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Biology of the Boxelder Bug in Cache Valley

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BIOLOGY OF THE BOXELDER BUG IN CACHE VALLEY

by

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INTRODUCTION

The boxelder bug, Leptocoris trivittatus (Say), is a hemipterous insect belonging to the family Corizidae. Although it rarely is a pest of agricultural crops, its habit of invading homes and other buildings for hibernation and to warm itself has made it an annoying household pest. It has proven to be a difficult insect to control. Only a few of the contact insecticides, useful in control of related insect pests, have given satisfactory control of the boxelder bug. Because it has not been considered as a critical problem, it has not received detailed attention from the scientific investigators. Its close association with boxelder trees has long been recognized. Elimination of boxelder trees has often been advocated for control of this insect. However, boxelder is not its only host and, furthermore, elimination of boxelder trees is not always practical or desirable.

Little of the biology of it has been worked out in Utah. Only a few feeding and injury records have been published. It was apparent that a more complete knowledge of its life cycle and seasonal biology would be desirable, in view of the importance of this insect pest. In this study, pre-oviposition activity, oviposition, length of incubation, number of eggs laid, and number of nymphal instars in the life span have been worked out. Also, the food and feeding habits of nymphs and adults have been studied. The data in this thesis were recorded from specimens collected from Logan, Smithfield, Hyrum, Brigham City, and Ogden.

REVIEW OF LITERATURE[1]

The boxelder bug has been the subject of considerable discussion in farm journals and papers of a semipopular nature. Much of this writing is in the form of short articles discussing the general habits and suggested measures of control. There were no published reports of a detailed study of the boxelder bug in the literature until Smith and Shepherd reported on their studies in Kansas. POPENOE AND MARLATT, (1888), reported that the original description, written by Thomas Say in 1825, was made from specimens collected by him while he was with Major Long's expedition to the Rocky Mountains in 1819-20, at Engineer Cantonment which was near the present site of Omaha, Nebraska, on the west side of the Missouri River. Say originally placed the boxelder bug in the family Lygaeidae. Later it was removed by Stall (1870) to the family Coreidae. Present day specialists in the Hemiptera placed it in the family Corizidae.

The first real outbreak of the insect was reported in the literature by Riley and Howard (1892) as occurring October 22, 1891, in Columbia County, Washington. I. Newkirk has called attention to the insect as doing much damage to fruit, such as apples, plums, grapes, and peaches. Riley and Howard recommended the use of a dilute kerosene-soap emulsion for its control. Popenoe and Marlatt (1888) reported it as being numerous and to have been observed feeding on ash, maple, ampelopsis, geranium, cacti, lilies, coleus and ageratum, as well as on many other plants. The authors included a plate of illustrations showing the eggs, nymphs, and adult forms.

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1 Smith and Shepherd (37)

This insect was reported by Lintner (1894) from North Dakota as having occurred in outbreak proportions. The wingless nymphs were described as occurring in patches varying from four to five feet, to 60 feet in diameter and forming a deep, writhing mass.

Gillette (1898) stated that he tried kerosene emulsion, whale-oil soap, tabacco decoctions, zenoleum and pyrethrum, all very strong. They had no effect except to make the bugs uncomfortable for a time. He stated that whale-oil soap or kerosene emulsion may kill the nymphs.

Aldrich (1898) observed that the boxelder bug began mating about April 17 and that one week later eggs were found attached by their sides to boxelder trees and also attached to strawberry leaves of the previous season, at a distance of fifty yards from any boxelder trees.

Howard (1898) reported that the boxelder bug was quite widely distributed. He reported it as being known in Colorado, Arizona, California, Kansas, Missouri, Utah, and Mexico by 1880. In 1881, it was reported from Iowa. Up to 1887 there was no record of the insect east of the Mississippi River. In 1889, it was reported from Nebraska; 1891, from Washington state, Texas, Idaho, North and South Dakota, Minnesota, Wisconsin, and Illinois; and in 1894, from Pennsylvania.

Milliken (1911) discussed the history and methods of prevention of this annoying insect. He suggested the bug may have come from Mexico and that it probably was present in America before 1820, but was not reported positively due to lack of competent observers.

Some of the more recent observations on the habits of the boxelder bug were made by Long (1928). He observed that it showed a preference for the pistillate female boxelder trees for feeding and egg deposition. He reported that trees standing in the same yard with branches almost touching showed bugs only on the pistillate type of tree. He observed that the eggs were deposited on the fruit, usually in groups of three to eight, with only one group of eggs on each bunch of fruit. The eggs were glued flatwise to the side of the samara on the wing, in the curve just below the seed kernel and at the edge of the midrib of the fruit. Long suggested as a control of the boxelder bug, the propagation of the boxelder tree from cuttings of staminate trees only.

Webster (1928) reported the boxelder bug as sucking the juice out of the apples at Berrian, and that they were thickest on Red June and Delicious apples in Benton County, Washington.

Swenk (1929) reported that the bug damaged tulip bulbs.

McDaniel (1933) reported that the boxelder bug had increased steadily for the last three seasons in several sections of Michigan. She recorded that some authorities contend only eggs deposited in opening bud of the pistillate boxelder trees hatched and produced young. She stated that when the bugs fed on fruit they caused it to become dimpled and deformed; that the young bugs fed throughout the summer and by early fall completed their growth. McDaniel stated that the elimination of boxelder trees in the vicinity of houses would settle the local question of control measures for all time.

Deay (1928), in his taxonomic work on the Coreidae of Kansas, found that the claspers of the genital capsule of the male are constant in the species and are of decided taxonomic value.

Hutson (1932), of the Michigan State College, reported an infestation of boxelder bugs on everbearing strawberries, the eggs, nymphs, and adults being found on the plants. The nymphs and adults were feeding on the foliage and fruit, with the result that the entire crop was lost and the plants apparently were much damaged. He reported that many plants were killed outright.

Ruggles (1935) stated that the boxelder bug is a native American insect whose original home was probably in the southwest. It had not been reported north of Missouri in 1888, but since then it has spread into most states northwest of the Mississippi and into many eastern states. He also pointed out the close correlation between abundance of this insect and dry weather. In Minnesota, it is regarded as a dry weather plague, with two generations a year.

McDaniel (1936) obtained excellent control both of adults and nymphs by using a sulfonated higher alcohol spray against them. A common representative of this material is Dreft, which is sold as a cleaning compound, used at the rate of 1 teaspoonful to one quart of water. It did not injure paint on buildings nor vegetation. She reported by letter approximately ninety percent control by use of pyrocide.

Knowlton[1] made many observations on the habits and habitat of the boxelder bug since 1925 to 1935. In 1935, he stated that large

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1 Knowlton, G. F. (22, 23, 24) pp 326, 443, 1935

numbers of the boxelder bug were congregated upon ripe and over-ripe plums at High Creek, approximately six miles east of Lewiston, Utah, on September 26, 1935. So abundant were the bugs on some fruits that little of the fruit surface was visible. He stated in 1943 a beeyard, located on the warm south slope and approximately 5 miles above the mouth of Big Cottonwood Canyon, Salt Lake County, Utah, was examined on the afternoon of November 16, 1943. Several thousands of boxelder bugs were present around the hives. These bugs apparently had been seeking shelter for winter under the hives and among dry oak leaves. Two masses of bugs near one hive entrance attracted the writer's particular attention. One of these consisted of nine boxelder bugs which were feeding on dying or recently dead honey bees. The second, much larger mass consisted of two layers and a portion of a third layer of the bugs which covered nearly dead bees. He stated that many bugs also were observed on the ripe and over-ripe plums, peaches, pears, and apples. The bugs were found looking for shelter at a distance of one-half to two miles from the nearest boxelder trees. During 1947, large numbers of the nymphs were found to be feeding on dead honey bees in a few different locations in Utah.

KEY TO TRIBES OF CORIZIDAE 1/

A. Hind femora spined beneath; front angles of pronotum prolonged forward in an acute spine. Tribe I Harmostini

AA. Hind femora unarmed beneath; front angles of pronotum obtuse, unarmed.

