THE IDENTIFICATION OF THE EGGS OF GRASSHOPPERS BY MEANS OF THE CHORIONIC SCULPTURING

by

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INTRODUCTION

Uvarov (1928) appears to have been the first to suggest that the eggs of grasshoppers might be identified on the basis of the chorionic sculpturing. He called attention to the fact that the chorion of the eggs of many of the Acrididae are marked with lines and reticulations which might be of systematic importance.

The first attempt to identify eggs on the basis of the chorionic sculpturing was made by Bushland (1934). He described the eggs of eighteen South Dakota grasshoppers and constructed a key for their differentiation. He emphasised the variations in the sculpturing of the cap. He made photographs chiefly of the cap and included very little of the sculpturing of the body or central portion of the egg. In his key, however, he made considerable use of the sculpturing on the body for purposes of differentiation.

Ratanov (1935) described the egg pods of fifty-five species of Siberian grasshoppers. Though he considered the color, shape, and sculpturing of the eggs to some extent, he was primarily interested in the pod. He did not publish a key for differentiating the pods.

Effective planning for grasshopper control depends largely on accurate information as to the kind of eggs present in an area and their distribution. Surveys in the past have often been inaccurate and consequently precise information has not been available to those engaged in control work partly because of the inability of fieldmen to identify

eggs specifically.

The purpose of the present investigation has been to study the eggs of various species of grasshoppers and to devise a key for their differentiation. Evidence of species relationships through similarities in the egg patterns has been investigated with some interesting results.

METHODS AND TECHNIQUE

Eggs were secured in four ways for this study: (1) By direct observation of oviposition in nature; (2) by rearing of adults from egg pods collected in nature; (3) from dissection of eggs from dried and preserved females; and (4) by confining gravid females in jars for oviposition. The third source mentioned was developed during the course of this investigation. The eggs were removed from pinned insects in the museum by making a median longitudinal incision along the abdominal sternities and lifting the eggs out with fine forceps and dissecting needles. It was necessary to soften the dried specimens but not specimens in liquid preservatives before dissection could be successfully carried out. This was accomplished by boiling the insect for from fifteen to twenty minutes in a solution of 200 cc. of water, 15 cc. of glycerine and 5 cc. of glacial acetic acid. Softening of the internal structures was hastened if the incision was made as soon as the exoskeleton became pliable enough to permit cutting.

Confining gravid females in jars for oviposition was, however, the chief source of material used in this study. The insects were placed in

ordinary pint fruit jars containing about two inches of moist, firmly packed sand. The females were fed daily and the jars were examined once each week for eggs. The pods after being numbered were placed in vials for storage and the insects were pinned, numbered and the identification checked. No preservative was used where the eggs were soon to be studied. The eggs became distorted and the chorion brittle if allowed to remain dry for a considerable period. It was found, however, that if such eggs were boiled gently for about five minutes in the water-blycerine-glacial acetic acid solution previously mentioned, they would return to their normal shape and the chorion became soft. Eggs which had been dry for four years were successfully prepared in this manner.

Those eggs which were to be kept permanently were placed in a preserving fluid. A series of tests to determine the best preservative, in which 70 per cent methyl alcohol, 70 per cent ethyl alcohol, and 10 per cent formalin were used, showed that none of the reagents caused the eggs to shrink within measureable limits, but that 10 per cent formalin preserved the color better than the alcohols.

Sections of the choria were mounted on microscope slides in order to permit detailed study of the chorionic pattern. When this phase of the work was started, it immediately became apparent that the usual method of dehydration with ethyl alcohol would be a very tedious and time consuming task. It was suggested to the writer that dehydration might be accomplished more quickly with dioxane or tertiary butyl alcohol. Dioxane proved to be very unsatisfactory as well as dangerous,

since the work had to be done under a binocular dissecting microscope thus exposing the worker to the poisonous fumes. Absolute tertiary butyl alcohol, however, gave excellent results. The technique used in making the slides was as follows:

1. The eggs were cut longitudinally into quarters by means of a small scalpel with the aid of a binocular dissecting microscope.
2. The quarters were boiled for about five minutes in a 0.5 per cent solution of potassium hydroxide to remove the egg contents and the vitelline membrane after which they were washed in tap water.
3. Each section was placed on a microscopic slide in a drop of water and dehydrated by flooding the slide with absolute tertiary butyl alcohol. The process of dehydration required about 10 seconds.
4. The excess alcohol was removed with blotting paper, balsam applied and the coverslip put in place and pushed down to flatten the section. The slide was then labeled with the species name of the egg and the number of the female which laid it.

In some cases the sections of the choria curled when boiled in the potassium hydroxide solution. These curled sections straightened out in most cases when placed in water to which alittle tertiary butyl alcohol had been added and allowed to stand for a few minutes. Occasionally, also, a section would curl slightly when the slide was flooded for de-

hydration but they could usually be flattened out with dissecting needles.

Photographs were made of the chorionic section to supplement the microscope slides in the study and descriptions, and as an aid to future workers in making determinations.

GENERAL CONSIDERATION OF GRASSHOPPER EGGS

Grasshopper eggs are oblong in shape and vary in size from about 2.5 mm x 0.75 mm in the eggs of the Acrydiinae to about 10 mm x 2.5 mm in those of Brachystola magna. They are produced in a paniostic type of ovary and are invariably covered with a shell or chorion. The substance of which the chorion is composed is tough, semi-transparent and closely resembles chitin, though according to Snodgrass (1935) the chorion is invariably non-chitinous. The eggs are usually yellow or brown in color, often having a greenish tinge. The eggs of Schistocerca lineata are wine red in color, the pigment producing he color being soluble in alcohol to some extent.

The chorion of most eggs is marked with lines and ridges which form more or less regular pentagonal and hexagonal cells. These cells show a wide variation among the various species, but no appreciable variation was found within any species. In some eggs, the boundaries of these cells are greatly produced while in others they are very weak. In some species the corners of the cells contain thickenings and in others there are thickenings in the centers of the cells or the cells lose their

pentagonal and hexagonal shape, becoming circular. According to Snodgrass (1935), when the egg is fully developed the follicular epithelium secretes the chorion. The chorionic sculpturing then reflects the arrangement of the epithelial cells which secreted the chorion.

In the eggs of the Locustidae with the exception of the Acrydiinae, the egg is divisible into two areas - the cap and body. The cap is on the posterior end of the egg and the remainder of it is the body. The cap is apparently formed by an interruption of the regular sculpturing by the insertion of the micropyles which are invariably found arranged in a row around the egg at the proximal margin of the cap. Early it was generally believed, and some writers still believe, that the cap is on the anterior end of the egg. Bushland concluded from his studies that it is on the posterior end. The writer's observations confirm Mr. Bushland's conclusion. The cap is directed caudad while the egg is in the ovary of the female. The cap is pointed downward in the pod and when the young nymph hatches it bursts the chorion on the end opposite the cap by swallowing air (Kunkel d'Herculais, 1890) and crawls out leaving the cap undisturbed. From this it is concluded that the cap is neither analagous nor homologous to the operculum of the egg of other insects. The eggs of the Acrydiinae and Tettigoniidae have no cap on the posterior end. Tettigoniid eggs are sculptured uniformly over the entire surface and the micropyles are scattered promiscously over the chorion. The anterior end of the eggs of the Acrydiinae is attenuated into a spurlike structure, which is unique for the eggs of this group.

The eggs of the Tettigoniidae are deposited singly while those of the Locustidae are deposited in pods. The eggs in a pod are surrounded by a frothy substance which is highly visicular, often adhers closely to the chorion of the eggs and is insoluble in any reagent which would not also dissolve the egg.

The descriptions of the egg patterns were made from photographs and microscopic slide mounts. The photographs were sufficient for studying the general characteristics of the eggs, but not for making detailed studies of the sculpturing. The patterns were studied under both the 4 mm. and 16 mm. objectives of a compound microscope. In the descriptions, the eggs were divided into two major areas, the cap and the body. The body is that portion anterior to the micropyles and comprises the greater portion of the egg. The general appearance of the egg, the type of sculpturing, the prominence of the reticulations and micropyles, and the variation over the egg were utilized for diagnostic purposes. The frothy substance previously mentioned remained attached to the sections of many of the eggs mounted and appears in the photographs as an irregular network superposed on the true sculpturing of the egg. It was disregarded in making the descriptions, since it apparently is not distinctive, and is not to be confused with the sculpturing. Its irregular form and distribution over the egg will differentiate it from the chorionic pattern.

KEY TO THE IDENTIFICATION OF THE EGGS

1. Egg differentiated into body and cap areas - - - - - - - - - - - 5
   Egg not so differentiated - - - - - - - - - - - - - - - - - - - 2

2. Anterior end of egg bearing a spur-like structure - - - - - - - 4
   Anterior end of egg without such a structure - - - - - - - - - - 3

3. All cells of the egg of uniform structure -
   Pediodectes nigromarginata
   Cells of egg not all of uniform structure - - - *Orchelimum vulgare*

4. Body of egg entirely covered with cells -
   Tettigidea parvipennis pennata
   Body of egg not entirely covered with cells -
   Apotettix eurycephalus

5. Body of egg sculptured - 12
   Body of egg not sculptured (often with granules) - - - - - - - - 6

6. Cap sculptured - 10
   Cap not sculptured (often bearing granules) - - - - - - - - - - 7

7. Tip of cap distinctly pigmented - - - - - - - - - - - - - - - - 9
   Tip of cap not so pigmented - - - - - - - - - - - - - - - - - - 8

8. Pigmented area bearing large granules - - - *Aeropedallus clavatus*
   Pigmented area bearing small granules - - - - *Ageneotettix deorum*

9. Cap with granules - - - - - - - - - - - - - - - *Syrbula admirabilis*
   Cap without granules - - - - - - - - - - - -
   Chortophaga viridifasciata

10. Cells borne on proximal portion of cap - - - - *Orphulella pelidna*
    Cells borne on median portion of cap - - - *Encoplatophus costalis*
    Cells borne on distal portion of cap - - - - - - - - - - - - - - 11

11. Cells faintly outlined - - - - - - - *Philobostoma quadrimaculatum*
    Cells well defined - - - - - - - - - - - - *Encoptolophus sordidus*

12. Egg unusually large (length about 10 mm. and sculpturing largely
    obscured - *Brachystola magna*
    Egg not unusually large and sculpturing plainly visible - - - 13

13. Cells on body of egg with thickenings in their corners - - - - 14
Cells on body of egg without thickenings in their corners - - 24

14. Thickenings appearing to occur in pairs - - - *Arphia pseudonietona*
Thickenings normally arranged in the corners of pentagonal and hexagonal cells - 15

15. Cells of the body of the egg with dots in their centers - - - 16
Cells of the body of the egg without such dots - - - - - - - 17

16. Cap cells all uniformly developed; tip of cap pigmented - - *Trimerotropis citrina*
Cap cells weakly developed proximally; tip of cap usually not pigmented - - - - - - - - - - - - - - - - - - - *Dicromorpha viridis*

17. Cap cells without thickenings in their corners - - - - - - - - 18
Cap cells with thickenings in their corners - - - - - - - - - - 21

18. Boundaries of body cells well developed - - - - - - - - - - - - 19
Boundaries of body cells weakly developed or absent - - - - - 20

19. Three rows of flattened irregularly shaped cells just above or anterior to micropyles - - - - - - - - - - - - *Schistocerca obscura*
No such cells anterior to micropyles; egg wine red in color - *Schistocerca lineata*

20. Thickenings regularly arranged over all or most of the body of the egg - *Dissostira carolina*
Thickenings fragmentally arranged over most of the body of the egg - *Dissostira longipennis*

21. Thickenings of body cells of the egg are strongly produced (length equal to about one-half of the diameter of the cells) - - *Hippiscus rugosus*
Thickenings of body cells not strongly produced - - - - - - - - - 22

22. Thickenings developed such that the cells seem to be formed by the fusion of their points - - - - - - - - - - - - - *Arphia xanthoptera*
Thickenings not so developed - - - - - - - - - - - - - - - - - - - 23

23. Cells at tip of cap distinct - - - - - - - - - *Spharagemon equale*
Cells at tip of cap more or less obscured by development of boundaries and by pigmentation - - - - - - - - - *Spharagemon collare*

24. Body cells of eggs angular - - - - - - - - - - - - - - - - - - - 27
Body cells of eggs circular - - - - - - - - - - - - - - - - - - - 25

25. Cap cells circular - 26
Cap cells angular - - - - - - - - - *Melanoplus bowditchi bowditchi*

26. Micropyles bifid anteriorly and with a sharp projection posteriorly - *Mermiria neomexicana*
Micropyles bifid anteriorly or not; if bifid with no sharp posterior projection - - - - - - - - *Mermiria maculipennis macclungi*

27. Tip of cap without cells - 35
Cap entirely covered by cells - - - - - - - - - - - - - - - - - - 28

28. Body cells with heavy boundaries - - - - - - - - - - - - - - - - - 31
Body cells with faint boundaries - - - - - - - - - - - - - - - - - 29

29. Cap cells angular - 30
Cap cells circular - - - - - - - - - - - - *Hadrotettix trifasciatus*

30. Proximal cells of cap more heavily outlined than the distals - *Melanoplus confusus*
Distal cells of the cap more heavily outlined than the proximals - *Melanoplus bivittatus*

31. Body cells of egg large, with sharply defined angles; cap cells with heavy boundaries - - - - - - - - - - - - - - - - *Bradynotes obesa*
Not as above - 32

