

*Phorodon galeopsidis* Kalt. Infesting the under side of the leaves of *Polygonum* sp. Collected July 25, 1912, at San Jose, Cal.

*Amphorophora rubicola* Oestl.

Collected on the leaves and terminal shoots of thimble-berry (*Rubus nutkanus* Moc.), May 13, 1913, in hilly canyons of Contra Costa Co., Cal. At that date about 95 per cent. of the lice were large pupæ or recently transformed adults. The dusky spot at the apex of the wing, mentioned by Oestlund (Synopsis of the Aphididæ of Minnesota, 1887) was present in all alate specimens examined.

*Macrosiphum ludoviciana* Oestl. What I take to be this species was observed infesting *Artemisia heterophylla*. The lice appeared first about February 6, 1913, at which date the plants were about eight inches in height. Toward the end of the month winged forms were produced and these migrated to other plants, the original centre of infestation in the area of plants under observation being confined to one plant. Several plants were destroyed by the lice settling in masses on the growing stalk but finally towards the end of April all the lice either left the area of plants under observation or were destroyed by enemies. Locality: Walnut Creek, Cal.

*Macrosiphum rudbeckiæ* Fitch. This louse in California seems to confine itself to the teasel (*Dipsacus fullonum* L.). I have collected it on many occasions in the vicinity of San Jose, California.

#### ADDITIONAL EXPLANATION OF FIGURES

Camera lucida drawings, nos. 1, 2, 4, 9, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22—eyepiece no. 1, objective 16mm.; nos. 3, 5, 6—eyepiece no. 1 (tube 170mm.), objective 16mm.; nos. 7, 8, 11—eyepiece 1, objective 3in.; fig. 10—eyepiece no. 1 (tube 170mm.), objective 3in.

## THE LIFE HISTORY OF THE SUGAR-BEET ROOT-LOUSE (*PEMPHIGUS BETAË* DOANE)<sup>1</sup>

By J. R. PARKER, *Montana Experiment Station*

Considering how scanty is the knowledge of life histories in the genus *Pemphigus*, it is thought worth while to set before the entomological public the life history of the economically important species, *Pemphigus betaë* Doane. This species is the most important pest of the sugar beet in Montana and each year does considerable injury, the tonnage in badly infested fields sometimes being reduced a third. A study of its life history was begun as an Adams project in 1909, but not until the past summer were all the stages in its complex life cycle known.

<sup>1</sup> The investigations upon which this paper is based were carried on at the Montana Experiment Station as an Adams project under the direction of Professor R. A. Cooley, Station Entomologist.

This paper will deal only with the life history, while technical descriptions, studies in synonymy and a discussion of control measures will be reserved for future publication.

#### WINGLESS VIVIPAROUS FEMALES—VIRGOGENIA OF EUROPEAN WRITERS

Early in the spring the full grown, subterranean, wingless, viviparous females which have survived the winter, begin to give birth to living young which also develop into wingless viviparous females. This rapid method of reproduction continues throughout the summer and is checked only by cold weather, lack of food or unfavorable soil conditions. A very wet spring may result in the death of all the hibernating lice, while in a dry spring they may feed and develop upon rootlets left in the ground from the previous season until the new crop of beets offers them more attractive food.

Wingless viviparous females have been found in Montana upon the following plants: very common upon pigweed (*Chenopodium album* L.) and sugar beets; common on table beets, foxtail (*Hordeum jubatum* L.) and salt grass (*Distichlis spicata* Greene); occasionally upon blue-joint (*Agropyron occidentale* Scribn.) and dock (*Rumex crispus* L.); rarely upon wheat, flax, alfalfa, and horseweed (*Iva xanthifolia* Mutt.).

#### WINGED FALL MIGRANTS—SEXUPARA OF EUROPEAN WRITERS

From midsummer until late fall a part of the young which are produced by the wingless viviparous females develop wing pads and when full grown acquire wings and fly away. The conditions of the soil in regard to moisture has much to do with the number of winged lice that are produced. If the ground is kept moist or the rootlets of the host plant are succulent, few winged lice are produced, but if the soil becomes dry and the rootlets tough, the production of winged lice is greatly accelerated. In September and October when the beet fields generally become quite dry, the ground is sometimes almost black with the myriads of winged lice that have crawled up from the roots. Doane makes this statement:<sup>1</sup> "These winged individuals are the ones that provide for the distribution of the species, for after making their way to the surface of the ground, they sometimes fly for considerable distances. Having settled at the root of some plant, they soon begin to bring forth living young and thus a new colony, the winter colony, is established.