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1 After Blatchley (3) pp 270, 284-85

B. Head abruptly narrowed behind the eyes into a distinct neck; side margins of pronotum entire; general color pale; smaller, length, not over 9 mm. Tribe II Corizini

BB. Head not narrowed behind the eyes; side margins of pronotum notched near front angles; general color black with red markings; larger, 11 or more mm. Tribe III Leptocorini

KEY TO GENERA OF LEPTOCORINI

A. Bucculae less than half the length of head; beak (in our species) but slightly if at all passing hind coxae . . . . I *Leptocoris*

AA. Bucculae reaching base of head; beak reaching to or beyond second ventral . . . . II *Jadera*

DESCRIPTION OF THE ADULTS

From W. S. Blatchley, "The Heteroptera of Eastern North America

Leptocoris trivittatus are elongate-oval, depressed above, subconvex beneath. Above fuscous-black, very finely pubescent, subopaque; ocelli, narrow median line and broader marginal stripe of pronotum behind transverse impression, also its hind margin very narrowly, clear red; costal and apical margins and usually the nervures of elytra, dorsum and inner wings, red or in part orange yellow; membrane fuscous; under surface fuscous-black, the margins and middle of abdomen, the sides of sternal pleura and the coxae, red; eyes brown. Head and pronotum minutely granulate-punctate, the latter with elevated narrow median line behind the transverse impression; beak reaching hind coxae, joint 1 as long as head, 3 and 4 subequal, 2 longest. Scutellum and elytra similarly punctate, the tip of the former very narrow, subacute. Length, 11 - 13.5 mm; width, 3 - 4 mm. (Plate 1 - Fig. 1)

Description by the writer:

The adult boxelder bug is brightly colored. The red color forms three broad lines over the balck thorax, hence the latin name *trivattatus* or three-banded. The harder proximal parts of the wings are edged with red, and all the veins are of the same color, but a more dingy shade.

The earlier nymphal stages are distinguished by the same color, which is even brighter red than in the adult insects, which enables one to readily detect them. The maturing nymph is nearly one-half inch in length, and a little darker in color than the earlier stages. The nymphs become marked with black when about half grown.

The eggs are light straw-colored when first laid. They turn a darker brown color within a few days. They gradually become darker red until before hatching, when they are of dark reddish-brown color. The egg is oval in outline and has a distinctly marked cap at the top of it. (Plate 2 - Fig. 2)

Sex Difference[1]

The boxelder bug may be distinguished as to sex on the basis of size and by examination of the external genitalia. Usually the females are larger than the males. The genital capsule of the male, from the ventral aspect, reveals a pair of claspers. There is also a projection from the ninth abdominal segment, on each side of the claspers, (Plate 1 Fig. 3). This gives the abdomen of the male the appearance of having four distinct posterior projections (Plate 1 - Fig. 3). These projections on the abdomen easily distinguish the male from the female (Plate 1 - Fig. 4). The relative sizes of female and male are shown in table 1. Sometimes we can distinguish the sexes by their activity, as the male is generally more active than the female, when disturbed.

Distribution[1]

The boxelder bug has been reported in the United States from

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1 Smith and Shepherd (37) pp 147-53

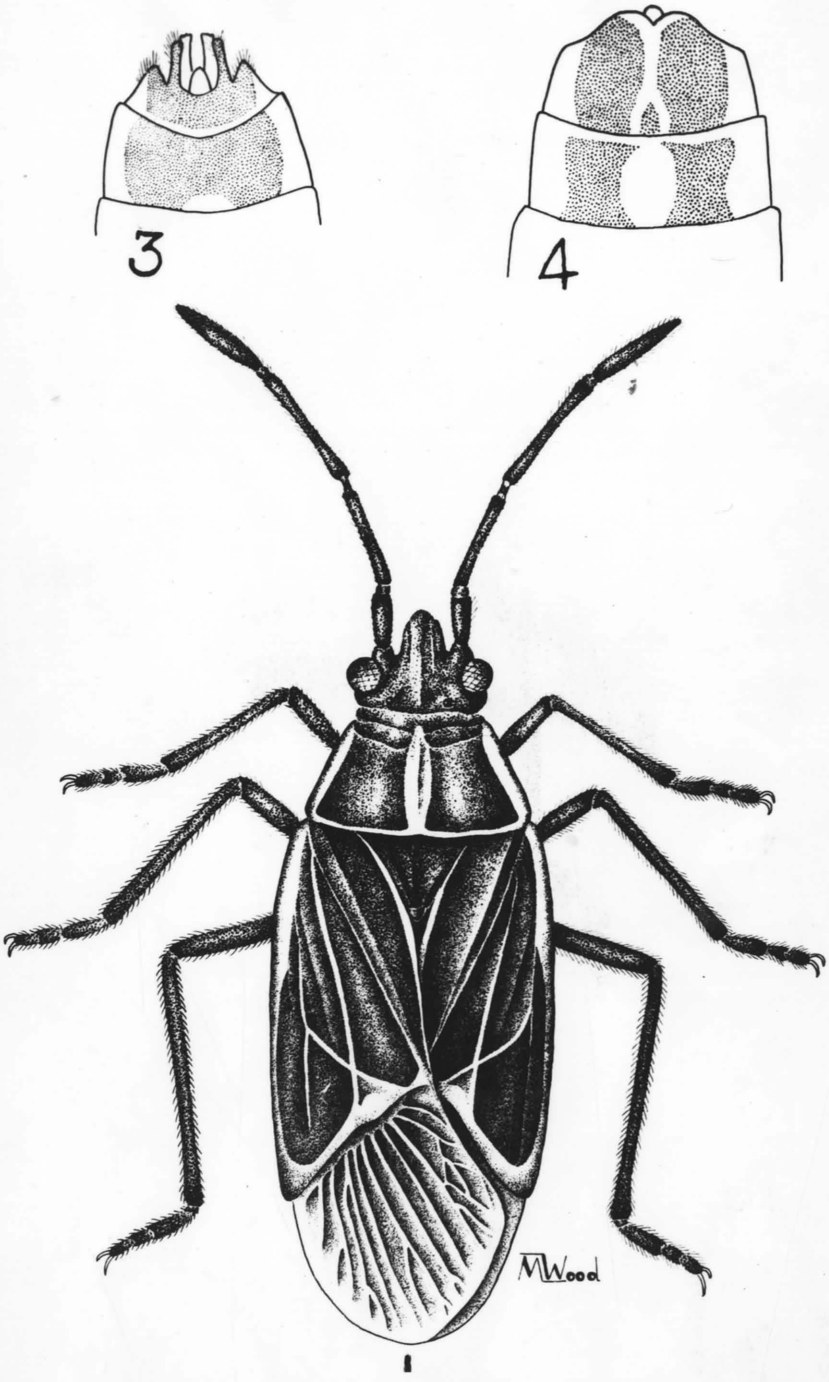
PLATE 1.

Figure 1. Adult female

Figure 3. Ventral view of the end of the abdomen of the male boxelder bug, showing genital claspers.

Figure 4. Ventral view of the end of the abdomen of the female boxelder bug, showing the genital valves.

PLATE # 1



twenty-seven states; namely, Washington, Oregon, California, Idaho, Utah, Arizona, New Mexico, Colorado, Montana, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Texas, Missouri, Iowa, Minnesota, Wisconsin, Illinois, Michigan, Ohio, Indiana, Kentucky, North Carolina, Maryland, and Pennsylvania. It also has been reported from Mexico, and from three provinces of Canada; namely, Quebec, British Columbia, and Saskatchewan.

No published record was found that this insect occurred in the states of Wyoming, Nevada, Arkansas, and Louisiana west of the Mississippi River, but considering its reported distribution, it is logical to assume that it is present at least in Wyoming and Nevada. The insect has not been reported south of North Carolina in the southeastern one-fourth of the United States. Neither has it been reported from New England. However, since the boxelder bug is found in Ottawa, Canada, and in Pennsylvania, Maryland and North Carolina, it probably is also present in New York, West Virginia, and Virginia.

Host Plants[1]

In the region around Logan, Utah, boxelder bugs feed and develop mainly on boxelder trees. However, to some extent they feed on the following other trees and plants: soft maple, ash, pin oak, trees of heaven, mulberry, honey locust, buckeye, linden, spirea, cactus, lilac, honeysuckle, iris, hollyhock, geranium, tulip, peony, tomato, asparagus, pigweed, crabgrass, foxtail, and several unidentified weeds, shrubs, and grasses. The bugs were observed feeding on grasses and

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1 Smith and Shepherd (37) pp 153

Table 1. Variation in size of 25 adult male and 25 female boxelder bugs during 1951.

	Body length in mm.		Width of thorax in mm.		Width across eyes in mm.	
	Male	Female	Male	Female	Male	Female
Maximum	12.2	14.3	4.4	5.1	3.2	2.4
Minimum	9.9	12.2	3.6	3.9	2.1	2.1
Average	11.8	13.6	3.8	4.3	2.9	2.3

weeds in the early spring, before the buds of the boxelder trees opened. They also were found to be feeding on fruits of apples, plums, grapes, peaches, tomatoes, and on sweet and sour cherries.

METHODS

Three screen study cages (fig. 5) and twenty glass bottles (fig. 6) were set up for observing the boxelder bugs' activities of mating, depositing eggs, hatching, feeding, moulting, relationship to natural enemies, and certain other habits. The screen cages were 15 inches long, 10 inches wide, and 12 inches high. To study oviposition, I put small pieces of dry wood in one cage, dry leaves of different trees in another, and some stones in a third. To observe feeding habits, I placed three different kinds of green plant materials in each cage. Plants used were peach, tomato, and cherry. The above studies were begun on March 20, 1951.

