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Leung, Yuk Maan

M. S.

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Title ----- A General Study of the Mint Flea-beetle, Longitarsus waterhousei. -----

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The mint flea-beetle, Longitarsus waterhousei, is a new discovery in Oregon. It might have been brought in in the infested roots from Michigan. As far as is known the beetle attacks the mint family only. The greatest damage is done by larvae which feed on the epidermis of the small rootlets and tunnel through the large roots in the spring, causing the abnormal growth of the plant or killing the plant completely in some cases. The adult beetles feed on the epidermis of the foliage and frequently riddle the leaves with tiny holes.

There is but one generation a year. The insects overwinter in the egg stage. The adult beetles appeared in the field sometime in July. The females begin to deposit eggs a month or so after emergence. The larvae will hatch at any time after spring approaches. After the larvae are fully developed, they leave the roots to pupate in the soil. The pupal stage takes about 26 days.

Several control methods are suggested.

A GENERAL STUDY OF THE MINT FLEA-BEETLE,  
LONGITARSUS WATERHOUSEI KUTSCH

by

YUK MAAN LEUNG

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APPROVED:



Head of Department of Entomology

In Charge of Major



Chairman of School Graduate Committee



Chairman of College Graduate Council

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## INTRODUCTION

Peppermint is one of the essential oils. It is extracted from the plants by distillation, and is used in medicines, extracts, and for flavoring candies and chewing gum. The mint industry has undergone some distinct changes during the last ten years. More than 300,000 pounds of oil, valued at more than \$1,000,000 are required to supply the commercial needs in the United States annually (3), and the demand increases from year to year, as shown in the table below:

Table I

## Production and Value of Mint in the United States\*

| <u>Year</u> | <u>Production</u> | <u>Value</u> |
|-------------|-------------------|--------------|
| 1932        | -                 | \$ 599,000   |
| 1933        | 503,000 lbs.      | \$ 902,000   |
| 1934        | 653,000 lbs.      | \$1,537,000  |
| 1935        | 1,169,000 lbs.    | \$2,000,000  |

England has ceased to produce peppermint commercially.

Japanese mint is not suited to American commercial use, and the production of the oil in the United States is chiefly confined to limited areas in Michigan, northern Indiana, and Oregon. Besides these several states, Ohio and California figure among the mint-producing states of secondary importance.

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\* Statistical abstract of the United States, 1936

Oregon is one of the important centers of mint production.\*

Table II

Mint Production in Oregon

| Year | Acreage | Yield per acre<br>(lbs. of oil) | Production<br>(1,000 lbs. of oil) |
|------|---------|---------------------------------|-----------------------------------|
| 1929 | 2,300   | 37.0                            | 85                                |
| 1930 | 2,000   | 35.0                            | 70                                |
| 1931 | 1,480   | 32.0                            | 47                                |
| 1932 | 1,480   | 25.0                            | 37                                |
| 1933 | 680     | 28.7                            | 20                                |
| 1934 | 1,600   | 40.0                            | 64                                |
| 1935 | 1,200   | 40.0                            | 48                                |
| 1936 | 1,890   | 42.4                            | 80                                |

Cultivated mint is generally regarded as a crop which is quite free from the attacks of insect pests; however, recent investigations have brought to light the fact that this crop has a very serious enemy in the mint flea-beetle.\*\* The muck region of southern Michigan and northern Indiana constitute the greatest mint-growing section in the world since they produce about one-half of the world's output of peppermint and spearmint.

In the past, mint growers of the above mentioned states maintained good yields; however, in more recent years the growers have suffered a tremendous loss annually

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\* Peppermint for oil (mim.) Division of Crop and Livestock Estimates, Bureau of Agricultural Economics. U.S.D.A. 1937

\*\*\* Sayre, C. B., Purdue Univ. Agri. Exp. Sta. Circ. No.65, p. 1

due to the attacks of the mint flea-beetle.

Oregon numbers among the main mint-producing regions in the United States. The loss due to the insect pest has been negligible to date, only a small area being infested. But optimism is unwarranted in the present situation; for experience has shown that it takes a considerable period of time to build up a population after the insect has been introduced and before damage is apparent.

The mint flea-beetle, Longitarsus waterhousei, which has proved to be very destructive to the mint family, is a recent discovery in Oregon. This thesis, suggested by Dr. D. C. Mote, is based on a study of the life history from field observations and review of the literature. The study may be helpful in future work on either life history or control of this insect pest.

#### ACKNOWLEDGEMENTS

I am particularly grateful to Dr. D. C. Mote, head of the department of entomology, under whose direction and with whose advice this study has been made. I wish to thank Mr. B. G. Thompson, assistant entomologist of the Oregon State Agricultural Experiment Station, for making the field work in connection with the experimental studies possible. Also, I wish to express my indebtedness to

Mr. L. G. Gentner, assistant entomologist of the Southern Oregon Experiment Station, for his suggestions in conducting the investigations, and for his kindness in giving two English specimens and two Michigan specimens for comparison. For assistance in every way possible, I also wish to express my gratitude to Dr. H. A. Scullen, Mr. H. H. White, Mr. J. Davis, and to Mr. R. Rosenstiel.