32. Boundaries of all cap cells equally developed or nearly so - - 33
Six or seven proximal rows of cells with heavier boundaries than the distals - - - - - - - - - - - - - - - - - *Melanoplus augustipennis*
Distal cells of cap more heavily outlined than the proximals - - *Schistocerca lineata*

33. Sculpturing distinct over the entire cap - - - - - - - - - - - - - 34
Sculpturing somewhat obscured at tip of cap - *Melanoplus differentialis*

34. Proximal cells larger than distals; all cells of cap outlined by fine ridges - *Dactylotum pictum*
Proximal cells of cap outlined by wavy ridges - *Trachyrachis kiowa kiowa*
Three rows of flattened irregularly shaped cells just anterior to the micropyles - - - - - - - - - - - - - - - - - *Schistocerca obscura*

35. Body cells with heavy boundaries - - - - - - - - - - - - - - - - - 37
Body cells with faint boundaries - - - - - - - - - - - - - - - - - 36

36. Five proximal or basal rows of cap cells with heavier boundaries than the distals - - - - - - - - - *Campylacantha olivacea olivacea*

Five or six rows of proximal cells on cap with heavy boundaries beyond which are three rows of less heavily developed cells - *Melanoplus gladstoni*

37. Proximal cells of cap with heavier boundaries than the distals- 40
All cells of cap with equally developed boundaries - - - - - - 38

38. Eight or nine rows of cells on basal portion of cap - - - - - 39
Five rows of cells on basal portion of cap - *Hesperotettix viridis praetensis*
Three rows of cells on basal portion of cap - *Aeoloplus turnbulli plagosus*

39. Cap cells more or less regularly shaped - - - - - -*Hypochlora alba*
Cap cells irregularly shaped - - - - - - - - - *Melanoplus packardi*

40. All cap cells more or less regularly shaped - - - - - - - - - - 42
Some of proximal cells irregularly shaped - - - - - - - - - - - 41

41. Four proximal rows of irregularly shaped, heavily outlined cells on cap beyond which are three rows of lighter, more regularly shaped cells - - - - - - - - - - - - - - - *Melanoplus foedus foedus*
Three proximal rows of irregularly shaped cells on cap beyond which are five rows of regularly shaped cells -*Phoetaliotes nebrascensis*

42. Five proximal rows of cells on cap with heavy boundaries - - - 43
Six or seven proximal rows of cells on cap with heavy boundaries beyond which are two rows of lighter cells - *Melanoplus femur-rubrum femur-rubrum*

43. Two rows of lighter cells on cap beyond the heavily bounded proximals - *Melanoplus lakinus*
Three rows of lighter cells on cap beyond the heavily bounded proximals - 44

44. Proximals on cap heavily bounded and irregularly arranged - *Melanoplus occidentalis occidentalis*
Proximals on cap heavily outlined on posterior end and more or less definitely arranged - - - - - *Melanoplus mexicanus mexicanus*

LIST OF SPECIES*

ACRIDIDAE

Acrydiinae

Apotettix eurycephalus Hancock
Tettigidea parvipennis pennata Morse

Acridinae

Aeropedallus clavatus (Thomas)
Ageneotettix deorum (Scudder)
Dicromorpha viridis (Scudder)
Mermiria maculipennis macclungi Rehn
Mermiria neomexicana (Thomas)
Opeia obscura (Thomas)
Orphullela pelidna (Burmeister)
Philobostoma quadrimaculatum Thomas
Syrbula admirabilis (Uhler)

Oedipodinae

Arphia pseudonietona (Thomas)
Arphia xanthoptera (Burmeister)
Chortophaga viridifasciata (De Geer)
Dissosteira carolina (Linnaeus)
Dissosteira longipennis (Thomas)
Encoptolophus costalis (Scudder)
Encoptolophus sordidus (Burmeister)
Hadrotettix trifasciatus (Say)
Hippiscus rugosus (Scudder)
Mestobragma plattei plattei (Thomas)
Spharagemon collare (Scudder)
Sparagemon equale (Say)
Trachyrachis kiowa kiowa (Caudell)
Trimerotropis citrina Scudder

Batrachotetriginae

Brachystola magna (Girard)

Cyrtacanthacrinae

*According to Hebard (1931).

Aeloplus turnbulli plagosus (Scudder)
Bradynotes obesa (Thomas)
Campylacantha o. olivacea (Scudder)
Dactylotum pictum (Thomas)
Hesperotettix viridis praetensis (Scudder)
Hypochlora alba (Dodge)
Melanoplus augustipennis (Dodge)
Melanoplus bivittatus (Say)
Melanoplus b. bowditchi Scudder
Melanoplus confusus Scudder
Melanoplus differentialis (Thomas)
Melanoplus femur-rubrum femur-rubrum (De Geer)
Melanoplus foedus foedus Scudder
Melanoplus gladstoni Scudder
Melanoplus lakinus (Scudder)
Melanoplus m. mexicanus (Saussure)
Melanoplus o. occidentalis (Thomas)
Melanoplus packardi Scudder
Phoetaliotes nebrascensis (Thomas)
Schistocerca lineata Scudder
Schistocerca obscura (Fabricius)

TETTIGONIIDAE

Conocephalinae

Orchelimum vulgare Harris

Decticinae

Pediodectes nigromarginata (Caudell)

DESCRIPTION OF THE EGGS

Aeoloplus turnbulli plagosus (Scudder)
Fig. 3

Color: Light brown

Average Size: 4.20 mm x 1.08 mm

Sculpturing: The body of the egg is marked with pentagonal and hexagonal cells. The reticulations in the central portion of the body are relatively well developed; they are finer at the anterior end of the egg, but the cells are distinct. The markings on the posterior third of the body are heavier than those found anterior to this region. Immediately anterior to the cap the reticulations become somewhat less distinct so that there appears to be a light band just in front of the cap. The proximal portion of the cap bears three rows of more or less oblong cells formed by dark colored reticulations. The remainder of the cap is smooth. The micropyles are scarcely, if at all visible. The smooth tip and the three rows of darkly outlined cells on the proximal portion of the cap, together with the rows of lightly outlined cells just anterior to the cap gives the posterior end of the egg a banded appearance which is distinctive for this egg.

Aeropedallus clavatus (Thomas)
Fig. 4

Color: Light brown

Average Size: 4.86 mm x 1.5 mm

Sculpturing: Both the body and the cap are devoid of sculpturing. The tip of the cap is more deeply pigmented than the rest of the egg and bears a few large granules. The micropyles are fairly prominent.

Ageneotettix deorum (Scudder)
Fig. 5

Color: Pale yellow

Average Size: 5.17 mm x 1.57 mm

Sculpturing: The chorion is entirely devoid of sculpturing. The micropyles are fairly prominent. The tip of the cap is pigmented so that it presents a light brown color. Around the proximal border of this pigmented area may be seen numerous small granules. A few granules may also be scattered over he remainder of the area.

Apotettix eurycephalus Hancock
Fig. 6

Color: Grey to greyish brown

Average Size: 2.53 mm x .73 mm

Sculpturing: The anterior end of the egg is much narrowed and attenuated so as to form a spur-like structure, a feature which serves to distinguish the eggs of the grouse locusts from the other Orthopterans. The posterior end of the egg does not bear a cap. The chorion is free from sculpturing except anteriorly around the base of the spur and on the posterior end. In these areas fairly well developed reticulations form pentagonal and hexagonal cells. The cells of the posterior group become progressively less well defined anteriorly.

Arphia pseudonietona (Thomas)
Fig. 7

Color: Light brown

Average Size: 4.86 mm x 1.5 mm

Sculpturing: The body is marked with faintly outlined cells having triangular thickenings in their corners. Two opposite sides of the majority of the cells have become greatly shortened so that the thickenings appear to occur in pairs. The cap is completely covered with fairly well defined cells which also bear triangular thickenings. The micropyles are prominent.

Arphia xanthoptera (Burmeister)
Fig. 8

Color: Dark brown

Average Size: 5.55 mm x 1.57 mm

Sculpturing: The sculpturing is characterized by well developed triangular thickenings in the corners of the cells, so that the linear reticulations are largely obscured. Because of this the cells are more or less rounded and appear to be formed by the junction of six or seven of these thickenings. At the anterior end of the egg the thickenings are very highly developed giving the cells the appearance of being formed by heavy reticulations. The cells on the proximal half of the cap closely resemble those found at the anterior tip of the egg. The cells on the distal half are smaller than those on the proximal half and are formed by the junction of prominent triangular thickenings. The micropyles are rather faint and the area they occupy is smooth.

Brachystola magna (Girard)
Fig. 9

Color: Dark brown

Average Size: 10.09 mm x 2.44 mm

Sculpturing: The egg is very heavily pigmented and the sculpturing is greatly obscured except in scattered areas. The reticulations are heavy and form pentagonal and hexagonal cells. The cap is difficult to see, but the cells resemble those on the body. The cap is more heavily pigmented than the body, being almost black. So far as the eggs considered here are concerned the relative great size of this egg distinguished it from the others.

Bradynotes obesa (Thomas)
Fig. 10

Color: Brown

Average Size: 5.87 mm x 1.63 mm

Sculpturing: The body is uniformly covered with heavy ridges which form clean cut pentagonal and hexagonal cells. A dark line courses along the middle of the ridges. At the anterior end of the egg the sculpturing tends to become slightly heavier.

Campylacantha olivacea olivacea (Scudder)
Fig. 11

Color: Yellowish brown

Average Size: 4.17 mm x .9 mm

Sculpturing: The reticulations on the body are fine but distinct

and form the boundaries of pentagonal and hexagonal cells. The thickness of the reticulations is uniform over the entire body of the egg. There are five complete rows of cells on the proximal portion of the cap whose shape roughly resembles that of the body cells, though they are more or less irregular, showing a tendency toward roundness. Their boundaries are slightly heavier than those of the body cells. The tip of the cap is smooth.

Chortophaga viridifasciata (De Geer)
Fig. 12

Color: Light brown

Average Size: 3.97 mm x .93 mm

Sculpturing: Both the body and cap are completely devoid of sculpturing. The micropyles are prominent.

Dactylotum pictum (Thomas)
Fig. 13

Color: Brown

Average Size: 5185 mm x 1.69 mm

Sculpturing: The body of the egg is covered with uniform reticulations which present a definite granular appearance and form the boundaries of pentagonal and hexagonal cells. The reticulations which form the cap cells closely resemble those on the body, except that they are slightly finer. The cells are decidedly longitudinally attenuated especially toward the tip of the cap.

Dicromorpha viridis (Scudder)
Fig. 14

Color: Light brown

Average Size: 4.96 mm x 1.19 mm

Sculpturing: The body of the egg is marked by pentagonal and hexagonal cells bounded by faint reticulations. In the corners of the cells are moderately well developed triangular thickenings. In the centers of the majority of the cells is a well developed nodule. At those points where the egg was in contact with other eggs in the pod the development of the sculpturing is somewhat suppressed, though the pattern is clearly evident. Immediately anterior to the micropyles is a smooth area about as wide as seven rows of body cells. The most proximal portion of the cap is smooth while the remainder is covered by somewhat irregular cells whose boundaries are distinctly heavier than are those of the body cells, the degree of development increasing as the tip is approached. Nodules are present as dots in the centers of some of the cap cells, though they are not so strongly produced as are those of the body cells. The micropyles are close together and are quite prominent.

Dissosteira carolina (Linnaeus)
Fig. 15

Color: Light brown

Average Size: 5.58 mm x 1.08 mm

Sculpturing: The entire body of the egg is marked with very faint

reticulations which form the boundaries of pentagonal and hexagonal cells. Well developed triangular thickenings are found in the corners of the cells. At the anterior end of the egg the reticulations are considerably heavier and the triangular thickenings are not in evidence to any great degree if at all. Immediately anterior to the micropyles the chorion is devoid of sculpturing. The cap is entirely covered with cells but they are poorly defined and irregular. The micropyles are prominent.

Dissosteira longipennis (Thomas)
Fig. 16

Color: Light brown

Average Size: 5.50 mm x 1.25 mm

Sculpturing: The sculpturing of the body is limited almost entirely to triangular thickenings. Linear reticulations are seldom seen and then only faintly. On the anterior end of the egg the thickenings are so arranged that the primitive pentagonal and hexagonal cellular pattern is evidenced. On the posterior half of the body the thickenings are very irregularly and fragmentally arranged; there being no sculpturing at all immediately anterior to the micropyles. The proximal two-thirds of the cap is characterized by the presence of well defined pentagonal and hexagonal cells. The cells on the distal third are more heavily outlined. The micropyles are distinct.

Encoptolophus costalis (Scudder)
Fig. 17

Color: Light brown

Average Size: 4.1 mm x .9 mm

Sculpturing: The body of the egg is devoid of sculpturing. The proximal third and the tip of the cap are smooth; the band between them bearing several rows of faintly outlined pentagonal and hexagonal cells.

Encoptolophus sordidus (Burmeister)
Fig. 18

Color: Light brown

Average Size: 4.32 mm x 1.18 mm

Sculpturing: The body of the egg is devoid of sculpturing. The cap is strongly granular and the distal half is faintly marked with pentagonal and hexagonal cells and the tip of the cap may be smooth. The micropyles are prominent.