Daily insect collections were made in various places and habitats surrounding Logan, in order to capture the first overwintering boxelder bugs to emerge during the early spring of 1951. Boxelder bugs were first collected out-of-doors on March 15, 1951, and placed in cages in the entomology research laboratory. Twenty females and sixteen males from this first collection were placed in an oviposition cage, peach and tomato plants being supplied for the bugs to feed on. Some specimens were painted with different color paints in order to identify individual bugs. This method was to confirm observations of female bugs mating with many males and male bugs mating with many females. Daily temperatures were regularly recorded. Careful attention was given to the captive specimens.

The larger cages appeared to offer no advantage over the bottles. Observations were more easily made by using the glass bottles. The young boxelder bugs readily survived and matured in the glass containers. Daily records were kept of nymphal development and activity. The procedures followed in the attempt to rear boxelder bugs on foliage of boxelder and on other maples were similar to those stated above. Dying and recently dead bees, beetles, and boxelder bugs were placed in the test jars. For twelve hours, activities of the confined boxelder bugs were observed. All feeding done by individual boxelder bugs was recorded. In order to insure maximum feeding activity, the bugs were starved for a period of two days before being placed with the above insects. This apparently caused an abnormal amount of feeding to occur on the dead or nearly dead specimens.

RESULTS

Mating:

Observations were made, using a wide-field binocular microscope in order to study the copulation process in more detail. For this purpose, a male and a female were placed together in a bottle. Within ten minutes the male aggressively approached the female and a struggle occurred, the female breaking loose and running away. Five minutes later, mating actually occurred. The male suddenly grasped the female, assuming a position with his body on the back of the female, but at an angle about of 45 degrees to her body, his head being high above her back. The male's abdomen was turned or twisted under the female's abdomen to a position which permitted the clasping of the female's genital valves. The male clasper, on the side next to the female, was used for

Fig. 5. Oviposition screen cages with different host plants in the laboratory, greenhouse and insectary.

Fig. 6. Oviposition glass bottles with different host plants in the laboratory, greenhouse, and insectary.

holding the abdomen of the female and directing the aedeagus into her valves. Upon being disturbed, the female walked away, pulling the male after her, with his head being in the opposite direction. Mating boxelder bugs frequently were observed connected in this manner, the larger female usually pulling the smaller male after her. Males, having a clasper on either side of their abdomen, could assume a position on either side of the female with the clasper next to the female locked into the female's valves. The male used his legs to hold the female until contact was accomplished. Both insects generally were motionless for a while after mating first occurred. The male used his beak to probe the female during the process of mating. The female kicked at the male with a hind legg at periodic intervals until the termination of the mating process. At the end of the copulation period, the male struggled furiously, releasing his clasper and removing himself from the female. Many matings were observed.

Copulation lasted for different period of time. Some lasted for as short a time as 5 minutes, while others continued for 15 to 24 hours. Mating by the same individual pairs occurred several times and during any time of the day or night while the boxelder bugs were kept together in the oviposition cages.

Oviposition:

Oviposition began from 1 to 8 days after copulation. In spring, from mating to first egg laying varied from three to eight days. Often the bugs came out of hibernation and fed for approximately two weeks before mating and the first egg laying began. In summer, oviposition occurred from one to three days after mating. The eggs were laid on stones, leaves, grasses, trees and shrubbery. The ovipositing female stood on or under or between the stones, bark of the trees, and among leaves. Nearly all of the females rotated their abdomens through an arc of 70 to 90 degrees for awhile before laying the eggs. A female bug would first select proper footing, brace herself well on the stones, bark or leaves and then start laying the eggs. The tip of her abdomen would move back and forth slightly above a median line, until the egg came out of the ovipositor. Each female deposited from twelve to twenty eggs. They doubtless lay more eggs than that, but I was unable to keep the females alive long enough to observe complete exhaustion of the egg supply. In Kansas, Smith and Shepherd (1938) secured a maximum of 12 eggs from any one female. The females deposited the eggs singly or in groups. These were arranged in more or less irregular clusters. The caged bugs laid eggs for a period of one to five days, averaging three days.

Adults remained alive for five to thirty-five days after laying the last eggs. Out-of-doors, adults appeared to survive longer than that. The majority of the eggs laid early in the season were deposited in the crevices of the bark of trees, especially on the underside of the pieces of the bark. The old boxelder and other maple trees, which had rough bark, were especially favored places for oviposition. Many eggs were found on the underside of twigs and limbs of Lombardy poplars. From the middle of May until early October, the females deposited their eggs anywhere and on many kinds of plants and stones.

Eggs:

The first eggs found were laid on April 5, 1951, in the research laboratory. They were cemented to various surfaces in groups of 3 to 12. Most eggs were laid on their sides, rather than on end. The eggs were light straw-color when first oviposited. They turned a darker brown color within a few days and gradually became darker red until they assumed dark reddish-brown color just before hatching. The eggs are oval in outline. They measured 1.44 to 1.55 mm. in length and 0.88 to 0.90 mm. in diameter. They have a distinctly marked cap at the top end, which is nearly as large as the end of the egg. In this cap occurs a circular structure, the microphyle (Plate 2 - Fig. 2). Hatching nymphs pushed these caps aside and slowly lifted themselves out of the eggs. Incubation periods (Table 2) ranged from 10 to 15 days in the laboratory, and 20 to 26 days out-of-doors, during April and May. After June 1, hatching out-of-doors occurred in 18 to 22 days. In the incubator at 95 degrees, incubation of the eggs lasted only five days. In the greenhouse, hatching required from 9 to 11 days at daytime temperatures, which averaged 80 degrees F.

The laboratory temperatures ranged from 71 degrees to 82 degrees F., average 75 degrees.

The outdoor temperatures in the spring were 75 to 87 degrees F. in sunny areas, but around 55 to 60 degrees F. at ground level. In the grass at night, temperatures ranged from 40 to 50 degrees. At these temperatures, the incubation period averaged 23 days.

Nymphal Instars:

There are 6 nymphal instars in the development of boxelder bugs before the adult stage is reached. This conclusion was also reached by Smith and Shepherd (37), whose descriptions of the nymphal instars

Table 2. Incubation periods of the boxelder bugs during 1951

Date of oviposition	Place of incubation	No. of eggs	Date of hatching	Length of incubation in days	Temperature
April 15	Greenhouse	45	April 24, 1951	9	80° F.
April 16	Laboratory research room	30	April 28, 1951	12	75° F.
May 6	Incubation box	15	May 11, 1951	5	95° F.
May 6	Out doors	50	May 29, 1951	23	67° F.

agree essentially with mine as stated below.

First Instar Nymphs: The first instar nymph (Plate 2 - Fig. 7) is bright red when it emerges from the egg. The antennae, legs, head and thorax soon turn darker red. The nymph is sparsely covered with short, bristly hairs. Its length varies from 1.5 to 1.8 mm., averaging approximately 1.7 mm. The abdomen becomes larger as it feeds.

Second Instar Nymph: The second instar nymph (Plate 2 - Fig. 8) is similar in appearance to the first instar nymph except that it is larger. Also, its antennae, head, legs and thorax are of a slightly darker red.

Third Instar Nymph: The third instar nymph resembles the second except for being a little larger in size (Plate 2 - Fig. 9). (Measurements in Table 3 are of all instars and the adults.)

Fourth Instar Nymph: The fourth instar nymph (Plate 2 - Fig. 10) has small slate-colored wing pads which may be seen through the outer covering of the thorax. The posterior tips of the wing pads are not free (Fig. 10).

Fifth Instar Nymph: The fifth instar nymph (Plate 2 - Fig. 11) has wing pads of a darker slate color and these are free at the posterior tips. The legs and antennae during this instar become almost black.

Sixth Instar Nymph: The elongate, slate-black wing pads project backward from the thorax over each side of the anterior third of the abdomen. The body in this instar becomes darker red with light slate colored markings on the dorsum (Plate 2 - Fig. 12).

PLATE 2

Figure 2. Eggs, and boxelder fruit with the eggs on.

Figure 7. The first instar of the boxelder bug.

Figure 8. The second nymphal instar of the bug.

Figure 9. The third nymphal instar of the bug.

Figure 10. The fourth nymphal instar of the bug.

Figure 11. The fifth nymphal instar of the bug.

Figure 12. The sixth nymphal instar of the bug.