#### STATEMENT OF THE PROBLEM

During the last three years it has been reported that some areas in Oregon have been infested by the mint flea-beetle. Though the infestation at present is limited to certain localities only, nevertheless the damage becomes more extensive each year. If no means are employed to check the dispersion of the insect before the damage is displayed to any great extent, it is doubtful whether the production of mint will be maintained regularly in the future. It is evident that the study of the insect in general is a significant one.

The investigation of its life history with particular reference to its seasonal habits, the distribution of infestation in different districts, and the preliminary study of the insect in general as a basis for future study of control measures is the purpose of this paper. It is hoped that this study will serve to stimu-

late interest for advanced work in control before the insect disperses to constitute a general menace. Here is a case where "an ounce of prevention is worth a pound of cure."

## REVIEW OF THE LITERATURE CONCERNING LONGITARSUS WATERHOUSEI

The presentation of the first publication concerning this species in the United States was made by L. G. Gentner in 1925 (4). He mentioned that the beetle was causing serious injury in southern Michigan and that its presence limited the period during which peppermint and spearmint could profitably be kept in the ground. Moreover, he stated that the pest was a new one, heretofore neither studied nor named.

Relative to the systematic status of this species, it is interesting to review briefly its development. Longitarsus menthae Gentner was first named by L. G. Gentner in 1925, but no technical description was given. Later it was discovered that it was synonymous with the European species.\* He then described it under the name of Longitarsus menthaphagus (5). In 1928, he published another paper in the same publication in which the name Longitarsus menthaphagus was changed. The matter of the

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\* Longitarsus menthae (Bedel) Faune Col. Bassin Seine, vp. 189 & 306 1898

name was precipitated by the visit to England in 1927 of Richard Stroud, assistant superintendent of the mint plantation of the A. M. Todd Company, at Mentha, Michigan. He asked L. G. Gentner to prepare a life history mount of this insect which he might show to English mint growers. While in London, he visited the British Museum and showed the mount to Major E. E. Austen, in charge, who immediately set his men to work to see whether any similar insects could be found in the collection. They finally found two specimens of Longitarsus waterhousei which they thought agreed quite well with the American specimens. These had been collected by Waterhouse about 1860, and had been sent to Kutchera of Germany who described them under that name. Later, seven of the English specimens were sent to America for identification. The specimens agreed very well with the American specimens, except that the series averages a little larger, and only two of the five females were fully winged. The other three show only a feeble development of the membranous wings. All of the females taken in this country have been fully winged. The males in both series are apterous. A comparison of the male genitalia of specimens of both series showed these to be identical. Mr. Gentner then sent some Michigan specimens to Major Austen of the British Museum, who referred them to Mr. K. G. Blair.

He also sent some to Dr. Franz Heikertinger of Austria, who is an authority on European Halticinae. Mr. Blair stated that though the British series ran a little larger than the American, he believed them to be conspecific. Dr. Heikertinger had compared the American with the European series and had found them to be identical even to the male genitalia. He also stated that it is the first species of *Longitarsus* common to both America and Europe, and that it is relatively rare in continental Europe. Such being the case, it seems definitely established that *L. menthaphagus* Gentner should stand as a synonym with *L. waterhousei* Kutsch., the latter of which names has priority.

#### TAXONOMIC POSITION OF *L. WATERHOUSEI*

The present position of the species *Longitarsus waterhousei* is:

Order - Coleoptera

Family - Chrysomelidae

Tribe - Galerucini

Sub-tribe - Halticini

Group - Aphthonae

Genus - *Longitarsus*

Species - *waterhousei* Kutsch

General characters of the family Chrysomelidae: a very

large family of medium- or small-sized beetles, usually short bodied and more or less oval in outline, the segments often comparatively stouter towards the tips. In color the beetles are often prettily variegated, though some are wholly of a brilliant metallic blue or green, while others are dull black or brown. All have the legs short, the fourth and fifth segments of the tarsus grown together, the fourth usually very small and concealed in a notch in the third segment.

The species agree in having the labial palpi three-segmented; mentum transverse and not large; maxillary palpi four-segmented and cylindrical. Head either prominent and more or less constricted behind (Eupoda) or inserted to the eyes; eyes entire or feebly emarginate on the inner side, finely granulated; mandibles usually short and robust, labrum transverse, usually round in front. Antennae variable in position and form, usually 11-segmented. Thorax often margined at the sides, the side pieces not separate from the prosternum, which is not prolonged. Elytra usually covering the abdomen, sometimes leaving the last dorsal segment exposed. Legs usually short, high thighs often enlarged for jumping; tibiae never serrate, usually without spines; tarsi with segments one to three broad and covered beneath with a brush of hair; fifth with two equal claws of variable form.