Hadrotettix trifasciatus (Say)
Fig. 19

Color: Russet brown

Average Size: 7.17 mm x 2.08 mm

Sculpturing: The majority of the body of the egg is very faintly marked with fine reticulations which form pentagonal and hexagonal cells. At the anterior end of the egg the reticulations become decidedly more pronounced so that the cells are clearly outlined. The cap is much more darkly colored than the body of the egg and is completely covered

by very heavily outlined rounded cells. That portion of the chorion which comprises the cap is distinctly granular. The granules being visible even in the heavy reticulations. The micropyles are distinct.

Hesperotettix viridis praetensis (Scudder)
Fig. 20

Color: Light brown

Average Size: 4.66 mm x 1.14 mm

Sculpturing: The body is marked with well developed reticulations which form pentagonal and hexagonal cells. The cap is marked with five rows of pentagonal and hexagonal cells, though they tend to be more rounded and their boundaries heavier than the body cells. Distad of these five rows of cells the cap is smooth. The micropyles are not prominent.

Hippiscus rugosus (Scudder)
Fig. 21

Color: Brown

Average Size: 6.51 mm x 1.8 mm

Sculpturing: The entire body of the egg is covered by hexagonal and pentagonal cells whose boundaries are distinct but are formed by poorly developed reticulations. The corners of the cells contain triangular thickenings which are produced to a length equal to about half the diameter of a cell. The reticulations forming the cap cells are considerably heavier than those forming the body cells and consequently the triangular thickenings are heavier. The entire cap is covered with

cells, those near the tip being heavier than those at the base. The micropyles are quite prominent. The outstanding feature of the egg is the presence of the developed triangular thickenings.

Hypochlora alba (Dodge)
Fig. 22

Color: Light brown

Average Size: 4.9 mm x 1.26 mm

Sculpturing: The body of the egg is covered by uniform pentagonal and hexagonal cells whose boundaries are moderately heavy. At the extreme anterior tip of the egg the reticulations are less strongly developed. Immediately anterior to the micropyles the cells are somewhat compressed anterio-posteriorly. There are eight or nine rows of irregularly shaped pentagonal and hexagonal cells on the cap, whose boundaries are more strongly developed than are those of the body cells. The tip of the cap is smooth. The micropyles are fairly prominent.

Melanoplus augustipennis (Dodge)
Fig. 23

Color: Cream yellow

Average Size: 4.79 mm x 1.33 mm

Sculpturing: The majority of the body of the egg is covered by well developed reticulations which form pentagonal and hexagonal cells. The ridges become definitely heavier near the anterior end of the egg. The anterior tip is smooth. Proximally the cap bears six or seven rows of heavily outlined cells and beyond these the cells become progressively

fainter until or almost until the tip is reached.

Melanoplus bivittatus (Say)
Fig. 24

Color: Olive to brownish yellow

Average Size: 4.45 mm x 1.2 mm

Sculpturing: The body is marked very faintly with pentagonal and hexagonal cells which tend to become more heavily outlined at the anterior end of the egg. The cap is completely covered by more or less heavily outlined cells of an irregular shape. The reticulations forming the cells become progressively heavier distally so that it is almost impossible to follow the cell pattern to the tip of the cap. The micropyles are fairly prominent.

Melanoplus bowditchi bowditchi Scudder
Fig. 25

Color: Light brown

Average Size: 4.22 mm x 1.08 mm

Sculpturing: The entire body of the egg is uniformly covered by well developed reticulations which present a granular appearance and form rounded cells. On one or more sides of many of these cells just inside the cell boundary and occasionally completely around the inside of the boundary is a dark colored thickened area which gives the egg a distinctive appearance. The reticulations are heavier just anterior to the cap. On the proximal portion of the cap are four rows of sharply outlined pentagonal and hexagonal cells which show heavily developed

thickenings inside their posterior borders. Distad of these are three or four rows of less sharply defined cells which rarely show a thickening inside the border. The tip of the cap is smooth. The micropyles are not particularly prominent.

Melanoplus confusus Scudder
Fig. 26

Color: Deep yellow

Average Size: 4.37 mm x 1.13 mm

Sculpturing: The body of the egg is faintly marked with pentagonal and hexagonal cells. The cap bears five proximal rows of heavily outlined cells. The remainder of the cap is covered by less heavily developed cells. The micropyles are faint.

Melanoplus differentialis (Thomas)
Fig. 27

Color: Olive and yellowish brown

Average Size: 4.49 mm x 1.1 mm

Sculpturing: The body is covered by pentagonal and hexagonal cells formed by heavy reticulations. At the anterior end of the egg these cells become much less prominently outlined. Immediately anterior to the micropyles the cells tend to become more or less anterio-posteriorly compressed. The cap is entirely covered with cells whose boundaries are slightly heavier than those of the body cells. The pattern is somewhat obscured at the distal end of the cap, though the cell boundaries can still be seen. The micropyles are only fairly visible.

Melanoplus femur-rubrum femur-rubrum (De Geer)
Fig. 28

Color: Light brown

Average Size: 4.37 mm x .85 mm

Sculpturing: The body of the egg is completely covered with moderately well developed ridges which form pentagonal and hexagonal cells. The cap bears six or seven proximal rows of heavily outlined cells, and distad of these are two rows of faintly outlined cells. The tip of the egg is smooth. The micropyles are fairly prominent.

Melanoplus foedus foedus Scudder
Fig. 29

Color: Deep yellow

Average Size: 4.98 mm x 1.16 mm

Sculpturing: The body of the egg is covered with moderately well developed reticulations which form pentagonal and hexagonal cells. Proximally the cap bears four rows of very heavily outlined, irregularly shaped cells, and distad of these are three rows of more regularly shaped cells formed by moderately well developed ridges. These merge into three or four rows of faintly outlined cells. The tip of the cap is smooth. The micropyles are very faint.

Melanoplus gladstoni Scudder
Fig. 30

Color: Brown with greenish tinge

Average Size: 4.87 mm x 1.04 mm

Sculpturing: The body of the egg is faintly marked with pentagonal and hexagonal cells. The cap bears five or six proximal rows of heavily outlined cells, distad of which are three rows of faintly outlined cells which become fainter as the tip is approached. The tip of the cap is smooth.

Melanoplus lakinus (Scudder)
Fig. 31

Color: Light brown

Average Size: 4.53 mm x 1.02 mm

Sculpturing: The body of the egg is marked with distinct reticulations which form pentagonal and hexagonal cells. The sculpturing is somewhat suppressed at the extreme anterior end of the egg, and slightly so in the last two or three rows of cells anterior to the micropyles. On the proximal portion of the cap are five rows of cells which have well developed boundaries and beyond these are two rows of less distinctly outlined cells. The tip of the cap is smooth. The micropyles are prominent and appear rounded.

Melanoplus mexicanus mexicanus (Saussure)
Fig. 32

Color: Yellowish brown

Average Size: 4.67 mm x 1.05 mm

Sculpturing: The body of the egg is covered with pentagonal and hexagonal cells which are formed by moderately well developed ridges. The cap bears five rows of proximal cells bounded by heavy ridges.

Distad of these are three rows of faintly outlined cells. The micropyles are only fairly distinct.

Melanoplus occidentalis occidentalis (Thomas)
Fig. 33

Color: Yellow

Average Size: 5.31 mm x 1.24 mm

Sculpturing: The body of the egg is covered with well developed reticulations which form pentagonal and hexagonal cells. The cap bears five proximal rows of cells which are heavily outlined and rather irregular in shape. Distad of these are three rows of faintly outlined cells. The tip of the cap is smooth and the micropyles are only faintly visible.

Melanoplus packardi Scudder
Fig. 34

Color: Yellowish brown

Average Size: 5.18 mm x 1.41 mm

Sculpturing: The body of the egg is covered with well developed ridges which form pentagonal and hexagonal cells. The anterior tip of the egg is smooth. The entire cap, except the tip which is smooth is covered with heavily outlined cells having an irregular shape. The micropyles are invisible.

Mermiria maculipennis macclungi Rehn
Fig. 35

Color: Purplish, with almost white longitudinal areas.

Average Size: 7.33 mm x 1.42 mm

Sculpturing: The pattern is almost identical with that of Mermiria neomexicana. At the anterior end of the egg the pattern is obscured by a thick granular substance. The micropyles are prominent and appear as relatively large black dots or are bifid anteriorly. If bifid, they do not have the sharp posterior projection seen in M. neomexicana, so that they may be used together with the thick granular substance at the anterior extremity to differentiate the egg from that of M. neomexicana.

Mermiria neomexicana (Thomas)
Fig. 36

Color: Purplish with white longitudinal stripes.

Average Size: 7.23 mm x 1.45 mm

Sculpturing: The reticulations are extremely heavy so that the cells take on the appearance of rounded pits or indentations in the chorion. At the extreme anterior end the sculpturing is somewhat obscured and proximad of this the pits are connected with each other by grooves which give them a stellate appearance. The sculpturing of the proximal third of the cap closely resembles that of the body. On the distal two-thirds the sculpturing is somewhat obscured and the pits are larger giving a cellular appearance. The micropyles are very numerous and appear as a prominent row of black spots around the egg at the anterior end of the cap. The shape of the micropyles is valuable in distinguishing the egg from that of Mermiria maculipennis macclungi. They are bifid at the anterior end and sharply pointed at the posterior end.

Mestobragma plattei plattei (Thomas)
Fig. 37

Color: Russet brown

Average Size: 5.65 mm x 1.36 mm

Sculpturing: There are four distinct types of sculpturing on the eggs. At the anterior tip is a small number of irregularly shaped cells whose boundaries are heavy ridges. Along the middle of each ridge is a uniform darker colored line. Posterior to these is a band occupying about one-fourth of the egg, on which the sculpturing is composed of heavy ridges similar to those which form the cells at the tip of the egg. The ridges show rough lateral projections and have a single darker colored line coursing along them. These lines give off short lateral projections in such a manner as to suggest the remnants of pentagonal and hexagonal cells. Occasionally two of these projections span the distance between adjacent ridges and join. The ridges run longitudinally along the egg dividing and anastomosing occasionally, forming a pattern which reminds one of brain coral. Except for a narrow band immediately anterior to the cap, the remainder of the egg is covered by a third type of sculpturing. This type is composed of short apparently irregularly arranged ridges which do not have the darker colored lines coursing along them. When studied closely they will be seen to be arranged as the remnants of the boundaries of pentagonal and hexagonal cells. Occasionally it is possible to see a fine network of lines which form pentagonal and hexagonal cells superposed on the fragmental ridges.

The fourth type of sculpturing found on the body is borne by the narrow band just anterior to the cap. Here there are definite cells. The boundaries are formed by ridges such as compose the sculpturing on the remainder of the body, and because of their heavy development the cells are rounded. The true pentagonal and hexagonal pattern can be seen, however, in the darker lines which follow the cell boundaries. The cap is completely covered with cells whose boundaries are about as heavy as the ridges on the body. They are pentagonal and hexagonal, tending to become narrowed toward the tip. Dark lines are again seen following the centers of the reticulations, especially on the proximal portion of the cap. The cap is more deeply colored than the body. Over the entire chorion at the centers of the cells are groups of definite granules. The micropyles may be seen, though they are not prominent.

Orchelimum vulgare Harris
Fig. 38

Color: Brown

Average Size: 5.99 mm x .84 mm

Sculpturing: The egg is not differentiated into body and cap. The sculpturing varies over the egg and is quite characteristic. In general the patterns are of two types, one of which is more or less restricted to each end of the egg, though the extent varies somewhat. One of these patterns strikingly resembles nucleated epithelial cells. The remainder of the egg is marked by minute dots so arranged that a network of clear lines can be seen coursing among them. The lines form

a honey comb network which reflects the familiar pentagonal and hexagonal cellular pattern. Located in this area about one-fourth the length of the egg from the end may be seen the micropyles. In the transition area between the two types of patterns several of the large cells and groups of small dots are replaced by larger dots. These large dots when under high power are seen as "nucleated" pentagonal and hexagonal cells exactly like the large ones except for size.

Orphullela pelidna (Burmeister)
Fig. 39

Color: Light brown

Average Size: 4.08 mm x .95 mm

Sculpturing: The body of the egg is free from any sculpturing, but presents a definite granular appearance. The proximal portion of the cap is faintly marked with cells, while the cells on the distal two-thirds of the cap are more distinctly outlined. The center of each cell is filled more or less completely by a raised area which resembles the ridges in appearance. The distal third of the cap is dark brown to black, a feature which serves to differentiate this egg from others having a smooth chorion. The micropyles are prominent.

Pediodectes nigromarginata (Caudell)
Fig. 40

Color: Brown

Average Size: 6.76 mm x 2.21 mm

Sculpturing: The egg is not differentiated into body and cap. The

entire chorion is marked by a homogeneous sculpturing of pentagonal and hexagonal cells. The reticulations are well developed and present a characteristic wavy appearance which serves to distinguish the egg from others.

Philobostoma quadrimaculatum Thomas
Fig. 41

Color: Light brown

Average Size: 4.8 mm x 1.43 mm

Sculpturing: The body of the egg is smooth. The cap is free from sculpturing except on the distal portion which bears a few large granules and is covered by faintly outlined cells. The egg closely resembles that of Encoptolophus sordidus, but can be differentiated from it on the basis of its larger granules and by the fact that the posterior borders of the cells are thickened. The micropyles are only faintly visible.