PLATE# 2

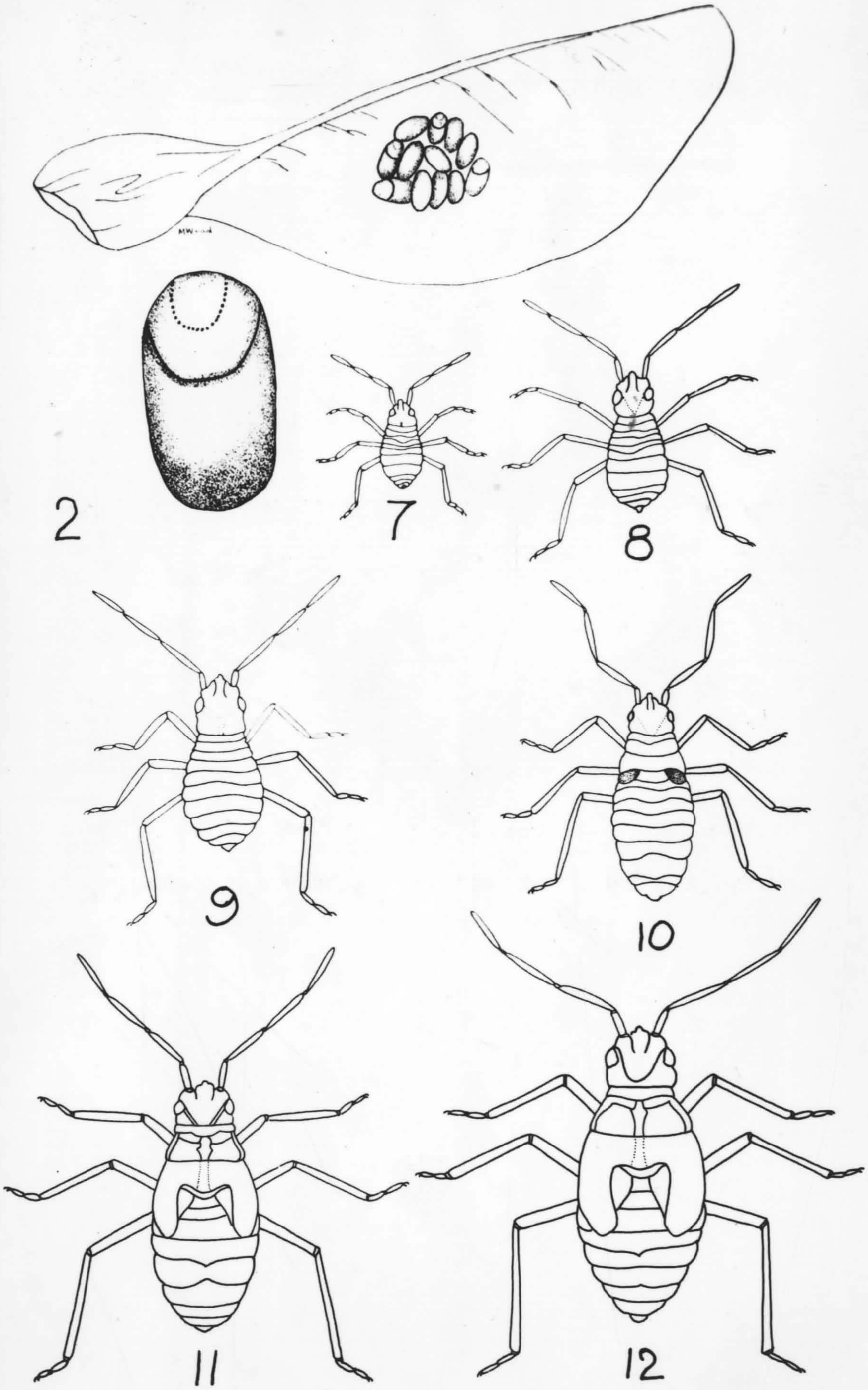

Table 3A. Sizes of the various stages of nymphal instars and adult males and females of the boxelder bug during 1951.

Stages	Width of abdomen in the large part in mm.			Width of nodes which join head with thorax in mm.			Width between the eyes in mm.			Length of antennae in mm.		
	Max.		Min.	Max.		Min.	Max.		Min.	Max.		Min.
First instar	.727	to	.724	.490	to	.480	.538	to	.532	1.839	to	1.829
Second "	1.159	to	1.156	.554	to	.546	.557	to	.543	1.913	to	1.893
Third "	1.738	to	1.22	.816	to	.804	.868	to	.858	2.890	to	2.884
Fourth "	1.783	to	1.7809	.918	to	.910	.938	to	.923	3.118	to	3.110
Fifth "	2.515	to	2.495	.988	to	.978	1.125	to	1.115	4.138	to	4.122
Sixth "	3.120	to	3.108	1.770	to	1.760	1.424	to	1.4112	5.802	to	5.788
Adult female	4.260	to	4.240	1.550	to	1.530	1.445	to	1.425	6.095	to	6.078
" male	3.120	to	3.108	1.255	to	1.235	1.406	to	1.392	5.728	to	5.712

Table 3B. Sizes of the various stages of 10 nymphal instars and 10 adult males and females of bugs during 1951.

Stages	Width of abdomen in the large part in mm.	Width of nodes which join head with thorax in mm.	Width between the eyes in mm.	Length of antennae in mm.
	Average	Average	Average	Average
First instar	0.725	0.485	0.535	1.833
Second "	1.157	0.550	0.550	1.903
Third "	1.730	0.810	0.863	2.887
Fourth "	1.781	0.914	0.931	3.114
Fifth "	2.505	0.983	1.200	4.130
Sixth "	3.114	1.765	1.418	5.795
Adult female	4.250	1.540	1.435	6.087
" male	3.114	1.245	1.399	5.720

Moulting:

Moulting was an interesting phenomenon to witness. Many maturing boxelder bugs were under observation while shedding their exoskeletons to become older nymphal instars or adults. The moult from the sixth instar to the adult stage was typical and easy to observe; therefore, it is described here.

A boxelder bug nymph, about to shed its exoskeleton, refused to feed for a number of hours prior to removing itself from its old body covering. The moulting boxelder bug looked large and had a distended abdomen which was bright red and appeared to be nearly empty. Because the boxelder bug nymph must pull itself out of the old exoskeleton, it withdrew the antennae, legs, and abdomen while the old covering to be discarded remained in place, not giving way under the pulling of the withdrawing appendages. The body covering was split dorsally by the action of the thorax as it arched upward, exerting powerful pressure on the dorsal suture. This action resulted in a head downward, strongly bowed appearance of the nymph. When the exuviae split down the dorsal suture, the head and thorax were freed almost immediately. The legs and antennae were removed by slow, steady pulling motions until, one by one, all were withdrawn. Only the tip of the abdomen remained in the old exuviae. The bug rested for from 2 to 6 minutes before completely withdrawing the abdomen; then it again rested for awhile before it was able to move about.

In the case of the last moult, while transforming to the winged adult, the caudal one-third of the abdomen was drawn out longer than the wings. Within 2 to 6 hours the adults assumed their normal shape and color. In the freshly emerged adult the abdomen, head, antennae, legs, pronotum and scutellum are bright red, while the corium and wing membranes are yellowish to brown. In 15 to 55 minutes after moulting, the new adult became darker in color.

Biology:

During the spring, summer, and fall of 1951, four groups of Leptocoris trivittatus nymphs were used in experiments to determine whether they could mature when one group was furnished with boxelder foliage, a second with maple foliage, a third with tree of heaven, and a fourth with ash foliage. Thirty boxelder bug nymphs were taken from hatching eggs during the early spring, 65 nymphs in summer, and 50 in fall. Each plant type was placed into an individual rearing bottle with 8 to 16 nymphs. Only on the boxelder and maple foliage did the growing boxelder bugs survive and become adults. Complete development also occurred on a mixed supply of maple and tree of heaven. p38?

The early spring group of nymphs required an average period of 77 days to mature (Table 5). The summer group required an average period of 60 days to mature from egg to adult (Table 6). The fall group required an average of 62 days for nymphal maturity (Table 7). The early spring group of nymphs averaged 9 days to complete the first instar, 10.5 days for the second, 12 days for the third, 12 days for the fourth, 16 days for the fifth, and 17.5 days to complete the sixth or last nymphal instar. In the summer group (Table 6), nymphs required an average of 6 days to complete the first instar, the second instar required 8.5 days, the third required 10.5 days, the fourth required 11 days, the fifth required 11.5 days, and the sixth instar required an average

Table 4.[1] Number of days between molts in boxelder bugs during 1932-33.

	1st molt	2nd molt	3rd molt	4th molt	5th molt	6th molt	Total days hatching to adult
Maximum	8	9	14	11	17	19	78
Minimum	3	5	7	10	12	13	50
Average	4.5	6.1	9.3	10.5	14.3	15	59.5
Number of insects, Ave.	32	19	9	6	6	10	----

1 Smith and Shepherd (37) pp 151

Table 5. Numbers of days between molts in the boxelder bugs, during the spring of 1951

	1st molt	2nd molt	3rd molt	4th molt	5th molt	6th molt	Total days hatching to adult
Maximum	10	11	13	12	18	20	84
Minimum	8	10	11	12	14	15	70
Average	9	10.5	12	12	16	17.5	77
Number of insects	30	25	16	12	12	9	

Table 6. Number of days between molts in the boxelder bugs during the summer of 1951.