They are called leaf-beetles because they feed upon the leaves of plants. All the species are diurnal in habit and move slowly over the surface of plants to which they adhere by means of the dense brush of hairs upon the under side of the tarsi.

On account of their leaf-eating habits the family comprises some very injurious forms. The eggs are usually yellowish and elongated, and are generally laid upon the leaves or stems of the plants upon which the larvae feed. The latter are of varying form, but for the most part are fleshy, convex or chunky hump-backed "slugs" or grubs. Many of them live on the leaves of the plants, when they feed often in company with the mature insects. Those that live exposed to the light differ from the great majority of Coleopterous larvae in being more or less highly colored. Some of them are flattened and curiously armed with spines, while others are partially covered with their own excrement. When ready to transform, many of the leaf-eating larvae fasten themselves by the tail or last abdominal segment to a leaf and enter the chrysalis stage, while others go into the ground when they are about to change to a pupa. (2)

General characters of the tribe Galerucini:

The tribe is well defined by the insertion of the antennae, which are placed upon the front, between the

eyes; they are usually approximate, and the front is generally carinate, with a narrow ridge. The eyes are not emarginate and finely granulated. Head exposed, and prothorax truncate or emarginate in front, with the sides distinctly margined. Scutel always visible. Elytra are rarely shorter (Metacycla) than the abdomen. Prosternum narrow or invisible between the coxae which are prominent and conical, and have the cavities sometimes open, sometimes closed, always transversely oval. Legs variable, tarsal claws variable, rarely simple. (10)

General characters of the genus longitarsus:

The members are very small oval or oblong convex species, usually uniform full yellow, brownish or piceous in hue, with the elytral punctures much confused; tarsi slender, the first segment of the hind pair nearly or fully half the length of tibiae and as long as all the following segments united, (2) antennae with third segment longer than fourth. (10)

HISTORY OF THE INTRODUCTION OF *L. WATERHOUSEI*

Commercial mint culture was introduced into the United States more than one hundred years ago and first became established as an industry in Wayne County, New York. From New York, peppermint culture extended westward first

to northern Ohio and later to southern Michigan and northern Indiana as early as 1835. The large areas of muck soil in this region were found to be so well adapted to mint culture that the region became the center of production. The area planted to peppermint in Michigan and Indiana is reported to have reached 40,000 acres in the last few years.

The success that attended mint culture on the muck lands of the Middle West naturally led to experimental plantings in other parts of the country where areas of similar land were available. About twenty-eight years ago, mint roots were introduced into Eugene, Oregon, from the A. M. Todd Company in Michigan. Reclaimed muck lands along the Willamette and Columbia Rivers in Oregon and Washington are now devoted to this crop to the extent of about 2,000 acres, with the result that the Pacific Coast is at present second most important production center, (1) and the output of oil from this region amounts to more than 15% of the total for the United States (9).

The earliest authentic record of injury to mint by the mint flea-beetle was in 1922, though the culture of peppermint was introduced more than one hundred years ago. During the year 1924 the appearance of the pest attracted the attention of the growers though it appears not to have caused serious damage until a period covering approximately the years from 1924 to 1927. It is certain that

the mint flea beetle was originally introduced into this country on mint roots brought over from England because of the higher yield of oil to be obtained from the English mint over that of the American variety. They were usually shipped in the spring, and it is quite possible that eggs or even young larvae may have been brought over with them.

(7)

During those early years the mint growers of all regions in Oregon have not complained of the infestation of any kind of insect damage. In 1934, however, a grower in Jefferson, some twenty-nine miles north of Corvallis, claimed that he discovered some beetles feeding on the foliage of the mint plants, during the summer; but the crop was not injured. In 1936 the beetle was so abundant that the crop was seriously infested. A hand full of beetles was collected when a net was swept in the infested area. During the spring of 1937, when the mint roots began to sprout, the roots were heavily damaged by the larvae in the soil so that in a portion of the field the crop did not grow normally. In some cases the injury to the main root was so serious that the rootlets died out entirely. The introduction of the pest into Oregon is not definitely recorded; however, it is reasonable to believe that it may have been introduced by the infested roots on which eggs or young larvae were lodged.

## ECONOMIC IMPORTANCE

The pest was unknown to peppermint growers in Oregon until four years ago when one of the mint growers in Jefferson reported that his crop was infested by small beetles. These insects became more numerous in 1936. Though the infesting beetle is not as yet very extensive, still it does occur in damaging numbers. The damage is done mainly by the larvae although the adults play an important part in destroying the foliage of the plant. The larvae feed on the roots, causing the abnormal growth of the plant and withering of the foliage. As a result, the yield of mint oil is greatly reduced. Normally the yield of mint ranges from twenty-five to fifty pounds to the acre, (3) but the production may be reduced to a fraction of this amount if the field is heavily infested.

The damage may become more serious each year in the same field. The adult males are apterous which accounts for the fact that the beetle will live in the same field from generation to generation. A new field, however, may be infested by the migration of the insects from the infested area in the vicinity. So far as is known, the mint flea-beetle infests the mint family only. Peppermint and spearmint are both seriously injured by the pest. Experiments have shown that it does not feed on plants other than those belonging to the mint family(6).

