. 18 - Sculpturing of <u>M</u>. <u>f</u>. <u>femurrubrum</u> egg.  $(120 \times)$ 

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Fig. 19 - Cap region of <u>M. f. femurrubrum</u> egg.  $(45 \times)$ 

Fig. 20 - <u>M. s. sanguinipes</u> egg. ( <u>ょ</u>ox)



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Fig. 21 - Sculpturing of <u>M. s. sanguinipes</u> egg. (120x)

Fig. 22 - Cap region of <u>M</u>. <u>s</u>. <u>sanguinipes</u> egg. (40x)

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Fig. 23 - <u>M</u>. <u>s</u>. <u>sanguinipes</u> egg. (30 x)



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Fig. 24 - M. f. femurrubrum, first instar.

Scale: 1 mm. (same for figures 24 to 52 incl.)

Fig. 25 - M. f. femurrubrum, second instar.



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#### Fig. 26 - M. f. femurrubrum, third instar.





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Fig. 27 - <u>M. f. femurrubrum</u>, fourth instar of five instar

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# cycle.



#### Fig. 28 - M. f. femurrubrum, fifth instar of six instar

cycle.



## Fig. 29 - M. f. femurrubrum, fifth instar of five instar

cycle.



#### Fig. 30 - M. s. sanguinipes, first instar.

Fig. 31 - M. s. sanguinipes, second instar.







## Fig. 33 - M. s. sanguinipes, fourth instar of six instar

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cycle.

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cycle.

Fig. 34 - M. s. sanguinipes, fourth instar of five instar



#### Fig. 35 - M. s. sanguinipes, fifth instar of five instar

cycle.



Fig. 36 - <u>M. b. borealis</u>, first instar.

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Fig. 37 - M. b. borealis, second instar.


# Fig. 38 - M. b. borealis, third instar.



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#### Fig. 39 - M. b. borealis, fourth instar of six instar

cycle.



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# Fig. 40 - M. b. borealis, fourth instar of five instar

cycle.



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#### Fig. 41 - M. b. borealis, fifth instar of five instar

cycle.



Fig. 42 – <u>Ch</u>. v. <u>viridifasciata</u>, first instar.

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Fig. 43 - <u>Ch</u>. <u>v</u>. <u>viridifasciata</u>, second instar.



Fig. 44 - Ch. v. viridifasciata, third instar.



# Fig. 45 - <u>Ch</u>. <u>v</u>. <u>viridifasciata</u>, fourth instar.

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Fig. 46 - <u>Ch</u>. <u>v</u>. <u>viridifasciata</u>, fifth instar.

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Fig. 47 - <u>Ch</u>. <u>v</u>. <u>viridifasciata</u>, sixth instar.

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# Fig. 48 - E. s. sordidus, first instar

Fig. 49 - <u>E</u>. <u>s. sordidus</u>, second instar.



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Fig. 50 - E. s. sordidus, third instar.



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Fig. 51 - E. s. sordidus, fourth instar.



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#### Fig. 52 – <u>E</u>. <u>s</u>. <u>sordidus</u>, fifth instar.



Fig. 53 - Ventral view of female genital appendages, first instar nymph of <u>M. f. femurrubrum</u>.

Fig. 54 - Ventral view of male genital appendages, first

instar nymph of <u>M</u>. <u>f</u>. <u>femurrubrum</u>.

Scale: 1 mm., same for Figs. 53 to 121.incl.

Fig. 55 - Ventral view of female genital appendages, second instar nymph of <u>M</u>. <u>f</u>. <u>femurrubrum</u>.

Fig. 56 - Ventral view of male genital appendages, second instar nymph of <u>M</u>. <u>f</u>. <u>femurrubrum</u>.

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#### Fig. 57 - Ventral view of female genital appendages, third

#### instar of <u>M</u>. <u>f</u>. <u>femurrubrum</u>.

Fig. 58 - Ventral view of male genital appendages, third instar of <u>M</u>. <u>f</u>. <u>femurrubrum</u>.







Fig. 59 - Ventral view of female genital appendages, fourth instar of five instar cycle of <u>M</u>. <u>f</u>. <u>femurrubrum</u>.



Fig. 60 - Ventral view of male genital appendages, fourth instar of five instar cycle of <u>M. f. femurrubrum</u>.



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Fig. 61 - Ventral view of female genital appendages, fifth of six instar cycle of <u>M. f. femurrubrum</u>.


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Fig. 62 - Ventral view of male genital appendages, fifth

instar of six instar cycle of <u>M</u>. <u>f</u>. <u>femurrubrum</u>.