Phoetaliotes nebrascensis (Thomas)
Fig. 42

Color: Olive to brownish yellow

Average Size: 4.4 mm x 1.1 mm

Sculpturing: The body of the egg is marked by moderately heavy reticulations which form pentagonal and hexagonal cells. The cells are more heavily outlined at the anterior end of the egg and are compressed anterio-posteriorly immediately anterior to the micropyles. The sculpturing of the cap is sharply contrasted to that of the body. The cells tend to be anterio-posteriorly lengthened and the first four or

five proximal rows of cells are more heavily outlined than are the distal cells. The tip of the cap is smooth. The micropyles are prominent.

Schistocerca lineata Scudder
Fig. 43

Color: Wine red

Average Size: 6.52 mm x 1.78 mm

Sculpturing: The cells are hexagonal and pentagonal and are formed of moderately heavy reticulations. There is a tendency toward thickenings in the corners of some of the cells. The reticularions on the anterior end are heavier than those on the remainder of the body. The sculpturing is somewhat obscured on the distal third of the cap. The micropyles are relatively inconspicuous and the reticulations are somewhat reduced in the area they occupy. The red color is the most striking feature of the egg and serves to distinguish it from the other eggs.

Schistocerca obscura (Fabricius)
Fig. 44

Color: Dark brown

Average Size: 5.96 mm x 1.55 mm

Sculpturing: The sculpturing on the body is well developed and forms cells which are fundamentally pentagonal and hexagonal, however, the presence of triangular thickenings in the corners of the cells give them a tendency toward roundness. The thickenings are not so conspicuous as is usual for eggs of this type due to the well developed cell boundaries. They appear more as pigmented areas in the cell corners.

Immediately anterior to the micropyles are three rows of more heavily outlined irregularly shaped cells which have no thickenings in their corners. These cells serve to distinguish the egg from that of Schistocerca lineata. The entire cap is covered with irregularly shaped cells whose boundaries are decidedly heavier than are those of the body cells. The micropyles are seen with difficulty.

Spharagemon collare (Scudder)
Fig. 45

Color: Light brown; lighter longitudinal stripes.

Average Size: 5.31 mm x 1.36 mm

Sculpturing: The majority of the body is covered with relatively faintly outlined pentagonal and hexagonal cells in whose corners are definite triangular thickenings. These thickenings, however, are nearly or entirely absent from those cells in areas which were in close contact with other eggs in the pod. At the anterior end the reticulations become heavier, but the thickenings in the corners of the cells are still evident. Anterior to the micropyles there is a smooth area about as side as nine rows of body cells. The proximal portion of the cap is smooth for a distance equal to about two rows of cells. The entire remainder of the cap is sculptured. The first four rows of cells distad of the smooth area are irregular and have triangular thickenings in their corners. The cells distad of these are formed of considerably heavier reticulations and there are thickenings in their corners. The micropyles are quite prominent.

Sparagemon equale (Say)
Fig. 46

Color: Light brown

Average Size: 4.55 mm x 1.18 mm

Sculpturing: The body of the egg is covered by pentagonal and hexagonal cells which are very faintly outlined. There are well developed triangular thickenings in the corners of the cells. At the anterior end of the egg the cells are much more heavily outlined. Anterior to the micropyles the sculpturing becomes quite fragmentary, finally disappearing entirely, leaving the chorion smooth. The proximal two-thirds of the cap is sculptured by cells which are more heavily outlined and whose triangular thickenings are more fully developed. The distal third of the cap is sculptured by heavily outlined cells, often so heavily that the cell boundaries are hard to distinguish. The micropyles are prominent.

Syrbula admirabilis (Uhler)
Fig. 47

Color: Light brown

Average Size: 4.39 mm x .98 mm

Sculpturing: The chorion is devoid of sculpturing but presents a definite granular appearance. The granules on the cap are larger than those on the body. Only a few granules are present just anterior to the cap. The micropyles are fairly prominent and close together.

Tettigidea parvipennis pennata Morse
Fig. 48

Color: Dark brown

Average Size: 3.29 mm x .70 mm

Sculpturing: The egg is not divided into cap and body areas, but the anterior end is attenuated into a spur-like structure. The entire chorion is marked with moderately well developed ridges which form pentagonal and hexagonal cells. The vitelline membrane bears numerous pigmented spots which gives a section mounted on a slide a spotted appearance.

Trachyrachis kiowa kiowa (Caudell)
Fig. 49

Color: Brown

Average Size: 5.09 mm x 1.2 mm

Sculpturing: The body of the egg is marked by quite well developed reticulations which form the boundaries of pentagonal and hexagonal cells. The cells tend toward roundness. The reticulations at the anterior end of the egg are slightly more heavily developed and the cell shape tends to become a little less regular. Immediately anterior to the micropyles the reticulations become noticeably more pronounced and the cells smaller and rounded. The entire cap is covered by pentagonal and hexagonal cells whose boundaries are heavier than are those of the majority of the body cells. The micropyles are distinct and form a deep brown, narrow, broken, band around the egg at the extreme proximal edge of the cap.

Trimerotropis citrina Scudder
Fig. 50

Color: Brown

Average Size: 5.33 mm x 1.39 mm

Sculpturing: The entire body of the egg is marked with faintly outlined pentagonal and hexagonal cells which have triangular thickenings in their corners and nodules in their centers. The nodules are often missing from the cells and at the points where the egg was in contact with others in the pod the thickenings in the corners of the cells may also be missing. Immediately anterior to the micropyles there is a band about as wide as the cap is long on which there are no nodules or thickenings at all. On the half of this band next to the micropyles the cells cannot even be seen. The entire cap is covered by cells whose boundaries are much more heavily developed than are those of the body cells and they are more irregular in shape, though they are fundamentally pentagonal and hexagonal. They have thickenings in their corners but no central nodules. The first six proximal rows of cells are quite distinct, but beyond these the sculpturing is somewhat obscured by deeper coloration. The micropyles are prominent.

SEGREGATION OF THE EGG PATTERNS INTO GROUPS

The study of the chorionic sculpturing of the forty-eight species included in this investigation has indicated some rather interesting species grouping. The present day classification of these species according to Hebard (1931), and the re-grouping according to the type of sculpturing is shown in Figures 1 and 2. Just how significant this grouping is, remains to be seen. No definite conclusions can be made regarding it until more extensive studies have been made and new and more complete evidence is available. Suffice it to say for the present that the eggs tend to segregate themselves into groups that do not coincide in all respects with the present taxonomic arrangement which is based on adult characteristics.

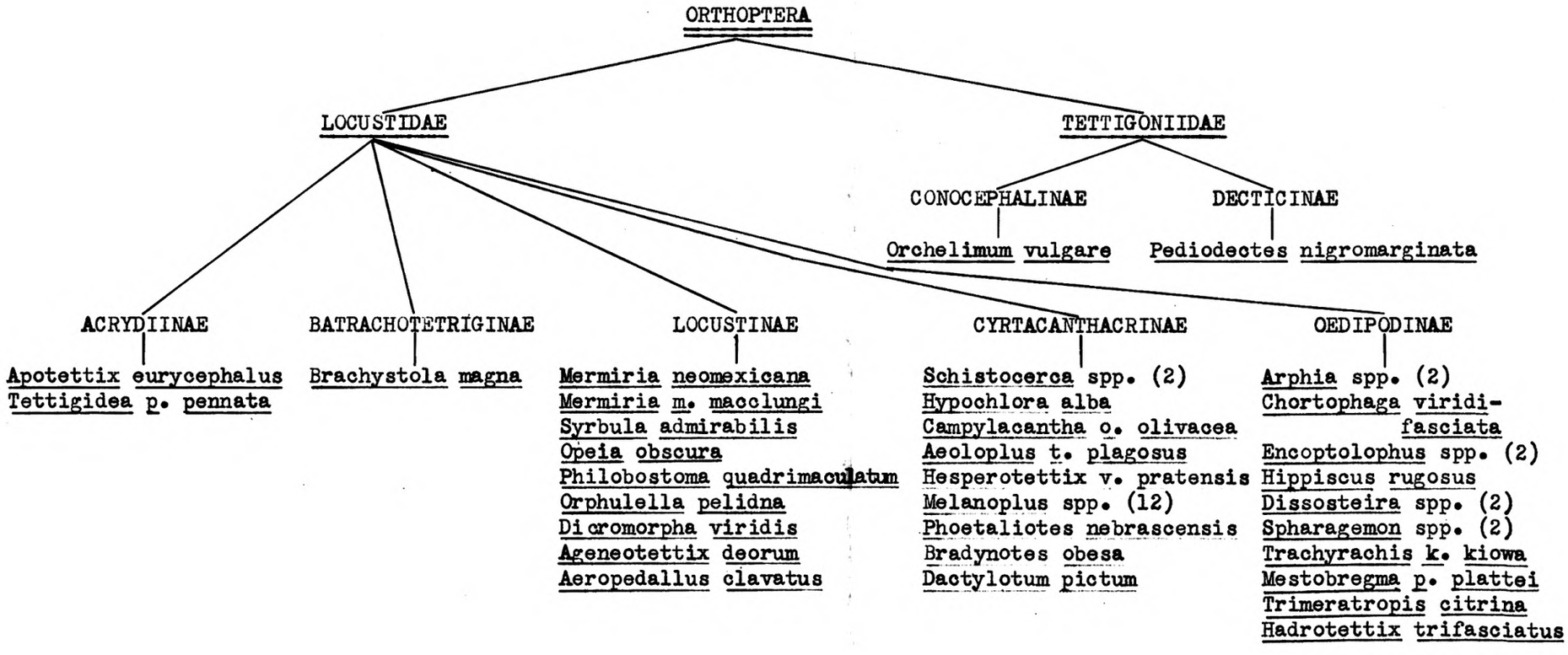

Fig. 1. The species of grasshoppers studied arranged according to Hebard (1931).

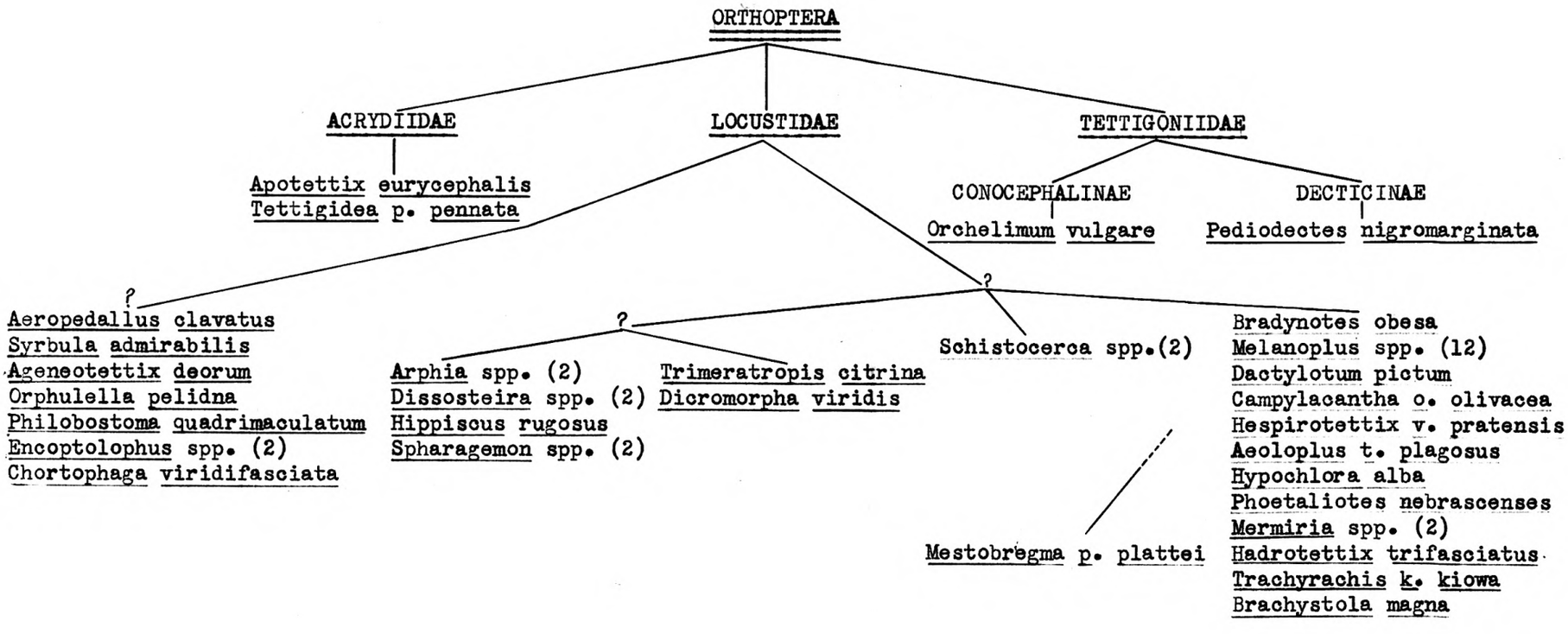

Fig. 2. The species of grasshoppers studied arranged according to similarity of egg patterns. (The color scheme of Fig. 1 is maintained to show the distribution of Hebard's groups through the egg groups.)

SUMMARY

1. A new and rapid technique has been developed for making microscopic mounts of chorionic sections of grasshopper eggs.
2. The eggs of forty-eight species have been described and photographed.
3. A key for the differentiation of these forty-eight species has been constructed.
4. Evidence has been found which may throw new light on the question of species relationships.

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APPENDIX

Explanation of Plate I

Fig. 3. *Aeoloplus turnbulli plagosus* 19x.

Fig. 4. *Aeropedallus clavatus* 19x.

Fig. 5. *Agenotettix deorum* 19x.

