

A REVISION
OF THE AMERICAN SPECIES
OF EMPOASCA KNOWN TO OCCUR
NORTH OF MEXICO

BY

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UNITED STATES DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.



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INTRODUCTION

Previous work on the genus *Empoasca*² in the form of monographic studies has been published by both Gillette (13)³ and Hartzell (17, 18). During the last 30 years the pioneer work of Doctor Gillette, in particular, has filled an important place as a guide for workers on the species of this genus. Economic problems, however,

¹The present revision has been made possible through the kindness and cooperation of J. E. Graf, W. H. Larrimer, and N. F. Howard, of the Bureau of Entomology, and President George W. Rightmire and R. C. Osburn, of the Ohio State University. The writer is also indebted to E. D. Ball for access to his valuable collection of western species, for review and criticism of the manuscript, and for the checking of characters; to Harold Morrison for kindnesses extended in the National Museum and for the privilege of examining material in his private collection; to Herbert Osborn for the privilege of using material in his private collection and for the use of his library; to J. G. Sanders for the use of valuable material in his private collection; to P. B. Lawson for material loaned from the Kansas University collection; to W. E. China, of the British Museum of Natural History, for typical specimens of *flavescens* from European localities; and to H. P. Severin, of Berkeley, Calif., for collecting and forwarding specimens of *abrupta* for experimental studies. W. P. Flint, F. F. Smith, F. W. Poos, A. A. Granovsky, H. H. Severin, A. N. Tissot, E. W. Davis, and Albert Hartzell have reared material and forwarded it for identification. All of this material has been of service in determining certain species limitations. To these, and to all who have assisted in any way, the author expresses his appreciation.

Since submitting this manuscript for publication (August, 1929) E. P. Van Duzee has published (Pan-Pacific Entomologist 6:148, April, 1930) the description of *Empoasca denaria* V. D. This is probably the species treated in this bulletin as *E. rubida*.

²Order Homoptera, family Cicadellidae.

³Italic numbers in parentheses refer to Literature Cited, p. 58.

brought about by species of this genus which have become important, have called for a more fundamental taxonomic basis upon which to build a species concept. The economic worker has not been able to determine definitely whether individuals of this genus found on various cultivated or wild host plants belonged to one or several species.

It is apparent that climatic or atmospheric factors and other similar vague terms have been used to explain differences in injury or crop infestations when a taxonomic problem alone was involved and when a knowledge of the insects would have properly explained these differences. The species could not be differentiated, neither could the problems be solved satisfactorily, with the previous inadequate characters. The urgent need for the differentiation of these insects, some of which are of great economic importance, furnished the chief stimulus that has produced the present study of this genus.

THE ECONOMIC PROBLEM AND ITS RELATION TO TAXONOMY

A full discussion of the economic importance of this group, with its various problems and diverse phases of economic interrelationships, does not belong to the present treatment of the genus. Therefore only a brief statement of this nature with special reference to the previous taxonomic standing of economic species, host-plant relationships, and distribution will be attempted.

The potato leaf hopper, *Empoasca fabae* Harris, has been considered for several years the most important economic species of the genus because of its severe damage to potatoes, beans, clover, alfalfa, rhubarb, eggplant, cotton, aster, dahlia, apple, and many other cultivated and wild host plants. This insect has been variously confused with other species, and in view also of its many variations in color and markings it has been designated in literature under at least eight different names. It has been called *E. flavescens* by many workers since the early work of Gillette placed *flavescens* (referring to this insect) as a common species in North America. But *flavescens* is apparently a purely European species, and present work upon specimens from the British Museum and from various European localities and comparisons with material available for study in the more important collections from Canada and the United States have shown that *flavescens* does not occur in North America. No economic damage in the European countries has been caused by *flavescens* comparable to that which *fabae* has caused in the United States, and it would seem that *flavescens* might be eliminated from present consideration as a possible economic pest in North America.

For many years *fabae* was known as *E. mali*, the specific name being given it by Le Baron (19) when he found it on apple in 1853. Walsh (27) called its various color forms *consobrina*, *viridescens*, and *malefica*. Forbes (12) named it *albopicta* in 1884, and in 1898 Gillette (13) called specimens which had been preserved in fluids before mounting by the name of *pallida*.

E. fabae has been considered as well distributed, at least in small numbers, throughout the United States. (Fig. 1, A.) H. H. Sev-

erin, in investigating leaf-hopper problems in California, found that hopperburn did not occur upon potatoes in that area, and that a different type of injury, a white stippling appearance only, was caused by the green leaf hoppers working on potatoes in that and

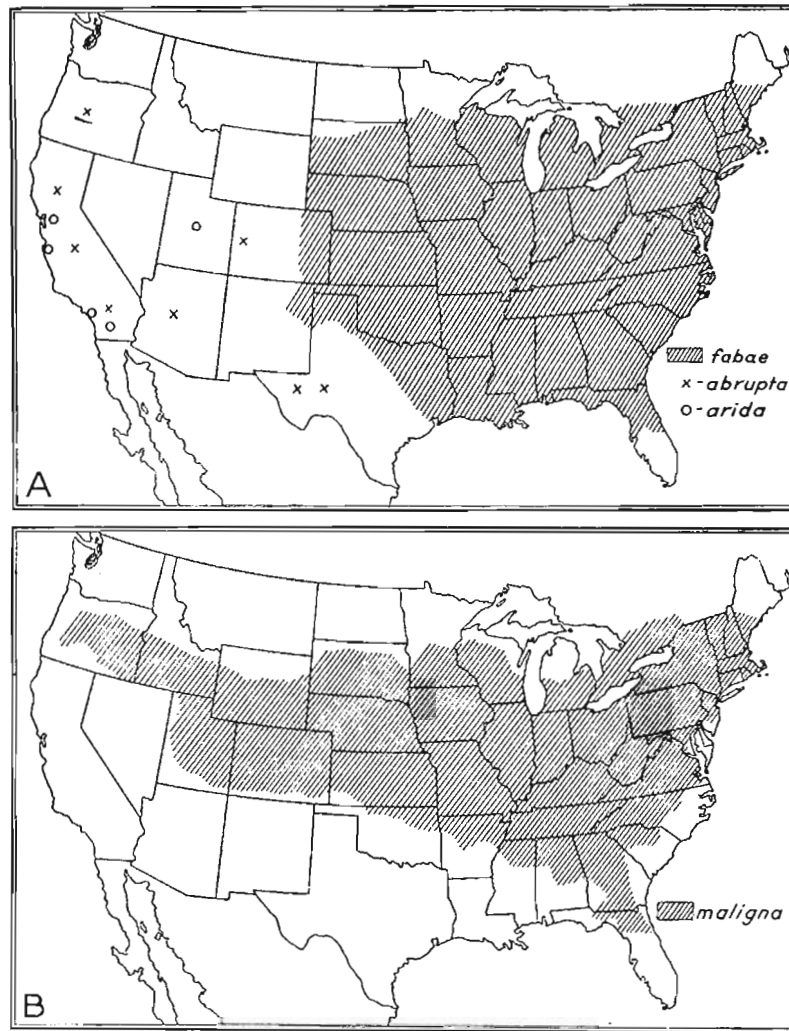


FIGURE 1.—Maps showing the present known distribution of the more common species of Empoasca in the United States: A, Range of *fabae* is indicated by the shading, localities in which *abrupta* has been found are indicated by the crosses, and the distribution of *arida* is shown by circles; B, distribution of *maligna*, the most important species found on Crataegus

neighboring States. This leaf hopper has been referred to as *E. flavescens* by Severin (22). This difference in injury might have been explained upon the basis of differences in climatic factors, but it is actually due to the fact that, as the present study has revealed, entomologists are dealing with entirely different species of insects

in the case of the California problem and throughout the arid West in general. There are at least three species which have not previously been named or properly designated and which have been confused with *fabae*. In view of its present distribution (Fig. 1, A), one of these species is here named *arida*. It is common in the West on alfalfa and sugar beets and probably has a much wider host range.

Probably the most important western species of economic standing is *abrupta*, another previously undescribed species, which is common in California as a potato pest. (Fig. 1, A.) This is the species which has been called *flavescens* by Professor Severin because it has answered more nearly the description of this European form than the previously described American species. This species, because of its work upon potato, has been confused with *fabae* and should probably be commonly called the "western potato leaf hopper." According to available records it occurs from Texas northward and westward through Arizona and California.

A third western species, *filamenta*, which is widespread and abundant upon potatoes, sugar beets, and beans especially, occurs in abundance in the region between the Rocky Mountains and the Sierra Nevada and extends northward through Wyoming, Montana, Idaho, and Oregon.

Another species which has apparently been confused with *fabae* occurs upon the potato plant in Louisiana and is here named *solana*.

In the eastern part of the United States other common species have been placed under the name *fabae*. The work of Doctor Poos has brought to light the life history of a very common one which passes the winter in the egg stage on *Erigeron annuus* and hatches early in the spring. Another common species which has apparently never been described, but is placed under the name of *fabae*, is *bifurcata*, which occurs on tansy and related plants.

Although the common *fabae* has been designated in literature as the apple leaf hopper, it is not essentially or primarily an apple pest, although it may occur upon the apple in comparatively small numbers, and young apple trees may occasionally be severely injured. The green apple leaf hopper is *maligna* (*unicolor*), a larger, more broad-headed species which apparently feeds entirely upon apple and wild varieties of *Crataegus*. (Fig. 1, B.) This species spends the winter in the egg stage in the apple twigs and hatches early in the spring. On the other hand, *E. fabae* usually makes its first appearance upon apple in the spring in the adult stage, and adults are normally found in small numbers upon apple in the spring before the eggs of the first generation hatch.

Considerable loss is caused in Florida by *minuenda*, which is a serious pest of avocado, and occurs in large numbers upon these trees. Several other species cause injury to different types of plants, but as many or all of these plants are economically unimportant, the insects are probably viewed in the same light. As a rule, when the food plants are known, the plant or group of related plants is found to be quite well defined for each species. The willows are attacked by *obtusata*, *smaragdula*, *osborni*, *albolinea*, *aureoviridis*, and *clypeata*, and probably others. These species have no important place in the literature because the willow is not an important economic plant.

But in a willow garden, where these plants are raised and used for the making of baskets and furniture, the injury about the oviposition scars causes loss, since the injured shoots can not be bent without breaking.

The species *trifasciata* is common on cottonwood (*Populus deltoides*), and *coccinea* is found on white pine (*Pinus strobus*); whereas the sagebrush (*Artemisia tridentata*) has a considerable population composed of *nigra* and varieties, *nigroscuta*, *typhlocyboides*, and *pulchella*. Species of *Alnus* support *atrolabes* and *unica*, and *junipera* is found on red cedar (*Juniperus virginiana*) throughout eastern Tennessee.

The importance of careful and thoroughly reliable taxonomic work by economic entomologists can not be easily overemphasized. Many economic aspects and phases of the present economic problem have remained unsolved or unknown for years because of inadequate taxonomic work. Practically none of the economic workers on problems concerned with insects of this genus have been able to determine food plant or geographic distribution because they were unable to differentiate the species on account of identical color characters. As a consequence our literature contains many erroneous statements concerning economic problems relating to *Empoasca*. It is evident that it is essential to know the correct identity of any species of this genus in order to predict or ascertain its economic status and its capacity for causing economic damage. Personal observations in the field have shown that when a green *Empoasca* leaf hopper appears upon a wild host plant in early spring, it can not be assumed, as has been the custom in the past, that it is *fabae*, even though it resembles *fabae* in size, appearance, and coloration.

GEOGRAPHICAL DISTRIBUTION

It is quite evident from material examined that the genus *Empoasca* is widely distributed. It is known to occur rather generally in North America and South America and is apparently abundant in Central America. Several species occur in Europe and Asia, and Naude (20) has found the insects in South Africa. The genus is probably more widely distributed than the foregoing data would indicate, especially in many intervening areas.

The exact distribution of any single species over large areas is uncertain at the present time, judging from results obtained during the present study. The economic species have probably seldom been correctly identified in different areas, especially those widely separated, and consequently the data which have been previously presented can not be relied upon. For instance, none of the material collected in North America has proved to be *flavescens*, and the distribution of this species is apparently more limited than was previously supposed. Likewise *fabae* has not been found on the west coast or in the mountain region of the Western States, and it is doubtful if this species is as widely distributed as has been previously stated. The whole question of distribution has been suddenly changed by the finding of more accurate or reliable specific characters, and the consequent finding that many of these leaf hoppers are entirely different from others which were previously thought to belong to the same species.

HISTORICAL RÉSUMÉ

As far as available records show, the first species of the genus as it now stands was described in 1794 by Fabricius (6, p. 46) under the name of *Cicada flavescentis*. In 1806 *C. smaragdula* was described by Fallen (7). In 1841 Harris (16, p. 186) described *fabae* under the generic name *Tettigonia*. Fitch in 1851 (11) described *coccinea* from pine as belonging to the genus *Empoa*. In 1858 Stål (23, p. 195) described *pura* as a member of *Typhlocyba*. This species was later cited as occurring in North America, but it probably does not occur here. The genus under discussion, however, was not described or named until 1864, when it was given the name *Empoasca* by Walsh (27). At this time he designated three species, *viridescens*, *obtusa*, and *consobrina* as belonging to this genus. In the same paper he discussed the genus *Empoa* and wrote:

Two species, one on pine and the other on oak, are described by Doctor Fitch, in his catalogue of New York Homoptera, and referred to this genus. As he says nothing of the venation of the wings, they may possibly belong to *Empoasca*. *Empoa rosea* and *E. fabae* Harris, are in the same predicament.

The species on pine was undoubtedly *coccinea*. Both *coccinea* and *fabae* have been placed in *Empoasca*, and the other species referred to in the above citation by Walsh have been placed in *Typhlocyba*. Walsh also described the genus *Chloroneura* at the same time and placed *malefica* and *maligna* in this genus, but made *abnormis*, which is now placed in *Dikraneura*, the type.

Two years later, in 1866, Fieber (9, p. 508) described the genera *Chloria* and *Kybos*. The former of these was preempted, and in 1872 (10) he proposed the name *Chlorita* for *Chloria*, and in 1875 Douglas (5, p. 26) gave the name *Cybus* as an emendation of *Kybos*.

Uhler (24, p. 474) in 1877 described *aureoviridis* under the genus *Typhlocyba*. Woodworth (28, p. 212) in 1889 attempted to group in a general way the American species previously described. He recognized the genus *Kybos* as distinct and made *Chlorita* a synonym of *Kybos*.

In 1890 Provancher (21, p. 340) described *unica* as a member of *Typhlocyba*, and Goding (15) described *birdii* as an *Empoasca*.

In 1895 Gillette and Baker (14, pp. 107-110) described five species and one variety under the names of *clypeata*, *aspera*, *nigra*, *pulchella*, *nigroscuta*, and the variety *typhlocyboidea* as belonging to *Empoasca*.

When Gillette (13) made the pioneer study of the species as a genus in 1898 (13), he placed the genera *Chloroneura*, *Kybos*, and *Chlorita* as synonyms of *Empoasca* since the characters used for separating these groups were too variable and could not be defined as generic characters. During this study he treated 14 European and American species which had previously been described, and named 16 others as new. This publication by Gillette has formed a working basis for the identification of these species of *Empoasca* for the last 30 years and has been a valuable contribution to our knowledge of the group in spite of the fact that entomologists have not been able to distinguish correctly the members of the *fabae* group. Gillette placed many names in synonymy and stated in his

introduction to the genus that "a further study will probably reduce others." The present study has proved this to be the case, and such reduction will probably always be necessary when these problems are reworked by future taxonomists who have better series of specimens and have found more constant characters for separation.

In 1914 Van Duzee (25, p. 56) described one species, *alboscripta*. With this exception no additions were made to this genus until 1923, when Doctor Hartzell, following his previous economic work, completed a paper on the genus *Empoasca* (18). In this paper he recognized all of the species previously described and added five which had not been named. Hartzell followed Gillette almost precisely and failed to distinguish the economic from allied species although he had previously studied the same material which was used for the present revision. In view of the fact that he did not distinguish between the eastern and western economic species and that several apparent synonyms of economic species remained unplaced, and since problems in biology, host plants, relationships, occurrence, and distribution of certain species remained unsolved, the present treatment was undertaken. An attempt is here made to rely on constant structural characters for identification purposes in so far as material is available in sufficient quantity to make possible the determination or ascertainment of these characters.

THE GENUS AND ITS POSITION

The genus *Empoasca* is closely allied to several other genera of small delicate leaf hoppers belonging to the subfamily Eupteryginae (Typhlocybini of Van Duzee). These are members of the order Homoptera and family Cicadellidae. This subfamily was previously distinguished from the other leaf hopper subfamilies by the absence of ocelli, reduction of venation at the base of the first pair of wings, and a few other minor characters. But a large number of the species of *Empoasca*, as well as members of other of these genera, have conspicuous ocelli. In many species the veins of the first pair of wings are conspicuous to the base, especially when a satisfactory method of study and technique is devised. But as a rule the weak venation at the base of the first pair of wings, the reduction or absence of claval veins, and the absence or reduction of anteapical cells is a good basis for separation.

The genus *Empoasca* can most easily be distinguished from its allied genera by the absence of an appendix in the first pair of wings and the possession of one apical cell in the posterior wing which is closed by a submarginal vein. No anteapical cells are present in the wings of these species.

Most of the species of *Empoasca* are of some shade of green with faint or variable markings. Bright pigmentation of red or other colors is occasionally found.

Although this group has been treated as a single genus, there are distinct and well-defined subgroups which the writer has chosen to designate as subgenera. The type of head (fig. 2) is probably the best character for the separation of the subgenera since it is easily recognized and quite constant.

EXTERNAL STRUCTURAL CHARACTERS

In all fairness to the previous workers it should be said that, with the exception of a few species, good external structural characters are lacking in this group, and as a consequence it has been necessary to resort to the structures in the male genital chamber which are usually concealed in the normal specimen. These are often referred to as internal genitalia. Yet if it must be decided whether a given form belongs to a species of economic importance and there is no other distinctive structural character, resort must be had to such differences for the more basic work. The external genital charac-

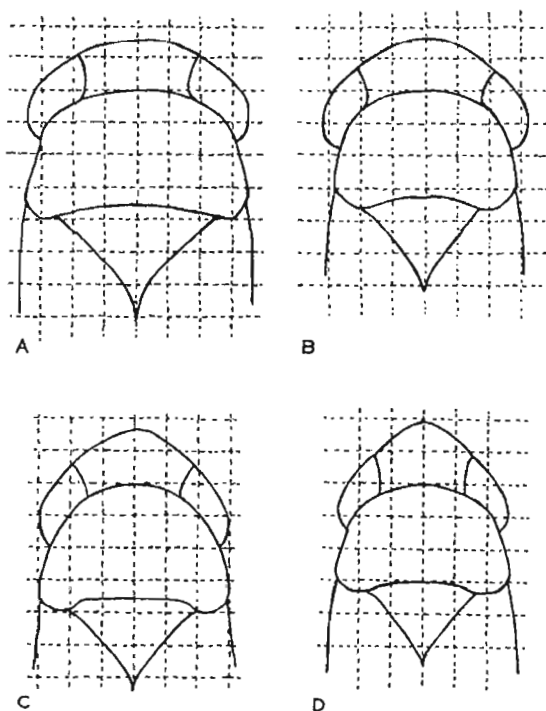


FIGURE 2.—Types of heads of the subgenera of *Empoasca*: A, Head of *atrolabes*, an example of the subgenus *Kybos* Fieber; B, *aspersa*, example of the subgenus *Hebata* nov.; C, *abrupta*, example of subgenus *Empoasca* Walsh; D, *radiata*, example of subgenus *Idona* nov.

ters are usually constant, but are so similar for most of the species of the genus that they can not be used as characters for specific designation.

Good external characters have been used in previous work on the genus for the separation of a limited number of species, but color characters or markings have been the basis for separation of the majority of the species of *Empoasca*. Most of the species of the genus, however, are rather uniformly green in color with but faint or variable markings and do not present the striking contrast in color which is seen between species of most of the allied genera. Color characters are somewhat variable at best, but it is almost im-

possible to use color in the case of the number or size of small spots or blotches on the vertex or pronotum of these rather uniformly colored species. For in these species there is a wide variation in such markings, and it has happened that specimens belonging to the same species and occurring upon the same food plant have been separated by this color character and placed under different specific names.

