

The Jumping Plant Lice (Family Psyllidae) of the Hawaiian Islands.

A STUDY IN INSECT EVOLUTION.

BY D. L. CRAWFORD.

The fauna and flora of the Hawaiian archipelago are of more than common interest because of the great isolation of these islands from other land bodies and also because they appear to have held such an isolated position for a very great lapse of time—perhaps since the Paleozoic era.

The native vertebrate fauna is exceedingly limited, an endemic bat being the only mammalian species surely native. A considerable number of birds occur, most of the species having developed here from a few early immigrants. No endemic reptiles nor amphibia are found here, with the possible exception of a species or two of skinks and these probably were brought in by human agency.

Among invertebrates, certain groups of land shells (Mollusca) and insects are the most abundant, and at the same time present some very remarkable features. First among these remarkable features is the large number of endemic species representing a comparatively small number of groups. That is to say a comparatively small number of insect and molluscan species have in the more or less remote past chanced to arrive here and establish themselves and, rejuvenated by the new and favorable environment in which they found themselves, have split up into a large number of derivative species and even genera, and in several cases even endemic families—one endemic family of beetles (Proterhinidae), one of land shells (Achatinellidae), and one of birds (Drepanididae). This of course indicates that plant immigrants had already established a flora of the Islands upon which these animal immigrants found sustenance.

A second remarkable and significant feature of the endemic

fauna is the fact that nearly all groups are inhabitants of dead wood and debris of the kind that sometimes drifts about the oceans, or if not of that type are usually strong in flight. There are no native leaf-eating beetles or grasshoppers or similar insects. The beetles are nearly all wood-borers or ground beetles which commonly hide away under bark. Nearly all the Hymenoptera are borers or forms which nest in logs, etc. Diptera are represented mostly by debris inhabiting forms, while of the Lepidoptera we have no native butterflies except one comparatively recent immigrant, but a considerable number of moths some of which are strong in flight and others pupate under bark or in similar situations.

The conclusion to be drawn from these facts is that these Islands have been in existence for a very great length of time—long enough for many species to have originated here from a few ancestors—a conclusion which is also supported by geological evidence which points to the existence of the land mass as far back as the Paleozoic. Another conclusion to be drawn from our data is that the islands have always been isolated and never a part of a continental land mass, hence receiving no migrations of animals overland but only by long and very precarious voyages over the ocean in logs and floating debris, and perhaps by flight and carriage by winds. From the very small number of ancestral types represented by the endemic species it would appear that only very rarely did insects and shells succeed in establishing themselves in these Islands.

The presence here of some very delicate insects is more difficult to explain. They do not inhabit logs nor debris although some are gall makers, and their span of life is very short, especially short in the absence of living foliage to furnish them food. Certain homopterous insects, the leaf hoppers and jumping plant lice, are good examples of this type. It is not possible to explain their entrance here by way of a land bridge now disappeared, for if there had been such a bridge beyond doubt more than the meagre few would have become established here. There remains, then, only the agency of

migrating birds, or high winds or ocean currents to account for the arrival here of such delicate insects.

Bird migrations hither are mostly, if not entirely, from America, and the Hawaiian jumping plant lice and leaf hoppers do not seem to have come from there. Windstorms seldom, if ever, blow from present land areas of the South Pacific to these Islands, nor do ocean currents come this way from that part of the world. However, we must consider that not more than one ancient immigrant of the Psyllidae and probably only three or four of leaf hoppers succeeded in establishing themselves here during several million years. It must be admitted that what now seems impossible might have succeeded by chance once in a million years. It is conceivable that once in several million years a windstorm might have carried a leaf with galls containing nymphal psyllids and dropped the leaf in an Hawaiian forest of the same kind of trees—an exceedingly rare chance!—whereupon the insect might establish itself. Another psyllid species has been a less ancient immigrant, but how it arrived or when it is not possible even to surmise. This one apparently has not given rise to other species than one which now lives on the native palms, but nevertheless seems to have arrived a long time ago.

THE JUMPING PLANT LICE.

Psyllidae, or Chermidae (Homoptera).

The jumping plant lice (Psyllidae or Chermidae) constitute a family of the homopterous sucking bugs, being allied to the true plant lice and scale bugs and also to the leaf hoppers and lantern flies. They are small insects, from 1-32 to 1-4 inch in length, with four wings, the third pair of legs usually developed for leaping from which habit the first part of their popular name has been derived. Their superficial resemblance to true plant lice (Aphididae) has suggested the latter part of their name.

The psyllids live by sucking the juice from plants by means of their slender, pointed beak which arises from the

lower part of the head next to the thorax and passes back pressed against the ventral surface of the thorax between the front pair of legs and then bends downward. In this way a greater leverage by more of the body is brought to bear upon the beak in forcing it into plant tissues.

The immature, or nymphal, stages of these insects are passed upon the same plants with the adults, and in the same active, sap-sucking manner detrimental to the plant. In many species the reaction of the insects' activities on the leaves or stems of the plant and the poison wastes secreted by the insects cause the growth of tumors or excrescences of characteristic forms, known as galls. The galls are usually characteristic of certain species and may often be used as an index of the species even though the insects themselves may not be discovered.

The feeding habits of jumping plant lice render them harmful to plant life, but fortunately these tiny insects do not attack many of our cultivated or garden plants and therefore they are considered of relatively small economic importance in agriculture. Moreover, they are far less prolific than are the true plant lice and scale bugs, and for this reason also are viewed with much less concern by economic entomologists.

There are a few species of the family which cause considerable damage in the orchard, field or garden. The pear psylla (several species, one in each of several countries) causes extensive damage to pear and allied orchard trees and receives much attention and expensive treatment. The tomato psyllid (*Paratrioza cockerelli*) is responsible for severe injury to tomatoes and peppers and other plants in southwestern United States. The laurel psyllid (*Trioza alacris*) seriously disfigures bay trees in Northern Europe and now in the United States, causing the leaves to become much rolled, curled up and generally distorted. Other species attack alder trees in America and Europe, while another is a pest on citrus trees in the Malay Archipelago and India.

The family is a relatively small and homogeneous group,

with representatives present in nearly all land areas of the earth. In Europe, North America and Australia the largest number of species have been described but some are known from most all other countries. Much remains to be learned about the psyllid fauna of the south Pacific lands, Asia, South America and Africa, and until more is known especially of the first our knowledge of the Hawaiian fauna and its origin will be limited.