	1st molt	2nd molt	3rd molt	4th molt	5th molt	6th molt	Total days hatching to adults
Maximum	7	9	11	12	12	13	64
Minimum	5	8	10	10	11	12	56
Average	6	8.5	10.5	11	11.5	12.5	60
Number of insects	65	60	50	46	40	30	

Table 7. Number of days between molts in the boxelder bug during the fall of 1951.

	1st molt	2nd molt	3rd molt	4th molt	5th molt	6th molt	Total days hatching to adult
Maximum	8	9	11	12	13	14	67
Minimum	5	7	9	10	13	13	57
Average	6.5	8	10	11	13	13.5	62
Number of insects	50	40	36	30	24	20	

of 12.5 days for completion. An average of 60 days was required to complete the generation. The fall group showed little difference from the summer group in length of instar periods as shown in Table 7. Casualties among the boxelder bug nymphs making up the early spring group were largest during the first, second, and third instar periods, when 81.2 percent of all nymphs died. Casualties during the first three instars of the summer group totaled approximately 68 percent. All the nymphs died which were feeding on tree of heaven and ash, in all three sets of life history attempts, but they completed their life cycles on ash and tree of heaven, as shown on page 18 in the preference feeding experiments. The length of life of the adult males was about the same as the females, but in some cases one or two days more or less (Tables 4, 5, and 6).

Feeding on Fruits:

In tests conducted in the laboratory, all Leptocoris trivittatus nymphs failed to mature when fed only on fruits. The nymphal and adult bugs readily fed on a number of different kinds of fruits, particularly when ripe, overripe, or injured. They also fed on the green plants. Fruits fed upon in the tests were: apples, plums, peaches, apricots, pears, grapes, cherries, watermelons, tomatoes, and cucumbers. Eight nymphs and six adults fed solely on fruits for up to 9 days, but all died during this time, apparently from starvation. The abdomens of bugs fed throughout their short life upon solely on fruits remained telescoped up against the thorax, none of them becoming distended with food. The evidence indicated that first, second, and third instar boxelder bug nymphs were unable to survive for long, or to reach maturity when fed only on the fruits. However, adult bugs were found to be feeding on fruits at distances of 2 to 3 miles from the nearest boxelder trees.

Feeding on Bees:

Freshly dead and dying bees were placed in cages with 15 newly hatched nymphs and 20 adults, in order to determine if nymphal and adult *Leptocoris* could be reared for any length of time when fed only on bees. Nymphs and adult bugs survived until the fifth day, during which time they were observed to suck juice from the bees. However, in summer they apparently had to feed on the plant hosts also to survive for long. A number of the *Leptocoris* sucked the juices from the thorax of the bees after their stylets pierced the body wall. On May 27, many adult boxelder bugs were in the front of the hives in the College apple orchard, some of them feeding on dead bees. However, I did not find any nymphs around the hives, perhaps because no eggs had been laid close to the hives.

Feeding on Beetles and Cicadas:

Beetles and cicadas were given to the nymphal boxelder bugs in cages. No feeding occurred on the first day, but the nymphs started feeding on one beetle and on a cicada during the second day. During the spring, summer and fall, experiments were conducted in which beetles and cicadas were alternately furnished every two to ten days to recently hatched boxelder bug nymphs (30 for the season). None of the nymphs survived to mature under this feeding procedure. However, when some boxelder material was added to the cages, in addition to the beetles and cicadas, the nymphs matured very well.

Sixty percent of the nymphs matured when they were fed with the beetles, cicadas, and also some green boxelder foliage. None of them matured when they fed only on insects.

Feeding on Boxelder Bugs:

The nymphs of the boxelder bug were found to be feeding out-of-doors on recently dead boxelder bugs. They also fed on dead boxelder bugs in cages. The nymphs were unable to live for longer than five to nine days when fed only on boxelder bugs.

Generations:

In general, Leptocoris trivittatus has two generations in Utah. It was found that the late hatching nymphs of the second generation did not become adult. The first generation, and also the early maturing second generation adults, mated and laid eggs during the season. The mature females laid eggs from late March to early October of 1951. see p 18

When the females came out of hibernation in the spring, they fed for awhile, then mated and laid eggs in cages. The overwintered females lived for from 5 to 35 days. The eggs of these overwintered females hatched, the nymphs matured into the new adults which mated and laid eggs. The eggs from this generation hatched and the second generation was produced, about 80 percent of which matured. Some of the second generation females laid eggs in the fall. Some of these late eggs hatched while the very late fall laid eggs did not hatch. It appeared that adults of first and second generation lived through the winter to lay eggs again next spring. About 35 percent of the second generation lay eggs, and about 25 percent of these hatched, but too late in the season to mature. The eggs of the second generation rarely hatched if laid after early October.

Nymphal Activity:

The activity of the boxelder bug nymphs reared in the cages was modified by the adequacy of the food furnished to them. The nymphs were very active in the first day without food, but their activity became reduced if they were kept without food. During the cage cleaning process, the contents of each cage was emptied out onto a large piece of paper, to permit careful daily cleaning of the inside surfaces of each cage. Each of the normal nymphs ran off the paper upon which it was placed, if given the opportunity. When the cages were clean, fresh boxelder foliage was placed inside. Then the boxelder bugs were herded or driven in such a manner that they crawled back into the cages. These nymphs could not be driven rapidly, but required prodding and pushing to make them crawl up into the neck of their cages. During the rest of the day, while the nymphs were in the cages, they moved from one side to another of the cages continually except when they rested or fed for short periods of time. When ready to feed, they placed the tip of the beak against the leaf or dead insect upon which they planned to feed.

The boxelder bug nymphs which fed entirely on boxelder foliage were exceedingly active. The nymphs which were on the paper during the cage cleaning processes had to be watched carefully or they would suddenly run off and lose themselves from sight before they could be stopped. This degree of activity made it difficult to drive them back into the cages. The boxelder bug nymphs could be observed in the cages engaged in search for their food as they crawled in and out of the boxelder foliage.

Nymphal activity was greatest where adequate food and favorable temperature existed. Activity was reduced at cooler temperatures, and in specimens receiving inadequate food.

Nymphal feeding procedures on the various trees and on dead insects were similar to the feeding habits of the adult boxelder bugs, except that the nymphs usually fed on the boxelder trees more than they did on other plants or on insects.

Adult Feeding Habits:

The ways of feeding on a wide variety of plants were studied. Feeding procedures by the boxelder bug was similar on all kinds of plants and insects. The bugs hold the food by their legs and feel of it with their antennae; then they place the tip of their beak against the plant tissue or insect. The stylets then are inserted into the tissues to accomplish actual feeding.

Adult Feeding Habits Upon Boxelder Trees:

Adult boxelder bugs were placed in a cage with several kinds of plants. After a few minutes the bugs walked about over all the plants. A few hours later, the bugs left the other kinds of plant material and came to the boxelder branches to feed. However, they fed only on the foliage, fruit, and younger branches. The bugs would, however, feed on any of the other plants mentioned above, when they were kept for a few days without food.

Adult Feeding Habits Upon Bees:

A few nearly dead adult honey bees were placed in a cage containing several adult *Leptocoris trivittatus*. Within a few minutes several bugs attacked each bee. Some of the boxelder bugs used their beaks and fore-legs to roll the weakly struggling bees onto their backs, after which they fed through the ventral sutures of the abdomen. Feeding occurred through the following sutures: between the thorax and right meta-thoracic coxa, through the corresponding suture on the left meta-thoracic coxa; between the abdomen and thorax; through the dorsal abdominal sutures just under the wing; between the thorax and right prothoracic coxa; through the genital segments; between the head and first segment of the beak; and between the first and second antennal segments. The boxelder bugs returned to feed through many of the sutures several times, especially those around the coxae, thorax, and abdomen. In some cases, feeding upon a moribund bee lasted from 10 to 20 minutes.

Adult Feeding Habits upon Beetles and Cicadas:

The dead ground beetles and the dead cicadas were given to adult boxelder bugs during three experiments. When a *Leptocoris trivittatus* fed, it seized the beetle or the cicada with its forelegs, turning and holding the dead insect's back, piercing and feeding through the sutures between the head and thorax, and also through the abdominal sutures. The average feeding time lasted about 8 minutes. The boxelder bugs did not seem as eager to feed upon the dead beetles and cicadas as they did on dying or freshly dead honey bees, or on freshly dead boxelder bugs.