The food plants which are infested include: \* Mentha aquatica, m. parietariaefolia, m. arvensis, m. crispa (cult.) and m. caudicans.

#### TYPES OF INJURIES

The damage is done by the adult and the larva, the latter playing the most important part in the ravage by spending its life in and on the roots and feeding externally on the small rootlets (Plate 5B), tunneling in the larger rootlets and mining beneath the epidermis of both the main root and the underground portion of the stem (Plate 5A). The tunnels may extend above the surface soil for some distance. If a plant is seriously infested, it does not send out rhizomes or side shoots. Moreover, the infested plant can be distinguished from the normal plant by the abnormal growth and color. The infested plant often shows an unhealthy appearance resulting in a dwarfed mien and poor-looking leaves (Plate 7). In place of a normal dark green color of the stems and leaves, it often times shows a reddish purple color and the underground parts of the stems may turn brown to blackish. The adult feeds on the foliage of the plant, in most cases on the epidermis of the leaves; but it is not un-

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\* Resultate Funfzehnjahriger Untersuchungen uber die Nabrungsplanzen Einheimischer Halticinen - Entomologische Blatter 22, Heft 1, p. 5, 1926

common to find the leaves riddled by the adults (Plate 6). The damage done by both the larvae and the adults causes a decided reduction in oil yield.

#### CULTIVATION OF PEPPERMINT IN RELATION TO THE LIFE CYCLE OF *L. WATERHOUSEI*

It is of value to mention briefly the cultivation of peppermint which is related to the life cycle of the insect to a certain extent. New plantings spring from nodes on both root stocks and runners, which are obtained from a portion of a field of one year's growth. They may be planted in the late fall or early spring. The root stocks are set in the furrows of the field and covered two to three inches deep. The "new" mint requires hoeing and weeding in the row.

There is no set rule that can be used as a guide for determining the proper time for harvesting. However, this time is indicated by the degree of maturity of the plants, as the oil content of the plant is governed to a great degree by the weather conditions. The majority of the growers watch the progress of the plants by examining the underside of a leaf from time to time. The development to maximum oil content is determined approximately by holding the leaf so that the sun shines on it; at that stage, the oil can be seen glistening upon the underside. New mint is usually ready to cut from August 20 to

September 10.

After the new mint is harvested, the ground is plowed late in the fall to a depth of four inches in order to balance the mint acreage. (3) It is significant that there are some points in the cultural methods related to the life cycle of the insect. In the first place, the stubble and crop remnants which are left in the fields after harvest are available for the adult beetles to feed on and lay eggs. Furthermore, the field is plowed under several inches deep after the mint is harvested. This procedure serves as protection during the winter for the eggs, which are deposited on the surface of the soil and on the fallen dead leaves.

#### STUDIES ON THE MINT FLEA BEETLE IN OREGON

##### Distribution in Oregon:

During the summer of 1937 the writer proceeded to different mint-growing regions with the view to investigating the distribution of this pest. So far as is known, the regions in the vicinity of Jefferson were the most seriously infested areas. The area was divided by a creek; and curiously enough, the crop on the south side of the creek was heavily damaged, even a portion of the plants being completely killed, while there was no evidence of infestation on the north side of the creek. This may be accounted for by the fact that the male adults are

apterous and can not fly to a new area to establish a foothold, but must be introduced by migration or by artificial means.