The several hundred species of Psyllidae of the world have been grouped into six subfamilies¹ characterized by wing venational features or peculiarities of the skeleton of the head or thorax. In North America five of the six subfamilies are represented, three very extensively and two less so. In Asia five of the six have representatives known and perhaps of the other also. In the Philippine Islands and Malay Archipelago at least four and perhaps all of the six groups have representatives. In other words, these insects have been well disseminated throughout the world, especially where land bridges have permitted a wider migration.

In the Hawaiian Archipelago, however, only one of the six subfamilies is represented, so far as known at present, and that by fifteen species falling into five genera, and thirteen of the fifteen are so suggestively similar in certain fundamental characteristics that one can scarcely avoid the conclusion that they have sprung from *one* common ancestral form. The extent of evolutionary changes effected in this small fauna seems to indicate a considerable lapse of time since the first introduction.

The subfamily Triozinae, to which all the Hawaiian species belong, is a specialized group set apart from the others by certain wing venational characters. The largest genus in the subfamily is *Trioza*, to which about one hundred species have been assigned throughout the world. Most of these species live free on leaf surfaces, sucking out the juices without forming galls

¹ For details of classification the reader is referred to the author's monograph of this family, Bulletin 85 of the U. S. National Museum, 1914.

or at most merely distorting or curling the leaves. There are a few species, however, which have the habit of causing characteristic galls to grow on leaves and inhabiting the inside of these galls.

These species are found in a good many regions of the southern hemisphere and of the southern part of the northern hemisphere. The most northerly representative of this type of *Trioza* is the species *arbolensis* found in southern United States. One species occurs in Mexico, making galls on avocado leaves, two have been recorded from South America and several from southern Asia, a large number from Australia, a few from Malay Archipelago and still others from other southern countries. A few of these have been assigned to another genus, *Cecidotrioza*, and it is possible that when our knowledge is more complete all these gall makers will be referred to such a genus.

Nearly all of these gall-forming species of *Trioza* resemble each other in certain wing venational characteristics and in the male genitalia, thus indicating perhaps a generic relationship to each other and distinct from other species of *Trioza*. The first marginal cell of the forewing is of a peculiar shape, the cubitus forking at about the midpoint or basad of it. The male anal valve in lateral, or profile, view has a straight anterior margin but the posterior margins (the lateral wings) are characteristically convex.

Although the Hawaiian species have undergone changes in the shape and form of the head, armature of the legs and size and shape of the wings, yet a marked homogeneity in the characters above referred to shows not only a close inter-relationship among these species but also points to a close affinity of these with the gall forming species of *Trioza* in Malay Archipelago and elsewhere. The fact that many of the Hawaiian species are gall forming is further indication of this affinity.

Most of the Hawaiian species live upon the foliage of *Metrosideros polymorpha* Gaud., called by the Hawaiians "Ohia lehua", and other species of the same genus. One (and

perhaps others also), a much modified species, inhabits galls on leaves of several native species of *Pelea*. Three others have been found on foliage of other native plants but their feeding habits are not fully known. Ohia lehua appears to be, by far, the most commonly attacked tree in these Islands. Several make galls on ohia leaves while others live free on the leaf surfaces.

The genus *Metrosideros*, according to Rock¹ is represented in the Hawaiian archipelago by five species, four of which are endemic and one widely distributed over Polynesia, New Zealand, Tahiti and other Pacific islands. It is the cosmopolitan species which is the chief food plant of the Hawaiian psyllids. Thus far no psyllid galls have been reported from the south Pacific or elsewhere the insects making which seem to be in any close way related to the Hawaiian species.

It seems probable that the four native species of *Metrosideros* have not sprung from the cosmopolitan species, but that the latter has been introduced more recently. That its introduction was very ancient, however, is evidenced by its position in the forests and its relations in these forests with the more recent trees. It is quite probable that these trees were first introduced by the very small and light seeds which are blown to great distances by winds. At what time after the establishment of the Ohia lehua here the gall psyllids came in is impossible to say, because of the absence of fossils.

Because of the volcanic nature of the rocks of these Islands, fossil remains of plants or animals are almost never found. A few have been discovered in the stratum overlying the volcanic rock—obviously of comparatively recent date, for the lava flows followed a long, previous existence of the Islands. One such fossil, found by J. C. Bridwell on the Island of Oahu but very unfortunately lost, was evidently an imprint of a leaf of *Metrosideros*. Upon this leaf imprint, it is said, were galls which beyond doubt were of psyllid origin. This is

¹ "The Ohia Lehua Trees of Hawaii," by Joseph F. Rock. Hawaii Bd. of Agric. and Forestry, Bot. Bull. 4, 1917.

a most interesting and significant discovery, showing that these gall-making psyllids have been present here and living upon *Metrosideros* for a considerable period of time.

Probably the original immigrant species was one inhabiting leaf galls of *Metrosideros* and, as new species have evolved from this, some have retained the gall-making habit on the same plant, others have taken to living free on the leaf surface in the nymphal stages, while still others have gone off to other plants, making leaf galls or living free.

From this ancestral species, a *Trioza*, have been derived thirteen species in three genera. Five of these belong to the cosmopolitan genus *Trioza*, five to an endemic genus, *Hevaheva*, and the remaining three to a more or less cosmopolitan genus, *Kuwayama*, members of which have arisen independently it would seem in various countries. These three species here appear to be not related directly to other species of the genus in other lands but rather to species of *Trioza* here.

Hevaheva is the most specialized of the genera and indicates a long evolution. The five species are closely inter-related, but *H. giffardi* shows considerably more specialization than the others. The genus is more closely related to *Trioza iolani* than to the other species of the Islands, but this relationship shows a gap not now bridged over. The relationships of the species of each genus are discussed later.

The other two genera are both Polynesian and apparently have come in at a much later date than the ancestral forms of the other assemblage. *Megatrioza* is abundantly represented in the Malay and Philippine archipelagoes and probably elsewhere in the tropics of the Old World. The one species here probably has not arrived recently and probably is endemic, for it occurs only in the higher mountains on the native palm (*Pritchardia*). It does not occur on lowland introduced palms and hence it seems that its arrival here must have long antedated the modern epoch. Less is known of the other genus, *Cerotrioza*, both here and elsewhere. It is possible that our

species here dates back to a less remote period, but appears to be endemic.

On the basis of land shell distribution, Pilsbry and others have advanced a theory that all these islands once constituted a single large island and that by continued subsidence the higher points of the large island were left as individual islands separated by channels.