In Montana we have not observed this to be true. All of the many winged lice which we have confined in glass tubes have given birth to young which could not possibly start winter colonies. For several

<sup>1</sup> Page 8, Bulletin No. 42, Washington Experiment Station.

years we were in doubt as to where these winged lice went. They could be seen to fly away from the beet fields, but their destination was a mystery. The native cottonwood (*Populus balsamifera* Linn.) was suspected of being the alternate host, but not until September, 1912, were our suspicions confirmed. The insects were first noticed on the edge of a weedy field where *P. betæ* had previously been noticed in abundance upon the roots of pigweed, foxtail and blue-joint. As one looked across the field the air above it swarmed with winged lice which were flying toward a row of cottonwoods on the edge of the field. This row consisted of trees in three stages of leaf ripening. Some had lost nearly all their leaves, on others the leaves were still a dark green, while one tree at the end of the row retained its leaves which were a light yellow in color. To this last tree the majority of the lice directed their flight. Alighting on the leaves they immediately started down the stems to the main branches and down the main branches to the trunk. Every branch was gray with an army of winged aphids all marching in one direction,—down the tree. When the main trunk was reached, the lice crawled down until a suitable crack or crevice was found into which they would crawl. Many continued to the ground and secreted themselves in the leaves, grass, and dirt around the base of the tree. A loose piece of bark pulled from near the base of the tree revealed a mass of the winged lice clustered beneath it. Some were already dead with the abdomen shrunken clear to the thorax. Crawling over the dead bodies were small yellow lice and other winged specimens were observed giving birth to these small yellow individuals. The swarming continued until dark and was repeated on a smaller scale on warm, still days throughout the fall. Upon microscopic examination the great majority of winged migrants proved to be *Pemphigus betæ*, although a few specimens of a much larger undetermined species were also observed.

Winged individuals have been collected from sugar beets, pigweed, foxtail and blue-joint.

#### TRUE SEXES—SEXUALES OF EUROPEAN WRITERS

An examination of the small yellow lice deposited by the fall migrants showed them to be the true sexes. The females are nearly twice the size of the males and each contains a single large egg which shows plainly through the body wall. Each fall migrant gives birth to from four to seven individuals, the majority of which are females. One was observed to give birth to seven young in forty minutes. Both sexes have rudimentary mouth parts and take no food, but nevertheless four molts are passed through. The time of molting varies in different individuals but in nearly every case is completed at the end of four days after birth.

Sexual activity is not shown until the fourth molt after which the males crawl blindly about attempting to copulate with any female they can find. In from seven to twelve days after birth the female deposits a single, pale yellow egg and in a short time dies. Sometimes death occurs before the egg is extruded in which case the walls of the abdomen gradually shrink away finally leaving the egg exposed. Normally the female secretes a mass of bluish, white threads in which the egg rests after deposition.

Gillette has also reported finding the true sexes upon cottonwood in Colorado.<sup>1</sup>

### EGGS

Eggs deposited by the sexual females remain in the crevices of the bark until the following spring, without change. By April 15, many of the eggs were turning darker in color and showed the eyes and a dark spot in the abdomen of the embryo. Hatching was first observed out of doors at Bozeman, May 3. The shell split near the head and by contractions of the body the young louse slowly forced its way out of the shell.

### STEM MOTHER—FUNDATRIX OF EUROPEAN WRITERS

The young lice hatching from the eggs crawl up the trees and cluster upon the expanding buds. As soon as the leaves unfold, feeding begins, generally on the upper side of the leaves in the angle between the mid-rib and the first or second vein. The resulting gall first starts as a depression at the point of attack, which gradually deepens and is finally closed from above by the growth of the leaf. The opening is a narrow slit or furrow parallel with the mid-rib or one of the large veins and scarcely noticeable from above. There is a high mortality among the immature stem-mothers. Out of thirty lice that were observed to start the formation of galls, only four lived to reach maturity.

Stem-mothers were first observed giving birth to young on the first day of June. The greatest number of young known to be borne by a single stem-mother was 172, while the average was about 75.

### WINGED SUMMER MIGRANTS—FUNDATRIGENIA OF EUROPEAN WRITERS

All of the progeny of the stem-mothers developed wing pads and by June 20, some had acquired wings and were leaving the galls. By July 20, 90 per cent of the galls were deserted.