Adult Feeding Habits Upon Boxelder Bugs:

I found that a boxelder bug nymph and adult eagerly fed on dead and dying adult boxelder bugs, both under field and laboratory conditions. The feeding processes were very much the same as when the bugs fed on other insects, such as bees, beetles and cicadas. The boxelder bug used its forelegs to eagerly seize and hold the dead boxelder bug nymphs and adults. The bugs fed through the following sutures: at the bases of the antennae and head; from under the collar of the nymph. Just behind the vertex of the head; between the right meta-thoracic coxa and prothorax coxa; between the abdominal segments, and at the juncture of the thorax with the abdomen. Feeding in this manner lasted as long as two hours and thirty minutes in the laboratory.

Preference Feeding Experiments:

Experiments were designed to reveal whether *Leptocoris trivittatus* adults and nymphs preferred certain plants to feed on among the shade trees found in the Logan area. In the experiments I used many species of plants, including maple, ash, cactus, boxelder, lilac, and many grasses. Eighty percent of the total plants used in the experiment were boxelder. Maple and ash were ten percent of the total plants collected, while other plants formed the remaining ten percent. Boxelder bugs did show a definite preference for the female boxelder, (*Acer negundo*). They fed on the various other plants in smaller ratios than occurred in the collections used in the experiments. Also, I used some dead bees, boxelder bugs, cicadas, and beetles in these experiments. Sixty-five percent of the total boxelder bugs which hatched from eggs and fed only on boxelder trees remained normal in appearance and completed their life cycle. Twenty percent of the bugs which fed on maple and ash foliage were able to complete their life cycles, but they required three to four days longer to become adult than the bugs which fed on boxelder trees. Thirty-five percent of the total bugs which hatched and fed only on tree of heaven were able to complete their nymphal life cycles. This was accomplished in the greenhouse at temperature of 75 to 94 degrees F. and humidity which averaged 65 percent. p27

All of the bugs which fed only on species of plants other than box-elder, maple, ash, and tree of heaven died during their nymphal stages.

The boxelder bug nymphs which fed on the boxelder foliage in the cages were a little larger than the nymphs which fed on other species of plants. This was because the nymphs like to feed on the boxelder foliage more than any other species of plant. Both the above nymphs were of the same age. None of the bugs which fed solely on dead insects remained alive more than six days.

Predators and Parasites:

1. Parasites: A red mite is parasitic on the adult and nymphal boxelder bug in Cache Valley. This mite was observed to attack the bugs on various segments of the abdomen and thorax. Sometimes the mites changed positions from one segment to another on the same host.

Many eggs were collected from different trees and from various other places. These were hatched under observation, but no insect parasite emerged from any of these eggs. No black eggs were found. (This is generally the color of those which are parasitized.) McCulloch (1916) found the adult boxelder bug to have immense numbers of flagellates in the intestinal tract. Mature bugs showed 100 percent infestation. McCulloch states that apparently the flagellates do no harm to the insects. Many of the bugs with which Miss McCulloch[1] worked came from Manhattan, Kansas. Maire Weir Kay[2] found two species of amoebae in the elementary canal of boxelder bugs. (*Endolimax leptocoridis* and *Entamoeba polyrmedia*) Here material was collected in Salt Lake City in 1936 to 1938.

1 McCulloch (27) pp 41
2 Kay (15) pp 724

Several boxelder bugs collected out-of-doors in Cache Valley were examined for flagellates but none were found.

2. Predators: During the spring, summer, and fall of 1951, observations were made on robins, blackbirds, thrashers and various species of sparrows which were feeding where the boxelder bugs were numerous. In no instance was a bird seen to catch or eat any of the bugs. When boxelder bugs are crushed they give off a pungent odor. This is produced by glands common to hemipterous insects. No predators except spiders were observed to feed on the boxelder bug. Spiders were found to feed for periods of 4 to 6 hours on individual boxelder bugs.

3. Fungus: Many dead boxelder bugs collected out-of-doors and taken from the indoor cages were examined for fungus but with negative results.

NATURAL CHECKS

Climatic

The effect of low and high temperature on the boxelder bug was tested by placing 150 adults in small screen cages and placing the cages in the entomology department insectary. About 100 of the unprotected bugs, or 66% were killed after 3 days when the temperature dropped to 15 degrees F. The remaining bugs were all dead after 10 days with the lowest temperature reaching 14 degrees F.

Considerable numbers of the boxelder bugs were found dead, during March of 1951, in places of hibernation such as beneath loose bark of the soft maple trees and just below the soil in the crack between the earth and the foundation of the college buildings and between the glass and screen of the Home Economics building.

It is apparent that winter protection is needed in Cache Valley as the boxelder bug cannot withstand continued extreme cold for any great length of time. During the winter of 1950-51, (February and March), a temperature of 10 to 15 degrees F. was reached at Logan. This temperature apparently caused considerable winter-killing among the hibernating boxelder bugs which were least well protected.

Newcomer (1928)[1] stated that a mild winter (minimum temperature of 12° F.) killed practically no boxelder bugs in the Yakima Valley of Washington.

Smith and Shepherd[2] stated that during the winter of 1932-33 a temperature of 18 degrees F. was reached at Manhattan, Kansas. This temperature caused considerable winter-killing among these bugs.

The summer temperature appeared to affect the behavior of the boxelder bugs. During the part of the day when the temperature was high (85 to 95 degrees F.) great numbers of the bugs were found clustered under the edges of bark and around the base of boxelder trees. This was especially true of the older nymphs and adults. Many younger nymphs were found under leaves and in the grass and weeds around and within a few yards of the host plants. The bugs remained near the ground during the heat of the day or during the cold days. Smith and Shepherd stated that high summer temperatures of 1934 and 1935 apparently destroyed nymphs, but in the summer of 1951, I did not find any such effect of the temperature on the nymphs or adults of the boxelder bugs. This bug

1 Newcomer ( ) pp 66
2 Smith and Shepherd (37) pp 66

seemed to survive best during the hot, dry weather at Logan. When the bugs become wet, they are almost helpless and after a short time (1-4 hours) they may die. This is especially true of the nymphs, and sometimes of the adults in glass cages.

Smith and Shepherd stated that many nymphs and adults were found dead on the ground after hard rains on June 25 and July 8, 1933. There was a high rate of mortality in nymphs kept in moist rearing jars in the Logan laboratory. When a few drops of moisture formed in the jar the bugs, whether nymphal or adult, usually died within 30 minutes.

Several times when it rained in Logan during the summer of 1951, I did not find much effect on adults and nymphs of the boxelder bugs, upon field examination, approximately 2% of the nymphs and 0.5% of the adults having been killed out-of-doors by the rains. The rain caused a mortality of approximately 10 percent among nymphs which were moulting.

In general, warm weather had little adverse effect on nymphs and adults of the boxelder bug. The dry, cold weather which dropped only to 20 degrees F. had little effect on any of the stages but when cold weather was combined with wet weather, large numbers of all stages of the bugs were killed. Cold reduced activity of the nymphs and adults, and large numbers of the bugs looked to be dead in the dry, cold weather. However, when warmed they became active again. The most severe cold weather was on November 16, 1951 when the temperature dropped to 12° F. in Logan. This killed more than 20 percent of the nymphs and about 10 percent of the adults and about 15 percent of the moulting nymphs.

Some nymphs survived until December 2, 1951, when there was heavy snow with cold weather. All nymphs and many unprotected adults which were still outdoors were killed.

Overwintering:

The boxelder bug overwinters in the adult stage. All bugs found in the spring were adults. The more noticeable overwintering places at Logan, Utah, were found to be in cracks around the foundation and around the windows of buildings, cracks in the bark of trees, and under fallen leaves. They also hibernate in old buildings, in cracked stone, lumber and wood, in clay banks, quarries, under loose bark and in hollows of trees. Adults were still active after October 15, 1951. Generally, they began to seek places of shelter from about October 15 to October 30, 1951, but came out of their shelters during November whenever the weather was warm and sunny. During relatively warm days in the cold part of the winter, great numbers of the bugs were seen clustering on the south and west sides of buildings, such as homes and schools. During warm days throughout the winter, the bugs congregated in masses outside their places of hibernation in protected locations in and around buildings. The habit of crawling into houses throughout the fall, winter, and spring makes the boxelder bug a very annoying pest.

At Logan, in the spring of 1951, the insects began to leave their places of hibernation about the last week of March. By the middle of April, most of the bugs had left their hibernation quarters. However, they still sought shelter during cold nights and other cold spells. When they came out of their hibernation, they fed for about two weeks before copulating and ovipositing.

Populations:

During nine months (from March to early December) estimates of adult populations were made by sweeping (twice in March and three times in the other months except once in December) with an insect net on vegetation around the bases of the boxelder trees, on areas of one square yard. This showed an increase in numbers of the overwintered adults which appeared on the first of April and continued to leave their hibernation quarters until the first of June. A gradual drop in overwintered population was evident from the second of June until the middle of July. Increases in the population of new adults began in late July, and became more apparent from early September to early October of 1951, as shown in Figure 13 and Table 8.