PLATE I

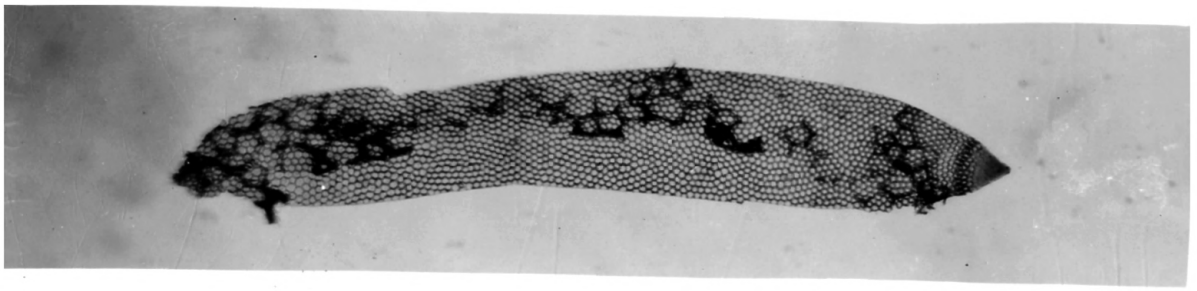

Fig. 3

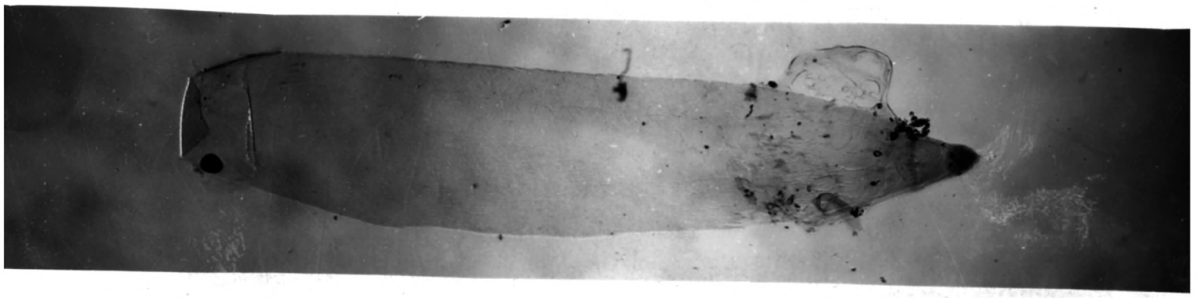

Fig. 4

Fig. 5

Explanation of Plate II

Fig. 6. *Apotettix eurycephalus* 35x.

Fig. 7. *Arphia pseudonietona* 19x.

Fig. 8. *Arphia xanthoptera* 19x.

PLATE II

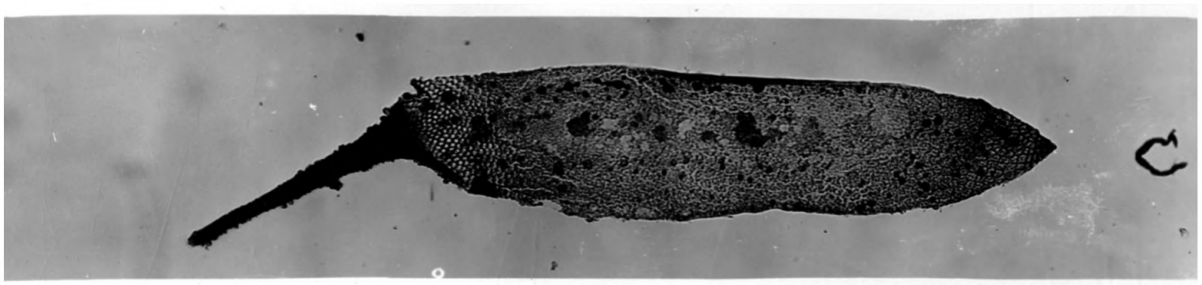

Fig. 6

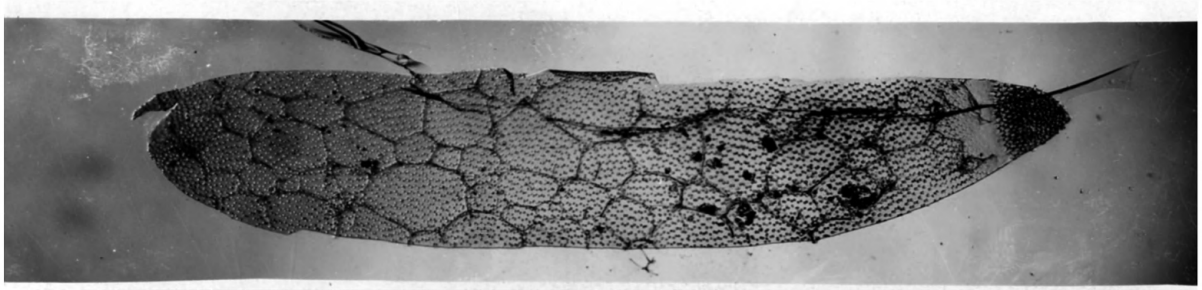

Fig. 7

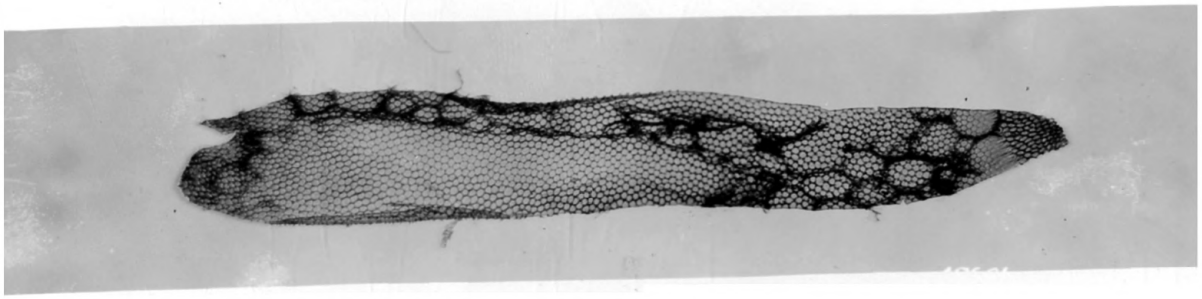

Fig. 8

Explanation of Plate II

Fig. 9. *Brachystola magna* 19x.

Fig. 10. *Bradynotes obesa* 19x.

Fig. 11. *Campylacantha olivacea olivacea* 19x.

PLATE III

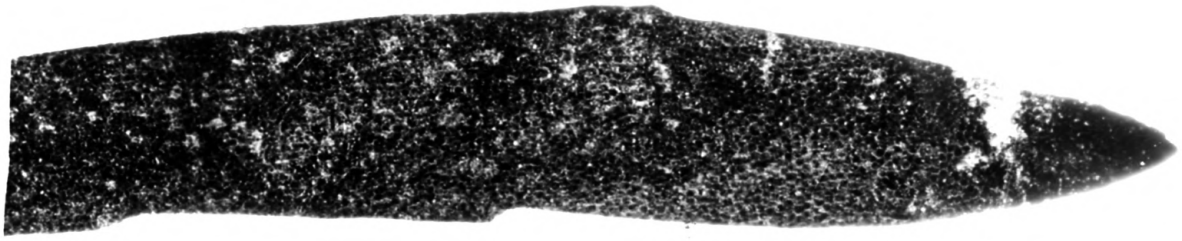

Fig. 9

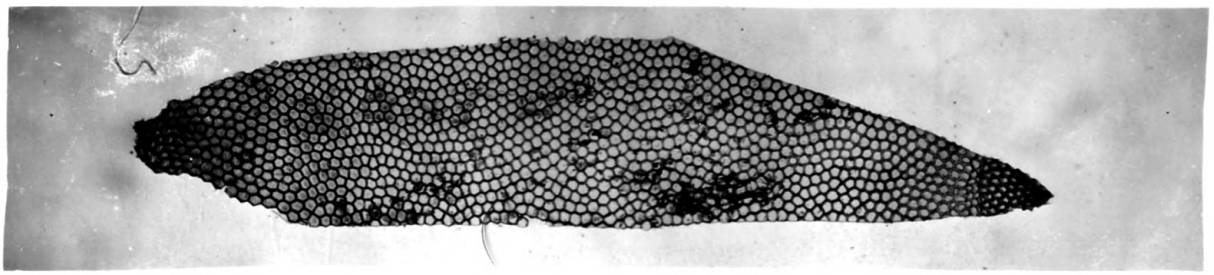

Fig. 10

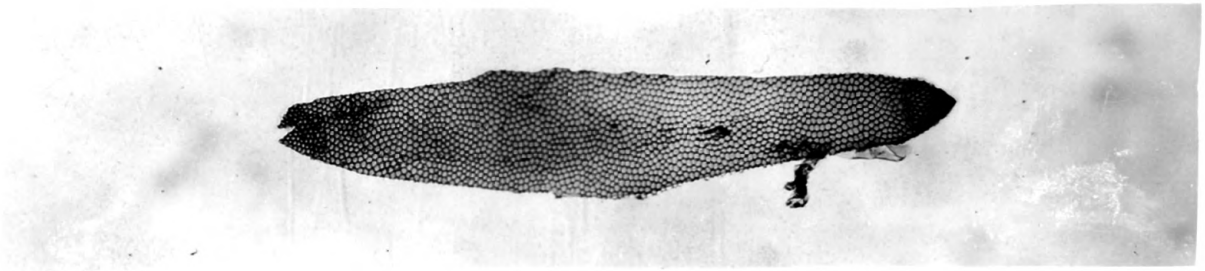

Fig. 11

Explanation of Plate IV

Fig. 12. *Chortophaga viridifasciata* 19x.

Fig. 13. *Dactylotum pictum* 19x.

Fig. 14. *Dicromorpha viridis* 19x.

PLATE IV

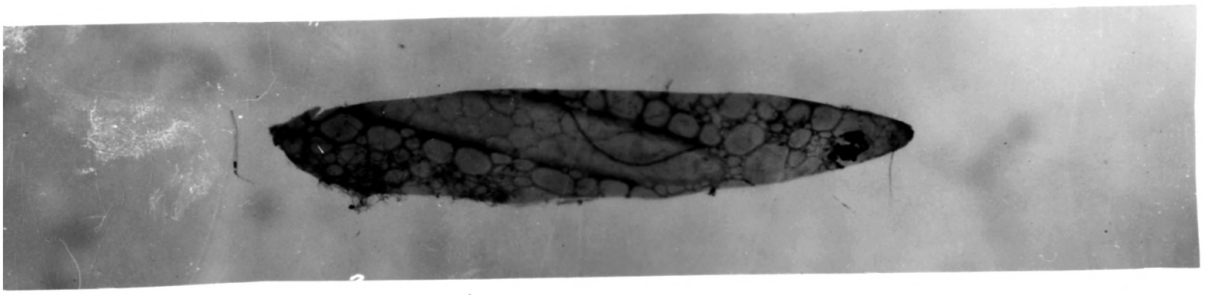

Fig. 12

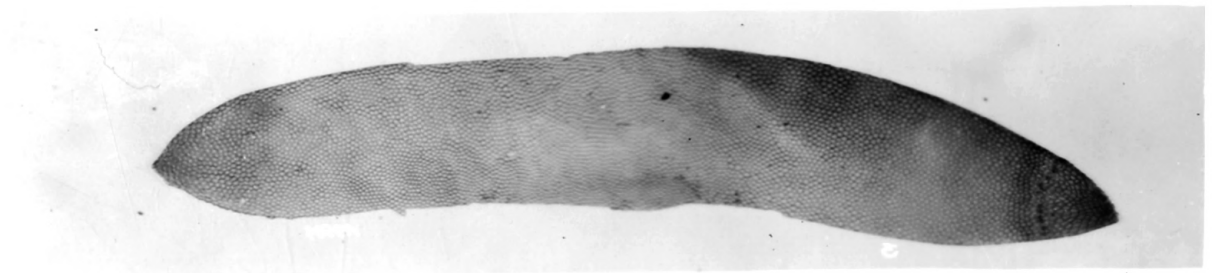

Fig. 13

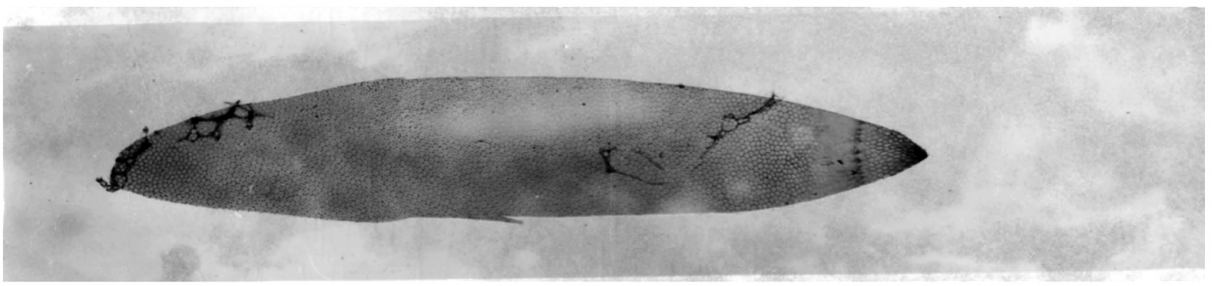

Fig. 14

Explanation of Plate V

Fig. 15. *Dissosteira carolina* 19x.