On the other hand, several similarly marked species have been placed under the same name. It is true that the similar color pattern is frequently a good recognition mark or indicator of the species concerned, but there should be a more basic character used for the designation of a type as a species, especially where wide geographic localities are represented or food-plant differences or greatly differing types of injury are apparent. Banding or striping is usually a rather constant character, but intensity of color and width of bands or stripes will vary, and these color markings may frequently be entirely wanting.

In the previous division of the species of the genus, wing venation was used as a chief character. Although certain groups can be separated in this way, the characters or types of characters seem to be too variable for specific separation.

CHARACTERS USED IN CLASSIFICATION

THE VERTEX

The shape and type of the vertex is used as a basis for dividing the genus into subgenera. The broadly curved head which is only slightly produced before the anterior margins of the eyes is a good character for the subgenus *Kybos* and separates those species quite easily from the group with the strongly curved or angled vertex which is rather strongly produced before the anterior margins of the eyes. Varying degrees of this curvature or length of vertex may occur, and this difference is used in grouping the species. The comparative length of vertex to basal width between the eyes is used in most species and is a rather constant character and easily recognized. (Fig. 2.)

THE LAST SEGMENT OF THE FEMALE

The ventral surface of the last segment (sternum or segment 7) of the female presents a good character for the separation of species in a few cases. Species like *pergandei*, *maligna*, *atrolabes*, *acodens*, *pectinata*, *trilobata* (fig. 3), and probably a few others can be distinguished by the notching or by other characters on the posterior margin of the last ventral segment, but in most of the species this character is of no value as the female segment is usually roundedly produced and entire.

MALE STRUCTURES

The external male structures are of practically no value for specific separation. For group characters the plates are frequently excellent and can be used to separate a group of closely related species from another similar group or groups. This is illustrated

by the long slender plates of the *maligna* group, as contrasted with the broad, heavily spined, apically upturned, and compressed plates of the *obtusa* group. So far as has been found, the male genital pieces located in the genital chamber and usually called the internal male genitalia are constant and excellent characters. These structures are composed of the oedagus, a central structure; a pair of ventral styles lying just dorsad of the plates; the style-oedagus connectives uniting these structures; and a pair of processes termed the lateral pygofer processes, which arise near the base on the dorsal sides of the pygofers. These last structures have not previously

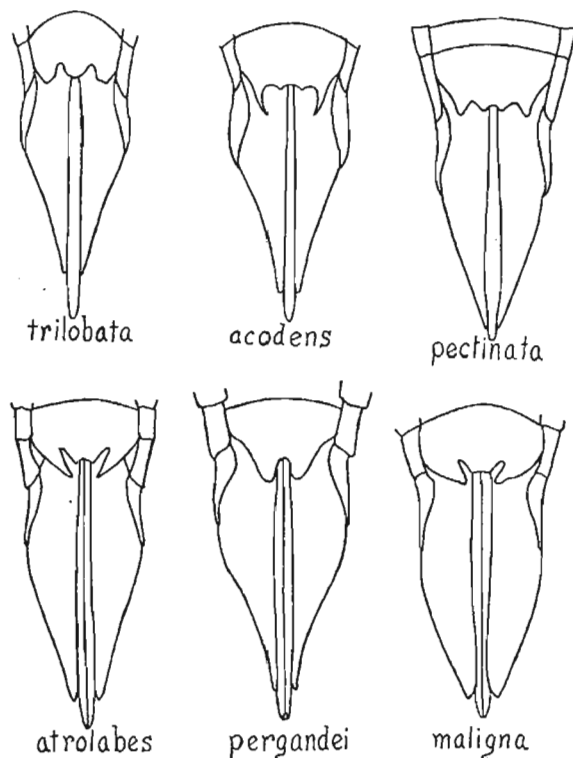


FIGURE 3.—Last segment of the female of six representative species of *Empoasca*

been seen in other genera, and no reference can be found in literature regarding them. Previous workers who have studied the internal genital pieces of species of *Empoasca* have apparently attempted to find only those pieces represented in the genital chamber of species of other genera. As a consequence none have figured or described the lateral processes of the pygofers.

MALE GENITAL PIECES

Figure 4 is a drawing of the male genital pieces of *maligna* in which the various structures used for separating the species are indicated both by name and by the type of line used in delineating

them. These same lines, a succession of dashes for the styles, a dash and dot for the oedagus, and a dash and three dots for the lateral processes of the pygofer, have been used in all the subsequent illustrations to distinguish these parts.

THE OEDAGUS

The oedagus is very similar in most of the species of the genus and is usually extended dorsally and enlarged at the apex to form a pair of proximate broad, flat plates. The general outline of the oedagus may vary slightly, but no good specific characters are exhibited except in species like *atrolabes*, where a long, ventral, apically extended spur arises near the middle on the posterior side; and in species like *coccinea* in which the ventral end of the oedagus is curved, and a pair of long structures, longer than the oedagus, extend caudally and dorsally.

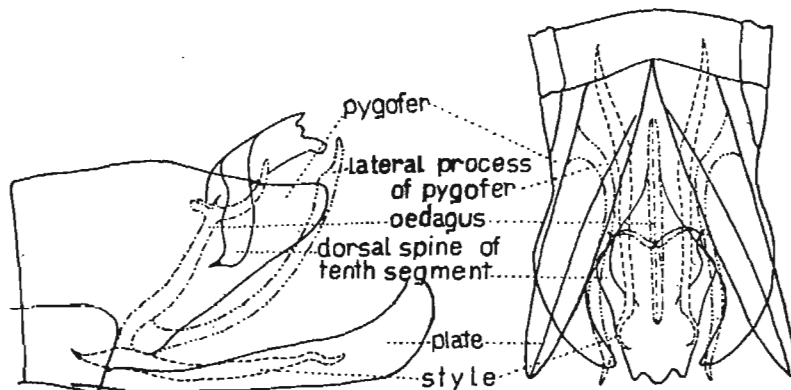


FIGURE 4.—Male genital pieces of *maligna*, with the various structures indicated by name and by the type of line used. In this and in the following drawings the styles are represented by a line of dashes, the oedagus by a dash and a dot, and the lateral processes of the pygofer by a dash and three dots.

THE STYLES

The styles, which are just dorsad of the plates, are quite different throughout the species of the genus, and specific characters could undoubtedly be secured by the use of these structures. They are not as distinctive, however, in most species as the pair of structures which lie just above them and arise from the lateral walls of the pygofer.

THE LATERAL PROCESSES OF THE PYGOFERS

The lateral processes arising from the pygofer are paired and are found to occur as prominent structures throughout the genus. In both lateral and ventral view they present structures, especially terminal processes, which are constant and are good characters for specific separation.

In certain groups of closely related species where slight differences in coloration have been used previously for specific characters in an attempt to separate them, these processes will be found to be excellent distinguishing characters. The *fabae* group has been confused by

this attempted separation on a color basis, and it is safe to say that no worker has ever been sure whether he had *fabae* or some closely related species. A study of the shape of these processes in *fabae*, as detailed in the ventral view in Figure 10, will show that they are roundedly broadened on the inner margin and then concavely tapered to the acute apex. It will be noted also that *flavescens* (fig. 10), the European representative of this group, a drawing of which is given for comparison with the American species, has the lateral processes enlarged and broadened near the apex, which is rounded from the outer margin to form an apex on the inner margin. In like manner the only structures by which *arida* (fig. 10), one of the common western species, may be distinguished from either of the former is by the curved, hooklike structure at the apex of these lateral processes. Superficially *abrupta* (fig. 10), a very common potato-infesting species in the West, resembles exactly these former species, and the abrupt narrowing, together with the produced finger extensions of these lateral processes, is the only way in which it may be distinguished. A number of other species which have not previously been distinguished from *fabae*, and can not be without these characters, have been found by the aid of these structures to be distinct species not only from the morphologic standpoint, but also biologically and ecologically. They also produce different types of plant injury. In *bifurcata* (fig. 9) the long vermiculate lateral processes are unique. These processes are variously modified throughout the genus and serve as good specific characters for the separation of practically all of the species.

THE DORSAL SPINES OF THE TENTH SEGMENT

The large spines, a pair of which occur dorsally on every species examined, arise from a chitinous ring surrounding the anal tube which is apparently the remnant of the tenth segment. They may extend inwardly into the genital chamber, or ventrally and anteriorly, or posteriorly. They are of various size, shape, and curvature and furnish excellent characters in the different species, especially when used in combination with the lateral processes of the pygofer. In *bifurcata* this spine structure is long and bifurcate with two terminal processes, and furnishes an unique character for determination.

TECHNIC AND METHOD OF STUDY

Similar methods of preparation and study of the chitinous structures of the male genital chamber have been used by different workers, and some of these methods have been described in previous papers by the writer and others. In the present study, at least the last four segments of the abdomen were removed by a sharp pointed scalpel or a very fine needle made by using a minute pin in a small wooden handle. If the insect is mounted on a point, this portion can usually be removed without further mutilation of the specimen or loosening it from the pin, if proper care and skill are used. By holding the pin so as to place the insect upside down with the point

where the abdomen is to be severed resting on the narrow edge of a small watch glass or similar surface, the needle can be inserted on the ventral side and the abdomen will usually part very easily. The removed portion is then placed in potassium-hydroxide solution. A 10 per cent solution will suffice, but a much stronger solution will usually expedite the process. With frail-bodied insects of this type it is better to leave them in this solution for a few hours without heating, for when heated the structures are usually distorted, but when allowed to soak gradually they remain normal.

After the softer parts of the body have been destroyed by the caustic-potash solution, the specimen is placed in an aqueous solution of glycerin with about 5 per cent of potassium hydroxide. It soon clears and should then be transferred to pure glycerin.

It was found that the most satisfactory way to handle and study these prepared specimens was to place them in small glass hydrogenation test cups. The strength of transmitted and reflected light can be adjusted for this type of container. The cups are very small and can be labeled on the side, easily handled, and stored temporarily in tin salve boxes for protecting and preserving the specimens. The glycerin makes an ideal medium for use in this study, since it is transparent, viscid, and nonvolatile, and specimens can be left in this material for several weeks or months without change in form or appearance.

If it is desirable to make drawings of these structures after comparative study, very minute pieces of broken glass can be used to hold them rather firmly at any angle as long as desired while submerged in glycerin in these cups. The specimens can afterwards be easily referred to for checking the details of the drawings.

Several workers in this field have been accustomed to mount these abdominal structures on slides and allow the cover glass to press upon them, thus changing the normal position and frequently the appearance of these structures before illustrations are made from them. Others have dissected out certain of these pieces and mounted them before drawing. It is the opinion of the writer that neither of these methods is so satisfactory as to study and draw these structures in natural position in the inflated abdomen as they are found normally. The student or worker can always duplicate this natural position for study, whereas it is doubtful if both or either of the former arrangements will permit of exact duplication of position with other specimens. This is important, as the relative position of the chitinous structures within the abdomen, their curvature, comparative length, and normal extension beyond the genital chamber are all important factors which are lost for identification if either of the former methods of preparation is used.

In order to make a drawing from the side the abdomen is rotated until one structure, in the case of paired structures, is superimposed upon the other.

If accurate measurements are made through the use of an ocular micrometer ruled in 0.05-millimeter squares and the outlines are then drawn on coordinate paper, little chance for play of the imagination will be left.

CLASSIFICATION OF THE SPECIES OF EMPOASCA

KEY TO THE SUBGENERA OF EMPOASCA

- A. Vertex broadly rounded, only slightly produced before anterior margins of the eyes and almost parallel margined; or if bluntly angularly produced, the vertex about twice as wide between eyes as median length.
 - B. Large, at least 3 to 5 mm. in length, usually with broad, rounded vertex which is not greatly produced.....Subgenus *Kybos*, p. 14
 - BB. Smaller, not over 3 mm. in length (except *coccinea*), vertex usually more produced and rounded or broadly bluntly angled.....Subgenus *Hebata*, p. 32
- AA. Vertex usually distinctly roundedly or angularly produced at middle, never parallel margined, and width between eyes usually not greatly exceeding one-half more than length.
 - C. Vertex angled and well produced but usually not more than one-half longer at middle than next the eyes (sometimes longer in *arida*).....Subgenus *Empoasca*, p. 36
 - CC. Vertex strongly produced, usually distinctly angled, almost twice as long at middle as next the eyes.....Subgenus *Idona*, p. 50

THE SUBGENUS KYBOS FIEBER

Vertex broad, almost parallel margined, scarcely produced before anterior margins of eyes. Largest species of group wedge-shaped in appearance. Type of subgenus, *smaragdula* Fallen.

KEY TO GROUPS

- A. Male plates long and narrow with almost parallel margins to near base, at least five times as long as basal width. Female segment usually notched, incised or lobed at apex.....*maligna* group, p. 14
- AA. Male plates broader at base and tapered, usually heavily clothed with spines. Plates not more than four times as long as broad. Female segment usually entire on posterior margin.....*obtusa* group, p. 19

KEY TO THE SPECIES OF THE MALIGNA GROUP

- A. Green without definite color markings except black spot before inner apical cell of elytron.
 - B. Female segment notched or with projecting teeth.
 - C. Female segment with a median U-shaped notch, styles of male tapered to rather acute tips.....*pergandei*, p. 15
 - CC. Female segment with teeth or median lobe, no U-shaped median notch; males unknown.
 - D. Female segment with teeth on outer angles.
 - E. Female segment with a long, slightly curved, sharp pointed tooth one-third the length of segment projecting from each outer angle, central portion with a pair of short teeth.....*acodens*, p. 16
 - EE. Female segment with teeth shorter and more blunt on outer angles, median third forming a broad tooth which is notched at middle.....*punctinata*, p. 16
 - DD. Female segment without teeth, divided by two rounding incisions into three rounded lobes.....*trilobata*, p. 17
 - BB. Female segment with an oblique notch either side of median sunken tooth, styles of male with the apical portion strongly curved. (Figs. 3, 5).....*maligna*, p. 17
 - AA. Brownish green to red, claval vein blue to bright red.
 - F. Dark green to brown, claval suture bluish, female segment with an oblique notch either side of sunken median tooth; male lateral processes of the pygofers long, tapering, and slightly sinuate near apex, oedagus with ventral caudal process.....*atrolabes*, p. 18
 - FF. Brighter in color, almost red, female segment rounded, without notch; male lateral processes of the pygofers expanded before tip and spearlike.....*unica*, p. 19

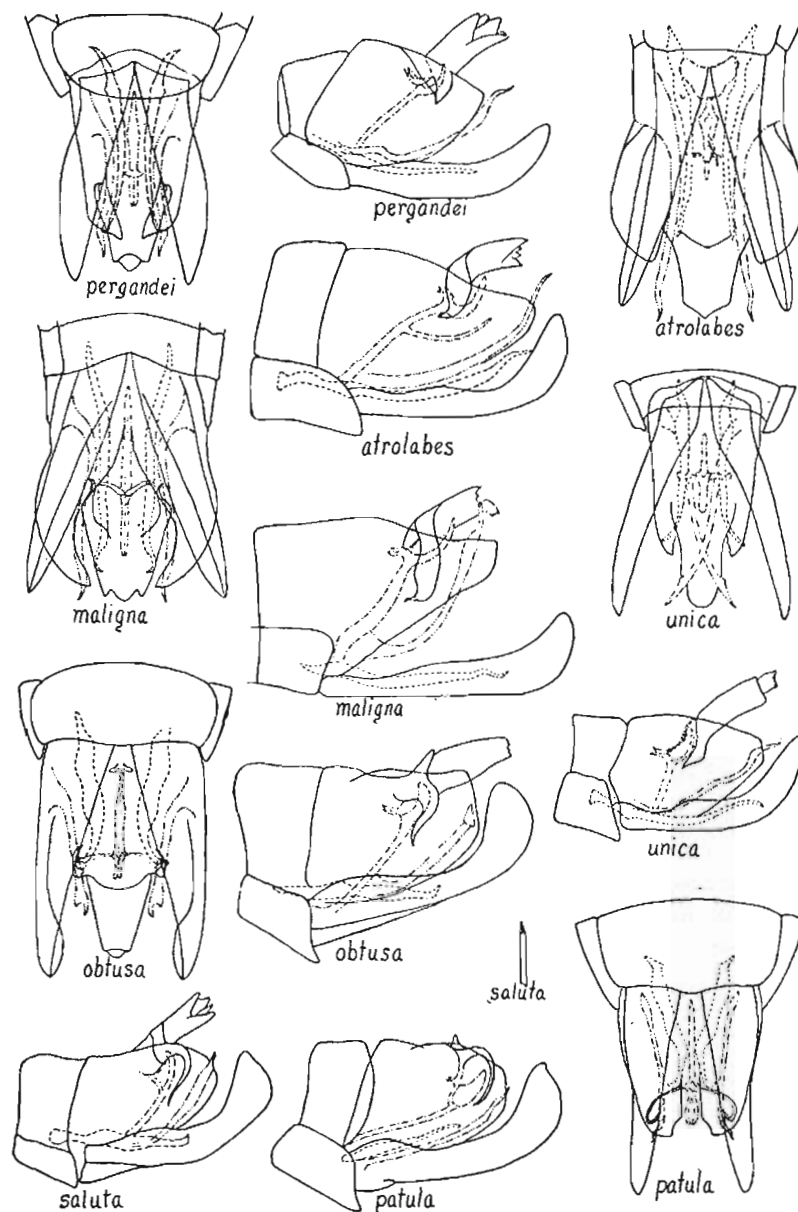


FIGURE 5.—Male genital pieces of species of *Empoasca*. $\times 50$. Instead of a complete drawing of the ventral aspect of the genitalia of *saluta*, only the apical portion of the lateral process of the pygofer is shown.

SPECIES OF THE MALIGNA GROUP

EMPOASCA PERGANDEI GILLETTE

(Figs. 3 and 5)

Described by Gillette as an *Empoasca* in 1898 (13).

In form, size, and color resembling *maligna*, but with a large black spot just before cross vein of inner apical cell and with genitalia distinct. Length 3.75 mm.

Vertex broadly rounded, slightly produced beyond the anterior margins of the eyes, almost twice as wide between eyes as length at middle, parallel margined; pronotum wider than head and more than twice as long as head.

Color: Pale green tinged with yellow; vertex, anterior portion of pronotum, and scutellum yellowish; elytra with a large black spot just before cross vein of inner apical cell.

Female genitalia: Last ventral segment with the posterior margin convexly, then concavely rounded and produced to central half which is divided by a U-shaped notch extending about one-fourth the distance to the base into two broadly rounded projecting lobes.

Male genitalia: Valve with a broad V-shaped notch; plates six times as long as width at base with tips tapered and upturned. Of the male genital pieces, the oedagus is simple, the styles are slightly curved and gradually tapered, and the lateral processes of the pygofer are curved inwardly near the apices.

Specimens in the National Museum are from Forest Hills, Mass. (type), Arnold Arboretum, Boston, Mass., and a series from Colorado. Other specimens examined are from North East, Dromgold, Rockville, and Hartstown, Pa. (Sanders and DeLong), Medford, Mass., and New Haven, Conn.

Type in U. S. National Museum.

EMPOASCA ACODENS N. SP.

(Fig. 3)

In general appearance resembling *pergandei* but female with sharp lobed genitalia. Male unknown. Length 3.5 mm.

Vertex almost parallel margined, as long as next the eyes and twice as wide between the eyes as length at middle.

Color: Pale greenish subhyaline washed with yellow, without definite markings.

Female genitalia: Last ventral segment rather long, posterior margin slightly sinuate between two long pointed teeth which are found on the outer angles of the posterior margin. These teeth are concavely rounded on the inner margins and almost straight on the outer margins and are produced almost one-third the length of the segment beyond the posterior margin.

Although only a single female exists in collected material, it is so unique that it seems advisable to describe it and attempt later to capture the male of the species.

Described from a single female collected in the Pocano Mountains at Tobyhanna, Pa., August 14, 1920, by J. G. Sanders. The food plant and other data are not known.