Fig. 63 - Ventral view of female genital appendages, fifth

instar of five instar cycle of <u>M</u>. <u>f</u>. <u>femurrubrum</u>.



Fig. 64 - Lateral view of female genital appendages, fifth instar of five instar cycle of <u>M</u>. <u>f</u>. <u>femurrubrum</u>.





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Fig. 65 - Ventral view of male genital appendages, fifth

instar of five instar cycle of <u>M</u>. <u>f</u>. <u>f</u>emurrubrum</u>.



Fig. 66 - Lateral view of male genital appendages, fifth instar of five instar cycle of <u>M. f. femurrubrum</u>.

Fig. 67 - Posterior view of male subgenital plate, fifth instar of five instar cycle of <u>M. f. femurrubrum</u>.



Fig. 69 - Ventral view of female genital appendages, first instar of <u>M. s. sanguinipes</u>.

Fig. 70 - Ventral view of male genital appendages, first instar of <u>M</u>. <u>s</u>. <u>sanguinipes</u>.

Fig. 71 - Ventral view of female genital appendages, second instar of <u>M. s. sanguinipes</u>.

Fig. 72 - Ventral view of male genital appendages, second instar of <u>M</u>. <u>s</u>. <u>sanguinipes</u>.



Fig.71

Fig. 73 - Ventral view of female genital appendages, third instar of <u>M</u>. <u>s. sanguinipes</u>.

Fig. 74 - Ventral view of male genital appendages, third instar of <u>M. s. sanguinipes.</u>



Fig. 75 - Ventral view of female genital appendages, fourth instar of five instar cycle of <u>M. s. sanguinipes</u>.

Fig. 76 - Ventral view of male genital appendages, fourth instar of five instar cycle of <u>M. s. sanguinipes</u>.





Fig. 77 - Ventral view of female genital appendages, fifth instar of five instar cycle of <u>M. s. sanguinipes</u>.

Fig. 78 - Lateral view of female genital appendages, fifth instar of five instar cycle of <u>M</u>. <u>s</u>. <u>sanguinipes</u>.





Fig. 79 - Ventral view of male genital appendages, fifth instar of five instar cycle of <u>M. s. sanguinipes</u>.

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Fig. 80 - Lateral view of male genital appendages, fifth instar of five instar cycle of <u>M</u>. <u>s</u>. <u>sanguinipes</u>.

Fig. 81 - Posterior view of male subgenital plate, fifth instar of five instar cycle of  $\underline{M}$ . s. sanguinipes.





Fig. 82 - Ventral view of female genital appendages, first instar of <u>M. b. borealis</u>.

Fig. 83 - Ventral view of male genital appendages, first instar of <u>M</u>. <u>b</u>. <u>borealis</u>.

Fig. 84 - Ventral view of female genital appendages, second instar of <u>M</u>. <u>b</u>. <u>borealis</u>.

Fig. 85 - Ventral view of male genital appendages, second instar of <u>M. b. borealis</u>.



Fig. 82



Fig. 83



Fig. 84

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## Fig. 86 - Ventral view of female genital appendages, third instar of <u>M</u>. <u>b</u>. <u>borealis</u>.

Fig. 87 - Ventral view of male genital appendages, third instar of <u>M</u>. <u>b</u>. <u>borealis</u>.



Fig. 88 - Ventral view of female genital appendages, fourth instar of five instar cycle of <u>M</u>. <u>b. borealis</u>.

Fig. 89 - Ventral view of male genital appendages, fourth instar of five instar cycle of <u>M. b. borealis</u>.





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Fig. 90 - Ventral view of female genital appendages, fifth instar of five instar cycle of <u>M</u>. <u>b</u>. <u>borealis</u>.

Fig. 91 - Lateral view of female genital appendages, fifth` instar of five instar cycle of <u>M</u>. <u>b</u>. <u>borealis</u>.



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Fig. 92 - Ventral view of female genital appendages, fifth

instar of five instar cycle of <u>M. b</u>. borealis.



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Fig. 93 - Lateral view of male genital appendages, fifth instar of five instar cycle of <u>M</u>. <u>b</u>. <u>borealis</u>.

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Fig. 94 - Posterior view of male subgenital plate, fifth instar of five instar cycle of <u>M</u>. <u>b</u>. <u>borealis</u>.



Fig. 95 - Ventral view of female genital appendages, first

instar of <u>Ch</u>. <u>v</u>. <u>viridifasciata</u>.

Fig. 96 - Ventral view of male genital appendages, first instar of <u>Ch</u>. <u>v</u>. <u>viridifasciata</u>.