Study was made of the proportion of sexes in the collections made of the adult boxelder bug during 1951. Large numbers of boxelder bugs were collected from different locations around Logan. The ratio of males to the females was approximately 4 to 6 as shown in Table 9.

Prevention[1]

Most of the damage and annoyance from the boxelder bug can be eliminated by the exercise of effective preventive measures. The boxelder bug nymphs were found to be most numerous on and around boxelder trees. Many of the bugs which hatched around Logan, remained near the place of hatching unless their place of shelter was removed, after which the bugs moved about 150 to 200 yards to new shelter. Cold weather shelter in one instance consisted of a heavy accumulation of leaves along a stone wall. Inasmuch as the nymphs spend most of their time

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1 Smith and Shepherd (37) pp 156

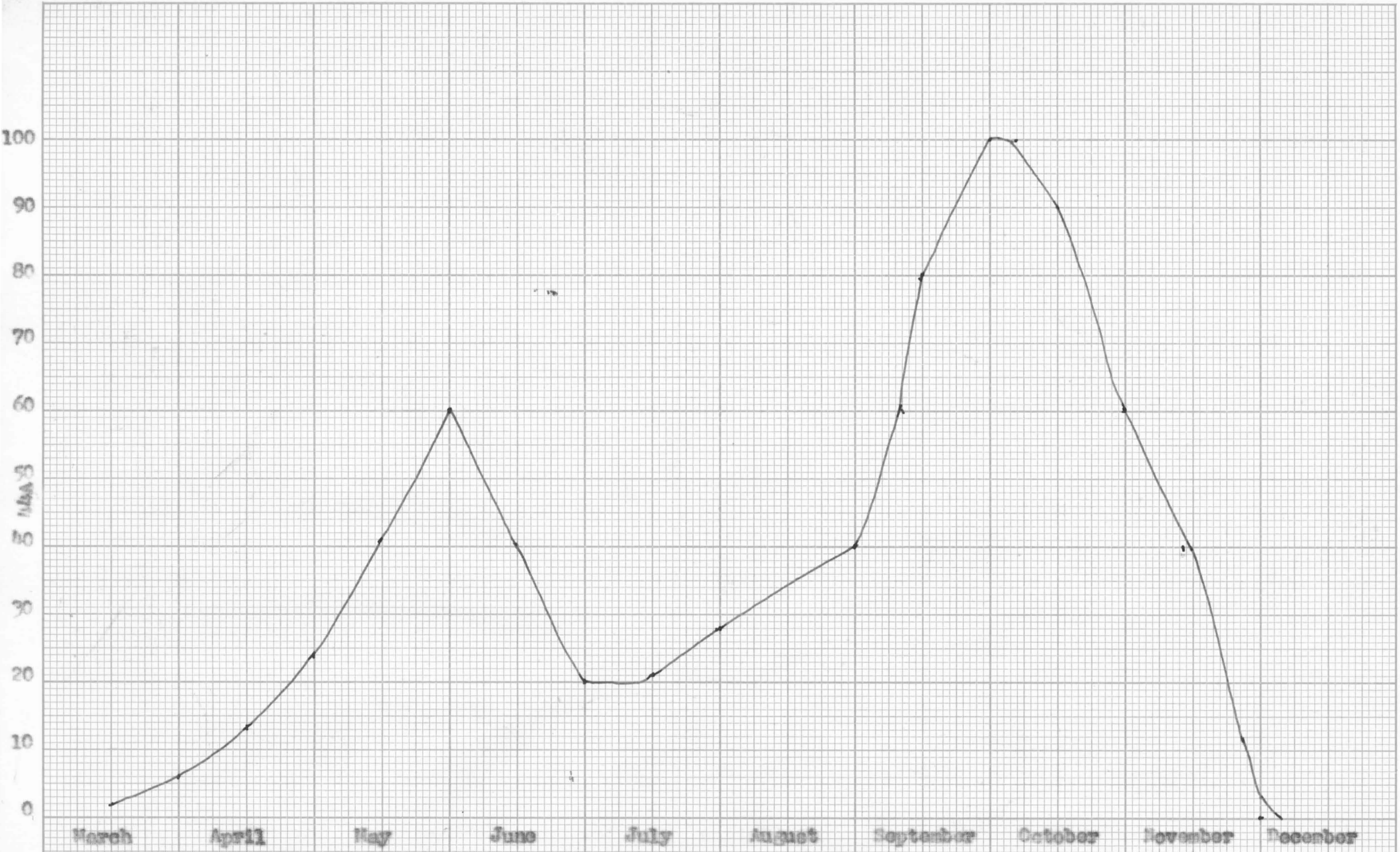

Figure 13. The population of adults swept from square yard areas during 1951

Table 8. The population of adults swept from square yard area in different locations of Cache Valley (Canyon, Senior High School, and stadium of U.S.A.C.). The sweeping made twice in March and three times during the other months, except one time in December, during 1951.

	Dates	Number of the bugs per square yard area		
		First of the month	Middle of the month	End of the month
Overwintered adults	March	---	2	6
	April	6	13	24
	May	25	41	60
	June	60	40	20
	July	20	21	28
New adults	August	28	34	40
	September	40	80	100
	October	100	90	60
	November	60	35	3
	December	2	--	--

Table 9. Shows proportion of sexes in the collection of boxelder bugs during 1951

Date of collections	Number of specimens	Number of males	Per cent of males	Number of females	Per cent of females	Place of collections
April 10	200	75	37.5	125	62.5	Logan Senior High School
May 29	250	105	42	145	58	Logan Canyon
June 3	190	78	41.05	112	58.95	Other locations

in such places as accumulations of old leaves, grass, and other debris, it follows that the removal of such protective covering during cold weather may largely remove the pest from the immediate vicinity.

Smith and Shepherd (37) stated that the elimination of boxelder trees near houses as recommended by McDaniel of Michigan, and the use of only staminate boxelder trees, as recommended by Long of New Mexico, would be of little or no value as a control measure for the boxelder bug in Kansas in 1932-33. In their investigations, no eggs of the bug were found on the boxelder tree, nor any clusters of bugs on the pistillate boxelder trees on the campus or near Manhattan, Kansas.

Dr. S. W. Edgecombe of Logan, Utah, observed that when he took out the single pistillate boxelder tree (Acer negundo) from near his lawn, he had no more annoyance from boxelder bugs, even when there still were some staminate boxelder trees in the lawn. Out-of-doors, I did not find any eggs on plants other than the female boxelder trees. However, the bugs did lay eggs on maple and tree of heaven in the laboratory; some of these hatched and become mature. It has been found that in one case the elimination of the female boxelder trees in Logan did reduce the numbers of the bugs from a high population to a somewhat lower one. We cannot expect the elimination of the boxelder trees to result in complete freedom from the boxelder bug, because it has been found that they lay their eggs on much plants, grasses, weeds and stones, and also that they feed on many hosts. The best mode of prevention would appear to be a combination of the elimination of the female boxelder trees; the removal of protective shelter from the nymphs and adults in the neighborhood of the building to be protected, and insecticidal control where such is necessary.

Control of the Boxelder Bug

Several insecticides have been tested in this study. A list of the insecticides with the results obtained is given in Table 10.

Kerosene applied undiluted proved to be the most effective insecticide for controlling the boxelder bug. Kerosene containing 5 percent of DDT was second in effectiveness. Liberal spraying with kerosene, or 5 percent DDT in kerosene, gave good kills of both nymphs and adults. Kerosene must not be applied on flowers or other growing plants or foliage and flowers will be burned. There was no damage when it was applied on the bases of trees and to bugs on the ground.

Application of hot water (170 to 181 degrees F.) also was very effective. The result is shown in Table 10. The other insecticides in general, gave unsatisfactory control results. The insecticides tried other than kerosene were: heptachlor emulsion at the rate of 10 cc of 25% concentrate in one quart of water, heptachlor ½, 1, and 2 percent dust, and 5 percent DDT dust.

Field Studies

Observational studies were conducted in the field from March until September, 1951. Mating, feeding, oviposition, incubation, and abundance of the various developmental stages were studied to more closely associate the activities of the bugs in the laboratory with their activities under natural conditions. In addition, search was made in the field for natural enemies of the bugs and studies were made of the influence of

Table 10. Insecticides with results obtained in the cages and under natural conditions.

Insecticides	Dosage	Stage of insect	No. of insects	No. dead in 4 hours	Tempera- ture	Percent dead	Applied	Date
Heptachlor	25% emul: 10 cc. per qt. of water	Nymphs and adults	100 100	3 6	67° F.	3% 6%	Spray	Oct. 11, 1951
DDT 5% and kerosene	DDT 5% with kerosene	Nymphs and adults	50 50	50 50	53° F.	100%	Spray	Oct. 16
Kerosene	Pure	Nymphs and Adults	100 100	100 100	62° F.	100%	Spray	Oct. 23
Water (hot)	181° F.	Nymphs and adults	50 50	43 43	62° F.	86% 90%	Spray	Oct. 23
Heptachlor	½, 1, and 2%	Nymphs and adults	50 50	No effect after 24	67° F.	----	Dust	Oct. 11
DDT	5%	Nymphs and adults	50 50	3 5	53° F.	6% 10%	Dust	Oct. 16

various environmental factors, such as climate, shelter, and proximity of food supply. Several preliminary tests were conducted to determine the effect of various insecticidal material when applied directly to clustering bugs. Mortality was measured at intervals of 4 hours following treatment.