Holotype female in Sanders and DeLong collection, Ohio State University, Columbus, Ohio.

EMPOASCA PECTINATA N. SP.

(Fig. 3)

Resembling *pergandei* in general appearance and coloration, but with distinct female genitalia. Length 3.75 mm.

Vertex parallel margined, twice as wide as length at middle and as long as middle as next the eye; pronotum with prominent humeral angles.

Color: Pale green, vertex and pronotum washed with yellow; elytra with a large black spot on either wing just before inner apical cross vein; apices of elytra hyaline and without coloration.

Female genitalia: Last ventral segment with the posterior margin composed of three or four distinct teeth; if three, the central tooth is about twice as broad as the two outer teeth and with a deep notch on each side; or the central tooth may be divided and present a row of four pointed teeth almost equal in size comprising the entire posterior margin.

This may prove to be only a varietal form, but the smaller size and distinct genitalia of the female seem to mark it as a distinct form.

Described from two female specimens in the collection of E. D. Ball, collected by him at Soldier, Utah, August 13, 1906.

Holotype female and paratype female in the E. D. Ball collection, University of Arizona, Tucson, Ariz.

EMPOASCA TRILOBATA N. SP.

(Fig. 3)

With head more produced than in *pergandei* and with female genitalia distinctly lobed. Length 3.5 mm.

Vertex roundedly produced, a little longer on middle than next the eye, and practically twice as wide between eyes as length at middle; pronotum with prominent humeral angles which are produced and wider than the vertex.

Color: Bright green, vertex, pronotum, and scutellum washed with yellow. Vertex with three pale areas; pronotum with three irregular pale areas just back of posterior margin; elytra bright green to apical cross veins, then hyaline without coloration; a large black spot just before inner apical cross vein.

Female genitalia: Last ventral segment about twice as long as preceding, posterior margin rather deeply roundedly notched on either side of central third, thus forming three rather broadly rounded lobes on the posterior margin.

Described from three female specimens. The holotype is from Snow Shoe, Pa., and was collected August 22, 1918, by J. G. Sanders. An allotype is from Woburn, Mass., and was collected September 26, 1919. A third female specimen, although differing slightly, is thought to belong to this species. It is designated a paratype and was collected at Penfield, Pa., August 24, 1918, by J. G. Sanders.

Holotype female and paratype females all in Sanders and DeLong collection, Columbus, Ohio.

EMPOASCA MALIGNA (WALSH)

(Figs. 3, 4, and 5)

Described by Walsh under *Chloroneura* in 1864 (27) as the common green leaf hopper on apple. The female was redescribed by Gillette in 1898 (13) as *Empoasca unicolor*. In the same paper the males, as they now stand in the museum as types, were redescribed as *Empoasca denticula*.

Distinguished from the other species of the genus by the bright green color, blunt head, and external genitalia of both sexes. Length 3.5 mm.

Vertex parallel margined, broadly rounded anteriorly and only slightly produced beyond anterior margins of eyes, width between eyes a little more than twice length at middle; pronotum with prominent lateral angles and appearing wider than head, more than twice as long as head; elytra long, rolled at apex, giving the insect a wedge-shaped appearance.

Color: Bright green, markings varying; usually with a median longitudinal stripe on vertex extending on to anterior portion of pronotum, a spot either side on vertex, and posterior margin of pronotum pale; scutellum usually orange-yellow with median pale stripe; face, vertex, and pronotum frequently tinted with orange; elytra bright green, apical fourth smoky.

Female genitalia: Last ventral segment with posterior margin roundedly produced to a central rather broad, blunt, sunken tooth formed by an obliquely directed notch on either side.

Male genitalia: Valve with a broad deep V-shaped notch extending more than halfway to base; plates long and narrow, more than five times as long as width at base; male genital pieces similar to those of *pergandei*; lateral processes of the pygofer long and slightly curved at tip; styles long and narrow, almost straight, and with inwardly curved apices (ventral view).

The type of this species was destroyed in the Chicago fire, and since this species is generally accepted as the one which Walsh had in hand, and in view of the use of this name in literature at present, a neotype is erected at this time for reference for future work and has been deposited in the author's collection. It is labeled "Delaware, Ohio, July 20, 1926 from apple."

Specimens in the National Museum are from Salineville, Ohio (types of *unicolor*), Colorado (male types of *denticula*), and other specimens from Chester, Pa., on apple, Arkansas (on apple), Maryland, and Idaho. Other specimens examined are from North East, Proctor, Charter Oak, Kane, Presque Isle, and Snow Shoe, Pa. (Sanders and DeLong) and from Brookings, S. Dak.

Specimens in the collection of Doctor Ball are from Hood River, Oreg. (Childs), Trout Lake and Madison, Wis., Rist Canon, Colo., and Soldier, Utah.

This insect is the true apple *Empoasca* and is abundant and destructive on cultivated and wild *Crataegus*. It overwinters as an egg in the apple twigs and hatches early in the spring. This is one of the most important economic species of the genus.

Neotype in the author's collection.

EMPOASCA ATROLABES GILLETTE

(Figs. 2, 3, and 5)

This species was described by C. P. Gillette as an *Empoasca* in 1898 (13).

Differs from closely related species by its dark-green color with pale-brownish markings and the large black spot near the apex of the wing. Genital characters similar to *maligna*. Length 3.5 mm.

Vertex scarcely produced beyond anterior margins of eyes, broadly rounded, a little more than half as long as middle as width between eyes; pronotum with prominently produced humeral angles, slightly wider than head and more than twice as long.

Color: Dark or dull green, vertex with pale mottling, anterior half of pronotum and scutellum yellowish brown; elytra with claval vein bluish green, a large black spot before the cross nervure of the inner apical cell, apical fourth of elytra smoky.

Female genitalia: Last ventral segment angularly produced to center of posterior margin where a broad sunken tooth sometimes notched at middle is formed by an oblique notch either side. The posterior margin ends in a sharp point on either side of this central excavation.

Male genitalia: Valve with a deep V-shaped notch as in *maligna*; plates long and narrow, about six times as long as width at base. Of the male genital pieces, the oedagus differs from that of any of the closely related species by having a long ventral caudal spur which projects from the body of the oedagus about two-thirds the way from the base, lateral processes of the pygofer very long and slightly waved at the apex, the styles much shorter and tapered at apex.

This insect is northern in distribution. The cotypes in the National Museum are from the Michigan Agricultural College, from New Hampshire, Colorado, and Massachusetts. Other specimens examined are from North East, Hartstown, and Bear Meadow, Pa.

Specimens in the E. D. Ball collections are from Ames, Iowa, Rist Canon, Colo., Franconia, N. H., and Oceola, Ladysmith, and Rhinelander, Wis.

This species is found on alder (*Alnus*) and is not considered of economic importance.

Type in United States National Museum.

EMPOASCA UNICA (PROVANCHER)

(Fig. 5)

Described by Provancher as a *Typhlocyba* in 1890 (21, p. 340) and redescribed by Gillette as *Empoasca splendida* in 1898 (13).

Resembling *atrolabes* in form and appearance, but more brightly colored and marked with brownish red and with female segment entire. Length 3.5 mm.

Vertex more angularly produced beyond the anterior margins of the eyes than in *atrolabes*, only a little wider between eyes than length at middle; pronotum as wide as head and about one-half longer.

Color: Vertex bluish green, anterior third yellowish; anterior two-thirds of pronotum brownish red, posterior margin banded with bluish green; scutellum pale brownish; elytra brownish red, a stripe along claval vein and another along costal margin bluish green, apical fourth smoky; face and beneath pale yellowish green.

Female genitalia: Last ventral segment more than twice the length of the preceding, posterior margin roundedly produced.

Male genitalia: Valve angularly notched about half way to base; plates long and very narrow, about six times as long as basal width. Of the male genital pieces, in ventral view the styles are tapered apically and somewhat divergent, the oedagus appears to be short, the lateral processes of the pygofer are long, cross near their apices, and are angularly broadened on the inner margin like a spear.

This species is southern in distribution. Specimens in the National Museum collection are from Alabama, Maryland, and Pennsylvania, all in the C. F. Baker collection. Other material examined is from Battle Point, Va. (Sanders), Hartstown, Pa., and throughout Tennessee (author's collection).

This species is abundant on certain species of alder (*Alnus*) but is not considered of economic importance.

KEY TO THE SPECIES OF THE OBTUSA GROUP

- A. Green or yellowish without definite stripes, bands, or dark markings.
 - B. Less than 5 mm. in length.
 - C. Male lateral processes of the pygofer enlarged near tip, in ventral view showing a conspicuous projecting fingerlike process on inner margin. (Fig. 5.)-----*obtusa*, p. 20
 - CC. Lateral processes of male without fingerlike processes on inner margin in ventral view.
 - D. Length 4.5 mm.
 - E. Lateral pygofer processes of male in ventral view narrowed before apex, then enlarged. In lateral view with a ventral fingerlike process.-----*incida*, p. 21
 - EE. In ventral and lateral view male lateral processes tapered to apex and sinuate.-----*patula* var. *magna*, p. 23
 - DD. Length 4 mm. or less.
 - F. Claval vein of elytra broadly white, male unknown-----*albolinea*, p. 23
 - FF. Claval vein same color as elytra, not white.
 - G. Male lateral processes of pygofer tapered and sinuate at apex-----*patula*, p. 22

- GG. Male lateral processes of pygofers abruptly narrowed near apex to form dorsal fingerlike process (in lateral view) ----- *saluta*, p. 24
- BB. Length 5 mm. or more, lateral processes of the pygofers stout, in lateral view enlarged and tapered near tip ----- *aureoviridis*, p. 24
- AA. Color uniformly brown, black, or banded or striped with dark markings.
- H. With definite bands, stripes, or color marking.
- I. Size 4 mm. or less.
- J. A rather conspicuous dark stripe along inner margins of elytra extending from base of pronotum ----- *smaragdula*, p. 25
- JJ. Elytra not striped but sometimes banded.
- K. Green with three conspicuous transverse bands one on the pronotum, one across the middle, and another across the apices of the elytra ----- *trifasciata*, p. 28
- KK. Either not green or without bands.
- L. Green with pronotum and scutellum frequently dark brown to black ----- *digita*, p. 26
- LL. White to gray, a brownish band across pronotum and two across elytra, one at apex, and one on middle of clavus ----- *copula*, p. 27
- II. Size larger, 5 mm.
- M. A transverse band across apex of elytra black, and a broad longitudinal stripe across vertex, pronotum, and scutellum and on to elytra black ----- *livingstoni*, p. 27
- MM. A large black stripe extending along inner margins of elytra from posterior portion of pronotum to apex of elytra ----- *aureoviridis* var. *vittata*, p. 25
- HH. Rather uniformly dark in color (brownish or black) without bands or stripes.
- N. Length 4 mm. or more; western in distribution.
- O. Male lateral processes of pygofers long, straight, tapered to acutely pointed tips ----- *clypeata*, p. 28
- OO. Tips of male lateral processes of pygofers not straight.
- P. In lateral view with tips of male processes strongly sinuate. Spines of anal chitinous ring more elongate and narrowed than in *clypeata*. (Fig. 7) ----- var. *annella*, p. 28
- PP. Tips of male lateral processes provided with shallow hooks bent laterally and anteriorly. (Fig. 8) ----- *adunca*, p. 31
- NN. Smaller, 3.5 mm., brown; eastern in distribution. Male lateral pygofer processes inflated before apex and with a ventral finger process (lateral view, fig. 7) ----- *osborni*, p. 31

SPECIES OF THE OBTUSA GROUP

EMPOASCA OBTUSA WALSH

(Fig. 5)

Described by Walsh in 1864 (27) as an *Empoasca*. The female, which has a slight incision in the last ventral segment, was apparently redescribed as *Empoasca incisa* by Gillette in 1898 (13).

This is the common green, broad-headed species without definite markings that occurs on willow and poplar. Length 4-4.5 mm.

Vertex produced on the middle half beyond the anterior margin of the eyes, slightly longer at middle than next eye, more than twice as wide between eyes as length at middle; pronotum almost two and one-half times as long as vertex.

Color: Pale green, without definite markings; vertex frequently tinged with yellow; pronotum and scutellum usually with central pale stripe and other irregular light markings; elytra greenish subhyaline, abdomen visible from above.

Female genitalia: Last ventral segment long, produced to blunt rounded apex.

Male genitalia: Valve broad, broadly angularly rounded, almost twice as wide as long; plates more than three times as long as basal width, tapered to curled narrow tips, heavily clothed with long pale spines. Of the male genital pieces, in ventral view the lateral processes of the pygofer are broadened apically and have prominent finger-like projections on the inner margins. These structures are used to distinguish the species of this group. The styles are constricted apically, and the apices are turned outward.

The type was destroyed in the Chicago fire, but in view of the fact that the species is quite well defined in the minds of workers on the Homoptera a neotype is erected at this time and deposited in the author's collection. It is labeled "Mitiwanga Ohio 8-15-27 from willow."

This is apparently a very common species on willow and poplar. Specimens in the National Museum collection are from Colorado (C. F. Baker collection), Ohio, Pennsylvania, Algonquin, Ill., Alabama, and Washington, D. C. Other specimens examined are from Williamsport, North East, Hartstown, and Presque Isle, Pa. (Sanders and DeLong.)

EMPOASCA INCIDA N. SP.

A yellowish species with vertex broad and parallel margined, but somewhat produced. Length 4.5 mm.

Vertex broadly, angularly produced almost one-half its length before the eyes, more than twice as wide between eyes as length at middle; pronotum more than twice as wide as long.

Color: Golden yellow, pronotum with three white spots on anterior margin, scutellum with white mottling, elytra with a white opaque appearance.

Female genitalia: Last ventral segment rather long, the posterior margin not strongly produced, gently convexly rounding.

Male genitalia: Valve about twice as long as preceding segment, posterior margin truncate or slightly produced; plates long, strongly curved, upturned, and laterally flared on apical third, heavily clothed ventrally with long spines and hairs. Of the male genital pieces, the lateral pygofer processes in ventral view are constricted and again enlarged near apex, in lateral view there is a ventral, slender, finger-like process; styles tapered at apex and strongly divergent; spines of tenth segment long and broadly curved.

Described from a series of 13 male and 13 female specimens from Vancouver, B. C., in the collection of E. D. Ball, labeled "Livingston" and collected July, August, and September, 1896.

Holotype male, allotype female, and male and female paratypes in the E. D. Ball collection, Tucson, Ariz.; male and female paratypes in the DeLong collection, Columbus, Ohio, and the United States National Museum collection, Washington, D. C.

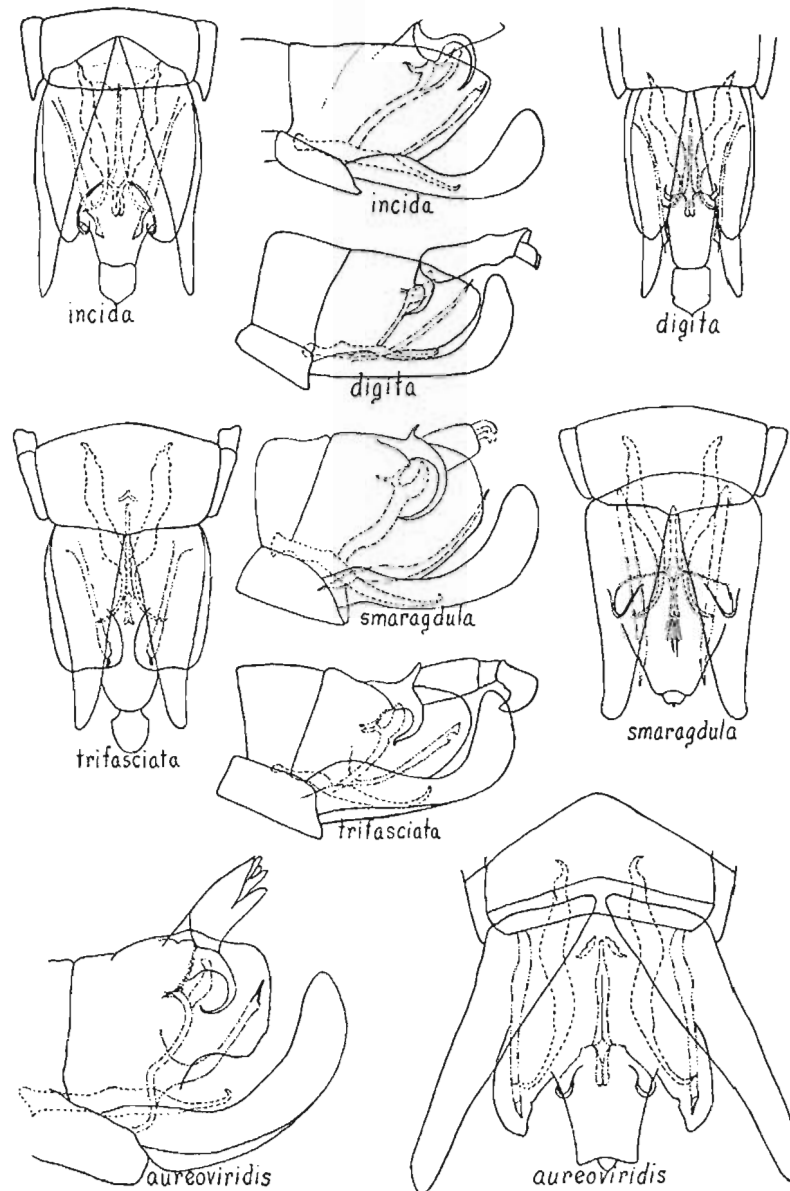


FIGURE 6.—Male genital pieces of species of *Empoasca*. $\times 50$

EMPOASCA PATULA N. SP.

(Fig. 5)

Resembling *obtusa* in form and appearance, but with vertex more produced and with distinct internal genital structures. Length 3.5 to 4 mm.

Vertex broadly rounded but considerably produced, extending almost half its length beyond anterior margins of eyes, only a little longer on middle than next the eyes, more than twice as broad as long; pronotum more than twice as long as vertex.

Color: Dull green washed with yellow, scutellum with basal angles sometimes orange; elytra pale green, subhyaline, sometimes their inner margin with a narrow pencil line black.

Female genitalia: Last ventral segment very strongly produced, apex narrowed and almost angled, convexly rounded from near base.

Male genitalia: Valve narrowed posteriorly and with posterior margin gently produced; plates rather broad at base, gradually narrowed to bluntly rounded tips, posterior half upturned and flaring, heavily clothed ventrally with long black spines. Of the male genital pieces, the lateral processes of the pygofers are slender, tapered at the apex, and sinuate. This is the character by which it can be distinguished from *obtusa* and closely related forms. In ventral view the styles are more curved outwardly, both basally and apically, than those of *obtusa*. Chitinous spines of tenth segment more slender and elongated than in *obtusa*.

Described from a series of specimens collected at Dyersburg, Tenn., June, 1915 (DeLong); Orono, Fort Kent, and Portland, Me., June, 1913 (Osborn); and Harrisburg and several other localities in Pennsylvania in June and July (Sanders and DeLong).

Holotype male, allotype female, and male and female paratypes in author's collection, Columbus, Ohio. Paratypes in United States National Museum collection and collections of Herbert Osborn, Columbus, Ohio, and E. D. Ball, Tucson, Ariz.

EMPOASCA PATULA VAR. MAGNA N. VAR.

Appearing entirely distinct from *patula*, but with internal genitalia almost exactly like those of preceding form. Much larger in size and with western distribution. Length 4.5 mm.

Vertex not so greatly produced and appearing broader.

Color: Bright yellowish green, almost devoid of markings; three white spots on pronotum usually more or less conspicuous; usually with a broad white stripe on scutellum; elytra appearing opaque, veins at apex yellow, conspicuous.

Genitalia: Both internal and external structures, same as in *patula*.

This form occurs only in the West and may be an entirely different species in spite of the similar genital structures. Described from a series of 5 males and 22 females from Vancouver, B. C., collected in August and September, 1896, by Livingston. These are all in the collection of E. D. Ball.

Holotype male, allotype female, and male and female paratypes in the E. D. Ball collection, Tucson, Ariz. Paratypes in United States National Museum collection and in the author's collection.