Our knowledge of the distribution of the native jumping plant lice is not yet sufficient to allow generalization, nor does it seem probable that this group has been resident here farther back than the Pliocene and possibly not as far back as that, while Pilsbry assumes the subsidence to have been earlier than that. So far as our present knowledge of this group goes it does not seem to indicate any union of the islands of this archipelago within the period of time in which this family has been resident here. Chance winds or currents or flights of birds might account for the present distribution of the species, for it is not wide. Most of them seem to be limited to one island, but *Trioza ohicola* occurs on both Oahu and Hawaii, nearly at opposite ends of the archipelago, but apparently on none of the islands between.

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The type specimens of new species and a representative collection of all the Hawaiian species have been deposited with the custodian of types of the Hawaiian Entomological Society, Honolulu.

SYNOPSIS OF GENERA.

A¹. Forewings not opaque; vertex not produced into processes in front.

B¹. Hind tibiae without basal spurs.

C¹. Forewing with three narrow black spots on hind margin, one in each marginal cell and a third between them; veins without prominent setae.

D¹. Genal cones present.....*Trioza* Foerster

D². Genal cones wanting.....*Kuwayama* Crawford

C². Forewing without marginal spots; veins with prominent setae.....*Hevaheva* Kirkaldy

B². Hind tibiae with basal spur and subapical spine....
.....*Megatrioza* Crawford

A². Forewings opaque or nearly so; vertex produced in front into two protuberances above genae.....
.....*Cerotrioza* Crawford

Genus *TRIOZA* Foerster.

This genus has representatives in practically all countries where Psyllidae occur. There are five closely related endemic species in this archipelago, so far as known all living on the foliage of ohia lehua (*Metrosideros* spp.). It seems quite certain that all are derivatives of a common ancestor which established itself here long ago, coming probably from some land area in the south Pacific. Living species resembling these in essential characters and certainly allied to them are known in Polynesia, Australia and South America, but it is not possible yet to make a more definite statement of the ancestry of these species.

The ancestral species has apparently divided by variation in the following manner: *Trioza iolani* and *ohiacola* are probably concurrent derivatives from the original species on the

Island of Oahu; *Trioza lanaiensis* split off from *T. iolani* by segregation on an island (Lanai) by itself and later gave rise to *T. pullata*; *T. hawaiiensis* was probably derived independently from the ancestral species but bears a closer resemblance to *T. iolani* than to *T. ohiacola*. The latter occurs now on both Oahu and Hawaii, but probably originated on the former.

Kuwayama and *Hevaheva* are derivatives here of the ancestral *Trioza* species.

KEY TO THE SPECIES.

A¹. Genal cones not as long as vertex; color of body typically dark brown; antennae not more than twice as long as width of head, usually less; cubital vein of forewing forked at or distad of midpoint; costa without visible setae. Oahu and Hawaii.

T. ohiacola n. sp.

A². Genal cones as long as vertex or longer.

B¹. Costa of forewing with setae; cubitus forked at or basad of midpoint; antennae twice as long as width of head or more; genal cones about as long as vertex; male forceps notched behind near apex; color usually orange or yellow. Oahu.

T. iolani Kirkaldy.

B². Costa of forewing without setae, or exceedingly short ones if present; male forceps not notched behind near apex.

C¹. Genal cones longer than vertex; antennae $2\frac{1}{2}$ to 3 times as long as width of head; thoracic dorsum usually striped with brown; male forceps abruptly narrowed near apex. Lanai.

T. lanaiensis n. sp.

C². Genal cones about as long as vertex, rarely longer.

D¹. Color of body black, dorsum conspicuously reticulated; antennae about twice as long as width of head. Lanai.

T. pullata n. sp.

D². Color orange or flavous, dorsum not conspicuously reticulated; antennae a little more than twice as long as width of head; male forceps converging uniformly to subacute apex; body usually large Hawaii. *T. hawaiiensis* n. sp.

Trioza iolani Kirkaldy.

Length of body, male 1.3 to 1.5 mm.; female 1.8 to 2.1; length of forewing 2.5 to 3.1. General color flavous, often pale greenish yellow, or darker orange yellow, rarely brown; mesonotum usually with two darker spots cephalad and sometimes more or less distinct brownish streaks on mesoscutum; antennal segments 4-10 and often distal half or all of 3d brown; tarsi and tips of genal cones brown; femora often brown; abdomen usually irregularly browned ventrad; forewings hyaline, often fumate slightly or flavous, or more commonly clear.

Head nearly as broad as mesothorax, much narrower than metathorax, somewhat deflexed; vertex nearly twice as broad as long, elevated at posterior ocelli, with a prominent foveal depression on each side of median suture, posterior margin narrowly elevated, median suture deeply impressed in anterior half and on each side of it the vertex roundly bulging; a few short setae on vertex; anterior ocellus at bottom of impression of median suture and scarcely visible from above. Genae large; genal cones usually about as long as vertex, sometimes a little shorter, subacute, somewhat divergent, with a few setae on ventral surface and one longer seta at tip of each cone. Clypeus small. Eyes large, hemispherical. Antennae somewhat variable in length, about twice as long as width of head with eyes, or more or occasionally less, slender, third segment longest.

Thorax rather broad, not strongly arched; pronotum short; dorsulum narrow cephalad; legs moderately long and stout; tarsi thick; hind tibiae with two or rarely three small black spines at apex on inside and one outside. Forewings reaching half their length beyond abdomen, hyaline, rounded at apex, veins usually black and prominent, minutely setose, costal setae longer; first marginal cell larger than second; cubitus forked at or basad of midpoint.

Abdomen moderately long, male much shorter than female. Male genital segment not large; forceps three-quarters as long as anal valve or a little more, arched, slightly broadening to near apex then more or less deeply notched on hind margin and coming to a narrow point; anal valve straight on anterior margin, truncate at apex, lateral wings angulately convex, broadest below middle. Female genital segment nearly as long as abdomen, converging to acute apex, dorsal valve a little longer than ventral and both acuminate at tip.

Described from several males and females collected on Oahu and determined by Mr. Kirkaldy. The distribution of this species is as follows:—Island of Oahu—Mt. Tantalus

(elevation 1500 ft.), 65 specimens collected by W. M. Giffard and others by Swezey mostly in the months of December and January; Pacific Heights, May 30, 1905; Palolo Hills; Wai-lupe, January 23, 1915; Opaëula, March 30, 1913; Kuli-ouou; Mt. Kaala (at elevation of 1500 ft.); Kaumuohona.