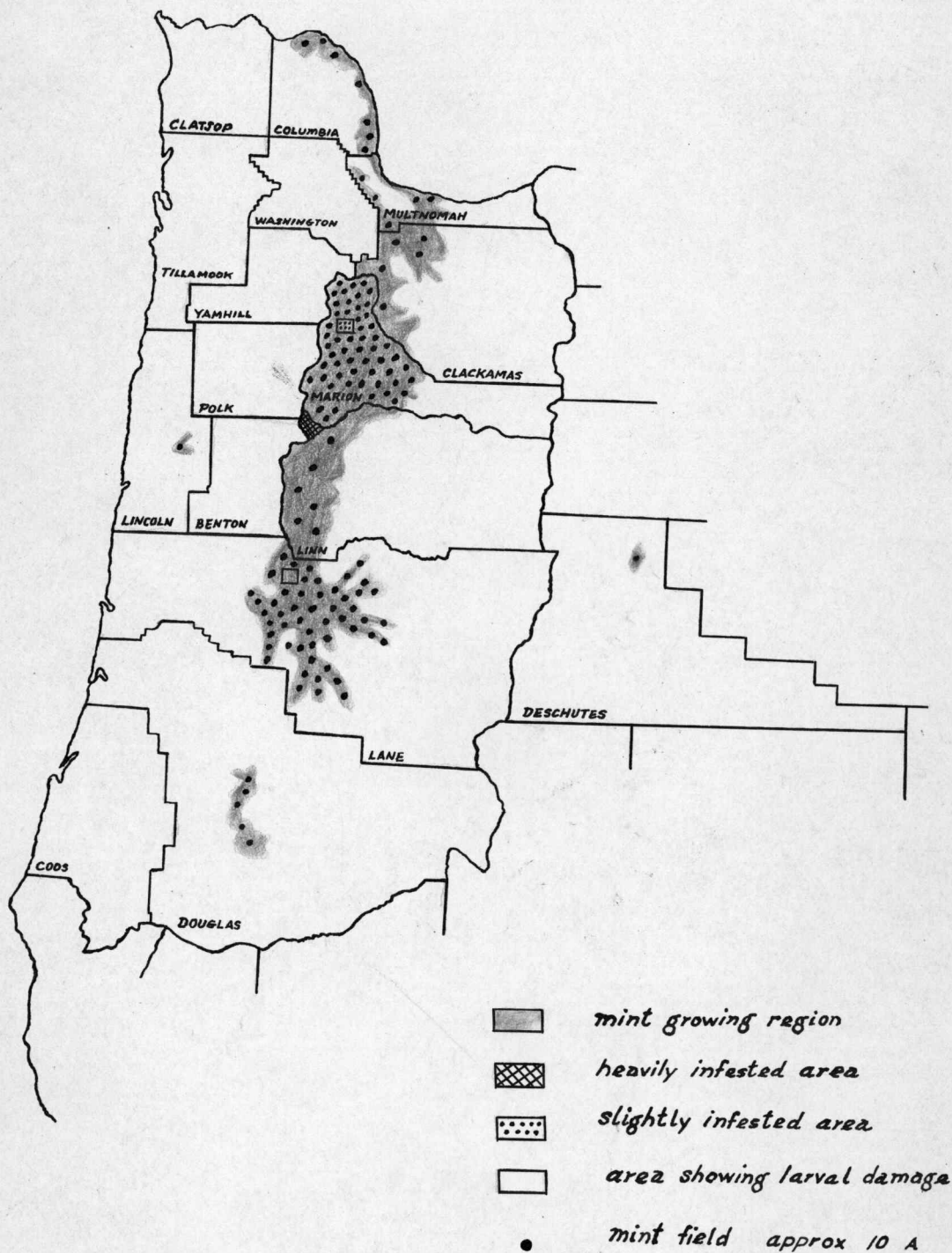
Beetles were also found in the mint fields at Brooks which is about eight miles north of Salem, but since they were not abundant, it was not considered as a serious infestation. There was an indication of the appearance of the beetles in another mint field which is located some three miles from Junction City. This field had been planted only two years, yet there was evidence of infestation. Though no adults were evident, some of the roots showed the work of the larvae, some decayed tap roots even showing.

Many other mint fields in Coburg, Springfield, Bischoff, Rogers, and Seeley have been investigated; however, none of the above-mentioned places have shown any indication of infestation so far. Some three hundred acres in Rainier, near the Columbia River, were observed by Mr. Joe Schuh; however, no infestation was evident. Chart I shows the distribution of the infested areas and the mint-growing districts.

Description of the various stages:

Adult - The male measures  $2/25$  to  $1/10$  inches in length, and the female is  $1/10$  to  $1-1/10$  inches long. It is elongated, oval, convex, and shining, and of a pale brownish hue. The head is a deeper brown, especially the

*Chart 1 Distribution of mint growing regions  
and infested areas in Oregon*



front part; the eyes are dark. The outer segments of the antennae are deeper in color, the basal segments much lighter, and the length about  $3/4$  or more the length of the body, segments two to five are gradually longer. The color of the prothorax and scutellum is darker than the body. The tip of the elytra is rounded to the suture, the pygidium exposed. The color of the legs, except that of the hind femora is somewhat lighter than that of the body. The hind femora is darker and has a still darker reddish-brown blotch showing through the integument. The femora is very much enlarged enabling the insect to jump readily. The abdomen is shining dark brown and pale at the tip, indistinctly punctate, smooth along the sides, segments somewhat transversely wrinkled. The differentiation between the male and the female lies in the fact that the membranous wings of the male are entirely lacking, its jumping habit is the habitual method of locomotion, and the base of elytra is not broader than the thorax, while in the female the body is larger and robust; the base of the elytra is distinctly broader than the thorax (Plate 1.) Membranous wings are always present though they have never been seen to fly.

Egg - The egg measures about one fortieth of an inch in length and the width is about one half the length. It is rather large in proportion to the size of the adult (Plate 4).

The shape is oval, elongated with orange-yellow color, and the shell is hard and leathery. The eggs are deposited singly on surface soil or among fallen leaves on the ground.

Larva - The larva measures about one fifth of an inch long when it is full grown; it is long and slender; whitish with a shining, pale-brown head and pale-brown at the posterior end of the abdomen. The body is smooth and covered with whitish hairs. Each possesses three pairs of legs, the color of which is darker than that of the body (Plate 2).

Pupa - It measures about one tenth of an inch in length; it is whitish in color and sparingly covered with short brown hairs. When it is full grown, the appendages are visible, and it resembles the adult in appearance (Plate 3).