Fig. 97 - Ventral view of female genital appendages, second instar of <u>Ch. v. viridifasciata</u>.

Fig. 98 - Ventral view of male genital appendages, second instar of <u>Ch. v. viridifasciata</u>.




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Fig. 99 - Ventral view of female genital appendages, third instar of <u>Ch</u>. <u>v</u>. <u>viridifasciata</u>.

Fig. 100 - Ventral view of male genital appendages, third instar of <u>Ch. v. viridifasciata</u>.





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Fig. 101 - Ventral view of female genital appendages,

## fourth instar of <u>Ch</u>. v. viridifasicata.

Fig. 102 - Ventral view of male genital appendages, fourth instar of <u>Ch. v. viridifasciata</u>.



Fig. 103 - Ventral view of female genital appendages, fifth instar of <u>Ch. v. viridifasciata.</u>

Fig. 104 - Lateral view of female genital appendages, fifth instar of <u>Ch. v. viridifasciata.</u>



# Fig. 105 - Ventral view of male genital appendages, fifth instar of <u>Ch. v. viridifasciata</u>.

Fig. 106 - Lateral view of male genital appendages, fifth instar of <u>Ch. v. viridifasciata</u>.

Fig. 107 - Posterior view of male subgenital plate, fifth instar of <u>Ch. v. viridifasciata</u>.



Fig. 108 - Ventral view of female genital appendages,

sixth instar of <u>Ch</u>. <u>v</u>. <u>viridifasciata</u>.



Fig. 109 - Ventral view of female genital appendages, first instar of <u>E. s. sordidus</u>.

Fig. 110 - Ventral view of male genital appendages, first instar of <u>E</u>. <u>s</u>. <u>sordidus</u>.

Fig. 111 - Ventral view of female genital appendages, second instar of <u>E. s. sordidus</u>.

Fig. 112 - Ventral view of male genital appendages, second instar of <u>E. s. sordidus</u>.



Fig. 113 - Ventral view of female genital appendages, third instar of <u>E. s. sordidus</u>.

Fig. 114 - Ventral view of male genital appendages,

third instar of <u>E. s.</u> sordidus.



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Fig. 115 - Ventral view of female genital appendages,

fourth instar of <u>E</u>. <u>s</u>. <u>sordidus</u>.

Fig. 116 - Ventral view of male genital appendages.

fourth instar of <u>E. s. sordidus</u>.



Fig. 117 - Ventral of female genital appendages,

fifth instar of <u>E. s. sordidus</u>.



Fig. 118 - Lateral view of female genital appendages, fifth instar of <u>E. s. sordidus</u>.



Fig. 119 - Ventral view of fmmale genital appendages,

fifth instar of <u>E. s. sordidus</u>.

Fig. 120 - Lateral view of 🏟 male genital appendages,

fifth instar of <u>E. s. sordidus</u>.

Fig. 121 - Posterior view of male subgenital plate, fifth instar of <u>E</u>. <u>s</u>. <u>sordidus</u>.



## Fig. 122 - M. f. femurrubrum, first instar, lateral

view (15 X)

## Fig. 123 - <u>M. f. femurrubrum,</u> first instar, lateral

view (30 X)





Fig. 124 - M. f. femurrubrum, second instar, lateral

view (15 X)

Fig. 125 - <u>M. f. femurrubrum</u>, third instar, lateral view (15 X)





r , Fig. 126 - <u>M</u>. <u>f</u>. <u>femurrubrum</u>, fourth instar of the six instar cycle, lateral view (7.5 X)

Fig. 127 - M. f. femurrubrum, fourth instar of the

five instar cycle, lateral view (7.5 X)



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Fig. 128 - <u>M. f. femurrubrum</u>, fifth instar of the six instar cycle, lateral view (7.5 X)

Fig. 129 - <u>M</u>. <u>f</u>. <u>femurrubrum</u>, fifth instar of five instar cycle, lateral view (7.5 X)



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#### Fig. 130 - M. s. sanguinipes, first instar, lateral

view (13.5 X)

Fig. 131 - <u>M. s. sanguinipes</u>, first instar, dorsal view (13.5 X)





#### Fig. 132 - M. s. sanguinipes, second instar,

lateral view. (15 X)

Fig. 133 - <u>M. s. sanguinipes</u>, third instar,

lateral view (7.5 X)





. . Fig. 134 - M. s. sanguinipes, third instar,

lateral view (15 X)

Fig. 135 - M. s. sanguinipes, fourth instar of six instar cycle, lateral view (7.5 X)