Fig. 16. *Dissosteira longipennis* 19x.

Fig. 17. *Encoptolophus costalis* 19x.

PLATE V

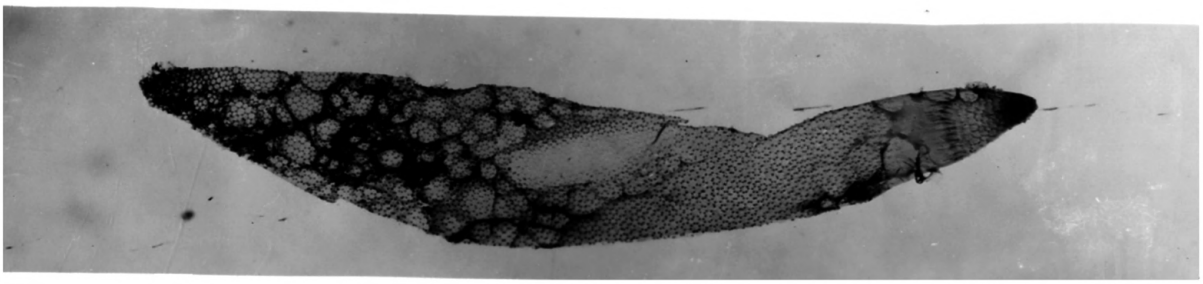

Fig. 15

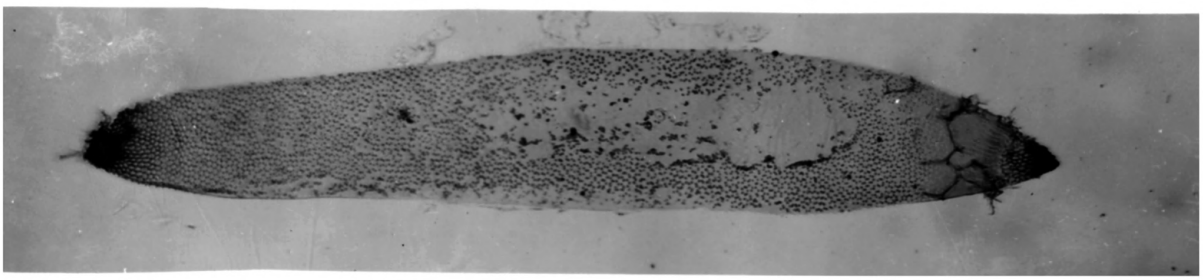

Fig. 16

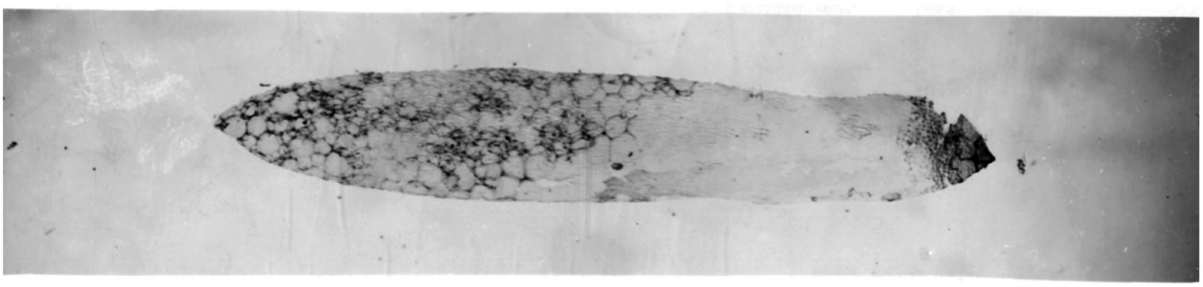

Fig. 17

Explanation of Plate VI

Fig. 18. Encoptolophus sordidus 19x.

Fig. 19. Hadrotettix trifasciatus 19x.

Fig. 20. Hesperotettix viridis praetensis 19x

PLATE VI

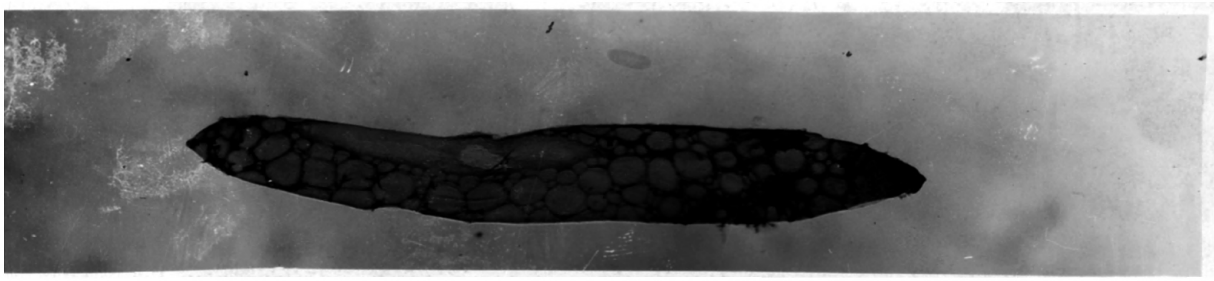

Fig. 18

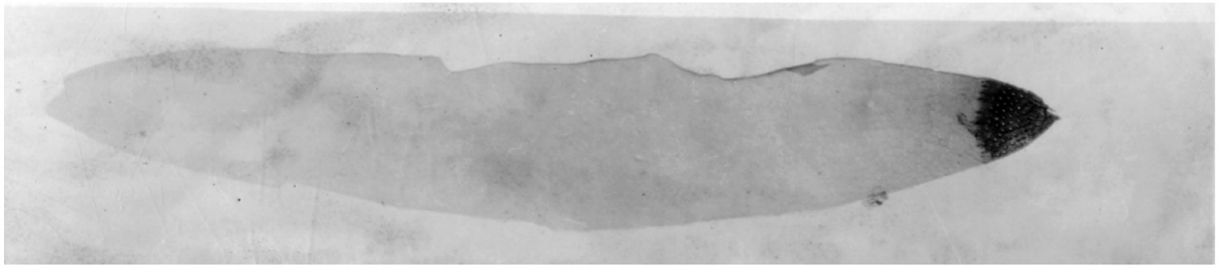

Fig. 19

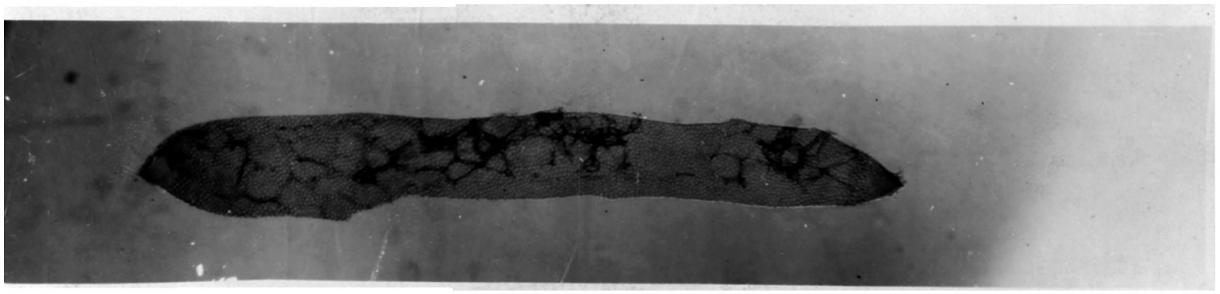

Fig. 20

Explanation of Plate VII

Fig. 21. Hippiscus rugosus 19x.

Fig. 22. Hypochlora alba 19x.

Fig. 23. Melanoplus augustipennis 19x.

PLATE VII

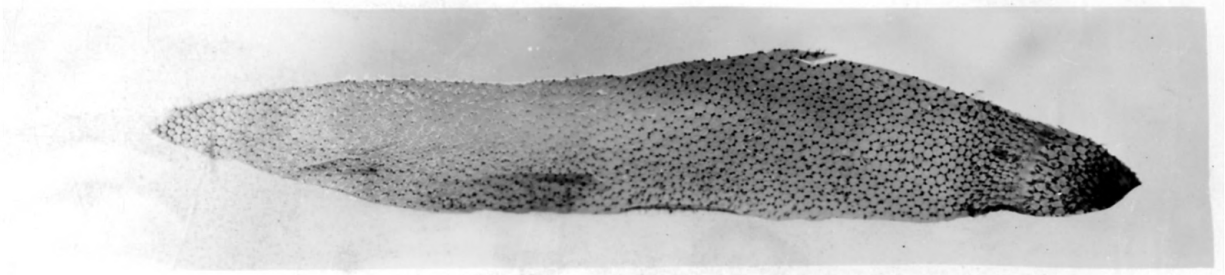

Fig. 21

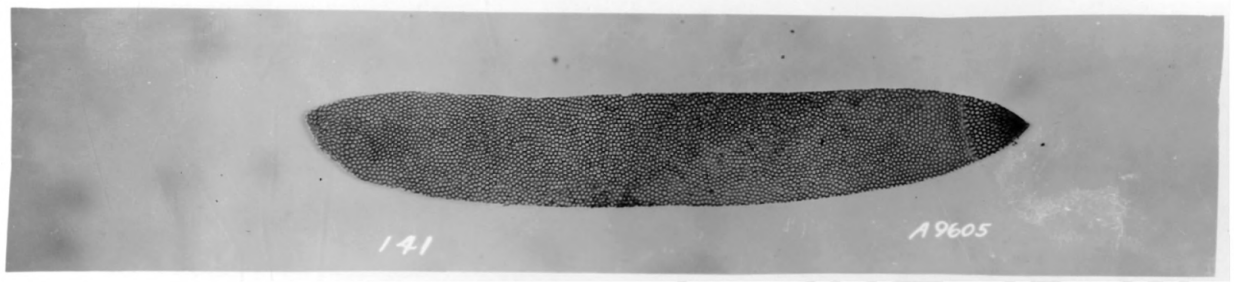

Fig. 22

Fig. 23

Explanation of Plate VIII

Fig. 24. Melanoplus bivittatus 19x.

Fig. 25. Melanoplus bowditchi bowditchi 19x.

Fig. 26. Melanoplus confusus 19x.

PLATE VIII

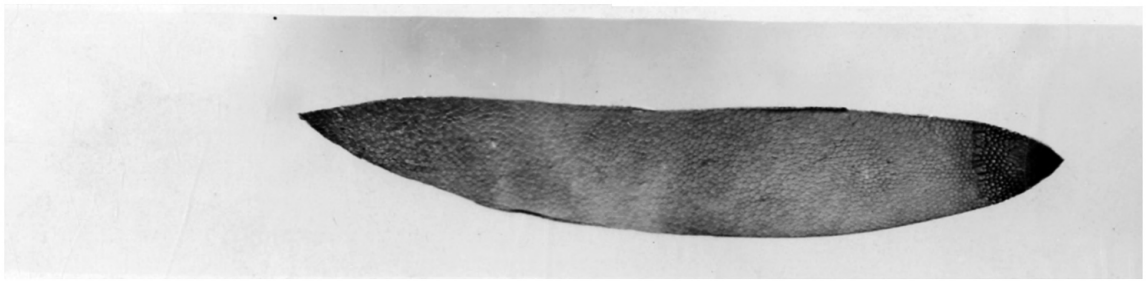

Fig. 24

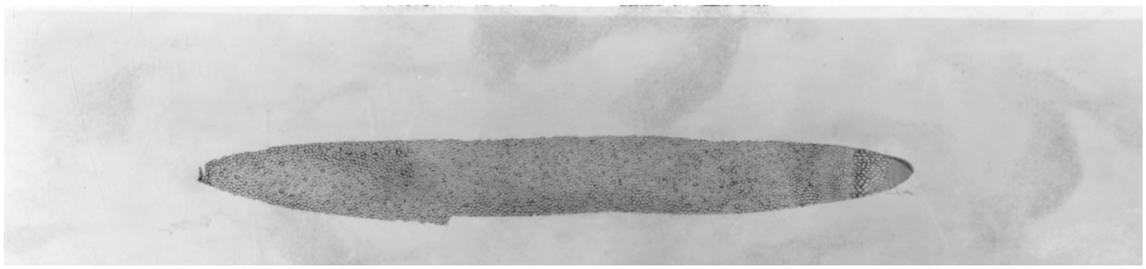

Fig. 25

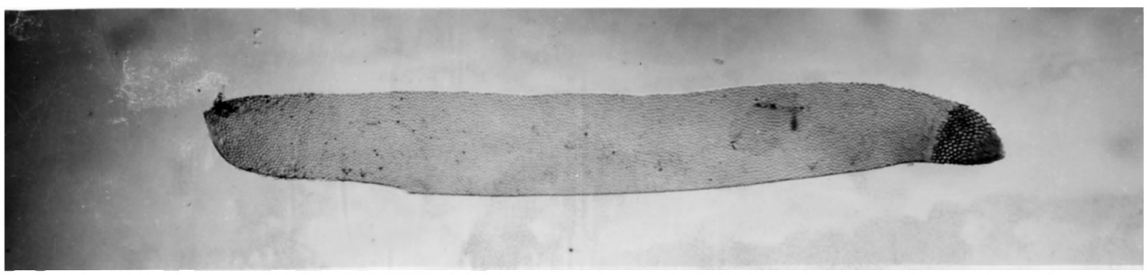

Fig. 26

Explanation of Plate IX

Fig. 27. *Melanoplus differentialis* 19x.

Fig. 28. *Melanoplus femur-rubrum femur-rubrum* 19x.