This and the following are the two most common species on Oahu, and may be found at most any season of the year on leaves of Ohia lehua (*Metrosideros polymorpha*).

Trioza ohiacola n. sp.

This species appears to be very close to *T. iolani* and, in fact, more or less grades into it. The habitat and the food plant are the same and both are found on the Island of Oahu. Although the two species are found together and resemble each other, there are nevertheless differences sufficient to indicate that they are distinct species.

In average size of body and wings *T. ohiacola* is a little smaller than the other and differs in the following characteristics:—General color typically much darker, usually dark reddish or chocolate brown, but sometimes light reddish or light brown or even orange yellow (the latter seem to be newly emerged adults); legs and antennae usually all or nearly all brown or chocolate colored.

Head narrower than in *T. iolani*; vertex with shallower discal depressions; genal cones usually about two-thirds as long as vertex, but sometimes more than two-thirds or rarely as long as vertex; antennae seldom twice as long as width of head, usually about $1\frac{1}{2}$ to $1\frac{3}{4}$ times as long. Thorax much more distinctly reticulated. Legs similar, less stout. Forewings usually clear, radius shorter than in *T. iolani*; cubitus forked at or distad of midpoint; costal setae much smaller, not easily visible.

Male forceps nearly or quite as long as anal valve, converging (in lateral view) gradually from near base to narrowly subacute apex, not as broad as in *T. iolani*; anal valve broadest at center, posterior margin angulately convex.

Distribution:—Island of Oahu—Alewa Heights, Pacific Heights, Mt. Tantalus, Kuliouou, Kaumuohona, Lanihuli, Palolo Hills, Palolo Crater, Mt. Kaala (at elevation of about 1600 ft.). Island of Hawaii—Niulii, May 19, 1917 (Swezey), on ohia lehua; Kilauea, June 27, 1917 (Swezey), on ohia lehua and also some collected at same locality by W. M. Giffard on August 21, 1917. The food plant in all cases seems to be ohia lehua (*Metrosideros* spp.).

Trioza lanaiensis n. sp.

Length of body, male 1.5 to 2.2 mm.; female 1.7 to 3.0; length of forewing 2.5 to 3.2. General color orange yellow to straw color, or commonly reddish brown, usually with darker streaks on mesonotum, and abdomen blotched with brown ventrad; antennae darker on distal half; tarsi dark; forewings usually clear but sometimes slightly milky or faintly yellowed. Body surface sparsely clothed with soft pubescence, stiffer and longer on vertex and mesoscutum.

Very similar in general to *T. iolani*, of which it appears to be a derivative, differing in some characteristics, however. Genal cones longer than vertex, sometimes one-quarter longer, acute, divergent, more hirsute. Antennae $2\frac{1}{2}$ to 3 times as long as width of head. Legs stouter and longer; hind tibiae usually with three, rarely four black spines at apex. Forewings a little longer, clear or slightly milky; veins with smaller, scarcely visible setae, even the costal setae scarcely visible under considerable magnification. Male forceps nearly as long as anal valve, constricted near base and narrowed abruptly near apex into a narrower, somewhat finger-like ending. Anal valve large, convex on posterior margin, with broadest point at middle. Female genital segment as long as abdomen or nearly so.

Distribution:—Island of Lanai—200 males and females collected at various points, Kaikolani, Kapano, and others, at altitudes ranging from 1500 to 3400 ft., in December, 1916, and January and February, 1917 (W. M. Giffard). Most of these were taken on foliage of ohia lehua (*Metrosideros* spp.), which is probably the only regular food plant of the species.

This appears to be an incipient, not yet clearly marked, species developing from the Oahuan species, *T. iolani*. Thus far it has not been found on any other island of the group, but it appears to be a very common one on this Island.

In this species there is considerable variation in size, but none that in itself seems to mark off a distinct species. Out of 200 specimens, about six are very large and seven very small, but between these there is almost every degree of variation so that it would be impracticable to designate either of these extremes as distinct species, which one quite probably would do if the series which Mr. Giffard collected had not been so extensive. It is quite possible that in time these variations will break the species into several distinct ones, for along with size fluctuations are also fluctuations in size of anatomical parts. It would appear that the species is right

now in process of rapid evolution, probably having been a relatively recent immigrant to this Island.

Out of the 200 specimens, one individual has genal cones a little shorter than the vertex but otherwise conforming to the species. Some individuals were killed too soon after emergence and parts of the exo-skeleton have shrunk, thus shortening the genal cones, but the one female referred to above was not of this category.

Trioza pullata n. sp.

This appears to be an incipient species derived from *T. lanaiensis*, paralleling in its differentiation another species, *T. ohiacola*, but evidently not directly related to the latter.

In size of body similar to the average example of *T. lanaiensis*. Color wholly black, or in spots dark brown; thoracic dorsum conspicuously reticulately marked, sparsely hairy. Genal cones about as long as vertex, seldom shorter, divergent. Antennae twice as long as width of head or sometimes less. Forewings clear, venation as in *T. lanaiensis* except radius shorter. Female genitalia similar; male unknown.

Distribution:—Island of Lanai—three females from Waio-pao, November 29, 1916 (W. M. Giffard, on leaves of *Cyathodes*; six females from another part of the Island not designated, December, 1916, and February, 1917 (Giffard).

The distinctive and constant characters of color, shorter genal cones and antennae probably mark this off as a separate species, though it is possible that a biologic study would show it to be but a local or perhaps even seasonal variation. The occurrence of some on *Cyathodes* does not indicate necessarily a difference in food habits, though that is possible.

Trioza hawaiiensis n. sp.

Length of body 2.0 to 3.0 mm.; length of forewing 2.8 to 3.9 mm. General color about as in *T. iolani*; front and middle tibiae on distal third or half and all tarsi black or brown; venter of abdomen blotched with brown; forewings clear.

Closely resembling *T. iolani* in many ways but larger and stouter; genal cones about as long as vertex, somewhat divergent, more pubescent. Antennae 2 to 2½ times as long as width of head. Legs longer and stouter; hind tibiae with a serrated callus at base. Forewings large,

veins and costa without visible setae or with very short setae. Female genitalia similar. Male forceps nearly or quite as long as anal valve, stout, uniformly converging on both margins to subacute apex, black pointed; anal valve short, posterior margin acutely rounded, broadest near mid-point.