EMPOASCA ALBOLINEA GILLETTE

Described by Gillette as an *Empoasca* in 1898 (13).

A rather strikingly colored species described from female specimens only, so the validity of the species can not be assured; probably it is closely related to *patula*. Length 3.5 mm.

Vertex strongly curved with about half its length produced beyond anterior margins of eyes, a little longer on middle than next the eyes, and more than twice as wide between eyes as length at middle.

Color: Vertex, pronotum, and scutellum orange yellow; vertex with a central white longitudinal stripe and a dash either side about half way to eye; pro-

notum with a pale line along anterior margin, a spot at middle on anterior margin, and an irregular blotch behind either eye white; usually a longitudinal white stripe across scutellum; elytra yellowish green, a whitish green stripe along commissural line, and claval vein broadly white; costal veins more greenish.

Genitalia: Female segment with posterior margin roundedly produced. Male unknown.

Known only by the type specimens from Douglas Co., Kans., and Illinois; and two female specimens, exactly like the types, which are in the collection of Herbert Osborn and were collected by him at Columbus, Ohio. Recorded as occurring on willow.

It is quite probable that this is only a highly marked color form of *obtusa*.

Type in United States National Museum.

EMPOASCA SALUTA N. SP.

(Fig. 5)

Resembling *obtusa* in general form and appearance. Length 3.5-4 mm.

Vertex almost parallel margined, slightly produced before anterior margins of eyes, more than twice as wide as long.

Color: Pale green tinged with white and yellow; elytra greenish, subhyaline.

Female genitalia: Last ventral segment with posterior margin roundedly produced.

Male genitalia: Plates long, triangular, tips upturned, ventral surface covered with heavy spines. Of the male genital pieces, in ventral view the lateral processes of the pygofer are long with hooked or sickle-shaped terminal processes. In lateral view these processes are rather broad to near the apex where they are rather abruptly constricted or notched on the ventral side to produce a dorsal fingerlike terminal process. Dorsal spines of tenth segment long and narrow with tips attenuated and directed ventrally.

Described from a series of 56 specimens labeled "Arizona" in the collection of C. F. Baker in the United States National Museum.

Holotype male, allotype female, and male and female paratypes in the United States National Museum.

EMPOASCA AUREOVIRIDIS (UHLER)

(Fig. 6)

Described by Uhler in 1877 as a *Typhlocyba* (24, p. 474).

In form and color resembling *obtusa*, uniformly green in color, and distinguished from *obtusa* chiefly by its larger size. Internal genitalia distinct. Length 5 to 5.5 mm.

Vertex parallel margined, only slightly produced beyond anterior margins of eyes, more than twice as wide as long; pronotum with prominent humeral angles, slightly wider than head and two and one-half times as long as head, posterior margin strongly concave between humeral angles; elytra very long.

Color: Yellowish green with irregular and variable mottling; vertex, pronotum, and scutellum usually washed with yellow and sometimes with pale median stripes or markings across pronotum and scutellum; elytra pale green, subhyaline.

Female genitalia: Last ventral segment strongly convexly produced, side margins deeply concavely indented on either side of central half, which is roundedly produced and slightly indented at middle, giving posterior margin a lobed appearance.

Male genitalia: Valve one-third longer than preceding segment, apex broad and almost truncate, slightly indented at middle; male plates long, turned

upward and flared at tips, apices rather broad and rounded, heavily armed ventrally with long white spines. Of the male genital pieces, the lateral processes of the pygofer in ventral view are rather abruptly tapered to the pointed apices; in lateral view dorsal margin straight, ventral margin enlarged near apex, then tapered to a sharply pointed apex; spines of tenth segment strongly curved anteriorly and inwardly.

A series of specimens from Colorado in the C. F. Baker collection, United States National Museum, are apparently this species. Other specimens examined in the collection of E. D. Ball are from Rico, Fort Collins, and Ward, Colo. Recorded as occurring upon willow.

Location of type unknown.

EMPOASCA AUREOVIRIDIS VAR. VITTATA HARTZELL

Described by Hartzell as *Empoasca vittata* 1923 (18).

In size and form agreeing with *aureoviridis* Uhler and distinguished only by the black stripe extending from the pronotum along the commissural line of the elytra to the apex. Length 5 mm.

Vertex almost parallel margined and only slightly produced before anterior margins of eyes.

Color: Pale green or yellowish with a brownish spot covering the median posterior two-thirds of the pronotum; this forms the anterior portion of a broad, brown stripe that extends across the scutellum and along the inner margins of the wings to the apex.

Genitalia: Female segment concavely produced to form prominent obtusely angled posterior margin. External and internal male genitalia agreeing almost exactly with those of *aureoviridis*. They can not be separated by any genital character.

Known only by a female from Stanford University, Calif., and a male from Colorado (author's collection) which agrees with the female in form and coloration.

Type in the author's collection.

EMPOASCA SMARAGDULA (FALLEN)

(Fig. 6)

Described by Fallen as a Cicada in 1806 (8, p. 53) and redescribed as *viridipes* by Curtis in 1837 (3, p. 640).

Usually distinguished from the other species of the genus by the black stripe extending from the posterior portion of the pronotum to the apex of the clavus along the commissural line. Length 4 mm.

Vertex broadly rounded, parallel margined, slightly produced before anterior margins of eyes; pronotum three times as long as vertex.

Color: Green to yellow, marked with dark brown or black; vertex usually green to golden yellow; pronotum with central portion brownish and lateral portions paler; scutellum brownish, together with dark portion on pronotum forming the stripe which extends along the elytra; elytra greenish, a broad brownish stripe extending to apex of clavus, basal third or fourth of elytra smoky; face and beneath yellowish to green.

Female genitalia: Last ventral segment long, convexly rounded to about half its length, then concavely rounded to form a blunt, rounded apex, the concaved portion showing a rounded indentation at either side.

Male genitalia: Valve rounded and sloping to a bluntly angled posterior margin; plates long, tips twisted laterally and curled, apices appearing pointed but broadly rounded and protruding upward, heavily set with black spines. Of the male genital pieces, the styles are more slender than in allied species and rather strongly curved outward at apex, the lateral processes of the pygofer are long and gradually tapered to the pointed apices, and the spines of the tenth segment are long and rather strongly curved.

The United States National Museum collection contains a series of specimens from Colorado (C. F. Baker collection) and two specimens from the Michigan Agricultural College. Other specimens examined are from Penfield, Pa. (author's collection). This insect is common on willow, and Gillette has recorded it on *Crataegus rivularis*.

Location of type unknown.

EMPOASCA TRIFASCIATA (GILLETTE)

(Fig. 6)

This species was described by Gillette as *Empoasca trifasciata* in 1898 (13), and has remained as a good species.

Easily separated from all the other species of the genus by the three transverse bands of black. Length 4 mm.

Vertex broadly rounded, scarcely produced beyond anterior margins of eyes, twice as wide between eyes as length at middle; pronotum more than twice as long as vertex. Elytra long, abdomen reaching to about apex of clavus.

Color: Pale green; vertex, upper portion of face, and anterior part of pronotum frequently tinged with orange; eyes dark; a broad band across posterior half of pronotum, a narrow one across elytra at middle of clavus, and a much broader one across apex of elytra dark brown to black.

Female genitalia: Last ventral segment slightly roundedly produced and slightly indented at middle.

Male genitalia: Valve produced and strongly rounded; plates long and tapering, heavily covered with white and black spines and usually recurved at the tips. Of the male genital pieces, the styles (in ventral view) are strongly constricted and narrowed about one-third the distance from the apex, forming long, slender, outwardly curved apices; the oedagus is long and narrow; the lateral processes of the pygofer in ventral view appear strongly constricted and twisted at the apex, in lateral view strongly notched just before the apex; the spines of the tenth segment are rather broad and thick.

It was described from specimens from Douglas County, Kans., Champaign, Ill., and Ames, Iowa. Other specimens in the National Museum are from St. Louis, Mo., and Chicopee, Mass. Specimens in E. D. Ball's collection are from Ames, Iowa, and Fort Collins, Colo. A common species on Carolina poplar (cottonwood).

Type in United States National Museum collection.

EMPOASCA DIGITA N. SP.

(Fig. 6)

Resembling *obtusa* in size and general appearance but with vertex, pronotum, and scutellum frequently black and with distinct internal genital characters. Length 4 mm.

Vertex broadly, roundedly produced about one-half its median length beyond anterior margins of eyes, parallel margined, almost three times as wide between eyes as length at middle; pronotum three times as long as vertex, humeral angles produced and prominent, pronotum wider than head including eyes.

Color: Green, sometimes pale, vertex frequently washed with brown; pronotum and scutellum frequently dark brown to black with a few pale areas; elytra frequently with a narrow black line along inner margin.

Female genitalia: Last ventral segment about four times as long as preceding, strongly produced and roundedly narrowed to blunt apex.

Male genitalia: Valve about two and one-half times as long as preceding segment, broad and slightly roundedly produced posteriorly; plates rather long with apical half upturned and laterally curled and flared, apices rather broadly rounded. Of the male genital pieces, the lateral processes of the

pygofers in ventral view are long and slender each with a slender fingerlike process on the outer margin; in lateral view they are tapered to a pointed apex; the styles in ventral view are very slender and strongly curved outwardly; the spines of the tenth segment are broad and not strongly curved.

Described from a series of seven female and three male specimens collected by R. D. Bird at Birtle, Manitoba, in July and August, 1928, and sent to the author for identification.

Holotype male, allotype female, and the paratypes male and female in the author's collection. Female paratypes in United States National Museum collection, Canadian National collection, Ottawa, Canada, and collection of E. D. Ball.

EMPOASCA COPULA N. SP.

(Fig. 7)

Superficially resembling *pulchella* because of the banded appearance, but larger, more robust, and definitely belonging to the *clypeata* group. Internal genitalia distinct. Length 3.75 mm.

Vertex parallel margined, produced about one-third its length before anterior margins of eyes, more than twice as wide between eyes as length at middle.

Color: Whitish to gray, marked with brown and tinged with golden yellow; vertex mostly golden yellow; pronotum brown, anterior margin with a narrow white area, lateral margins mottled; scutellum dark brown, apical third paler; elytra with a dark band across middle of clavus extending to costal margin and a band across apex extending forward to apex of clavus; face golden yellow with a median white stripe; lorae white.

Male genitalia: Valve about two and one-half times as long as preceding segment, posterior margin slightly produced and broadly angled; plates triangular, about twice as long as valve, gradually tapered and set with heavy spines. Of the male genital pieces the oedagus is very similar to that in other closely related species, the styles are similar but more slender than in related species and gradually tapered to the rather blunt divergent apices, and the lateral processes of the pygofers in lateral view have a distinct terminal dorsal finger process which appears on the inner terminal portion in ventral view. These latter processes easily distinguish this species.

Described from two male specimens collected in Wisconsin in 1916 by the author. One was taken at Merrillan August 3 and the other at Ladysmith August 9.

Holotype male and paratype male in the author's collection.

Described by Gillette in 1898 (13).

EMPOASCA LIVINGSTONI GILLETTE

(Fig. 7)

One of the largest species of the genus. Brownish in color or green with longitudinal brown stripe and apical band of black. Length 5 mm.

Vertex almost parallel margined, only slightly produced before anterior margins of eyes and more than twice as wide as middle length; pronotum two and one-half times as long as vertex, deeply concave posteriorly, lateral angles rounded; elytra greatly exceeding abdomen.

Color: In well-marked specimens the color is greenish or yellowish green; posterior portion of vertex dark brown or black; central half of pronotum black; scutellum and a rather broad stripe extending about half the length of elytra along the commissural line and a broad band covering apical cells of elytra black; other specimens are entirely dark brown to black.

Female genitalia: Last ventral segment strongly produced, lateral margin deeply concavely notched on either side about halfway to apex, forming a produced lobe which is about one-half the width of the segment.

Male genitalia: Valve about three times as long as preceding segment, slightly concave, almost truncated; plates long but appearing short because of their upturned and flaring tips, the apices of which are broadly rounded, heavily clothed ventrally with long white spines. Of the male genital pieces, the styles are heavy at base, greatly narrowed at about half their length, and divergently produced, each with a heavy tuft of long hairs on the dorsal side which extends well into the genital chamber; the lateral processes of the pygofer in ventral view are rather heavy, slightly enlarged before apex, then rather abruptly pointed, in lateral view appearing slightly enlarged and with a terminal ventral finger process; the spines of the tenth segment rather long and broadly curved.

The cotypes in the Museum are from Easton, Wash., and the other specimens in the collection are from Colorado and from Vancouver, B. C. A series of specimens in the collection of E. D. Ball are from Vancouver, B. C., and were collected by Livingston in July and August, 1896.

Cotypes in United States National Museum.

EMPOASCA CLYPEATA GILLETTE AND BAKER

(Fig. 7)

Described by Gillette and Baker in 1895 (14, p. 108).

Similar in size and form to *obtusa* but usually pale to dark brown in color. Internal genitalia distinct. Length 4 mm.

Vertex broadly rounded, produced about one-third its length beyond anterior margins of eyes, almost one-fourth longer on middle than next eye, more than twice as wide as long; pronotum more than twice as long as vertex; elytra greatly exceeding abdomen.

Color: Yellowish brown, frequently tinted with dull green, posterior portion of pronotum darker; elytra brownish subhyaline, veins yellowish; beneath yellowish with variable brown markings.

Female genitalia: Last ventral segment strongly produced, sides sloping to pointed apex which is blunt at tip.

Male genitalia: Valve with broad, slightly angled apex; plates compressed laterally and upturned at tips, heavily armed ventrally with long dark spines, apices rounded and flaring. Of the male genital pieces, the lateral processes of the pygofer are long, slender, and tapered to acute tips in lateral and ventral views; the spines of the anal tube ring (tenth segment) are heavy at the base, somewhat right angled, and are not so long or slender as in *annella*; and the styles are rather slender and rather strongly recurved.

There is a large series of specimens from Colorado (C. F. Baker collection) and a small series from California. Recorded as occurring on willow.

The type, in the United States National Museum, is from Colorado.

EMPOASCA CLYPEATA VAR. ANNELLA HARTZELL

(Fig. 7)

Described by Hartzell in 1923 (18) as a new species.

Resembling *clypeata* in form and appearance, but with a little different coloration and internal genital structures slightly different. Length 4.3 to 4.5 mm.

Vertex broad and almost parallel margined, slightly produced before anterior margins of eyes, more than twice as wide as long.

Color: Dark brown, vertex sometimes pale, pronotum and scutellum frequently with a light median stripe ending in a white spot on disk of scutellum; elytra appearing striped, brown tinged with green and with claval suture heavily, broadly brown and with a broad stripe on the corium, apical fourth brown.

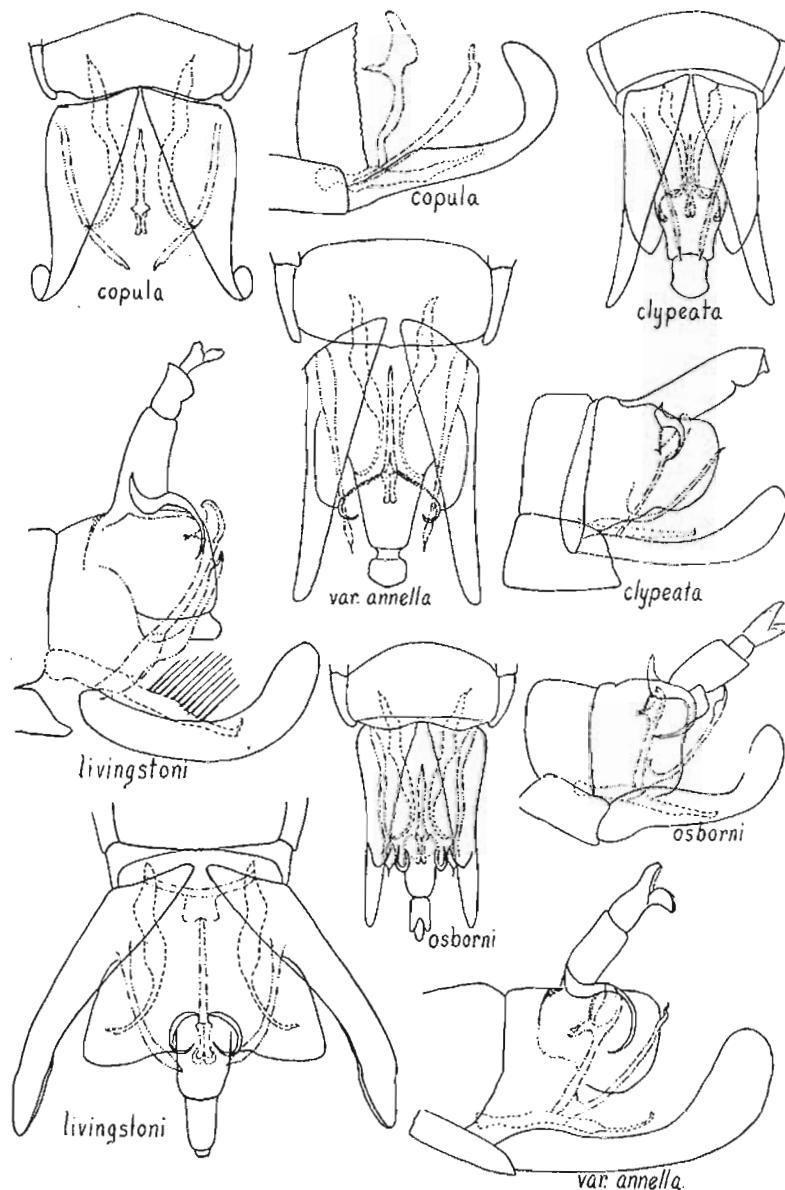


FIGURE 7.—Male genital pieces of species of *Empoasca*. $\times 50$

Genitalia: External genitalia not differing from *clypeata*.

The internal genital characters in the male which distinguish this variety are the waved or sinuated tips of the lateral processes of the pygofer and the long, slender, broadly curved spines of the anal tube ring which extends both ventrally and inwardly into the genital chamber.

Possibly this may prove to be a distinct species, but with our present material it is well within the range of probable variation and would seem to be only a color form.

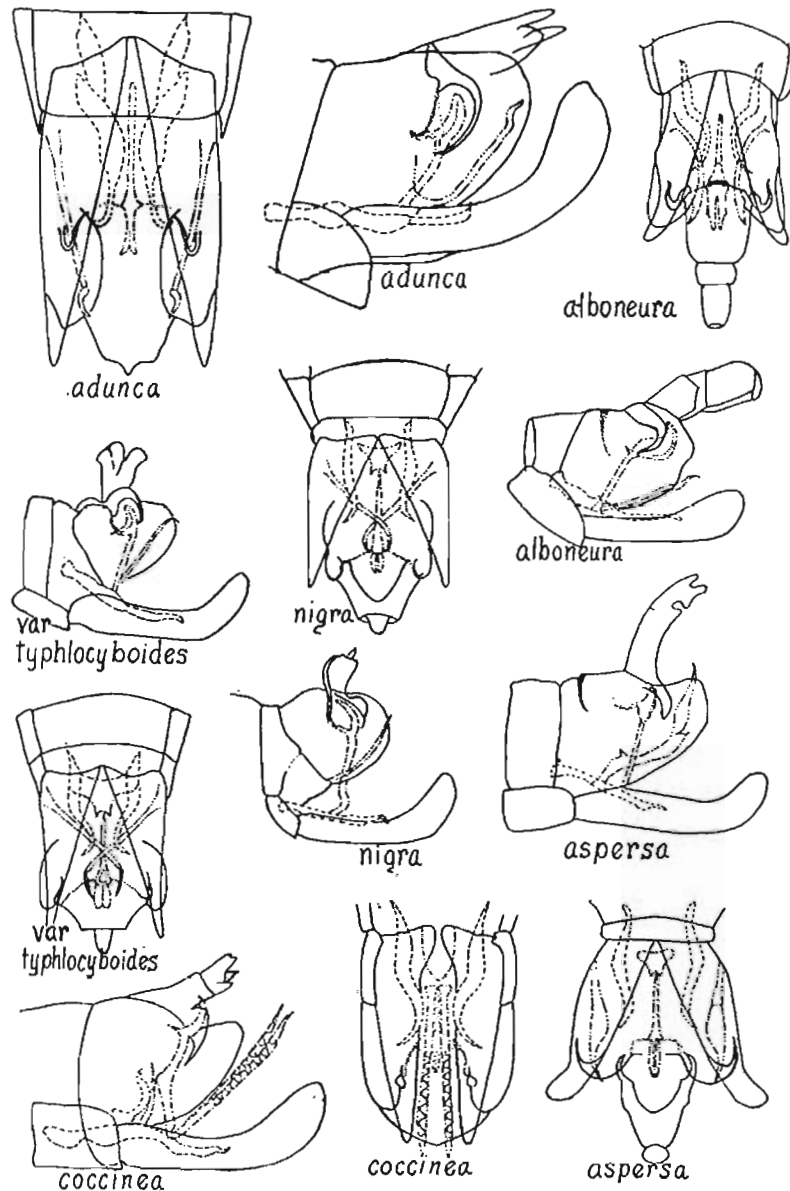


FIGURE 8.—Male genital pieces of species of *Empoasca*. $\times 55$

A large series of specimens from Colorado (C. F. Baker collection) is in the United States National Museum. There is also a series of specimens in the collection of E. D. Ball, labeled "Vinta Pam'l."