Fig. 29. *Melanoplus foedus foedus* 19x.

PLATE IX

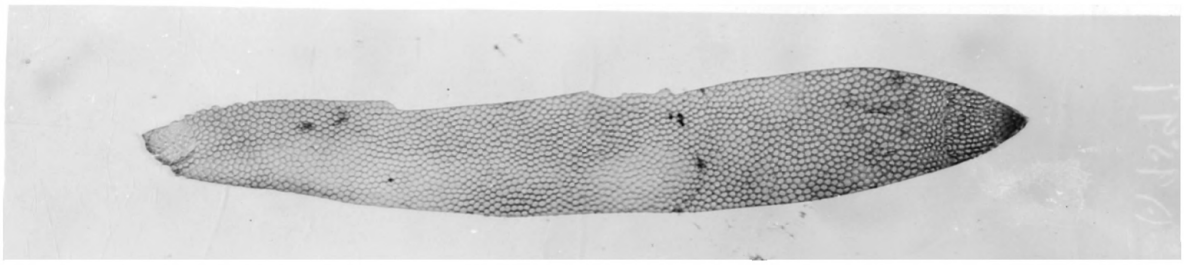

Fig. 27

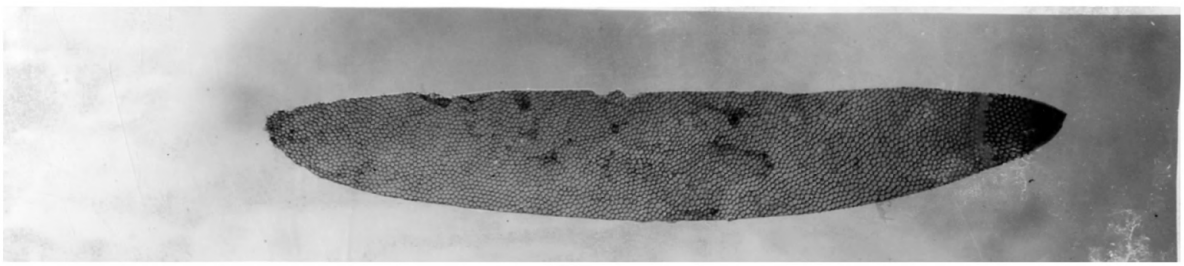

Fig. 28

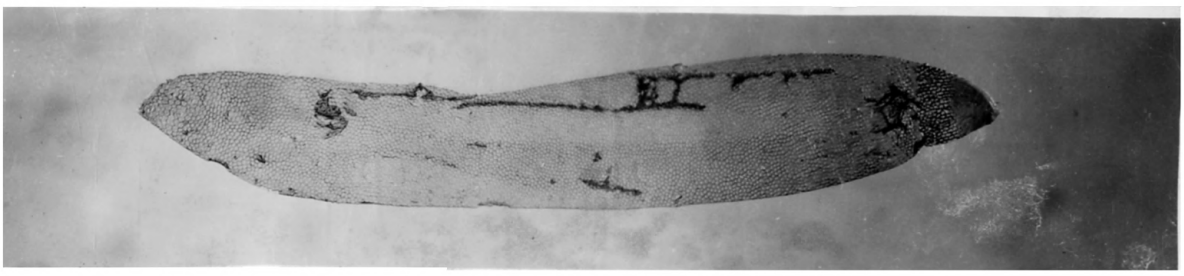

Fig. 29

Explanation of Plate X

Fig. 30. Melanoplus gladstoni 19x.

Fig. 31. Melanoplus lakinus 19x.

Fig. 32. Melanoplus mexicanus mexicanus 19x.

PLATE X

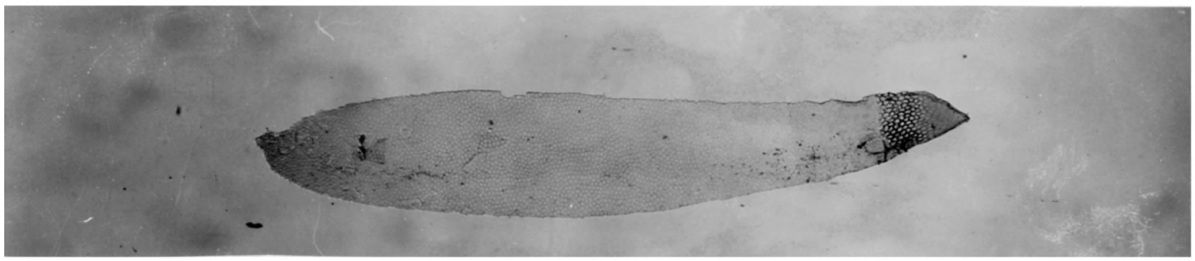

Fig. 30

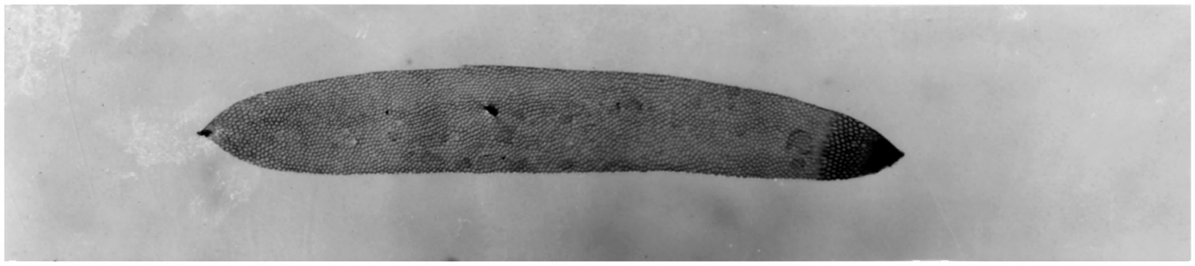

Fig. 31

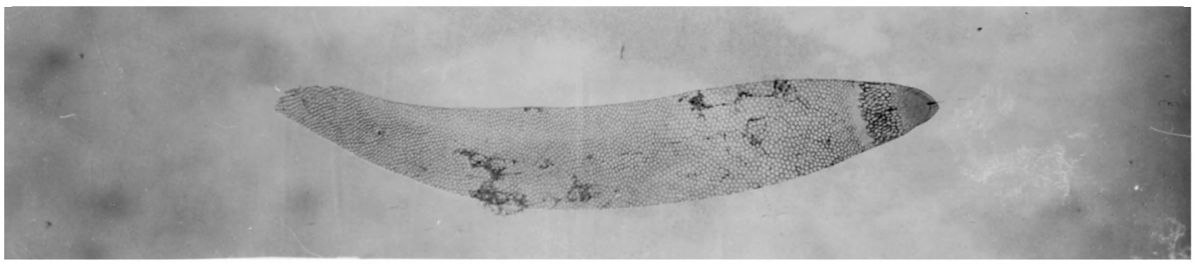

Fig. 32

Explanation of Plate XI

Fig. 33. *Melanoplus occidentalis occidentalis* 19x.

Fig. 34. *Melanoplus packardi* 19x.

Fig. 35. *Mermiria maculipennis macclungi* 19x.

PLATE XI

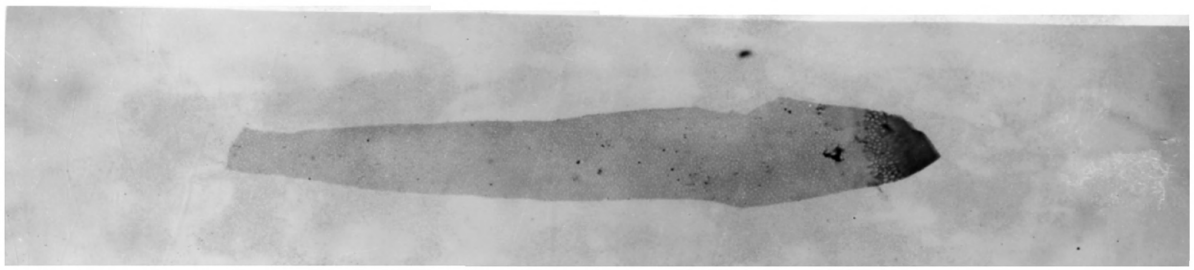

Fig. 33

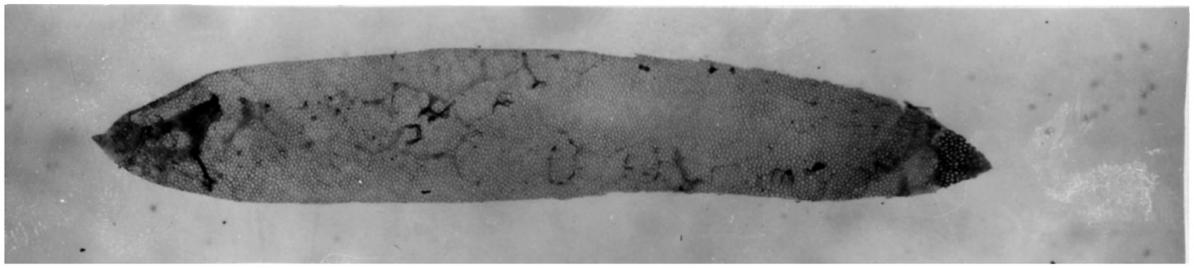

Fig. 34

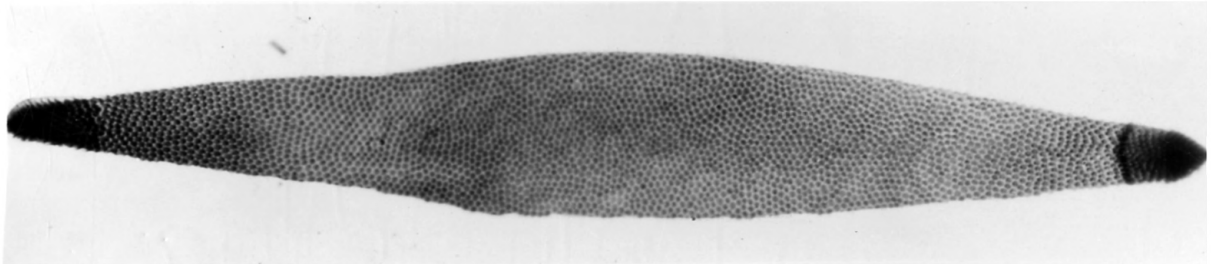

Fig. 35

Explanation of Plate XII

Fig. 36. *Mermiria neomexicana* 19x.

Fig. 37. *Mestobregma plattei plattei* 19x.

Fig. 38. *Orchelimum vulgare* 19x.

PLATE XII

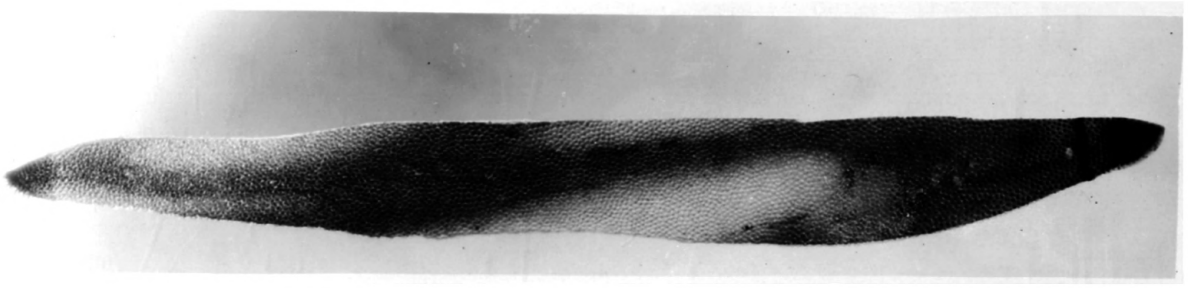

Fig. 36

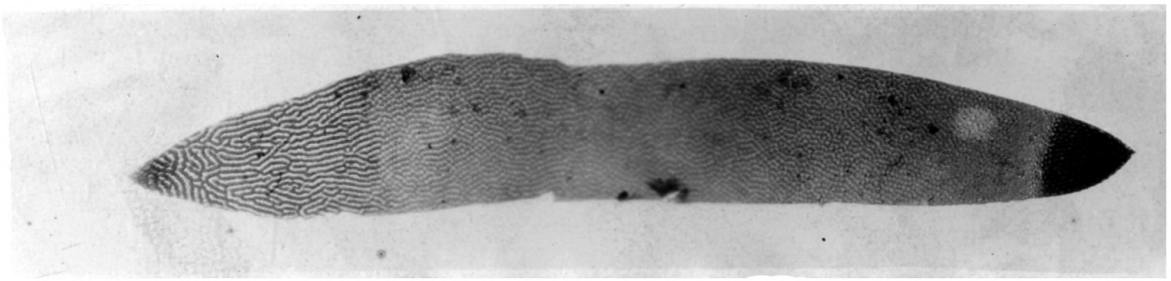

Fig. 37

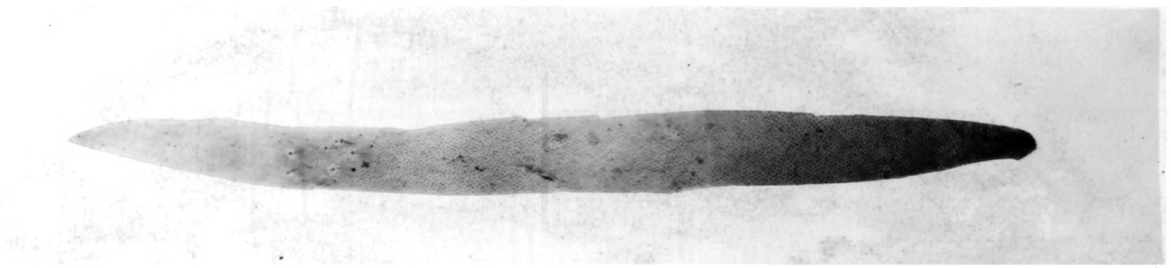

Fig. 38

Explanation of Plate XIII

Fig. 39. Orphulella pelidna 19x.