Distribution:—Island of Hawaii—Kilauea, near Volcano, 4000 ft. elevation, August 21, 1917 (W. M. Giffard); Kau Road, January 16, 1917 (Giffard); Kahuku, January 15, 1917 (Giffard); Kilauea, June 27, 1917 (O. H. Swezey), on ohia lehua; Niulii, May 22, 1917 (Swezey).

This appears to be closely related to *T. iolani* but nevertheless not a derivative of it. It is more probably a corelated derivative form of the ancestor of both. It seems to be limited to the Island of Hawaii. Large individuals of *T. iolani*, equaling in size this present species, occur on Oahu but these differ sharply in male genitalia, costal setae and other minor characters.

Genus *Kuwayama* Crawford.

The chief distinguishing characteristic of this genus is the absence of genal cones, the genae beneath the antennal sockets being more or less roundly swollen but not produced into conical processes as in *Trioza*. The form of the genae in this subfamily appears to be not at all fixed but varies more readily than wing characters and some others. For this reason, it seems certain that the species placed in this genus from various countries of the world do not represent a common origin at all, but independent or parallel evolution toward the same end.

The three species of this genus, native to these Islands, seem almost certainly to have been derived from some *Trioza* species, probably *T. ohicola* or an ancestral type preceding it.

KEY TO THE SPECIES.

A¹. Color of body nearly all black or dark brown; dorsum conspicuously reticulately marked; cubital vein of forewing forked a little distad of midpoint; antennae scarcely longer than width of head; male forceps very short, not more than three times as long as broad. Oahu and Molokai. *K. gracilis* n. sp.

A². Color not uniformly black, very rarely even brown over most of body; cubital vein of forewing forked at or very slightly distad of midpoint; male forceps at least 4 times as long as broad.

B¹. Color typically yellow and black; head and some of notum black and remainder yellow, but sometimes color mostly yellowish or rarely mostly brown; reticulation of dorsum indistinct; antennae distinctly longer than width of head; insect about 2.5 mm. long to tip of folded wings. Hawaii and Lanai. *K. nigricapita* n. sp.

B². Color uniformly orange or yellowish; reticulation sometimes distinct; antennae not longer than width of head; insect about 2.0 mm. long to tip of folded wings. Hawaii. *K. minuta* n. sp.

Kuwayama nigricapita n. sp.

Length of body, male 1.1 mm.; female 1.6 mm.; length of forewing, male 1.8; female 2.3. Color dark brown or black contrasted with yellow; head usually entirely black, sometimes brown on vertex but eyes black; male usually orange or pale yellow on thorax and abdomen; female usually with pronotum, anterior portion of dorsulum, mesoscutum, metascutum and narrow longitudinal band on abdominal notum black or brown, but sometimes some or all of these areas pale; remainder of female body orange or pale yellow; legs yellow in both sexes, with tarsi often black; antennae paler than head, the distal third or half sometimes darker than the basal portion; beak black.

Head nearly as broad as metathorax, somewhat declivous; vertex more than half as long as broad, with a prominent discal depression on each side of median line, reticulately marked, sometimes slightly hairy. Genae subspherically swollen beneath each antennal socket, lobes nearly contiguous beneath front ocellus, cones wanting and clypeus therefore not concealed from view. Beak short, conspicuous by its dark

color against the orange venter. Antennae slender, about $1\frac{1}{4}$ times as long as width of head.

Thorax narrow, scarcely arched, not hairy. Legs rather small, slender; forewings hyaline, clear, radius short, first marginal cell a little larger than second, veins not setose. Male genitalia small; forceps slender, acuminate, subacute, nearly or quite as long as anal valve. Anal valve straight on anterior margin but convex on posterior margin, broadest sub-basally. Female genital segment nearly as long as abdomen, dorsal valve longer than ventral, both acute.

Distribution:—Island of Hawaii—Niulii, May 19-24, 1917 (O. H. Swezey), 44 specimens of both sexes on foliage of ohia lehua (*Metrosideros* sp.). Some of these were bred from nymphs living free on the surface of the leaves. Other related species make galls on these same leaves. Kohala Mountains (Swezey), May 24, 1917, on ohia lehua; Mt. Kilauea, January 1, 1917 (W. M. Giffard). Island of Lanai—several localities at elevation of 2500 to 3000 ft., January, 1917 (Giffard).

Kuwayama minuta n. sp.

Length of body 0.8 to 1.1 mm.; length of forewing 1.6 mm. General color pale lemon yellow to orange; eyes brown or black; hind femora lemon yellow in dark forms as well as light; antennae brown except basal one-fourth pale.

Very similar to *K. nigricapita*, from which it appears to have been derived, but differing in the following respects: Body uniformly smaller in both sexes; color nearly uniform over entire body; antennae scarcely longer than width of head. Male genitalia smaller; forceps shorter and more slender.

Island of Hawaii—Mt. Kilauea, June 27, 1917 (O. H. Swezey), bred from free-living nymphs on surface of leaves of ohia lehua.

Kuwayama gracilis n. sp.

Length of body, male 1.0 mm.; female 1.7 mm.; length of forewing, male 1.3, female 1.9. General color black to dark brown; tibiae and sometimes basal half of antennae a lighter shade of brown. Body robust, small.

Head deflexed, not quite as broad as mesothorax; vertex reticulately marked, a little more than half as long as broad, with a shallow, broad foveal depression on each side of median suture. Genae swollen sub-spherically beneath antennal bases, with several long hairs. Eyes large. Antennae about as long as width of head, or a little longer, slender.

Thorax broad, arched, reticulately marked. Legs short and stout; hind tibiae with three short spines at apex. Forewings short, rounded at apex, hyaline, clear, veins black or reddish. Abdomen short. Male forceps short, relatively broad, about half or three-fourths as long as anal valve, narrowing to acute apex. Anal valve moderately broad, anterior margin straight, posterior margin arcuately convex, broadest below middle; female genital segment nearly as long as abdomen, dorsal valve longer than ventral, both acutely pointed.

Distribution:—Island of Oahu—Alewa Heights, March 26, 1916; Waialae Ridge, April 22, 1917; Mt. Kaala at elevation of 2000 to 2300 ft., March 4, 1917; Wailupe, January 23, 1916; Niu, Feb. 10, 1918 (Swezey), on ohia lehua; in all, there are 52 specimens, both sexes, collected by O. H. Swezey and P. H. Timberlake on leaves of ohia lehua. Island of Molokai—One female apparently of this species from Kamoku, July 15, 1910 (D. T. Fullaway).

Genus HEVAHEVA Kirkaldy.