Type in the author's collection.

EMPOASCA ADUNCA N. SP.

(Fig. 8)

Resembling *obtusa* in form and appearance but more yellowish brown and with distinct internal genitalia. Length 4.2 to 4.5 mm.

Vertex broadly rounded and produced about one-third its length before anterior margins of eyes, slightly longer on middle than next the eyes, twice as wide between eyes as length at middle; pronotum twice as long as vertex, humeral angles rounded off, not prominent.

Color: Pale green to brown, tinged with yellow, usually pale brown in appearance; pale specimens with three white spots or areas on anterior margin of pronotum; elytra with inner margins marked with a narrow line.

Genitalia: In external appearance very similar to those of the others of this group. Female genitalia: Last ventral segment strongly produced and rounded, concavely notched either side of central produced third which is rounded at apex.

Male genitalia: Valve more than three times as long as preceding segment, lateral margins rounded, posterior margin almost truncate, frequently with a pair of small rounded teeth at middle formed by a slight median incision; plates long, apical portion upturned and curved laterally, heavily clothed with long spines and hairs. Of the male genital pieces, the internal genital structures which will easily distinguish this species are the shallow hooks bent laterally and anteriorly on the apices of the lateral processes of the pygofers.

Described from a large series of specimens from Colorado (C. F. Baker collection) which are in the United States National Museum.

Holotype male, allotype female, and paratypes male and female in the United States National Museum collection.

EMPOASCA OSBORNI HARTZELL

(Fig. 7)

Described by Hartzell in 1923 (18).

A pale brownish species smaller than *clypeata* and occurring on willow in the eastern and southern parts of the United States. Form similar to that of *obtusa*. Length 3.5 mm.

Vertex more produced than in *clypeata*, produced almost one-half of its length beyond anterior margin of eyes, about twice as wide as long and slightly longer at middle than next the eye. Pronotum twice as long as vertex, humeral angles not greatly produced or prominent.

Color: Dull yellowish green to brown with darker markings sometimes washed with orange on vertex and pronotum; frequently a pair of dark brown blotches extending from middle toward the eye upon either side of margin of vertex above ocelli; pronotum heavily mottled with dark brown; scutellum with a pale area at middle; elytra pale brownish, subhyaline, venation conspicuous on posterior half; beneath yellow to green.

Female genitalia: Last ventral segment strongly roundedly produced to a prominent rounded apex.

Male genitalia: Valve twice as long as preceding segment, posterior margin broad, gently sloping and angled, slightly indented at center; plates appressed and upturned at tips, heavily armed with long black spines. Of the male genital pieces, the styles are long and slender, the lateral processes of the pygofers have rather abruptly broadened, rounded portions near the apex and are then abruptly narrowed to the slender attenuated tips (ventral view). In lateral view these processes are narrow, enlarged at apex, and terminate in a ventral caudal fingerlike process. The spines of the tenth segment are long and strongly curved, and their apices are directed anteriorly.

The type specimens are from Marietta, Ohio, collected in September, 1905. A series of specimens in the author's collection were collected from willow at Knoxville, Tenn., in April, June, and September, 1917, by W. B. Cartwright.

Type in Osborn collection.

THE SUBGENUS *HEBATA* NOV.

Smaller in size than species of the subgenus *Kybos* and with vertex bluntly rounded or angled. Vertex appearing broad, rounded, but not parallel margined.

Type of subgenus, *nigra* Gillette and Baker.

KEY TO THE SPECIES OF THE SUBGENUS *HEBATA* NOV.

(*nigra-aspersa* group)

- A. Color black, or pale green with black or red markings. Occurring on sagebrush. Less than 3 mm. in length.
 - B. Rather uniformly black in color.-----*nigra*, p. 32
 - BB. Pale with black or reddish to brownish markings.
 - C. A black spot on scutellum and posterior portion of pronotum and a spot on commissural line just before apex of clavus-----var. *nigroscuta*, p. 33
 - CC. Without black markings but marked with red or reddish brown.
 - D. Pale with broken reddish stripes between veins of elytra-----var. *typhlocyboides*, p. 33
 - DD. White to gray with red stripes as above but intensified by smoky bands across middle of elytra and apical cross veins-----var. *pulchella*, p. 34
 - AA. Pale to dark green or tinted with red on vertex and pronotum, but without spots or lines of red or black coloration. Usually 3 mm. or slightly more in length.
 - E. Dark green or reddish in color. Oedagus of male with a pair of long processes extending caudally and dorsally from basal end. Occurs on pine-----*coccinea*, p. 35
 - EE. Usually paler or brighter green. Oedagus of male without processes arising from basal end.
 - F. Elytra pale green, usually mottled with smoky, giving it a mosaic appearance. Male lateral processes of pygofers strongly curved and tapered to acute tips. (Figs. 2 and 8)-----*aspersa*, p. 34
 - FF. Elytra dull green, veins pale, giving it a striped appearance. Male lateral processes of pygofers slightly enlarged near apex and rather abruptly pointed. (Fig. 8)-----*albocincta*, p. 35

SPECIES OF THE SUBGENUS *HEBATA* NOV.

EMPOASCA NIGRA GILLETTE AND BAKER

(Fig. 8)

Described by Gillette and Baker in 1895 (14, p. 108).

A small black species with blunt head, occurring on sagebrush. Length 2.5 to 2.75 mm.

Head blunt and rounded, produced more than one-half its length beyond anterior margins of eyes, one-third longer on middle than next the eye, almost twice as wide as long; pronotum more than twice as long as vertex, head wider than pronotum, humeral angles not produced laterally; elytra rather short, about three and one-half times as long as broad.

Color: Dark brown to black with varying paler and darker areas; elytra usually with a lighter area just before apical cross veins, apical fourth usually subhyaline; beneath dark brown or black.

Female genitalia: Last ventral segment rather long, posterior margin somewhat produced and angularly rounded.

Male genitalia: Valve broad at apex and truncated; plates about four times as long as wide at base, slightly convexly rounded to what appear to

be pointed apices because the apical fourth is upturned. Of the male genital pieces, the styles are short with the apices curved outwardly; the lateral processes of the pygofers long and slender, normally crossing each other near tips and with apices on opposite side of oedagus from base as seen in ventral view; the spines of the tenth segment rather heavy and rather well curved near apices.

The type and a series of specimens in the National Museum are from Colorado (C. F. Baker collection). Recorded from sagebrush (*Artemisia tridentata*).

Type in United States National Museum.

EMPOASCA NIGRA VAR. TYPHLOCYBOIDES GILLETTE AND BAKER

(Fig. 8)

Described by Gillette and Baker in 1895 as *Empoasca typhlocyboides* (14, p. 110) and redescribed by Gillette as *E. robusta* in 1898 (13).

Size and form same as those of *nigra* and with the same external and internal genital characters, but with different color and markings. Length 2.5 to 2.75 mm.

Color: Pale yellowish to milky white with dull reddish markings which may vary in pattern and intensity; vertex usually yellowish; pronotum and elytra ranging from pale yellow to milk white, in well-marked specimens with two longitudinal lines extending from ocelli across vertex and pronotum to basal angles of scutellum, pale reddish or yellowish; elytra frequently with dull reddish mottling between wing veins or sometimes with the anterior half showing only a few reddish markings on a milky white background and with a somewhat definite band across middle of elytra; beneath pale.

Genital characters: Exactly as in *nigra*.

The type specimens of *robusta* are only very pale female specimens of *typhlocyboides* and can not be distinguished from pale specimens in this latter type series.

Specimens in the collection of E. D. Ball are from Salt Lake City and Marysvale, Utah, June, 1906, and from Gunnison, Colo., August, 1899. Occurs abundantly on sagebrush (*Artemisia tridentata*).

Type in United States National Museum collection, from Nevada Co., Colo.

EMPOASCA NIGRA VAR. NIGROSCUTA GILLETTE AND BAKER

Described by Gillette and Baker as an *Empoasca* in 1895 (14, p. 108).

Agreeing with *nigra* in general size, form, and genital structures, but with different color markings. Length 2.3 to 2.8 mm.

Color: Yellowish or milky white with dull reddish markings as in *typhlocyboides*, but differing from it by a black spot covering the scutellum and posterior portion of pronotum just before it and another black spot along commissural line just before clavus; abdomen black above and pale beneath.

External and male internal genitalia same as in *nigra*.

Specimens in the collection of E. D. Ball are from Marysvale, Salt Lake City, and Helper, Utah, Reno, Nev., and Penticton, British Columbia (Downs). An abundant species on sagebrush (*Artemisia tridentata*).

Type in United States National Museum (C. F. Baker collection) with other specimens from Colorado.

EMPOASCA NIGRA VAR. PULCHELLA GILLETTE AND BAKER

Described by Gillette and Baker as an *Empoasca* in 1895 (14, p. 109).

Very similar to *typhlocyboides* in coloration and resembling the other members of the *nigra* group in size and form. No male specimens are in the type set, nor have any been available for study, but it is undoubtedly only a color variety of *nigra*. Length 2.75 mm.

Ground color as in *typhlocyboides*, pale yellowish to milky white; vertex and pronotum with vermiculate reddish brown markings; elytra milky white with the markings of *typhlocyboides*, but intensified by a darker or smoky area just back of scutellum almost forming a band in some specimens, a smoky band across elytra just before apex of clavus, and a third which is quite distinct across apex of elytra, especially intensified at the cross veins of the apical cells; veins at apex of wing pale and conspicuous.

No male specimens have been examined. Occurs on sagebrush (*Artemisia tridentata*).

Type and a series of specimens from Colorado are in the United States National Museum collection.

EMPOASCA ASPERSA GILLETTE AND BAKER

(Figs. 2 and 8)

Described by Gillette and Baker in 1895 (14, p. 107). Gillette's later citation of this species as a synonym of *tessellata* Fieber was in error, according to Van Duzee (26, p. 705).

A small, green, blunt-headed species, in general size and appearance resembling *alboneura*, but with different coloration and genital characters. Length 3 mm.

Vertex bluntly rounded, produced more than half its length beyond anterior margins of eyes, not twice as wide as long; pronotum about one and one-half times as long as vertex; elytra rather short.

Color: Vertex, pronotum, and scutellum yellowish to pale green, varying in intensity and without definite markings; elytra pale green, usually entirely mottled with smoky, giving it a sort of mosaic appearance; veins light green, conspicuous.

Female genitalia: Last ventral segment roundedly produced.

Male genitalia: Valve with a V-shaped notch on posterior margin; plates broad at base, tapering to pointed tips, which are usually upturned; almost four times as long as width at base. Of the male genital structures, the styles are slightly enlarged and bent outward near the middle, and the tips are divergent; the lateral processes of the pygofer are unique by their inflation or broadening on the inner margins near their middle and then concave, narrowing to long, curved, attenuated apices. In lateral view they are even more striking by their irregular shape and especially by the ventral incision about one-third the distance from the apex. The spines of the tenth segment are short, broad, and scarcely rounded.

A large series of specimens from Colorado (C. F. Baker collection) and two specimens from Utah (Knowlton) are in the National Museum collection. Specimens in the collection of E. D. Ball are from Salt Lake City, Thompson, Cisco, Monroe, Richfield, Provo, Joseph, Marysvale, Logan, and Helper, Utah; from Pasadena, Ontario, Riverside, Salinas, Tia Juana, Cabazon, Santa Barbara, and Spreckles, Calif.; and from Gunnison, Fort Collins, Palisade, and Grand Junction, Colo.

A western species recorded by Gillette from Bigelovia and sagebrush (*Artemisia tridentata*).

Type in United States National Museum.

EMPOASCA ALBONEURA GILLETTE

(Fig. 8)

Described by Gillette in 1898 as *Empoasca alboneura* (13) and apparently redescribed as *E. tumida* in the same paper.

Easily distinguished from the other species of the genus by the light veins, color markings, and distinct genitalia. Length 3 mm.

Vertex strongly but bluntly angled, produced more than half its length beyond the anterior margins of the eyes, one-third longer on middle than next the eyes, not quite twice as wide between eyes as length at middle.

Color: Dull greenish; vertex with a median stripe and an oblique dash either side white; pronotum with three large pale spots on anterior margin; elytra dull greenish, veins pale and conspicuous, green color of elytra sometimes appearing tinted with brown.

Female genitalia: Last ventral segment with the posterior margin roundedly produced.

Male genitalia: Valve angularly notched; plates appearing tapered to pointed apices because of folded and upturned tips, about four times as long as width at base. Of the male genital pieces, the styles are narrow and are strongly curved inwardly at middle, then their apices diverge; the oedagus is enlarged and broad on apical half in ventral view; the lateral processes of the pygofer are convexly curved inward, the apices slightly broadened and concavely narrowed on outer margins to pointed tips (ventral view); in lateral view appearing almost straight and tapered to acutely angled, attenuated apices.

The cotypes in the National Museum collection are labeled "Riley, Kans."; "Horace, Kans."; and "Nevada County, Calif." The species was also described from a series of specimens from Mississippi. Other specimens in the collection are from Alabama, Colorado, Oregon, Virginia, District of Columbia, Los Angeles County, Calif., and Mexico. Specimens in the E. D. Ball collection are from Fort Collins, Trinidad, and Alder, Colo., Ravenna, Calif., Wells, Nev., and Tia Juana, Victoria, and Jalapa, Mexico.

A very common species, distributed almost throughout the United States on herbaceous plants.

Type in United States National Museum.

The male of *tumida* is unknown. However, female specimens of *tumida* can not be distinguished from the types of *alboneura* except by a slight variation in size. It is highly probable that they are the same. This probability is strengthened by the fact that one specimen in each type set was collected from plum at the same place and on the same day (Fort Collins, Colo., September 31). These data, together with the similar color and appearance, indicate very strongly that *tumida* is a synonym of this species.

EMPOASCA COCCINEA (FITCH)

(Fig. 8)

Described by Fitch as *Empoa coccinea* in 1851 (11).

A small green to reddish species common on pine. Distinguished from related species by the genitalia. Length 3.2 mm.

Vertex appearing bulbous, strongly roundedly produced about one-third its length beyond anterior margins of the eyes. About one-fourth longer on middle than next the eyes, almost twice as wide between eyes as length at middle. Pronotum about one and one-half times as long as vertex.

Color: Varying from dull green to rather bright red; when green, usually tinged with red. Elytra greenish or smoky subhyaline.

Female genitalia: Last ventral segment with posterior margin rather broadly roundedly produced, more than twice as long as preceding segment.

Male genitalia: Valve broadly rounded; plates broad at base, evenly tapered to pointed acute tips, about three times as long as basal width. Of the male genital pieces, the oedagus is unique among the species of the genus by the possession of a pair of long structures which extend slightly posteriorly and caudally from the base of the oedagus proper; the lateral processes of the pygofers are very short; the spines of the tenth segment are very broad, but tapered and slender on the apical fourth. By these characters it is easily distinguished from all the other species of the genus.

Specimens in the United States National Museum are from Pennsylvania (Wirtner), Arnold Arboretum, Boston, Mass. (Morrison), and from Maryland.

A common species on white pine and collected occasionally on other species of pine. Known only from the eastern and north-eastern part of the United States and Canada. The known distribution apparently corresponds with the northern coniferous forest area.

Type in New York State Museum collection, Albany, N. Y.

THE SUBGENUS EMPOASCA WALSH

Vertex produced and strongly rounded or bluntly angled, length at middle usually about one-half width between eyes. Usually green or yellowish with white spots.

Type of subgenus, *fabae* Walsh.

KEY TO THE SPECIES OF THE SUBGENUS EMPOASCA WALSH

(*fabae* group)

- A. Size small, less than 3 mm. in length. Male lateral processes of pygofers slightly inflated laterally near base, then narrowed, in lateral view with apical third curved sharply upward and then interiorly. (Fig. 9)
-----*recurvata*, p. 38
- AA. Larger, 3 mm. or more in length.
 - B. Size 4 mm. in length.-----*snowi*, p. 39
 - BB. Less than 4 mm. in length.
 - C. Dull brownish red with white areolar spots; male lateral processes of pygofers long and slender; known only from California.-----*rubida*, p. 39
 - CC. Sometimes with brownish banding on elytra but without reddish coloration. Mostly green or yellowish.
 - D. Male plates narrow at base, long and appearing almost parallel margined to near apex, about three and one-half times as long as basal width.-----*barbara*, p. 40
 - DD. Male plates more triangular or broader proportionately at base.
 - E. Spines of chitinous ring around anal tube long and bifurcate at about two-thirds their length.-----*bifurcata*, p. 40
 - EE. Spines of chitinous ring around anal tube single, not bifurcate.
 - F. Male lateral processes of the pygofers slender, practically straight, tapered and neither enlarged, curved, nor hooked near tips.
 - G. Color yellowish, marked with white, elytra strongly mottled or banded with brown or smoky, male processes rather heavy.-----*birdii*, p. 41
 - GG. Pale green sometimes washed with orange, but without brownish coloration or banding of elytra.
 - H. Elytra with veins broadly white margined with green or smoky and with white spots on clavus and corium, dorsal spines with teeth on ventral margins.-----*pallidula*, p. 42

- HH. Elytra greenish without white veins, dorsal spines long without ventral teeth.
- I. Elytra green with orange tint and marked with large white spots ----- *hamata*, p. 43
- II. Elytra green without coloration or spotting.
- J. Later processes of pygofer long and narrow ----- *filamenta*, p. 43
- JJ. Lateral processes of pygofer shorter ----- *var. abbreviata*, p. 44
- FF. Male lateral processes of pygofer enlarged before apex or with curved or hooked tips or with fingerlike projections.
- K. Male lateral processes practically parallel margined, but broadly curved or bent near apex.
- L. Elytra usually banded with black, male lateral processes with apices curved outwardly, spines of anal ring curved directly into genital chamber. (Fig. 10) ----- *vincula*, p. 44
- LL. Elytra without dark markings, male lateral processes crossed, tips strongly curved inwardly, spines of anal ring directed ventrally and anteriorly ----- *deluda*, p. 46
- KK. Male lateral processes not parallel margined at apex or with hooked or fingerlike processes.
- M. Male lateral pygofer processes narrowed near middle and with long, tapering, terminal processes ----- *cerca*, p. 46
- MM. Male lateral pygofer processes with terminal portions short and not tapered.
- N. Male lateral processes narrowed and produced in fingerlike projections at apex (ventral view).
- O. Male processes from ventral view roundly inflated on inner margin, then gradually tapered to slightly curved attenuated apices ----- *fabae*, p. 47
- OO. Male processes usually not inflated (ventral view), but rather abruptly narrowed to fingerlike apical projections.
- P. Length 3.5 mm., male process rather abruptly narrowed near apex to outer thick fingerlike projections. (Fig. 10) ----- *abrupta*, p. 48
- PP. Smaller, about 3 mm. in length, outer fingerlike projections very narrow and attenuate. (Fig. 10) ----- *erigron*, p. 48
- NN. Male lateral process decidedly curved or hooked at apex (ventral view).
- Q. Apices of male lateral processes strongly curved or hooked with apex extending inwardly ----- *arida*, p. 49
- QQ. Apices of male lateral processes with a short attenuated hook at apex (ventral view) and a more pronounced hook at apex (lateral view) ----- *solana*, p. 50