#### Seasonal history and habits:

There is but one generation a year. The insects overwinter in the egg stage. The adult beetles appeared in the field as early as on the first of July, the emergence reaching its maximum rate when the temperature was raised. On the twenty first of July a tremendous number of beetles were observed in the field. It was found that some fifteen to twenty adults were feeding on one plant. Adults do not all appear at one time, but may continue to emerge over a period of time, due to the fact that the

rate of development may vary considerable. The adults feed on the epidermis of both surfaces of the foliage, and they may make small holes in the leaves or the leaves may be perforated, which results in their turning brown and dropping off. The lower and higher leaves are both infested (Plate 6). In the laboratory, the lower side of the top leaves were preferred to the lower part of the plant. They usually feed in the morning and in the afternoon; during the hot noon they hide on the lower part of the plant or on the fallen leaves on the ground and under the shade of the plant.

After the adults have been feeding for some time, mating takes place and the females begin to deposit eggs a month or so after emergence. The first observation in the field was on the fourth of August, and on the fifth in the laboratory. The eggs are laid singly from time to time on the surface of the soil, between soil particles, or adhering to the fallen leaves and the decayed roots above the soil. The egg-laying period may take some time. More eggs were found in the field on the twenty-eighth of August. The adults continue to feed until cold weather comes. During the day of harvest (August 14th) the beetles were still very active. In the laboratory they were kept alive until October 2nd at which time no mint plant was available with which to feed them.

By the time severely cold weather has set in,

the eggs have been turned under with the mint sod where they remain during the winter. It is a common practice to plow the mint sod under in the fall, and this serves as an ideal winter protection to the eggs. Where the sod is not turned under, the eggs may receive protection by being covered over by the drifting of the muck, or by gradually settling down into the soil.

The larvae will hatch at any time after spring approaches. The earliest record of observation of the larvae in 1937 was made on the second of June. (They may have hatched some time in May; for the first adult appeared early in July.) After they are hatched, the whitish young larvae are very active among the roots where they begin to feed. They may first feed on the tender epidermis of the rhizomes and rootlets. As they develop, they tunnel into the large rootlets and the main roots. In most cases infested plants do not grow side roots. The infested plants can be identified by the abnormal growth and the reddish-purple color of the leaves and stems. Often during harvesting, the whole plant will be taken up by the machine since the main root will be completely decayed due to the action of the larvae. Moreover, the larvae may kill the whole plant after the main root has been tunneled. Several acres were completely destroyed in a seriously infested field in Jefferson. When the weather is warmer, the eggs

continue to hatch. On the sixteenth of June an immense number of larvae were observed when several holes about two to three inches deep were dug out in the field. There were as many as twelve to sixteen larvae per square foot. The larvae attain maturity after feeding a month or more in the roots. In the laboratory all larvae pupated by the third of July.

After the larvae are fully developed, they leave the roots to pupate in an oval earth cell which is about three to four inches below the surface soil. The pupal period varies from twenty to thirty-two days at room temperature, the average being twenty-six days. In the mint field no pupa was observed on July twenty-first. The following chart indicates the average seasonal history:

Chart II

## Seasonal History of the Mint Flea-beetle

| Jan.-Apr.                        | May                   | June | July                          | Aug. | Sept.-Dec.                       |
|----------------------------------|-----------------------|------|-------------------------------|------|----------------------------------|
| <u>Overwinter</u><br><u>Eggs</u> |                       |      |                               |      |                                  |
|                                  | <u>Larvae hatched</u> |      |                               |      |                                  |
|                                  |                       |      | <u>Pupal</u><br><u>period</u> |      |                                  |
|                                  |                       |      | <u>Adult</u> <u>feeding</u>   |      |                                  |
|                                  |                       |      |                               |      | <u>Overwinter</u><br><u>Eggs</u> |

Temperature may play an important role in the development of the beetle. In 1937 the weather was still cold and rainy during May and June. This may have postponed the development to some extent. (6) In Michigan, it is stated that its development is considerably affected by climatic conditions, a warm season hastening their growth. Likewise, in a cold and wet season, the development is retarded.

The adults appear over a period of time. In the high, dry parts of the field the development is more rapid than in the lower part where the soil may be very moist. Other factors, such as the depth at which the eggs lie in the soil in the spring, the killing of the original host plant, and the necessity of migration to another may also contribute in influencing the rate of development. A new field is invaded by migration of the adults from the infested field. Though the females are winged, they have never been observed in flight. Beetles emerging in the fields in which there is no mint to feed on may migrate for a considerable distance to growing mint plants. In this migration they are guided apparently by the strong mint odor given off by the plants. (6)

Regarding the deposition of eggs in the mint field, there is no particular relation of the place they are laid to the plant itself, for normally the roots spread rather uniformly through the ground.