SUMMARY AND CONCLUSIONS

The boxelder bug, Leptocoris trivittatus Say, is found throughout most of the United States, except the southeastern area. Its principal host plant is the boxelder tree, and especially the pistillate boxelder. Under natural conditions in Utah, boxelder bugs were not found to complete development on any other host. However, under confinement, they completed their development on maple, tree of heaven, and ash. It seems possible, therefore, that in the absence of boxelder, these bugs could still survive on other related trees. This may explain why Smith and Shepherd in Kansas did not achieve control by eliminating boxelder trees.

Intermittent or occasional feeding by both nymphs and adults under natural conditions occurs in Utah on a wide variety of trees, shrubs, and herbs, such as boxelder, (Norway) soft maple, ash, pin oak, tree of heaven, mulberry, honey locust, buckeye, linden, spirea, ampelopsis, cactus, lilac, honeysuckle, iris, hollyhock, geranium, tulip, peony, asparagus, pigweed, foxtail, and grass. Under confinement they also fed on many materials, even including dead and dying insects, but in no case did they mature, except as stated above.

There has been no report of injury to boxelder trees from the feeding of the boxelder bug. Damage to plants has been reported only in the case of the intermittent feeding mentioned above. Scarring of fruit caused by the feeding punctures of the bugs has been the principal form of economic damage.

Mating of overwintered bugs starts in late March and continues until they die during the month of June. Oviposition starts from 2 to 8 days after mating occurs. Eggs are laid in small clusters on or near boxelder trees. The total number laid by a single bug, according to observations made in cages, varies from 12 to 20. Incubation was found to vary from 9 days in a warm greenhouse to 26 days out-of-doors. Development through the six nymphal instars averages about 75 days.

Appearance of the new adults starts in July and reaches the high point by the end of September. These adults feed, mate, and lay eggs, about 80 percent of which become adults. This last generation matures in late September, mates, and lays some eggs but these eggs do not get past early nymphal stage before being killed by cold weather.

Adults of both the summer and fall generations overwinter. In preparation, the bugs seek shelter during the first cold days of October and tend to cluster together in crevices, trash, and under various objects. Mortality is high, and apparently only those bugs in the most sheltered locations survive. Hibernation is not complete since prolonged warm spells, even during the winter, cause the bugs to become active and seek further shelter, often in large groups. Warm days in March cause them to become increasingly active until feeding and eventually mating occur.

It is the overwintering habit which causes boxelder bugs to become a nuisance in homes and buildings. In seeking shelter and warmth they congregate on the south and southwest sides of houses and other buildings, frequently entering them through the windows and doors. Indoors their presence and their dropping of feces become a great annoyance.

The most logical means of reducing the numbers of boxelder bugs under most conditions, would probably be the elimination of boxelder trees. It is even possible that elimination of only the pistillate trees would be effective. Benefit should also be derived from the removal of various forms of shelter from around the premises. It was found that the bugs are very resistant to most insecticides. Kerosene was the most effective of many materials applied directly to the bugs. DDT in kerosene was also effective but did not appear to be more effective than kerosene alone.

LITERATURE CITED

(1) Ainslie, C. N. 1931 — Boxelder bug. Insect pest survey, Iowa, 11:552.

(2) Bare, O. S. 1946 — Boxelder bug. Neb. Agr. Ext. E. C. 1545: (1-4) processed.

(3) Blatchley, W. S. 1926 — Heteroptera of eastern North America. The Nature Publishing Company, pp. 270, 284-285.

(4) Chambers, E. L. 1931 — Boxelder bug. Insect pest survey, Wisconsin, 11:623.

(5) Cory, E. N. 1931 — Boxelder bug. Insect pest survey, Maryland, 11:622.

(6) Crosly, C. R. 1934 — The boxelder bug in New York. Jour. Econ. Ent. 27 (6): 1196.

(7) Davis, J. J. 1931 — Boxelder bug. Insect pest survey, Indiana, 11:385, 552, 622.

(8) ______ 1935 — Insects of Indiana for 1934. Proc. Ind. Acad. Sci. 44:198-206.

(9) Drake, C. J. 1931 — Boxelder bug. Insect pest survey, Iowa, 11:70.

(10) Flint, W. P. 1931 — Boxelder bug. Insect pest survey, Illinois, 11:552, 622.

(11) Gillette, C. P. 1931 — Boxelder bug. Insect pest survey, Colorado, 11:71.

(12) Haseman, L. 1931 — Boxelder bug. Insect pest survey, Missouri, 11:71.

(13) Hutson, R. 1932 — Leptocoris trivittatus feeding habits on apple and strawberry. Jour. Econ. Ent. 25 (5):1107.

(14) Jaques, H. E. 1931 — Boxelder bug. Insect pest survey, Iowa, 11:70.

(15) Kay, N. W. 1940 — American Midland Naturalist, 23:724.

(16) Knowlton, G. F. 1925 — The boxelder bug in Utah. Insect pest survey, 5:277.

(17) ______ 1931 — The boxelder bug in Utah. Insect pest survey, 11:71, 132, 231, 623.

(18) Knowlton, G. F. 1931 — Some economic insects of Utah - 1930. Proc. Utah Acad. Sci. 8:144.

(19) ______ 1932 — Notes on injurious Utah insects - 1932. Proc. Utah Acad. Sci. 9:81.

(20) ______ 1932 — Boxelder bug. Utah Agr. Exp. Sta. (Bien. Rept.) Bul. 235 : 56.

(21) ______ 1933 — The boxelder bug. Utah Agr. Exp. Sta. Leaflet 3 : 1-2, illus.

(22) ______ 1941 — Boxelder bug feeding habits. Jour. Econ. Ent. 34 (2):326.

(23) ______ 1944 — Boxelder bug observations. Jour. Econ. Ent. 37 (3):443.

(24) ______ 1947 — Boxelder bug nymphs feeding on dead honeybees. Jour. Econ. Ent. 40 (6):1915.

(25) ______ 1951 — The boxelder bug. Utah Agr. Ext. Ser. Bul. 218: 1-2

(26) Long, W. H. 1928 — Why only staminate boxelders should be grown. Review of Applied Entomology, 16:522.

(27) McColloch, J. W. 1929 — Boxelder Bug. Insect pest survey, Kansas, 9:41

(28) McCulloch, I. 1916 — Flagellates in the intestinal tract of boxelder bug. Review of Applied Ent. 5 (b):18.

(29) McDaniel, E. I. 1933 — The boxelder bug as a household pest. Quart. Bul. Mich. Agr. Exp. Sta., 15 (4):226-227.

(30) ______ 1936 — Leptocoris trivitattus Say killed by a sulfanated higher alcohol spray. Jour. Econ. Ent. 29 (6):1176.

(31) Munro, J. A. 1931 — Boxelder bug. Insect pest survey, North Dakota, 11:132, 385.

(32) Parker, R. L. 1930 — Boxelder bug. Insect pest survey, Kansas, 10:66.

(33) Ruggles, A. G. 1931 — Boxelder bug. Insect pest survey, Minnesota, 11:623.

(34) ______ 1935 — Boxelder bug. Minnesota, Agr. Exp. Sta. Folder, 52:2-4.

(35) Schweis, G. G. 1931 — Boxelder bug. Insect pest survey, Nevada, 11:552.

(36) Sherman, F. 1931 — Boxelder bug. Insect pest survey, South Carolina, 11:622.

(37) Smith, R. C. and Shepherd, B. L. 1938 — The life history and control of boxelder bug in Kansas. Trans. Kans. Acad. Sci. 40:143-159.

(38) Stearns, L. A. 1931 — Boxelder bug. Insect pest survey, Delaware, 11:551, 622.

(39) Swenk, M. H. 1930 — Boxelder bug. Insect pest survey, Nebraska, 10:66.

(40) ________ 1931 — Boxelder bug. Insect pest survey, Nebraska, 11:623.

(41) Wakeland, C 1931 — Boxelder bug. Insect pest survey, Indiana, 11:132.

(42) Webster, R. L. 1926 — Boxelder bug. Insect pest survey, Washington, 6:200.

(43) ________ 1932 — Boxelder bug. Washington Agr. Exp. Sta. (1930-31) Bul. 260 : 30-34.

(44) Willey, C. R. — Boxelder bug. Insect pest survey, Virginia, 11:622.