Several good characters distinguish this from other genera of the Triozinae. The forewings lack the three narrow, granular spots on the hind margin which are present, so far as I know, in all other genera of the subfamily; the veins, as well as body surface, are covered with long stiff hairs. The hind tibiae have five to ten black spines at apex instead of the three or four present in most other genera of the subfamily. Genal cones are present, but variable in length and form.

This genus is probably endemic here and probably a derivative of *Trioza*. The wing venation is suggestively similar in these two genera here, and in the *Trioza* species the veins and body surface have minute setae which have apparently been highly developed in *Hevaheva*. The marginal granular spots are variable in size in our species of *Trioza* and slight indications of their presence in a few species of *Hevaheva* suggest the possibility of the transition.

KEY TO THE SPECIES.

A¹. Forewings hyaline, not colored nor clouded.

B¹. Body straw-yellow or pale orange colored; wing veins and body surface with long setae; living in galls on leaves of *Pelea*. Oahu. *H. perkinsi* Kirkaldy.

B². Body brown or black; wing veins and body surface with short setae. Hawaii. *H. hyalina* n. sp.

A². Forewings colored, not transparent.

B¹. Forewings nearly all brown or black; body black, dorsum reticulately marked. Oahu. *H. silvestris* Kirkaldy.

B². Forewings irregularly maculated or clouded with brown.

C¹. Notum more or less variegated brown and reddish or orange; genal cones 2-3 as long as vertex; wing veins with moderately long setae; wing nearly all brown or black. Oahu. *H. monticola* Kirkaldy.

C². Notum mostly brown or black; genal cones 1-3 as long as vertex or less; wing veins with very long setae (see wing pattern in figure). Hawaii. *H. giffardi* n. sp.

Hevaheva perkinsi Kirkaldy.

Length of body 0.8 to 1.4 mm.; length of forewing 1.7 to 2.3 mm. General color pale lemon yellow to orange red, vertex and dorsum sometimes a little darker; antennae often brownish on distal half or two-thirds; tarsi dark. Body surface covered sparsely with stiff hairs.

Head nearly as broad as mesothorax, much narrower than metathorax, small, deflexed; vertex half as long as broad, deeply impressed discally on each side of median suture, with several very long stiff hairs near each posterior ocellus; genal cones not quite as long as vertex, conical, subacute, somewhat divergent and sparsely hirsute. Antennae about as long as or a little longer than width of head, slender, with several moderately long setae on apical third.

Thorax broad, not much arched, sparsely hirsute; pronotum short. Legs rather large, femora large; hind tibiae with 5 to 7 short black spines at apex; tarsi thick. Forewings hyaline, clear or slightly fumate or ochreous, veins setiferous; first marginal cell a little larger than second, latter variable in size.

Abdomen short. Male genitalia small; anal valve a little longer than forceps, truncate at apex, straight on anterior margin, very convex on posterior margin; forceps slender, subterete, arched, black-pointed at tips. Female genital segment about half as long as abdomen, thick at base and abruptly converging to acute apex, valves subequal in length.

Distribution:—Island of Oahu—Mt. Olympus (1800 to 2500 ft.), bred from conical galls on leaves of *Pelea clusiaefolia* and *P. lydgatei*, August 20, 1917 (Crawford); same locality on foliage of *Pelea* (Swezey); Wailupe, January 23, 1915, on *Pelea* (Swezey); Mt. Kaala, on *Pelea* (Swezey).

Hevaheva silvestris Kirkaldy.

Length of body about 1.3 mm.; length of forewing 1.9 mm. General color dark brown to blackish or reddish; legs and antennae pale, latter yellowish except last two segments dark; femora and tarsi darker than tibiae; forewings dark brown, with one or two irregular, more hyaline areas. Body surface covered sparsely with stiff hairs.

Head not quite as broad as mesothorax, much narrower than metathorax, deflexed; vertex not quite twice as broad as long, with a deep discal depression on each side of median suture, sharply elevated on posterior margin, with a few stiff hairs near posterior ocelli. Genal cones about half as long as vertex, conical, acute, sparsely hairy, scarcely divergent. Antennae not longer than width of head, slender.

Thorax moderately broad, stiffly pubescent. Legs short, femora thick; hind tibiae with about six short black spines at apex. Forewings not transparent, rounded at apex, narrow, veins setigerous, radial margin thick. Abdomen short. Male genital segment small; forceps a little more than half as long as anal valve, slender, terete on basal half but angulate above, apex sharply curved inward and subacutely pointed. Anal valve broad in caudal view, longer than forceps, anterior margin (lateral view) straight and posterior margin convex with greatest breadth sub-basally. Female genital segment short, thick at base, abruptly converging to subacute apex.

Distribution:—Island of Oahu—Mt. Tantalus (Perkins); Kaumuohona (Swezey), 1 female determined by Kirkaldy; Mt. Olympus, elevation 2000 ft. (Swezey); Wailupe, January 23, 1915 (Swezey); Palolo Hills, on foliage of *Pelea rotundifolia*, many males and females. The life habits of this species are not well known.

Hevaheva hyalina n. sp.

Size of body and wings about the same as in *H. silvestris*. Color of body about the same or a little lighter, but forewings hyaline or nearly so, very slightly browned or smoky, not opaquely colored; legs and antennae lighter colored or similar. Hairs on body surface and wing veins much shorter and somewhat less conspicuous.

Structural characters about the same, but antennae a little longer and genal cones a little larger; wing venation similar, but setae shorter; genitalia similar, differing only in minor characters.

Distribution:—Island of Hawaii—Olaa, Glenwood, elevation 2400 ft., September 9, 1917 (W. M. Giffard), 1 pair.

This species appears to be a derivative of *H. silvestris* by segregation on a separate island. Further collecting, however, is necessary to establish the relationships beyond doubt.

Hevaheva monticola Kirkaldy.

Length of body 1.4 mm.; length of forewing 2.1 mm. General color brown; vertex, posterior half of dorsulum, and notum between forewings very light brown or orange; antennae orange, except last two segments black; femora and tibiae brown, tarsi lighter; forewings hyaline but clouded and maculated with brown as indicated in figure. Body surface with stiff pubescence.

Head rather broad, as broad as mesothorax but narrower than metathorax, declivous; vertex about half as long as broad, with a deep discal depression on each side of median suture and much elevated narrowly on posterior margin, with a few long hairs near posterior ocelli. Genal cones about two-thirds as long as vertex, conical, subacute, only a little divergent, sparsely pubescent. Antennae only a little longer than width of head, slender, distal segments with setae.