During the process of egg-depositing, the female may be seen crawling slowly over the ground, stopping, pressing the abdomen close to the surface, and laying an egg; or in other instances, she may be seen forcing the extended tip of the abdomen between soil particles and there depositing an egg. After each egg has been deposited, the female ordinarily crawls a short distance before depositing another. (6)

#### CONTROL SUGGESTIONS

Due to limitation of time, the writer has not organized records of experimental data, though several trials of dusing with calcium arsenate have been made. At Mentha, Michigan, where the mint fields were heavily infested, different experiments have been carried on for this purpose. For poisoning the mint flea-beetle, it has been found that dust is preferable to liquid spray, the reason being that it can be blown in a thick mint growth and it will cover the foliage completely. It is also more quickly and easily applied. In consequence the dust should be light and fluffy, and should stick to the plants well, and not repel the beetles, but should kill them rather than drive them to other mint fields.

The poisons which they used in their experiments were paris green, calcium arsenate, lead arsenate and

calcium fluosilicate compound. They found that paris green gave the quickest kill, but it is relatively heavy, does not cover well, and of higher cost. The result was not entirely satisfactory. Calcium fluosilicate compound, applied undiluted in the form purchased (about 22%) gave satisfactory results, since it covered well and adhered evenly, though the action was slow. It was recommended for use alone for protecting new mint against beetles. It acts both as a stomach poison and as a contact insecticide.

In using arsenicals, heavier doses were necessary for similar results, the mint flea-beetle being very resistant to such compounds. The use of lead arsenate was not advised since it did not give effective control even when large quantities were used. The reason was that it apparently had a repelling rather than a fatal effect on the beetles. Among other arsenicals, lime arsenate, however, was recommended. It was light enough in weight to dust well and it adhered to the foliage evenly. The kill was nearly as quick as with paris green.

Several different materials can be used as spreader, such as finely-ground raw gypsum, hydrated lime, talc, and flour. They found that gypsum was too heavy to dust well, especially when mixed with paris green, though it was non-repellent to the beetles. Hydrated lime seemed to have a repellent effect though its lightness was favorable.

Flour gave good results, but it had a tendency to pack in the duster. Among these carriers, talc proved to be superior to the rest, having the combined advantages of being light, dusting evenly, and not repelling the beetles.

The workers in the experiment in Michigan found the most practical and satisfactory dusts among the various combinations such as a mixture of ten to twenty pounds of calcium-arsenate with talc to make a hundred pounds, or one consisting of ten to twenty pounds of calcium arsenate with equal amounts of calcium-fluosilicate compound and talc to make one hundred pounds. In the latter combination, finely ground raw gypsum could be substituted for the talc, producing a heavier dusting mixture; or the calcium arsenate could be used with the calcium fluosilicate compound alone which would increase the cost somewhat.

"The dusts should cost the grower from \$5.50 to \$7.00 per one hundred pounds, depending upon the materials used. On the uncut mint they should be applied at the rate of 40-50 pounds per acre, while on the stubble, 30-40 pounds should be sufficient. To protect new mint, the first application should be made as soon as the beetles appear. Two or three applications may be necessary per season. Heavy rains may wash off much of the poison, so that another application must be made. On small acreages, the dusts may be applied with some of the larger types of crank or level dusters which can be carried about by a man.

With this kind of dusters, several acres may be covered in a day. Large acreages will require traction or power dusters, some of which are able to cover as high as 40 acres per day.

"The cost of controlling the mint flea-beetle will probably be the greatest during the first year or two. If the plan of control mentioned above is carefully carried out, the cost should decrease from year to year, as the infestation decreases."

Calcium cyanide and nicotine dust were also tried out at Mentha; however neither of them has proved satisfactory. The former was effective in killing the beetles, but it burned the plants badly. The latter had no value whatsoever; for after the dust had been applied and the beetles were apparently killed, they were active again a few hours later.

Relative to the control of larvae, there is no practical measure as far as is now known. Little can be done by artificial means since the larvae spend their entire lives in the roots under the soil.

Other methods of control are suggested which are based upon the life habits of the beetle. Since new mint is usually planted in fields that have been summer-fallowed or -cultivated, it should have little larval injury, except where eggs have been introduced with the roots used in planting the field. It is therefore important to select the

roots from a field that is as free as possible from flea-beetle eggs. If the soil is thoroughly shaken from the roots as they are dug, there should be little danger of their carrying many eggs. Roots are ordinarily dug before the eggs have hatched. New mint should be protected against the invasion of the adults, especially during July. As soon as the beetles begin to appear, the mint along those margins of the new field which adjoins infested fields should be poisoned in order to kill the beetles as they gradually migrate into it. One should not wait until the new mint has been cut, for by that time the beetles may have already invaded the fields for a considerable distance. As much of the egg-laying as possible should be prevented in infested fields by poisoning the stubble and crop remnants immediately after the mint has been harvested to kill the beetles feeding there. Special attention should be given to those fields from which roots are to be dug for planting.(6)

#### SUMMARY

Peppermint was introduced into Oregon some twenty eight years ago. It was free from insect attack until four years ago when the beetle was noted on mint plants. Damage has been reported for the last three years when some of the fields in Jefferson have been heavily invaded by mint flea-beetles. There was no adequate report to record when

and how the pest was introduced. They may have been brought in in the infested roots from Michigan. Except for the above-mentioned regions, other mint fields have not been infested up to the present time. As far as is known the beetle attacks the mint family only. The greatest damage is done by larvae which feed on the epidermis of the small rootlets and tunnel through the large roots in the spring, causing the abnormal growth of the plant or killing the plant completely in some cases. The adult beetles feed on the epidermis of the foliage and frequently riddle the leaves with tiny holes.