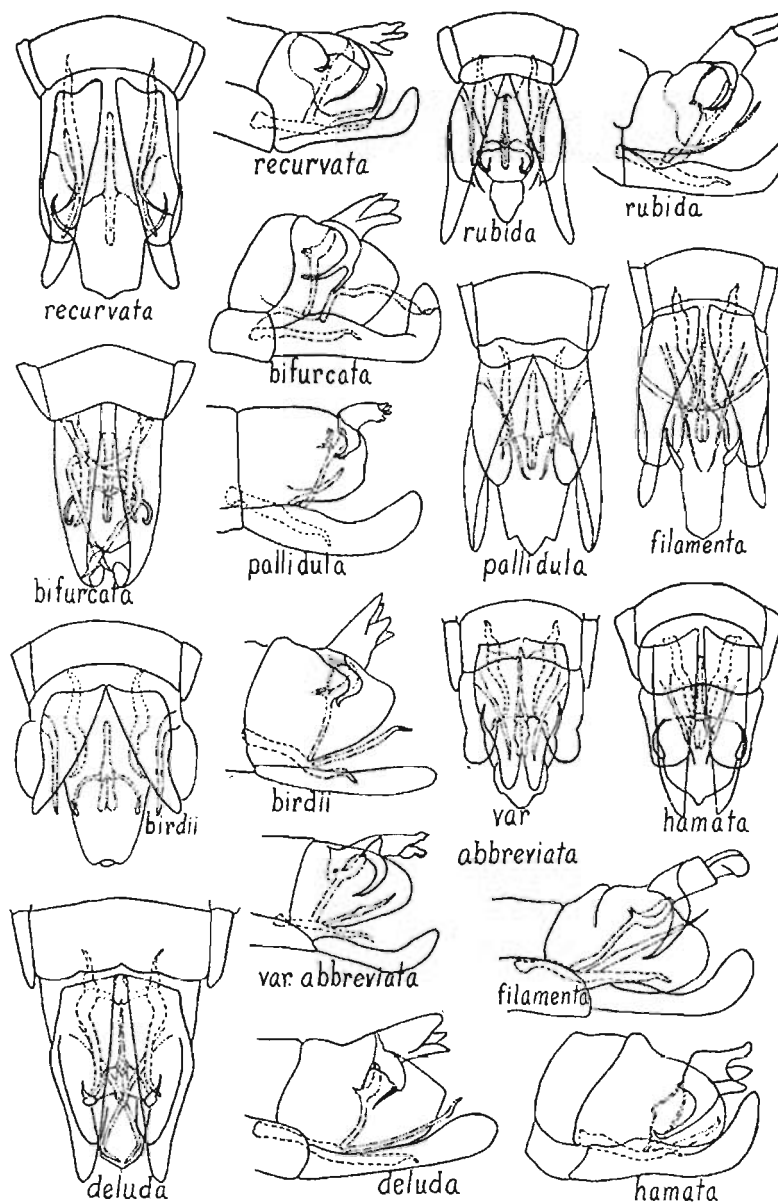


FIGURE 9.—Male genital pieces of *Empoasca*. $\times 55$

SPECIES OF THE SUBGENUS *EMPOASCA* WALSH

EMPOASCA RECURVATA N. SP.

(Fig. 9)

A small, blunt-headed species with robust male plates and distinct internal genitalia. Length 2.75 mm.

Vertex strongly rounded, bulbous, produced about one-half its length before anterior margins of the eyes, about one-third longer on middle than next eyes,

about one-half wider between eyes than length at middle; pronotum one-half longer than vertex, humeral angles prominent, pronotum wider than vertex.

Color: Pale green washed with yellow; vertex with a pair of pale green spots just back of margin; pronotum with three white spots which may be somewhat fused on anterior margin of pronotum; elytra yellowish green, definitely clouded.

Genitalia: Male valve broad and concave on posterior margin; plates three times as long as valve, parallel margined at base, tapered near tip to acute apices which are slightly upturned. Of the male genital pieces, the styles are long, slender, and almost straight with the exception of the slender divergent tips; the lateral processes in ventral view are constricted near base then slightly enlarged, again constricted about the middle and produced as slender parallel margined apical portions which in lateral view are abruptly curved upward with the apex bent slightly forward; the spines of the lateral processes are heavy at the base and a long, slender, slightly curved portion arises from this and extends ventrally and anteriorly.

Described from two male specimens collected by the author at Clarksville, Tenn., July 13, 1915, and August 4, 1917.

Holotype male and paratype male in author's collection.

EMPOASCA SNOWI GILLETTE

Described by Gillette in 1898 (13).

Since this species is represented by a single female type specimen it has been rather difficult to place it among our known and more common species. Apparently it is rather closely related to *arida* and *abrupta*. Length 4 mm.

Vertex rather strongly angled and produced about one-half its length beyond anterior margins of eyes, about one and one-half times as wide as length at middle; pronotum about twice as long as vertex.

Color: Greenish marked with orange yellow; vertex with a blotch next either eye and a somewhat irregular band between eyes just above margin of vertex; pronotum orange yellow with a row of five white spots along anterior margin of vertex, the second and fourth smaller and located just behind the inner margin of each eye; elytra greenish subhyaline, claval vein appearing striped with yellow.

Female genitalia: Last ventral segment with posterior margin slightly roundedly produced, a rounded notch on either side of central half dividing segment into three lobes, a small produced and rounded lobe at either side and a much larger, broadly rounded one at middle which is a little more produced. This female segment seems different from that of any other species of the genus.

A single female specimen in the United States National Museum from Magdalena Mountains, N. Mex., August, 1894, taken by Snow, is the only known record of this species. In view of this fact it has been rather difficult to place it.

EMPOASCA RUBIDA N. SP.

(Fig. 9)

A blunt-headed species with dull reddish mottling and white areolar markings. Length 3-3.3 mm.

Vertex bluntly rounded, produced about one-half its length before the anterior margins of the eyes, one-third longer on middle than next the eyes, about one-third wider between eyes than length at middle.

Color: Dull brownish red with white markings; vertex with a median stripe, a pair of spots enveloping ocelli, a smaller one between each of these and the corresponding eye, and a pair on the base next the eyes white; pronotum with three large white spots on the anterior margin, a small pale area on each humeral angle, and a larger one on the disk; scutellum with a median pale stripe on basal half and a pale spot at either side near middle; elytra with the

claval suture, a spot at base, one at about middle of clavus, two large spots on corium along claval suture, one at tip of clavus, and the costal area milky white; apices somewhat smoky subhyaline, nervures pale.

Female genitalia: Last ventral segment with the posterior margin slightly angularly produced.

Male genitalia: Valve almost truncated, slightly concave at middle; plates rather narrow, more than three times as long as basal width, tips slightly upturned. Of the male genital pieces, the styles are almost straight, slightly enlarged near the middle and with apices slightly divergent; the lateral processes of the pygofer appear almost straight in both ventral and lateral views and are slender, gradually tapering to long, acute, attenuated tips; the spines of the tenth segment are rather long and broadly curved.

Described from a large series of about 50 male and female specimens in the collection of E. D. Ball, all taken in California. The localities represented are Hamilton, San Francisco, Oxnard, and Spreckles. These were collected from April to September, inclusive, during 1907, 1908, and 1912.

Holotype male, allotype female, and male and female paratypes in the E. D. Ball collection, Tucson, Ariz. Paratypes in United States National Museum collection and author's collection, Columbus, Ohio.

EMPOASCA BARBARA HARTZELL

Described by Hartzell in 1923 (18).

A long, slender species with strongly produced head and long, slender male plates. Length 3.5 mm.

Vertex produced more than half its length beyond anterior margins of the eyes, more than one-third longer on middle than next the eyes, one-half wider between eyes than length at middle; pronotum twice as wide as long, humeral angles prominent.

Color: Dull greenish with variable pale markings; vertex, pronotum, and scutellum tinged with brown.

Male genitalia: Plates appearing long and slender, similar to those of the *maligna-atrolabes* group. Since so few specimens are known no material has been available for working out the internal genitalia.

Known only from male specimens collected in a pine grove at Pacific Grove, Calif., by Harold Morrison, in May, 1915.

Type in the Morrison collection, United States National Museum.

EMPOASCA BIFURCATA N. SP.

(Fig. 9)

A bright green species with yellow head, which has been confused with *fabae* and the European *flavescens* and has been placed under both names. It differs in having the head more produced, different genitalia, and a brighter green color. Length 3.2 to 3.5 mm.

Vertex produced more than half its length before the anterior margins of the eyes, almost one-half longer on middle than next eyes, one-half wider between eyes than middle length; pronotum twice as long as vertex.

Color: Bright green, vertex golden yellowish mottled with paler yellow around the ocelli and posterior to them; pronotum greenish, disk golden yellow, three large white spots on anterior margin of pronotum; scutellum with central white portion; elytra bright green, apices not colored, subhyaline, veins green.

Female genitalia: Last ventral segment with posterior margin roundedly produced.

Male genitalia: Valve concavely rounded; plates long with apical third upturned, frequently separated exposing styles, plates appearing from beneath short and broad. Of the male genital pieces, the lateral processes are very long and vermiculate, curving upward and laterally crossing the process from the other side and curving back again at the apex where it is broadened, then narrowed to form a sharp apex; the styles are almost straight; the spines of the tenth segment are broad, curving downward and anteriorly, and have a pair of long, divergent, fingerlike processes which are at least one-third the length of these chitinous spines.

The species is named "*bifurcata*" because of the bifurcate chitinous spines which are so conspicuous on each side of the chitinous anal ring (tenth segment). This is the only species known to have this type of spine.

Described from a series of more than 100 specimens ranging from Wisconsin and northern Pennsylvania to Miami, Fla. North East, Harrisburg, Hartstown, Cheswick, Landisburg, New Bloomfield, and many other localities in Pennsylvania are represented by material at hand collected by J. G. Sanders and the author. Specimens from Somerville, N. J., were collected by Professor Sanders also. A large series of specimens from Miami and Paradise Key, Fla., were collected by the author. Two specimens in the E. D. Ball collection are from Osceola, Wis., collected July 22, 1917.

Paratype specimens in the United States National Museum collection are from Agricultural College, Miss., Maryland, Kansas, Massachusetts, Alabama, and the District of Columbia, all in the C. F. Baker collection, and specimens from shrubs, Arnold Arboretum, Boston, Mass. (Morrison), and from Texas and Louisiana collected from tansy and other herbaceous plants. This is apparently a very common species throughout the eastern part of the United States.

Holotype male, allotype female, and paratype male and female in Sanders and DeLong collection, Columbus, Ohio. Paratypes in United States National Museum, the Canadian National collection, and the private collections of Herbert Osborn, Columbus, Ohio, and E. D. Ball, Tucson, Ariz.

EMPOASCA BIRDII GODING

(Fig. 9)

Described by Goding in 1890 (15) and treated as a variety of *Empoasca flavescens* by Gillette in 1898 (33), it has proved to be a good species and apparently is not closely related to *flavescens*. This species was apparently redescribed in 1898 by Gillette (13) from a series of specimens taken from cotton and which had been placed in alcohol before being mounted, so the green color had entirely disappeared leaving pure white insects which were described as *pallida*. Some of the specimens in the type series are apparently *fabae*, but the type is undoubtedly *birdii*.

Apparently rather closely related to the *fabae* group, but rather easily distinguished from them by the coloration and by the distinct genital characters. Length 3.3 mm.

Vertex rather broadly roundedly produced almost one-half its length beyond anterior margins of the eyes, about one-third longer on middle than next the

eyes, more than one-half wider between eyes than length at middle; pronotum twice as long as vertex; elytra usually rather long and narrow.

Color: Usually pale yellow marked with white or pale brown; vertex with a pale area around either ocellus, a median longitudinal line, and an oblique dash either side near eye, the remainder rather orange yellow; pronotum with three pale spots on anterior margin, a median spot, and one behind either eye; scutellum with a pale median-longitudinal band; elytra mottled and banded with brown or smoky, leaving pale areas along costa and at apex of clavus.

Female genitalia: Last ventral segment slightly produced, appearing keeled and angled at middle.

Male genitalia: Valve broad, concavely rounded between prominent lateral angles; plates broad at base, triangular, tapered to acute tips about two and one-half times as long as basal width. Of the male genital pieces, the lateral processes of the pygofer are almost straight, but not tapered to slender acute apices; the spines of the tenth segment are broad, rather strongly curved, and narrowed at apex.

Described from Illinois. Specimens in the United States National Museum collection are from Rutland, Ill. (Goding), Colorado, New York, Massachusetts, and Vancouver, British Columbia. Specimens in the E. D. Ball collection are from Franconia, N. H., and Kansas City, Mo. Specimens in the author's collection are from Columbus, Trinway, and Wooster, Ohio, and Indianapolis, Ind.

It breeds upon some of the common weeds, especially pigweed, and is found abundantly in cultivated fields where these weeds occur, but apparently it is not a pest of cultivated plants.

The specimens from Illinois in the United States National Museum are apparently the cotypes.

EMPOASCA PALLIDULA N. SP.

(Fig. 9)

A pale-green species with blunt head and many white areas upon the elytra. Length 3.5 mm.

Vertex bluntly angled and produced more than half its length before the anterior margins of the eyes, about one-third longer on middle than next eye and more than one-half wider between eyes than length at middle; pronotum about twice as long as vertex and with humeral angles prominent.

Color: Yellowish to pale green with white markings; vertex tinged with yellow, frequently marked with white spots; pronotum pale green with variable white markings; elytra pale green, the veins broadly white, two white spots on clavus, one on corium, and one before cross vein or inner apical cell, veins margined with green or smoky.

Female genitalia: Last ventral segment long with posterior margin angularly produced from prominent lateral angles to roundedly produced apex.

Male genitalia: Valve more than twice as long as preceding segment, truncated behind and gently rounded on either side to a shallow central notch; plates triangular, tapered to pointed apices, about three times as long as basal width. Of the male genital pieces, the styles are rather short, slightly broader at middle, and with both ends curved outwardly; oedagus broad; lateral processes almost straight and narrow, apices attenuated and turned inward; spines broad and rather short, narrowed at apex and with ventral apical portion serrate.

Described from nine female and six male specimens, all collected at Sabino Canyon, Ariz., June 29, 1919, by W. D. Edmondston.

Holotype male, allotype female, and paratypes male and female in author's collection. Paratypes in United States National Museum collection and in the private collection of E. D. Ball.

EMPOASCA HAMATA N. SP.

(Fig. 9)

Pale green washed with orange and marked with white. Length, 3 mm.

Vertex more than one-third wider between eyes than length at middle; pronotum almost twice as long as vertex.

Color: Vertex with median line, a basal spot next to either eye, and a spot enveloping each ocellus white; pronotum orange with three white spots on anterior margin, one at middle and one behind outer portion of each eye, also with white spots on apical third; elytra washed with orange, two spots anterior to claval vein, and two posterior, and claval vein milk white, apical third whitish subhyaline.

Female genitalia: Last ventral segment with posterior margin gradually, but rather strongly, produced and bluntly angled at middle.

Male genitalia: Valve angularly notched; plates more than three times as long as basal width, gradually tapered to acutely pointed apices which are upturned. Of the male genital pieces, the lateral processes of the pygofer are short and straight, constricted not far from base (in ventral view) and constricted again near apex, in lateral view the tips upturned; dorsal spines of tenth segment long, apical two-thirds narrowed, produced ventrally and anteriorly, and with tip turned upward.

Described from four specimens, three females and one male, collected at Mission Canyon, Santa Barbara, Calif., June 2, 1915, by Harold Morrison.

Holotype male, allotype female, and female paratypes in Morrison collection, United States National Museum.

EMPOASCA HAMATA VAR. ALLENOTA N. VAR.

Similar to *hamata*.

A small species with produced vertex and with elytra marked with white areolar spots. Male unknown. Length 3 mm.

Vertex more than one-third wider between eyes than length at middle; pronotum more than one-third longer than vertex; elytra exceeding abdomen by almost half their length.

Color: Vertex orange red, a broad median line, an oval oblique dash on either side not far from eye, a round spot enveloping each ocellus, and a small spot on margin next to either eye white; pronotum dull greenish, a broad median line, a small irregular spot behind each eye, and irregular vermiculate markings between these on anterior margin white; scutellum with a white median longitudinal line and a white spot half way along either side; elytra dull greenish tinged with orange yellow, a large elongate spot on anterior third of clavus, an oblique dash on posterior third, two large spots on corium just anterior to claval vein and venation of apex broadly white; face orange red with a median white stripe on upper half and a round spot halfway between each ocellus and antennal socket white.

Female genitalia: Last ventral segment with posterior margin produced from lateral angles to a bluntly angled apex.

Described from 14 female specimens labeled "Cala." in the C. F. Baker collection in the United States National Museum. Known only by female specimens.

Holotype female and female paratypes in the United States National Museum collection.

EMPOASCA FILAMENTA N. SP.

(Fig. 9)

Resembling *abrupta* and *arida* in size, form, and color, but distinguished by the different internal genital characters. Length 3.2 to 3.75 mm.

Vertex more than one-half longer on middle than next the eye, produced about one-half its length beyond the anterior margins of the eyes, more than a half wider between eyes than length at middle.

Color: Green varying in intensity, tints, and markings, frequently washed with yellow; vertex usually with the median stripe and oblique dashes, one either side just above the margin and again at base, white; pronotum usually with the three white spots on the anterior margin; scutellum with the broad white longitudinal stripe; elytra subhyaline.

Female genitalia: Last ventral segment twice as long as preceding segment, posterior margin strongly roundedly produced.

Male genitalia: Valve rather long, posterior margin concavely rounded; plates as broad as valve at base, gradually tapering to long attenuated tips which are frequently upturned. Of the male genital pieces, the lateral processes of the pygofer are long and slender, tapered to elongated and attenuated tips; the spines of the tenth segment are long, broad at base, rather broadly curved forward and extending about two-thirds the distance to the base of the pygofer.

Described from a series of three female specimens collected in Oregon September 7, and 6 males, 2 from the same locality and of the same date, 2 from Hood River, Oreg. (Webster No. 5914), collected by J. A. Hyslop, and 2 from Friday Harbor, Wash., collected from herbs in the Conifer Forest, July 26, 1928, by Martha Shackelford.

Holotype male, allotype female, and male and female paratypes in author's collection. Paratype males at Hood River, Oreg. (Webster No. 5914).

EMPOASCA FILAMENTA VAR. ABBREVIATA N. VAR.

(Fig. 9)

Size and coloration similar to those of *filamenta* and differing only in genital characters. Length 3.5 mm.

Male genital pieces: The chief difference between this and *filamenta* is in the shorter lateral processes of the pygofer, which seem to be proportionately wider. This may be only a variation in this character; yet it may be distinct from the preceding. Until more knowledge of these forms is obtained, it should probably be placed as a variety only. The styles are similar in these two forms, and the dorsal spine of the tenth segment is alike in both cases.

Collected at Hood River, Oreg., September 7. A series of seven specimens is at hand.

Holotype male, allotype female, and paratypes in author's collection.

EMPOASCA VINCULA N. SP.

(Fig. 10)

A banded species resembling *birdii* superficially, but with distinct genitalia. Length 3.75 mm.

Vertex bluntly angled, produced more than one-half its length beyond the anterior margins of the eyes, one-third longer on middle than next the eyes, more than one-half wider between eyes than length at middle; pronotum twice as long as vertex.

Color: Green; vertex, pronotum, and scutellum tinged with yellow and brown; elytra greenish, base of clavus, an elongated spot on center, claval suture, and the apical fourth of the elytra brown, veins and cross veins pale. These mottled areas give the elytra a banded appearance.

Female genitalia: Last ventral segment with posterior margin almost truncate, slightly produced at middle.

Male genitalia: Valve about twice as long as preceding segment, truncated posteriorly; plates large, parallel margined for about half their length, then tapered to acute tips. Of the male genital pieces, the lateral processes of the pygofer are long, with blunt, divergent apices, not narrowed or tapered; spines

of tenth segment heavy at base, sloping forward, narrowed and hooked backward and strongly inward into the genital chamber. It is unique in this respect and differs from any other species of the genus.