On July 3, a Pemphigus having all the structural characteristics of the winged individuals in the galls was observed on the leaves of *Chenopodium*, giving birth to young. The young at birth were enveloped in a

<sup>1</sup> Page 24, Twenty-fourth Annual Report of the Colorado Experiment Station.

membrane, but soon freed themselves and after wandering about on the leaf for a moment or two started down the leaf stalk and continued to the ground. This deposition of young upon *Chenopodium* was observed many times during the next two weeks and in every case the young lice proceeded directly to the ground.

On July 5, 250 plants of *Chenopodium album* were dug and their roots carefully examined for *Pemphigus betæ* colonies. Plants were examined on many parts of the college grounds, only one or two being dug in each locality. Sixty-five plants were found to be infested with colonies of *Pemphigus betæ* made up for the most part of very young lice. They were on fine rootlets that lay close to the surface of the ground and in most cases the ground was cracked so that they had easy access to the roots if they descended from the leaves. On August 5, a similar search was made and out of the same number of plants examined in the same localities, 151 colonies were found.

This, together with the fact that *Pemphigus betæ* seldom becomes abundant in the beetfields before the middle of July, has led us to believe that the principal source of infestation is the summer migrants, from the cottonwood galls.

Fifty migrants confined singly in glass tubes gave birth to a total of 480 young or 9.6 each. The greatest number produced by any one individual was 19. Young born to these migrants were placed upon sprouting sugar beet seed in germination cups; they began to feed immediately upon the fine rootlets. Others were placed upon the roots of the sugar beet plants growing in pots and in time developed into typical *Pemphigus betæ* colonies of wingless viviparous females. To avoid any chances of error, the roots of beet plants used in the experiments were dipped in "Black Leaf 40" and the soil used was carefully examined to see that it contained no root lice other than the young of the summer migrants.

The summer migrants, while resembling the fall migrants in general appearance, differ very materially in structure, a fact which seems to have been overlooked by most American workers in writing up other species in this group, but which has been especially noted by Tullgren, a Swedish writer.<sup>1</sup> The two principal differences in this species are in the number of sensoria on the antennæ and the absence or presence of wax glands on the thorax. In the fall migrants the arrangement of the larger sensoria is as follows: III 4-9; IV 2-3; V 0; VI 0. In the

<sup>1</sup> Aphidologische Studien Arkiv For Zoologi Band 5, No. 14.

The manuscript for this paper was submitted for publication November 8, 1913. In the December number of the Annals of the Entomological Society of America, volume 6, number 4, page 488, Professor C. P. Gillette has called attention to the marked difference which exists between the alate fundatrigenia and the alate sexupara of *Thecabius populimonilis* Riley.

summer migrant the arrangement is as follows: III 6-10; IV 2-3; V 2-5; VI 1-4. In the fall migrant paired wax glands are found upon the pro-, meso- and meta-notum, while in the summer migrants none are found upon any of the thoracic segments. According to the keys and descriptions of American writers these differences would surely place the fall and summer migrants in two distinct species and I believe that the summer migrant will prove to be an already described species, possibly *Pemphigus populicaulis* Fitch. Further study is needed before this point is decided.

#### SUMMARY

Wingless viviparous females are found in the ground the year around upon the roots of beets, weeds and grasses.

In the fall winged individuals are produced which fly to cottonwood trees and deposit the true sexes.

The sexes mate and the female deposits a single winter egg in the crevices of cottonwood bark.

The following spring the young louse hatching from the egg ascends the tree, forms a gall, in which a single generation of lice is produced, all of which are winged and become the summer migrants.

The summer migrants fly to beets, weeds, and grasses and upon the leaves of such plants give birth to young which descend to the roots and start new colonies of winged viviparous females.

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## THE SAN JOSÉ SCALE IN NOVA SCOTIA

By ROBERT MATHESON

Nova Scotia is the most easterly province of the Dominion of Canada, situated between 43° 30' and 47° north latitude. It is almost completely surrounded by water, being connected to the mainland by a narrow strip of land only twelve miles wide. It is also deeply cleft by many bays and harbors so that no place is more than a comparatively short distance from the coast. It has an area of 20,500 square miles, a considerable portion of which is not well suited to agriculture. The northwestern portion of the province lies in the transition zone while the remainder has been placed in the Canadian zone. I do not think this represents in all cases the true distribution of the faunal zones of the province but this is due to our lack of knowledge of the local fauna. The section from Windsor to Digby lying between the north and south mountains forms the main fruit section and is spoken of as the "fruit belt." Here apples, plums, cherries and pears are grown extensively while peaches and grapes do fairly well in certain sections though not grown commercially to any extent. Small fruits