Thorax rather narrow, not much arched, surface with scattered, stiff hairs; leg rather short, stout, femora thick; hind tibiae with about 7 short black spines at apex. Forewings elongate, rounded at apex, veins prominent, setose; marginal cells subequal or first a little larger than second; radial margin thick; membrane maculated with brown conspicuously.

Male genitalia small; forceps about half as long as anal valve, sharply curved inward and acute at apex, rather slender. Anal valve straight on anterior margin, roundly convex on posterior. Female genital segment short and thick, about half as long as abdomen, abruptly tapering to acute apex; valves subequal.

Distribution:—Island of Oahu—Mt. Tantalus, elevation 2000 ft., October (Perkins); Palolo Hills (Swezey); Kaunohona (Swezey).

Hevaheva giffardi n. sp.

Length of body 1.7 mm.; length of forewing 3.0 mm.; general color dark brown to dull black; legs, metacoxae, pleurae and antennae light or pale brown or yellowish. Body surface covered sparsely with long stiff hairs.

Head as broad as mesothorax, not quite as broad as metathorax, somewhat declivous; vertex broad, about half as long as broad, narrowly elevated on posterior margin, with a deep, discal fossal depression on each side of median suture extending obliquely toward antennal bases, roundly convex between each depression and median suture; with a few long stiff hairs along median suture and near each posterior ocellus, genal cones short, one-third or one-fourth as long as vertex, divergent, subacute, with a tuft of short hairs at base of each near anterior ocellus. Antennae about as long as width of head, or sometimes a little longer, slender with a few setae distad.

Thorax moderately broad and arched, with conspicuously long and stiff hairs; legs rather long, slender, hairy; hind tibiae with 4 or 5 short black spines at apex. Forewings broad, hyaline but maculated conspicuously with brown (as indicated in figure), veins and margins beset with long setae, the costal and apical margins with a double row and the others with single row; first marginal cell very large; radius long.

Abdomen short. Male forceps slender, acuminate, about $\frac{3}{4}$ as long as anal valve or more, subacute at apex. Anal valve with anterior margin straight, posterior margin convex, broadest near base, fringed caudad with long, fine hairs. Female genital segment not as long as abdomen, acutely pointed, dorsal valve a little longer than ventral, with a large tuft of long hairs at about the middle of the dorsal valve dorsad.

Distribution:—Island of Hawaii—Olaa, elevation 3000 ft., September 8, 1917 (W. M. Giffard), 26 specimens, both sexes. Taken on leaves of *Platydesma campanulata*.

This is the most ornate of the species thus far known in these Islands and appears to be limited to Hawaii in the mountains.

Megatrioza palmicola n. sp.

Length of body, male 2.7 mm.; female 4.0 mm.; length of forewing, male 3.8 mm.; female 4.7 mm. General color brown to light brown; head tawny or flavous, eyes dark, and often a short narrow dark streak on each side of median suture of vertex; pronotum usually brown; thoracic dorsum with several more or less prominent, longitudinal brown streaks; abdomen brown; venter, legs and antennae flavous. Body large, surface somewhat hairy.

Head about as broad as mesothorax but not as broad as metathorax, declivous; vertex about half as long as broad, with a discal depression

on each side of median suture, posterior ocelli slightly elevated, anterior half bulging and clothed with moderately long hairs. Genal cones short, seldom more than $\frac{1}{4}$ or 1-3 as long as vertex, subacute, divergent, somewhat separated. Eyes very large. Antennae slender, not quite twice as long as width of head.

Thorax large, broad, well arched, surface briefly and sparsely pubescent; legs rather long, stout, pubescent; hind tibiae with a spur at base and two prominent teeth at apex, one bifid and one simple and a third long tooth a little before the apex. Forewings large, long, hyaline or very slightly smoky, with four dark spots on hind margin, one at tip of clavus and the other three the regular marginal spots characteristic of this subfamily but darker and more prominent.

Abdomen long in both sexes; male forceps nearly as long as anal valve, slender, narrowing slightly toward subacute apex, hairy. Anal valve much broader than forceps, posterior margin convex, broadest near base and narrowing distad to truncate apex. Female genital segment large, not as long as abdomen but often nearly so, both valves acutely pointed, dorsal longer than ventral.

Distribution:—Island of Oahu—Punaluu (O. H. Swezey); Wailupe, January 23, 1915 (Swezey); Mt. Olympus, elevation 2500 ft., September, 1917 (Swezey and Crawford); Waihole, August 23, 1916.

Food plant: Fan palm (*Pritchardia* spp.), native palms. This species appears to occur only on the endemic palms which are comparatively rare on Oahu. The insects live on the younger fronds, especially those just unfolding, from which they can readily suck the sap and in the folds of which they find good refuge and seclusion.

Megatrionza is a Polynesian genus, distinguished by the armature of the hind tibiae together with certain cephalic and wing characters. Thus far there are ten known species of this genus¹ in the Malay Archipelago and Peninsula and the Philippines, though there are doubtless many more to be discovered, as this appears to be a large genus. None of these known ten species shows any marked relationship to the Hawaiian species, so that it is probable that the latter is derived from some other still unknown species. It is possible that it may occur elsewhere, being merely an introduction here, but the indications

¹ These species are described in a forthcoming paper on paleotropical Psyllidae by the author of this paper.

are that it is truly endemic since it occurs only on the native palms in the mountains and not on cultivated palms in the coast lands.

The species bears some resemblance to the endemic *Trioza* species and at first was believed by the writer to have been derived from the same ancestry. In wing venation and male genitalia there is a similarity but the form of the genal cones and especially the tibial armature are distinct, while in all these characters there is considerable similarity to *Megatrioza*.

Genus *Cerotrioza* novum.

Head scarcely declivous, rather long; vertex produced in front into two horn-like epiphyses over antennal bases; genae produced more or less into cones or subspherically swollen. Antennae slender. Thorax not much arched, narrow; hind tibiae with small basal spur or callus and small subapical spine. Forewings narrow, opaque or semi-opaque, maculated; first marginal cell usually larger than second; hind wings nearly as long as forewings.

Type of genus:—*Cerotrioza bivittata*.

Two additional species, not yet described, are known from the South Pacific—one from Borneo and another from Singapore. The genus appears to be somewhat related to *Megatrioza* but has become very specialized in some features. The Hawaiian species is manifestly related to the other two but hardly derived from either. It is probably endemic here but its origin must still be a matter of conjecture. It appears to have no relationship to the other endemic species of psyllids here.