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Fig. 136 - <u>M. s. sanguinipes</u>, fourth instar of six instar cycle, lateral view (15 X)

Fig. 137 - <u>M</u>. <u>s</u>. <u>sanguinipes</u>, fourth instar of five instar cycle, lateral view (7.5 X)





#### Fig. 138 - M. s. sanguinipes, fifth instar of five

instar cycle, lateral view (7.5 X)

## Fig. 139 - <u>M. b. borealis</u>, first instar, lateral view (15 X)



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## Fig. 140 - M. b. borealis, second instar, lateral

view (15 X)

Fig. 141 - M. b. borealis, third instar, lateral

view (15 X)



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#### Fig. 142 - M. b. borealis, fourth instar of six

instar cycle, lateral view (7.5 X)

Fig. 143 - M. b. borealis, fourth instar of five instar cycle, lateral view (7.5 X)





## Fig. 144 - M. b. borealis, fifth instar of five

instar cycle, lateral view (7.5 X)

Fig. 145 - M. b. borealis, fourth instar of five

instar cycle, head and pronotum, lateral

view (30 X)

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## Fig. 146 - M. f. femurrubrum, fourth instar of five

instar cycle, head and pronotum, lateral

view (30 X)

Fig. 147 - <u>M. s. sanguinipes</u>, fourth instar of five instar cycle, head and pronotum, lateral view (30 X)



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Fig. 148 - <u>M. f. femurrubrum</u>, hind wing pad of fourth instar of five instar cycle, dorso-lateral view (65 X)

Fig. 149 - <u>M</u>. <u>f</u>. <u>femurrubrum</u>, hind wing pad of fifth instar of five instar cycle, dorso-lateral view (30 X)





 Fig. 150 - M. b. borealis, larva seen through the

serosal cuticle, lateral view (30 X)

Fig. 151 - <u>M</u>. <u>b</u>. <u>borealis</u>, larva pulled out of egg showing colour pattern, lateral view

(30 X)



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## Fig. 152 - Ch. v. viridifasciata, first instar,

lateral view (15 X)

#### Fig. 153 - Ch. v. viridifasciata, second instar,

lateral view (15 X)



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#### Fig. 154 - <u>Ch</u>. <u>v</u>. <u>viridifasciata</u>, third instar,

#### lateral view (7.5 X)

Fig. 155 - Ch. v. viridifasciata, fourth instar,

lateral view (7.5 X)



Fig. 156 - Ch. v. viridifasciata, fifth instar,

lateral view (7.5 X)

Fig. 157 - E. s. sordidus, first instar, lateral

view (15 X)







Fig. 158 - E. <u>s</u>. <u>sordidus</u>, second instar,

lateral view (15 X)

Fig. 159 - E. s. sordidus, third instar,

lateral view (7.5 X)



Fig. 160 - E. s. sordidus, fourth instar,

lateral view (7.5 X)

Fig. 161 - <u>E. s. sordidus</u>, fifth instar, lateral view (7.5 X)





Fig. 162 - M. f. femurrubrum, adult female,

lateral view (scale: 1 cm.)

Fig. 163 - M. f. femurrubrum, adult male,

lateral view (scale: 1 cm.)





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Fig. 164 - <u>M. s. sanguinipes</u>, adult female,

lateral view (scale: 1 cm.)

Fig. 165 - <u>M. s. sanguinipes</u>, adult male,

lateral view (scale: 1 cm.)





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Fig. 166 - M. b. borealis, adult female,

lateral view (scale: 1 cm.)

Fig. 167 - <u>M. b. borealis</u>, adult male, lateral view (scale: 1 cm.)



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# Fig. 168 - <u>Ch. v. viridifasciata</u>, adult female,

lateral view (scale: 1 cm.)

Fig. 169 - Ch. v. viridifasciata, adult male,

lateral view (scale: 1 cm.)



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Fig. 170 - E. s. sordidus, adult female,

lateral view (scale: 1 cm.)

Fig. 171 - E. s. sordidus, adult male,

lateral view (scale: 1 cm.)



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## Fig. 172 - <u>E. s. sordidus</u>, adult male, dorsal

## view of pronotum ( 7 X)



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in the nymphal instars of <u>M</u>. <u>f</u>. <u>femurrubrum</u>. (solid: five nymphal instar cycle, broken line: six nymphal instar cycle. The same applies to Figs. 174, 175, 176 and 177.)







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Fig. 175 - Ratio of the hind wing pad length to the pronotal length in the nymphal instars of <u>M</u>. <u>b</u>. <u>borealis</u>.





in the nymphal instars of <u>Ch. v. viridifasciata</u>.