Fig. 40. Pediodectes nigromarginata 19x.

Fig. 41. Philobostoma quadrimaculatum 19x.

PLATE XIII

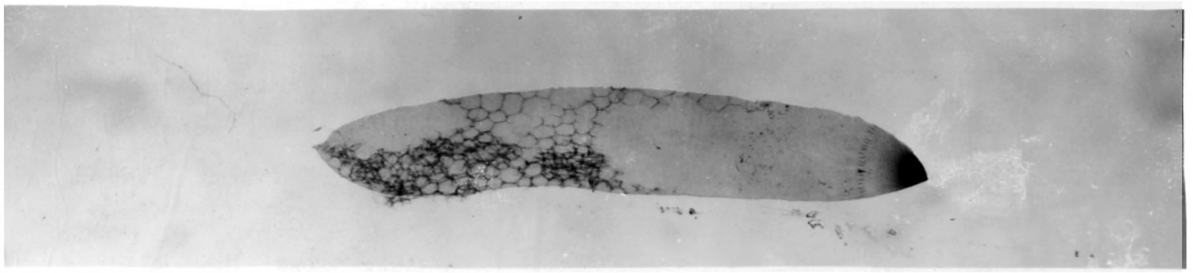

Fig. 39

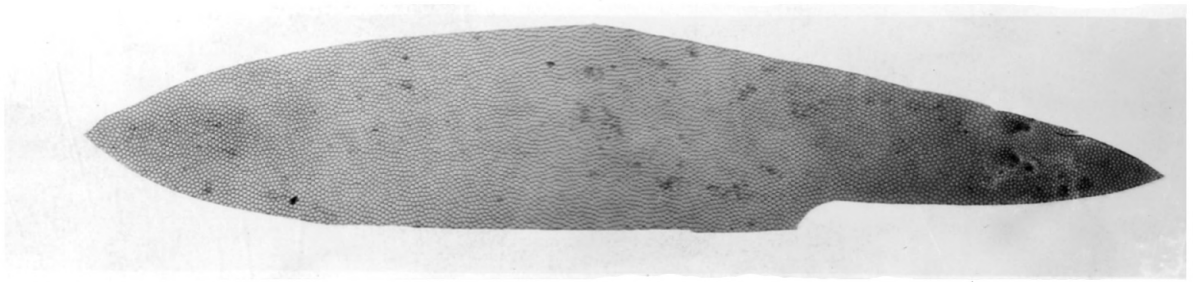

Fig. 40

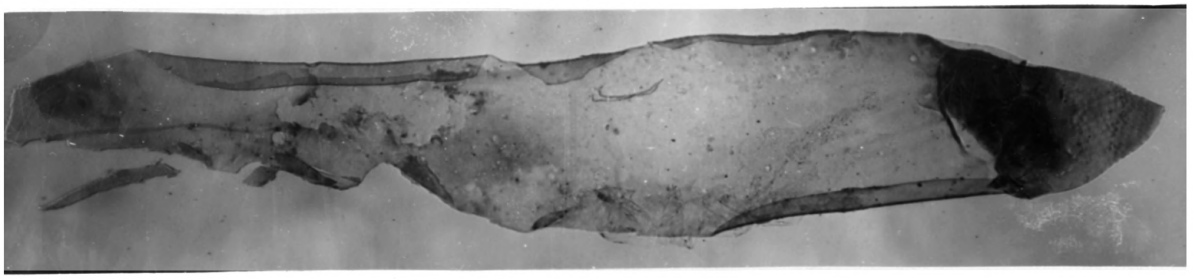

Fig. 41

Explanation of Plate XIV

Fig. 42. *Phoetaliotes nebrascensis* 19x.

Fig. 43. *Schistocerca lineata* 19x.

Fig. 44. *Schistocerca obscura* 19x.

PLATE XIV

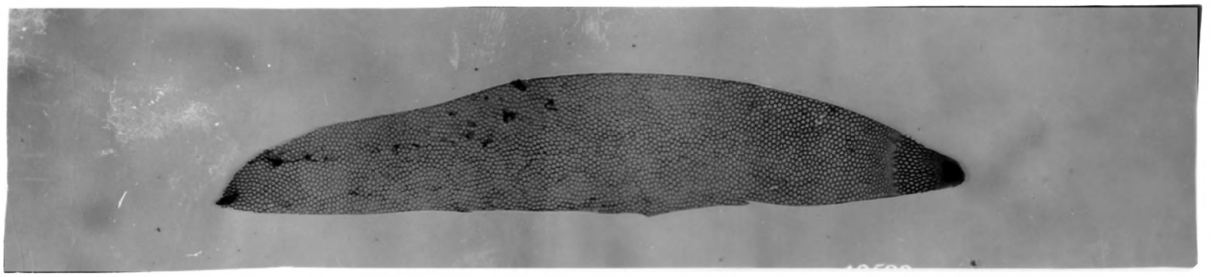

Fig. 42

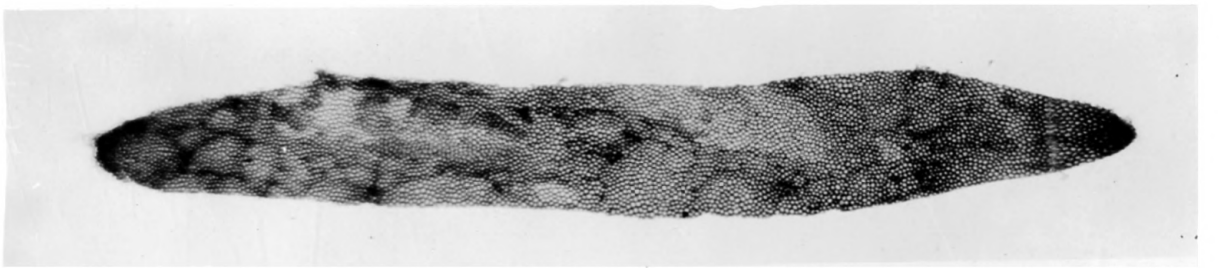

Fig. 43

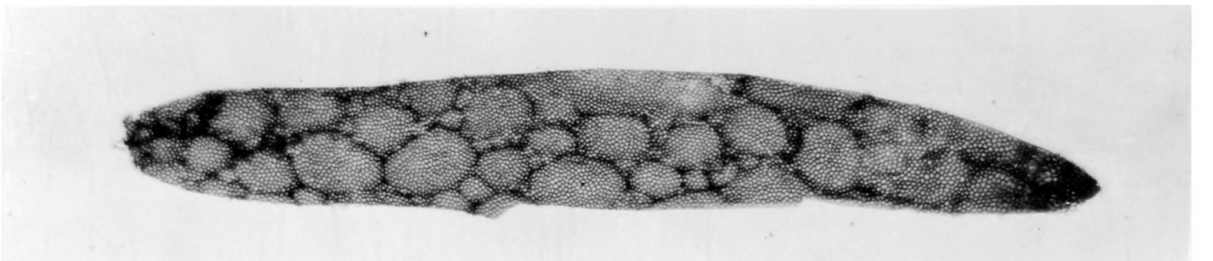

Fig. 44

Explanation of Plate XV

Fig. 45. Spharagemon collare 19x.

Fig. 46. Spharagemon equale 19x.

Fig. 47. Syrbula admirabilis 19x.

PLATE XV

Fig. 45

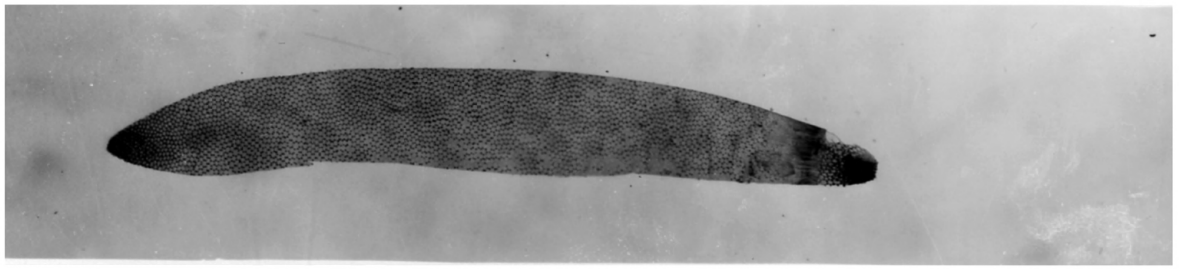

Fig. 46

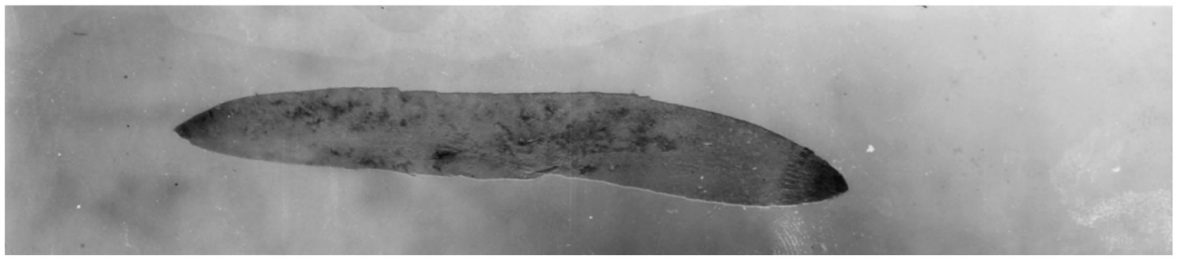

Fig. 47

Explanation of Plate XVI

Fig. 48. *Tettigidea parvipennis pennata* 35x.

Fig. 49. *Trachyrachis kiowa kiowa* 19x.

Fig. 50. *Trimerotropis citrina* 19x.

PLATE XVI

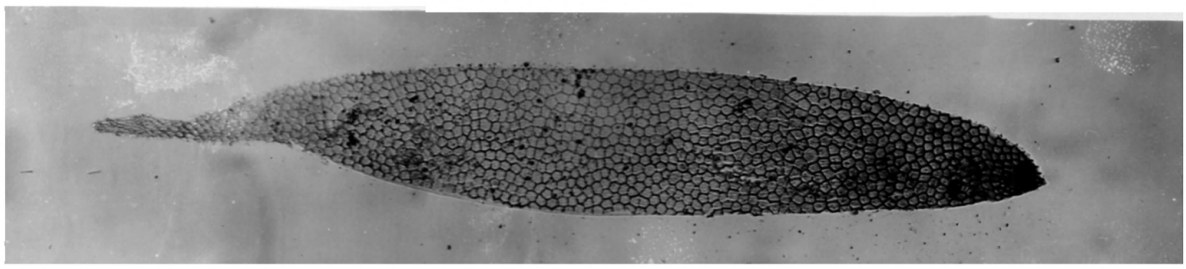

Fig. 48

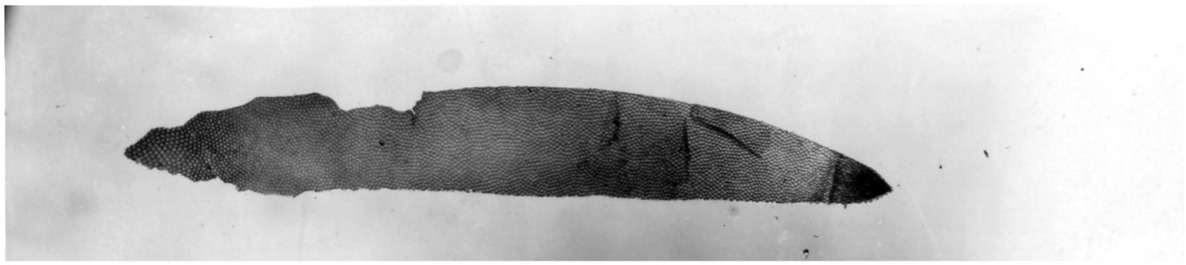

Fig. 49

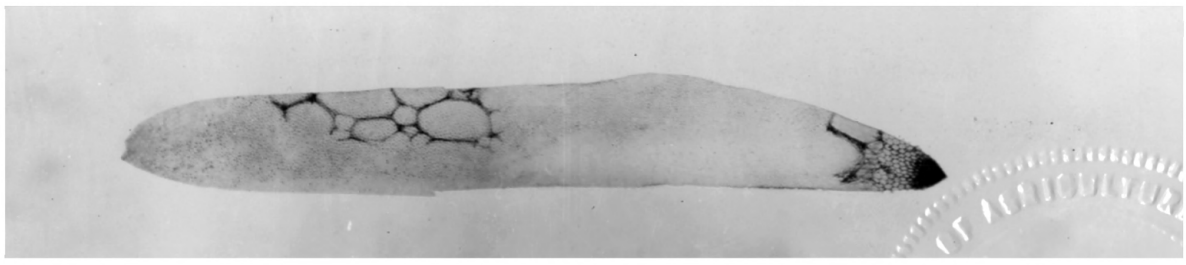

Fig. 50