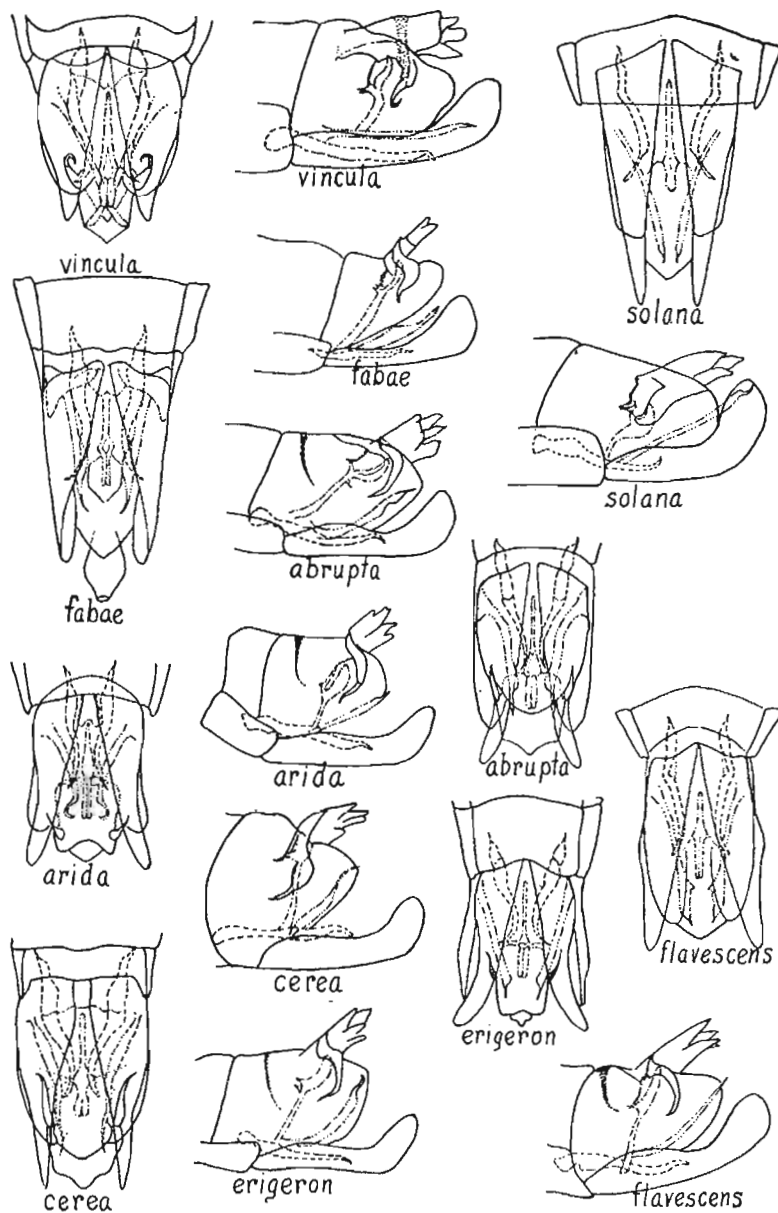


FIGURE 10.—Male genital pieces of species of *Empoasca*. $\times 55$

Described from three female and two male specimens collected at Birtle, Manitoba, from May 26 to August 8, 1928, by R. D. Bird.

Holotype male, allotype female, and male and female paratypes in author's collection. Paratype female in United States National Museum collection.

EMPOASCA DELUDA N. SP.

(Fig. 9)

In general appearance resembling *fabae* or *abrupta*, but with distinct genital characters. Length 3.5 to 3.75 mm.

Vertex bluntly angled, produced more than half its length beyond anterior margins of eyes, one-third longer on middle than next to eyes, more than one-half wider between eyes than length at middle; pronotum twice as long as vertex.

Color: Bright green; vertex with pale markings on median line and disk either side; pronotum with three large white areas, one at middle and one behind either eye on anterior portion of pronotum; scutellum with the apical third white; elytra greenish with subhyaline white spots, sometimes only pale greenish areas.

Female genitalia: Last ventral segment with margin on posterior half rather strongly, evenly, convexly rounded.

Male genitalia: Valve longer than and as broad as preceding segment, posterior margin slightly concave between the lateral angles; plates robust, broad at base, two and one-half times as long as broad, evenly sloping to blunt pointed apices. Of the male genital pieces, the styles are curved and enlarged at about the middle, the apical half more narrowed, almost straight, the apices slightly divergent; the lateral processes of the pygofers are long and slender, sloping inward and crossing near middle, with apical portions curving inward and almost meeting at center; the spines of the tenth segment have the basal portion broad and heavy and a spinelike structure arising from this and extending anteriorly and slightly ventrally.

Described from seven female and two male specimens collected at Birtle, Manitoba, May 26 to August 27, 1928, by R. D. Bird.

Holotype male, allotype female, and paratype male and female in author's collection. Paratypes in United States National Museum collection and in the E. D. Ball collection, Tucson, Ariz.

EMPOASCA CEREAE N. SP.

(Fig. 10)

Resembling *fabae* in general appearance, markings similar to *abrupta*. Length 3 mm.

Vertex roundedly produced, almost twice as wide between eyes as length at middle, one-third longer on middle than next the eyes; pronotum twice as long as vertex; elytra exceeding abdomen by about half its length.

Color: Vertex, pronotum, and scutellum green to bright yellow; vertex with a pair of oblique spots near eyes on basal portion, a pair on margin, one each side of apex, and one next each eye white; three white spots on anterior margin of pronotum, one at middle, and one behind each eye; scutellum with spots forming a rather irregular transverse band just back of middle; elytra greenish subhyaline.

Female genitalia: Last ventral segment roundedly produced on posterior margin, obtusely angled at middle.

Male genitalia: Valve concavely rounded on posterior margin; plates triangular, about three times as long as width at base. Of the male genital pieces, in ventral view the lateral processes of the pygofers are parallel margined for about one-third their length, then taper to long attenuated tips; in lateral view these processes have long narrow apices; the styles are curved inward at about half their length and are narrowed with the apices slightly diverging; the dorsal spines of the tenth segment are roundedly inflated from the base, then narrowed and produced into a terminal process which is curved ventrally and anteriorly.

Described from a series of 50 specimens, both sexes, in the collection of E. D. Ball. These were collected at Monroe, Helper, and Soldier, Utah, July and August, 1906, and from Hamilton County, Calif., by E. G. Titus from sugar beets August 21, 1907.

Holotype male, allotype female, and paratypes in collection of E. D. Ball. Paratypes in the United States National Museum collection and in the author's collection.

EMPOASCA FABAE HARRIS

(Fig. 10)

Because of its economic importance and the great variability in color and color patterns this species is known in literature under a variety of names. As far as can be ascertained it was first described by Harris in 1841 (16, p. 186) under the genus *Tettigonia*. In 1853 (19) it was redescribed as *mali* by Le Baron as a member of *Tettigonia*. Again in 1864 (27), when Walsh erected the genus *Empoasca*, it was apparently redescribed under three different names where color variations were encountered. The types were destroyed in the Chicago fire, and his species can not be verified, and the original descriptions do not distinguish them specifically. In his paper Walsh redescribed it as *viridescens*, *consobrina*, and *malefica*, the last named under the genus *Chloroneura*. In 1884 (12) Forbes redescribed it as *albopicta* in the genus *Empoa*.

Again in 1898 Gillette (13) redescribed it in part as *pallida* from a series of specimens taken from cotton and placed in alcohol which had caused the green color to entirely disappear, leaving pure white insects. Also in the same paper he referred certain of these color forms to *flavescens*, a European species which does not occur in North America so far as can be determined from material examined. Therefore, a large number of American references by Gillette and workers who followed him have actually dealt with *fabae* or with one of the other closely related species. These records will probably never be correctly placed unless specimens have been retained.

The most common and variable species in the genus, at least in the eastern part of the United States. Pale green, usually with a row of white spots on anterior margin of pronotum. Length 3.5 mm.

Vertex bluntly angled, a little longer on middle than next eye and about one-third wider between eyes than length at middle.

Color: Yellowish to pale green, markings variable; vertex frequently with pale or dark green spots; pronotum usually with a row of six or more pale spots along anterior margin which are sometimes missing or indistinct; elytra greenish subhyaline.

Female genitalia: Last ventral segment moderately produced and roundedly truncated.

Male genitalia: Valve produced and rounded or bluntly angled; plates triangularly tapered to pointed apices which are frequently upturned. Of the male genital pieces, the lateral processes of the pygofer are rounded on inner margins and broadened on apical half, then concavely rounded to narrow attenuated tips which are slightly curved inward; the spines of the tenth segment are broad with tips narrowed and directed downward. This combination of characters will distinguish it from the closely related species.

Specimens in the United States National Museum are from Pennsylvania (on apple), Virginia, Michigan, Chicago and Algonquin, Ill., Alabama, Massachusetts, Arkansas (on apple), Louisiana (potato and apple), District of Columbia, Florida, Kansas, Maryland, Iowa, New York, Missouri, Nebraska, and North Carolina (on cotton; described as *pallida* by Gillette).

This is probably the most injurious species of the genus. It is known to occur on a great variety of plants. It is common on potato,

bean, clover, alfalfa, eggplant, rhubarb, cotton, dahlia, and to a large extent upon apple, especially the younger trees or nursery stock. These are probably the most important food plants, although it has been recorded from many others.

Life-history studies (4) have revealed four distinct broods of these leaf hoppers during the season, with one complete generation, a second almost complete, a partial third, and a smaller partial fourth generation. Under field conditions in Ohio in 1927 the first eggs were laid about May 25, and on November 1 eggs were still hatching.

EMPOASCA ABRUPTA N. SP.

(Figs. 2 and 10)

Resembling *fabae* in size, form, and appearance but usually with different markings. The internal genitalia are distinct. Found only in the West and Southwest. Length 3.5 mm.

Vertex produced almost one-half its length before the anterior margins of the eyes, about one-third longer on middle than next the eyes and one-half wider between eyes than length at middle; elytra long.

Color: Green marked with white; vertex with a median stripe, a pair of oblique dashes just above ocelli, and a pair on the base white; pronotum usually with three large white spots on anterior margin; a broad white stripe across middle of scutellum; elytra greenish, subhyaline, nervures green.

Female genitalia: Last ventral segment strongly roundedly produced, more than twice the length of the preceding segment.

Male genitalia: Valve a little longer than last ventral segment, posterior margin concavely rounded; plates rather broad at base, long and tapered to pointed apices. Of the male genital pieces, the lateral processes of the pygofer in ventral view are rather broad and almost parallel marginol to near apex where they are abruptly narrowed to form slender, fingerlike processes on their outer margins; the spines of the tenth segment are rather long, tapering, directed downward and then forward at the apex.

A large number of this species were collected on potato and forwarded from California by H. H. P. Severin. The injuries to potato and bean are entirely different from the injury produced by *fabae* upon the same plants. It should probably be given the common name, "western potato leaf hopper."

This species, together with *arida*, replaces *fabae* as a truck-crop pest in the extreme western part of the United States.

Described from a series of 17 specimens collected at Stockton, Calif., August, 1919, by F. E. Blaisdell, a series collected from potato by H. H. P. Severin near Berkeley, Calif., May, 1929, and a series of specimens in the United States National Museum from California, Colorado, Arizona, Texas, and Oregon.

Holotype male, allotype female, and paratypes in author's collection. Paratypes in the United States National Museum collection, in Canadian National collection, and in the collection of E. D. Ball.

EMPOASCA ERIGERON N. SP.

(Fig. 10)

A small green species resembling *fabae* but with more produced head. Length 3 mm.

Vertex bluntly produced about one-half its length beyond the anterior margins of the eyes, more than one-half as long on middle as next the eyes, and about one-half wider between eyes than length at middle; pronotum one-half longer than vertex.

Color: Green, tinged with yellow, markings variable; vertex usually with a median stripe and a pale, curved, parenthesis mark at either side on disk and extending the length of the vertex; pronotum with three large white spots on anterior margin, one at middle, and one behind each eye; elytra yellowish brown, apical portion white, veins conspicuous.

Female genitalia: Last ventral segment with posterior margin roundedly produced.

Male genitalia: Valve slightly indented on posterior margin; plates about three times as long as width at base, tips upturned one-third their length with apices bluntly angled. Of the male genital pieces, the lateral processes of the pygofers are long and almost parallel margined with fingerlike processes on outer margins in ventral view, in lateral view with a narrowed, curved, fingerlike portion at apex; spines of tenth segment broad at base, directed ventrally and with apical portion curved sharply and directed almost anteriorly.

Described from a series of 42 specimens taken by the author at Covington, Dyersburg, and Clarksville, Tenn., in June, July, and August of 1915 and 1917.

Since describing this species from material collected about 12 years ago, a large number of specimens have been examined from Washington, D. C. (Poos), and Columbus, Ohio (DeLong). Doctor Poos has found in connection with his work with *fabae* that the species *erigeron* passes the winter in the egg stage upon *Erigeron annuus* and several other wild hosts. In Ohio it hatches in these habitats in late April and early May and is one of the earliest of the genus flying in the spring. Because of this it has undoubtedly been mistaken for *fabae* upon wild host plants in early spring by previous workers, especially since it is so common and abundant.

Holotype male, allotype female, and paratypes in author's collection. Paratypes in the United States National Museum collection and in the collection of E. D. Ball.

EMPOASCA ARIDA N. SP.

(Fig. 10)

Resembling *fabae* in form and appearance and definitely distinguished from it only by an examination of the internal male genitalia. It occurs only in the western part of the United States according to present records. Length 3.2 to 3.5 mm.

Vertex bluntly produced about half its length before the anterior margins of the eyes, more than one-half longer on middle than next the eyes, one-half wider than length at middle; pronotum twice as long as vertex, humeral angles produced and prominent.

Color: Green, vertex and pronotum often tinged with yellow, markings variable; sometimes with three rather large white spots on anterior margin of pronotum or a series of about six smaller spots; scutellum usually with a median pale stripe sometimes almost concealed by the pronotum; elytra greenish subhyaline, abdomen usually visible from above.

Female genitalia: Last ventral segment with posterior margin roundedly produced.

Male genitalia: Valve twice as long as preceding segment, posterior margin roundedly produced; plates rather broad at base, two and one-half times as long as wide, tips upturned, plates frequently separated at tips, exposing upturned apices. Of the male genital pieces, the lateral processes of the pygofers in ventral view are almost parallel margined to near apex where they are narrowed, and formed into a hooked curved portion extending from the outer margins and with the apex extending inward; the spines of the tenth segment are long, tapering, broadly curved, with apices extending ventrally.

Described from a large series of more than 250 specimens in the collection of E. D. Ball, taken chiefly from sugar beets and alfalfa

in Utah and California. Localities represented by this material are Oxnard, Chino, Stanford University, Salinas, Riverside, Pasadena, Spreckles, and Sacramento, Calif., and Logan and Soldier, Utah.

In the western part of the United States this species apparently partially replaces or is comparable to *fabae* in the East, especially upon such plants as the sugar beet.

Holotype male, allotype female, and paratypes in the E. D. Ball collection. Paratypes in the United States National Museum collection and in that of the author.

EMPOASCA SOLANA N. SP.

(Fig. 10)

In size and appearance resembling *fabae*, but bright green without markings on vertex or pronotum and with distinct internal genitalia. Length 3.3 mm.

Vertex bluntly produced, about one-third longer on middle than next the eyes, almost one-half wider between eyes than length at middle, produced about one-half its length beyond anterior margins of the eyes; pronotum about one-half longer than vertex.

Color: Bright green, washed with yellow; vertex and pronotum strongly tinged with golden yellow; scutellum with a median white stripe and some white spots on posterior half; elytra greenish subhyaline tinged with yellow.

Male genitalia: Valve three times as long as preceding segment, posterior margin slightly produced and rounded; plates triangular, elongate, rather broad at base, three times as long as basal width, gradually tapered to long acute tips. Of the male genital pieces the styles are almost parallel margined on the basal two-thirds and slope inward, then are narrowed and curved outward from outer margin; the lateral processes of the pygofers in ventral view appear abruptly narrowed and slightly attenuated at apex, in lateral view they are long and narrow, terminally narrowed, concavely curved upward forming a slightly hooked, narrowed apex; the spines of the tenth segment appear as rather broad chitinous plates with apices narrowed and bluntly rounded and directed anteriorly and ventrally.

Described from two male specimens collected on potato at Baton Rouge, La., one by T. H. Cutrer, October 28, 1918, and the other May 16, 1922, by C. E. Smith.

Holotype male, collected May 16, 1922, in the United States National Museum collection. Paratype male, collected October 28, 1918, in the author's collection.

THE SUBGENUS IDONA NOV.

Vertex strongly produced, sometimes bluntly, but usually distinctly angled. In all species the vertex is almost as long at middle as width between the eyes. In some cases the vertex is longer on middle than the width.

Type of subgenus, *minuenda* Ball.

KEY TO SPECIES OF THE SUBGENUS IDONA NOV.

- A. Length more than 3 mm.
 - B. Length 4 mm. *panda*, p. 51
 - BB. Less than 4 mm. in length.
 - C. Dark green washed with brown, without definite markings; vertex yellowish green; occurs on red cedar. *junipera*, p. 51
 - CC. Paler greenish or yellow with distinct color markings.
 - D. Long and narrow, pale yellowish green, unmarked; male lateral processes of pygofers very short and tapered. (Fig. 11) *elongata*, p. 53

- DD. More robust, shorter, not over 3.5 mm.; reddish brown, or with red markings; male lateral processes of pygofers long and with distinct apical structures.
- E. White to pale green, vertex mottled with bright red leaving white areoles; male lateral processes of pygofers long and bowed----- *rufa*, p. 53
- EE. With dull red or brownish red coloration and without white areoles on vertex.
- F. Yellowish tinged with red; pronotum and scutellum dull reddish; male lateral processes of pygofers with inwardly curved tips----- *tincta*, p. 54
- FF. Elytra pale green with brownish markings, a large pale area on base of clavus at either side; male lateral processes of pygofers with fingerlike tips, projecting on outer apical margins----- *morrisoni*, p. 54
- AA. Length less than 3 mm.
- G. Very small, not exceeding 2 mm. in length, common on avocado in Florida----- *minuenda*, p. 55
- GG. Larger, 2.5 mm. or more.
- H. Vertex strongly angled, almost as long at middle as width between eyes; elytra pale green, a reddish or orange stripe along claval suture----- *radiata*, p. 56
- HH. Vertex more bluntly angled, about one-half wider between eyes than length at middle; elytra greenish, veins white.
----- *mexicana*, p. 56

SPECIES OF THE SUBGENUS IDONA NOV.

EMPOASCA PANDA N. SP.

(Fig. 11)

A rather large species with strongly produced vertex, yellowish, marked with white. Length 4 mm.

Vertex produced more than half its length beyond anterior margins of eyes, almost twice as long on middle as next the eyes, about two-thirds wider between eyes than length at middle; pronotum more than twice as long as vertex; humeral angles produced and prominent.

Color: Golden yellow, elytra pale green; vertex with median white stripe, a pair of oblique dashes just above margin and a pair on basal portion white; three white spots on anterior margin of pronotum; scutellum with a broad median white stripe.

Female genitalia: Last ventral segment roundedly produced.

Male genitalia: Valve broad, slightly concave; plates rather long, gradually tapered to acutely angled tips. Of the male genital pieces, in ventral view the lateral processes taper to pointed apices, in lateral view they are convexly bowed outward just before the apex; the styles are rather short and in ventral view are roundedly inflated at the base, the apices taper and are divergent; the dorsal spines are heavy at the base, and a terminal spur projects at right angles from the basal portion.

Described from two female and two male specimens from Vancouver, B. C., in the C. F. Baker collection, labeled 2228.

Holotype male, allotype female, and paratypes in the United States National Museum collection.

EMPOASCA JUNIPERA N. SP.

A dark green species which occurs on red cedar and has the most pointed head of any of the species of the genus. Length 3.3 mm.