Cerotrioza bivittata n. sp.

Length of body 1.8 mm.; length of forewing 2.2 mm. General color pale greenish yellow on dorsum and venter; eyes dark and a broad, dark brown vitta alongside of head continued on pleurae of thorax to base of forewings and thence along central axis of each forewing to apex; legs pale yellow or straw colored; antennae whitish, except two basal segments brownish and apical two black. Body slender.

Head scarcely deflexed, very long. Vertex longer than broad, with a discal, sulcate depression on each side of median line and the two meeting at median line near anterior end; with two rounded, knoblike prolongations at anterior end of vertex reaching out beyond and over antennal sockets, with front ocellus at base of emargination between them. Frons visible as a very small sclerite bearing the front ocellus

at one end. Genae swollen somewhat beneath antennal bases. Clypeus small. Antennae slender, about $1\frac{1}{2}$ times as long as width of head.

Thorax narrow, scarcely arched. Pronotum moderately long; legs long and slender, slightly hairy; tibial spines very small, black. Forewings long and slender, opaque and whitish, subacute at apex, venation similar to that of other species of this genus, with a broad, axial brown band from base to apex with numerous darker brown spots within it; veins beset with short setae.

Abdomen slender, long. Male genitalia small; forceps small, terete, acute, arcuate, about 2-3 as long as anal valve; latter broad in caudal view, posterior margin (lateral view) convex. Female genital segment half as long as abdomen, dorsal valve blunt, a little longer than ventral.

Distribution:—Island of Oahu—Opaeula, March 30, 1913 (O. H. Swezey), 3 males on *Xylosma Hawaiiense*; Niu, Feb. 10, 1918 (Swezey), 2 females and 1 male, on same plant.

PLATE VIII.

EXPLANATION OF FIGURES.

Figure 1. *Trioza iolani*, forewing.

1a. Wing margin highly magnified and showing setae.

1b. Frontal view of head and genal cones.

1c. Profile view of male genitalia.

2. *Trioza lanaiensis*, forewing.

2a—2c. same views as in 1.

3. *Kuwayama nigricapita*, forewing.

3a—3c. Same as in 1, drawn to same scale.

4. *Hevaheva perkinsi*, forewing.

4a—4c. Same as above, drawn to same scale.

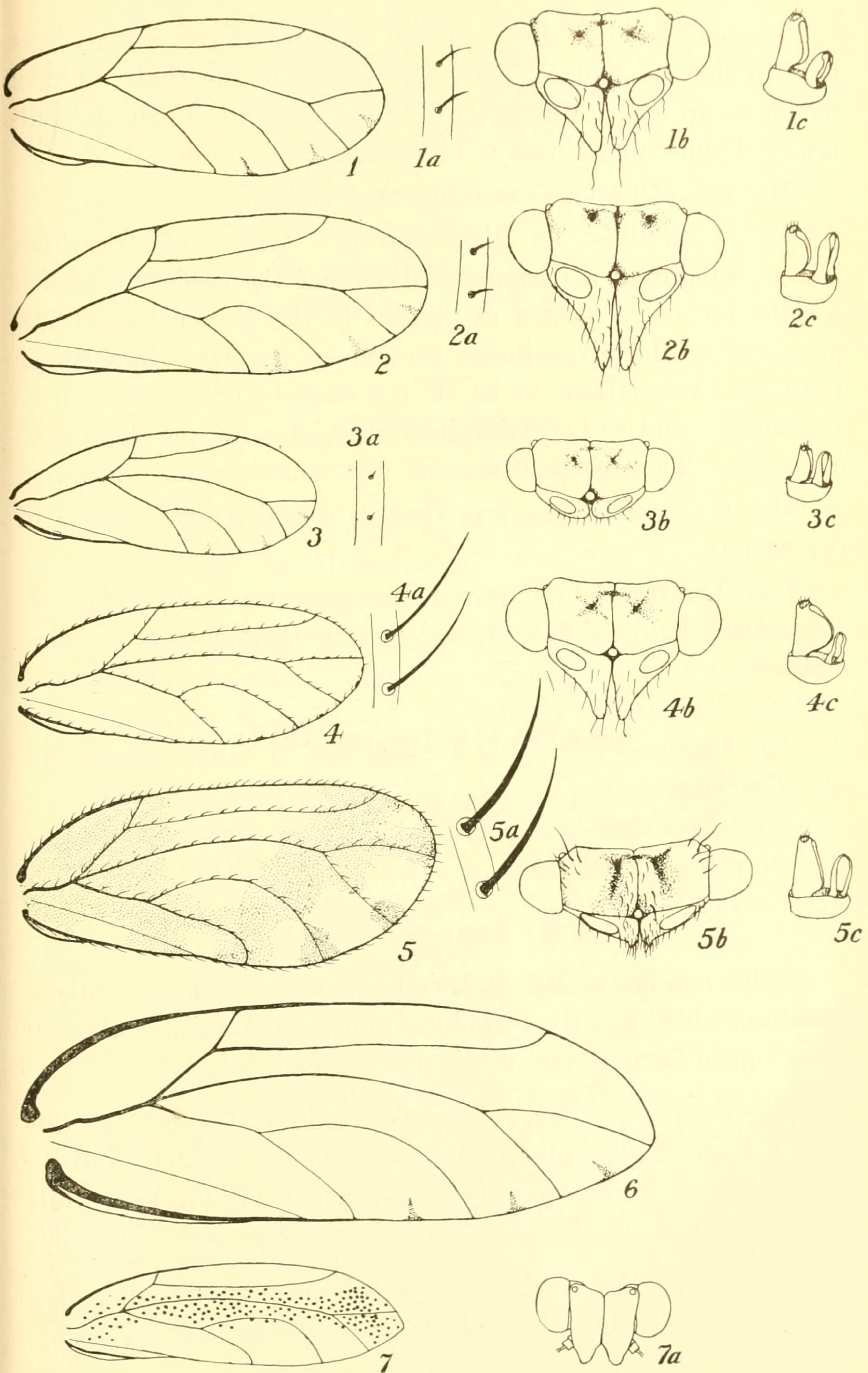
5. *Hevaheva giffardi*, forewing.

5a—5c. Same as above, drawn to same scale.

6. *Megatriona palmicola*, forewing, drawn to same scale as others.

7. *Cerotrioza bivittata*, forewing.

7a. Dorsal view of head, showing processes of vertex; genae not visible.



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