Vertex produced more than one-half its length before the anterior margins of the eyes, almost twice as long on middle as next the eyes, one-half wider between eyes than middle length; pronotum less than one-half longer than vertex.

Color: Dark green tinted with brown; vertex yellow-green, a bright green area above apex; pronotum with a pale area behind either eye; elytra brownish green, unmarked, apices smoky; face and beneath yellowish to green.

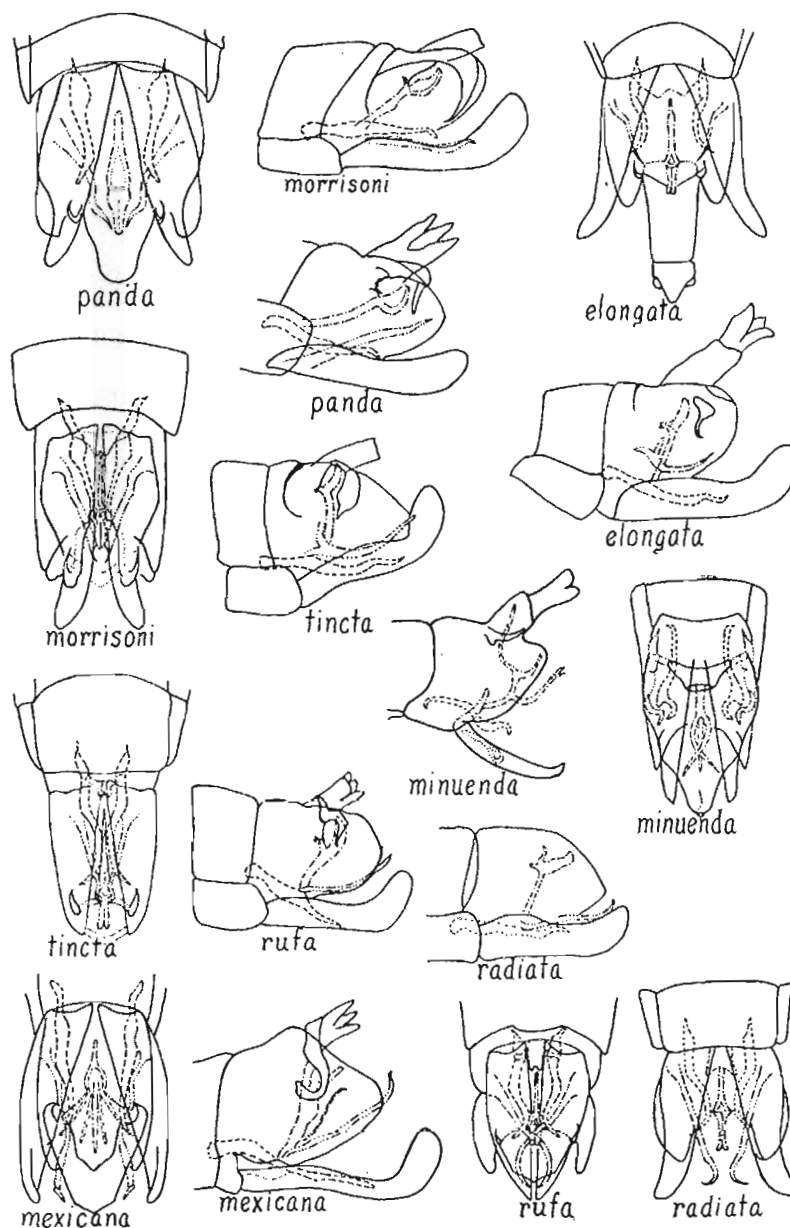


FIGURE 11.—Male genital pieces of species of *Empoasca*. $\times 53$.

Female genitalia: Last ventral segment more than twice as long as preceding, posterior margin appearing almost truncate, slightly indented on either side of central slightly produced lobe or tooth.

Male genitalia: Valve slightly produced, plates appearing short, rather narrow, and with upturned tips.

Described from a series of one male and six female specimens collected from red cedar, *Juniperus virginiana*, at Newport, Tenn., June 14, 1928, by Neale F. Howard and the author. The female is designated as the type; although the male is apparently of the same species, it has a slightly shorter vertex.

Holotype female, allotype male, and paratypes in the author's collection. Paratype female in the United States National Museum collection.

EMPOASCA ELONGATA N. SP.

(Fig. 11)

A long, slender species, pale green to yellow, with a rather strongly produced head and with distinct genital characters. Length 3.75 mm.

Vertex produced about two-thirds its length beyond anterior margins of the eyes, almost twice as long on middle as next the eyes, about one-half wider between eyes than length at middle; elytra very long and narrow.

Color: Green to yellowish, pronotum and scutellum sometimes tinged with orange-yellow; vertex usually with a median stripe and pronotum usually with three spots on the anterior margin and a white stripe on scutellum; elytra pale green, an orange stripe extending from base of wing just outside the claval suture almost to cross veins, also an orange stripe on inner margins of elytra along commissural line from scutellum to apex of clavus.

Female genitalia: Last ventral segment with posterior margin rather gently, broadly curved and only slightly produced.

Male genitalia: Valve narrowed, posterior margin slightly produced; plates rather small, narrow, and appearing rather short, about two and one-half times as long as broad at base, tips rather strongly upturned, plates densely covered with fine white hairs. Of the male genital pieces, the styles are narrow, quite strongly curved outward on apical half; the lateral processes of the pygofer are rather short, curved at base, then tapering to acutely pointed tips; the spines of the tenth segment are narrowed apically and directed ventrally and posteriorly.

Described from a series of 16 females and 7 males collected at Friday Harbor, San Juan Island, Wash., July 26, 1928, by Martha Schakleford, from shrubs in coniferous and alder forests. Also from a series of 12 specimens in E. D. Ball's collection from Sacramento, and Spreckles, Calif., and Helper, Utah, collected in August and September, 1906 and 1907.

Holotype male and allotype female, and paratypes in the author's collection. Paratypes in the collection of E. D. Ball and in the United States National Museum collection.

EMPOASCA RUFA, N. SP.

(Fig. 11)

A small white species with reddish mottling on the head and with distinct genital characters. Length 3.2 mm.

Vertex bluntly pointed, produced about one-half its length beyond anterior margins of the eyes, almost twice as long on middle as next eyes, about one-fourth broader between eyes than length at middle; pronotum one-half longer than vertex.

Color: White, upper portion of face, margin of vertex between eyes, and vertex with a complete network of bright red pigmentation with round white spots exposed. On the vertex there is a large white spot just above apex which is constricted behind, then expanded to form a large basal spot; a pair of spots either side between this basal spot and the eye and a pair on each side of apex on the margin; the outer spot on each side envelopes the ocellus.

Pronotum milk white flecked with gray; elytra milky white flecked with small round gray spots, a larger one about the middle of the clavus along the commissural line of each elytron, apex faintly smoky, nervures white.

Female genitalia: Last ventral segment slightly concavely rounded from prominent lateral angles.

Male genitalia: Valve produced, posterior margin concave; plates appearing twice as long as valve and pointed, but with tips upturned and blunt or rounded. Of the male genital pieces, the styles are strongly curved outward at middle with tips strongly diverging; the oedagus is narrow at base, enlarged at apex; the lateral processes of the pygofers are long and curving, in ventral view directed inward, and crossing just beyond middle, then with apices produced and curved inward until they almost touch; the spines of the tenth segment are short and broad, directed backward, then downward, with apices acutely pointed.

Described from a series of one female and seven male specimens collected at Pasadena, Calif., June 17, 1908, by E. D. Ball. The male is designated as the type.

Holotype male, allotype female, and paratypes in the E. D. Ball collection. Paratype male in the author's collection.

EMPOASCA TINCTA N. SP.

(Fig. 11)

Easily distinguished from the other members of the genus by its pointed head and dull reddish tint. Length 3.5 mm.

Vertex decidedly pointed or angled and produced more than half its length before the anterior margins of the eyes, almost twice as long at middle as next the eyes, about one-half wider between the eyes than length at middle.

Color: Vertex yellowish, sometimes tinged with red; pronotum and scutellum dull reddish; elytra slightly tinged, subhyaline; abdomen reddish, and easily visible from above; beneath, yellow tinged with red.

Female genitalia: Last ventral segment with posterior margin roundedly produced, the entire margin shallowly notched so as to form about six short, rounded lobes.

Male genitalia: Valve rather broad, truncated posteriorly, and slightly notched at middle; plates rather broad at base, produced and appearing blunt at the tips, but with apical portion turned upward. Of the male genital pieces, the styles are long and slender, curved inward just beyond the center, their apices diverging; the lateral processes of the pygofers are slender, curved outward just before the apex, their tips converging; the spines of the tenth segment are broad and appear more like plates with apices narrowed and pointed and directed ventrally.

Described from a series of six female and five male specimens from Ephraim, Utah, July 20, 1914, in the collection of E. D. Ball.

Holotype male, allotype female, and paratypes in the E. D. Ball collection. Paratypes in the author's collection and in the United States National Museum collection.

EMPOASCA MORRISONI HARTZELL

(Fig. 11)

Described by Hartzell in 1923 (18).

A species with prominently produced head and distinct white markings. Internal genital characters distinct. Length 3.5 mm.

Vertex prominently produced and sharply rounded, almost twice as long at middle as next the eye, one-half wider between the eyes than length at middle, produced more than one-half its length before anterior margins of the eyes, pronotum long, about twice as long as vertex.

Color: Vertex, pronotum, and scutellum pale brown; vertex with a median white line and a spot on either side just above apex; pronotum with three large white spots, one at middle and one behind either eye along anterior margin; elytra pale green marked with brown and white, anterior third washed with brown, a large pale green area almost white on the base of the clavus, apical third of elytra brown or smoky, veins broadly greenish and prominent.

Female genitalia: Last ventral segment roundedly produced to rather prominently angled apex.

Male genitalia: Plates about four times as long as basal width, tips upturned. Of the male genital pieces, the styles are enlarged at the center and produced almost straight, sloping inwardly to apices; the lateral processes of the pygofer are long, almost parallel margined and with slender produced fingerlike processes on the outer margins as seen in ventral view; the spines of the tenth segment are long, broad at base, then gradually narrowed to acute apices which are directed ventrally and slightly anteriorly.

This species is known only from a series of specimens collected by Harold Morrison in a pine grove at Pacific Grove, Calif., May 29, 1915.

Type in the Morrison collection, United States National Museum.

EMPOASCA MINUENDA BALL

(Fig. 11)

Described by Ball in 1921 (1).

A very small, green species with strongly angled vertex. It is a pest of avocado. Length 2 mm.

Vertex sharply angled, produced about one-half its length before the anterior margins of the eyes, twice as long on middle as next eyes and as long at middle as width between the eyes; pronotum one-half longer than vertex.

Color: Varying from pale to golden yellow, without definite markings except in varietal forms.

Female genitalia: Last ventral segment with the posterior margin roundedly produced.

Male genitalia: Valve triangularly produced; plates elongate, triangular, narrowed to attenuate apices which are upturned. The structures of the male genital pieces are very peculiar in *minuenda* and rather difficult to describe. In ventral view a pair of processes arise at about the middle of the oedagus and extend caudally and posteriorly. The oedagus extends dorsally from this point and another portion curves off in the same manner, but is not paired. The lateral processes of the pygofer seem to be lacking or so minute that they are not easily recognized. The styles are long and narrow at the base, then become enlarged and divergent with a convexly curved fingerlike process arising on the inner margin of each near its apex.

Described from specimens collected at Miami, Fla., on avocado by G. F. Mozzette and known only from this place and food plant.

This species resembles very strongly a *Dikraneura* in general appearance, and the wing venation is slightly different from the typical *Empoasca* venation, but according to the present classification it should probably be placed in the *radiata* group.

Type in collection of E. D. Ball.

EMPOASCA MINUENDA VAR. MOZNETTEI BALL

Described by Ball as variety *moznettei* in 1921 (1).

Differing from typical *minuenda* by a pair of separated spots on the pronotum, three spots, one large and two small, on the scutellum, and six spots on each elytron black. Two are found on the clavus, three on the costa, and one on the corium of the elytra.

Found on avocado with typical *minuenda*.

EMPOASCA MINUENDA VAR. CLAVIGERANA BALL

Described by Ball as variety *clavigerana* in 1921 (1).

Differing from typical *minuenda* by a pair of dark stripes which arise just back of margin of vertex and extend across vertex, pronotum, and scutellum, and along inner margins of elytra where they frequently appear as one stripe, fusing on the scutellum. These stripes are sometimes composed only of broken dashes.

Occurs on avocado in company with the preceding species and variety.

EMPOASCA RADIATA GILLETTE

(Figs. 2 and 11)

Described by Gillette in 1898 (13).

A small species with strongly produced vertex and with reddish or orange stripes on clavus of elytra. Length 2.75 mm.

Vertex produced more than one-half its length beyond the anterior margins of the eyes, twice as long on middle as next to eyes and only slightly wider between eyes than length at middle; pronotum about one-third longer than vertex, humeral angles prominent so that pronotum is wider than head.

Color: Dull greenish, marked with white and red; vertex with a paler median line and oblique dashes which are sometimes wanting; pronotum with three rather large white spots on anterior margin; scutellum with posterior half white; elytra pale greenish, a stripe along claval suture, a broad one along anal margin, and a stripe along anterior half of commissural line red or orange.

Female genitalia: Last ventral segment produced, posterior margin roundedly notched either side of produced central half.

Male genitalia: Valve about twice as long as preceding segment, posterior margin concavely rounded; plates rather long but appearing short and with pointed apices because of the lateral curling of the apical fourth. Of the male genital pieces, the styles are strongly curved at middle with tips divergent; the lateral processes of the pygofer are long with apices curved outward.

The type is from Colorado and other specimens in the National Museum collection are from Texas. Specimens in the author's collection are from Washington, D. C., and Knoxville, Clarksville, and Paris, Tenn.

This species was collected from herbaceous vegetation. The exact food plant is not known.

Type in the United States National Museum.

EMPOASCA MEXICANA GILLETTE

(Fig. 11)

Described by Gillette in 1898 (13).

A very small species with bluntly pointed head and a striped appearance. Internal male structures unique. Length 2.5 mm.

Vertex bluntly angled, produced more than one-half its length before anterior margins of the eyes, almost twice as long on middle as next the eyes, about one-half wider between eyes than median length; pronotum one-half longer than vertex.

Color: Green washed with yellow, vertex and pronotum varying from green to golden yellow; vertex with a median pale stripe sometimes extending across pronotum, a spot either side on margin, and a spot on either side at base white; scutellum with white mottling; elytra greenish subhyaline, the veins broadly white, causing the insect to appear striped.

Female genitalia: Last ventral segment broad, almost truncate.

Male genitalia: Valve concave and slightly broadly notched at center; plates robust, rather heavy, elongate, tips upturned and blunt, outer margins convexly

rounded, sparsely clothed with short, inconspicuous hairs. Of the male genital pieces, the styles are long and narrow, wider on basal than on apical half; the lateral processes are long and in lateral view curved upward at the tip, in ventral view they are narrow on basal two-thirds, then widened, and the apices are sharp pointed and directed inward; the oedagus is rather large, with a pair of long, slender processes arising on the posterior side near the base and extending almost dorsally. Another process arises in similar location but more dorsally. The dorsal spines of the tenth segment extend ventrally and curve sharply anteriorly. The apices of these processes are broad and heavy.

A series of specimens consisting of five females and three males collected at Marfa, Tex., June 5, 1908, by Mitchell and Cushman, and now in the United States National Museum collection, are apparently this species. Gillette's type could not be located in the National Museum.

LIST OF DESCRIBED SPECIES WITH SYNONYMS

In the present revision 51 species have been treated. Twenty-four of these have been described before and 27 are described as new in this bulletin. In addition to those mentioned above, 13 species are placed as synonyms of other described species, and 1 European species is placed as a synonym of an American species because it was cited in error. Also 10 varieties are treated, 7 of which were previously described and 3 of which are described as new in this revision.

The species and varieties have been placed in four subgenera, two of which were previously described and two of which are described in this bulletin. A list of the species and varieties treated in this revision follows:

Subgenus *Krbos* Fieber:

- pergandei* Gillette (1898).
- acodens* n. sp.
- pectinata* n. sp.
- trilobata* n. sp.
- marginata* Walsh (1864).
- unicolor* Gillette (1898).
- denticula* Gillette (1898).
- atrolabes* Gillette (1898).
- unica* Provancher (1890).
- splendida* Gillette (1898).
- obtusata* Walsh (1864).
- incisa* Gillette (1898).
- incisa* n. sp.
- patula* n. sp.
- patula* var. *magna* n. var.
- albolinea* Gillette (1898).
- saluta* n. sp.
- aureoviridis* Uhler (1877).
- aureoviridis* var. *vittata* Hartzell (1923).
- amaragdula* Fallen (1806).
- viridipes* Curtis (1837).
- trifasciata* Gillette (1898).
- digita* n. sp.
- copula* n. sp.
- livingstoni* Gillette (1898).
- clipeata* Gillette and Baker (1895).
- clipeata* var. *annella* Hartzell (1923).
- adunca* n. sp.
- osborni* Hartzell (1923).

Subgenus *Hebata* nov.:

- nigra* Gillette and Baker (1895).
- nigra* var. *typhlocyboides* (1895).
- robusta* Gillette (1898).
- nigra* var. *nigroscuta* Gillette and Baker (1895).
- nigra* var. *pulchella* Gillette and Baker (1895).
- aspera* Gillette and Baker (1895).
- albocura* Gillette (1898).
- tumida* Gillette (1898).
- coccinea* Fitch (1851).

Subgenus *Empoasca* Walsh:

- recurvata* n. sp.
- snovi* Gillette (1898).
- rubida* n. sp.
- barbara* Hartzell (1923).
- bifurcata* n. sp.
- birdii* Goding (1890).
- pallida* Gillette (1898) in part.
- pallidula* n. sp.
- hamata* n. sp.
- hamata* var. *albonota* n. var.
- filamenta* n. sp.
- filamenta* var. *abbreviata* n. var.
- vincula* n. sp.
- detuda* n. sp.
- cercia* n. sp.
- fabae* Harris (1841).
- mati* LeBaron (1853).
- viridescens* Walsh (1864).
- consobrina* Walsh (1864).
- malefica* Walsh (1864).
- albopicta* Forbes (1884).
- pallida* Gillette (1898) in part.
- flavescens* Fabricius (1794) (American records cited in error).

Subgenus *Idona* nov.:

- abrupta* n. sp.
- erigeron* n. sp.
- arida* n. sp.
- solana* n. sp.
- panda* n. sp.
- junipera* n. sp.
- elongata* n. sp.
- rufa* n. sp.
- linctata* n. sp.
- morrisoni* Hartzell (1923).
- minuenda* Ball (1921).
- minuenda* var. *moznetti* Ball (1921).
- minuenda* var. *clavigerana* Ball (1921).
- radiata* Gillette (1898).
- mexicana* Gillette (1898).

SPECIES NOT INCLUDED IN THIS REVISION

Empoasca tessellata (Fieber). Described by Fieber (10) in 1872 as *Chlorita tessellata*. Although specimens of this European species have not been examined, it is apparently different from Gillette and Baker's *aspersa* which had been cited as a synonym and if so it apparently does not occur in North America.

Empoasca salinarum (Berg). Described as *Typhlocyba salinarum* by Berg (2, p. 274) in 1879. It apparently does not occur in North America.

Empoasca flavescens (Fabricius). Described as *Cicada flavescens* by Fabricius (6, p. 46) in 1794. As stated previously in this paper, *flavescens* has not been found in any material available for examination at this time. A drawing has been included in Figure 8, however, to facilitate comparison with American species.

Empoasca pura (Stål). Described as *Typhlocyba pura* by Stål (23, p. 195) in 1858. No specimens authentically identified have been available for comparison, and from the description it seems doubtful that this species is represented in North America. It has therefore been omitted from this revision of the North American species.

Empoasca alboscipita Van Duzee. Described by Van Duzee (25, p. 56) as *Empoasca alboscipita* in 1914. This is undoubtedly a true *Empoasca* but it has been impossible to secure any material authentically identified. Since a number of species are closely related it has been impossible to place it, and it has therefore been omitted from the present revision.

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