The infestation of a new field is by gradual migration by jumping or crawling or by infested roots on which eggs or young larvae are lodged.

There is but one generation a year. They winter over as in the egg stage. The larvae may appear some time in May. After feeding in the roots for about one month or so, they become full grown and leave the roots to pupate in an oval earth cell which is about three to four inches below the surface. The pupal period is from twenty to thirty-two days at room temperature. The adult beetles appear early in July. After they emerge, they feed on the foliage. The egg-laying period occurs during the early part of August. The eggs are deposited singly between the soil particles or on the fallen leaves. Fall ploughing may serve as an adequate winter protection to the eggs.

Climatic conditions affect the development of the insect, cold weather retarding its growth, the warm season hastening maturity.

It is advisable to move the soil away from the roots before transporting to a new field. The new mint should be protected against invasion during July by putting poison along the margins adjoining infested fields.

In killing the adult beetles, it is recommended that dusts are preferable to liquid sprays. The most satisfactory dusts used at Mehtha were a mixture of ten to twenty pounds of calcium arsenate with enough talc to make one hundred pounds, and another dust consisting of ten to twenty pounds of calcium arsenate mixed with equal parts of calcium fluosilicate compound and talc to make one hundred pounds. Calcium fluosilicate when used alone gave good control, but with slow effectiveness. Other chemical compounds were tried out, but none of them gave satisfactory results.

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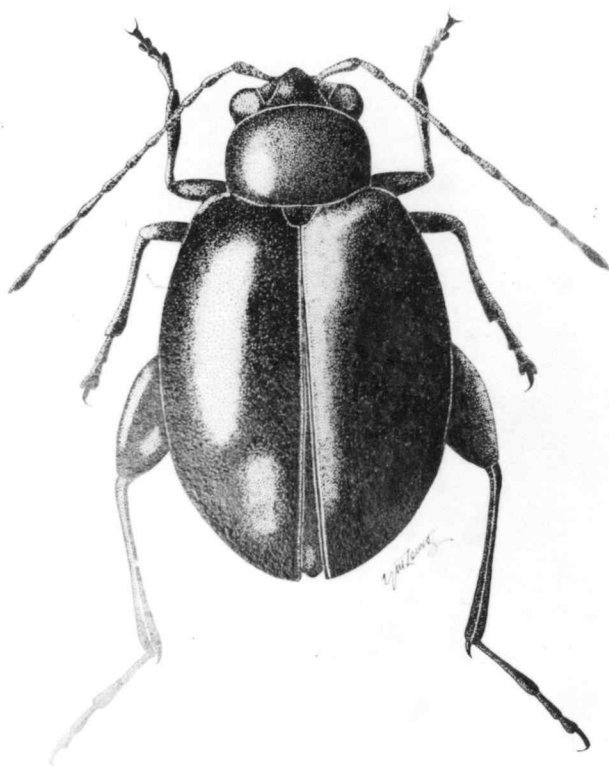


Plate 1

Dorsal view of adult Longitarsus waterhousei Kutch

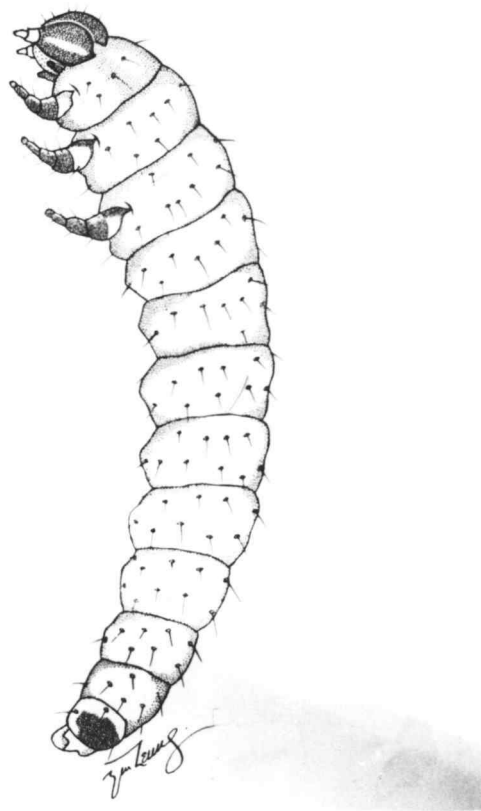


Plate 2

Full grown larva, L. waterhousei

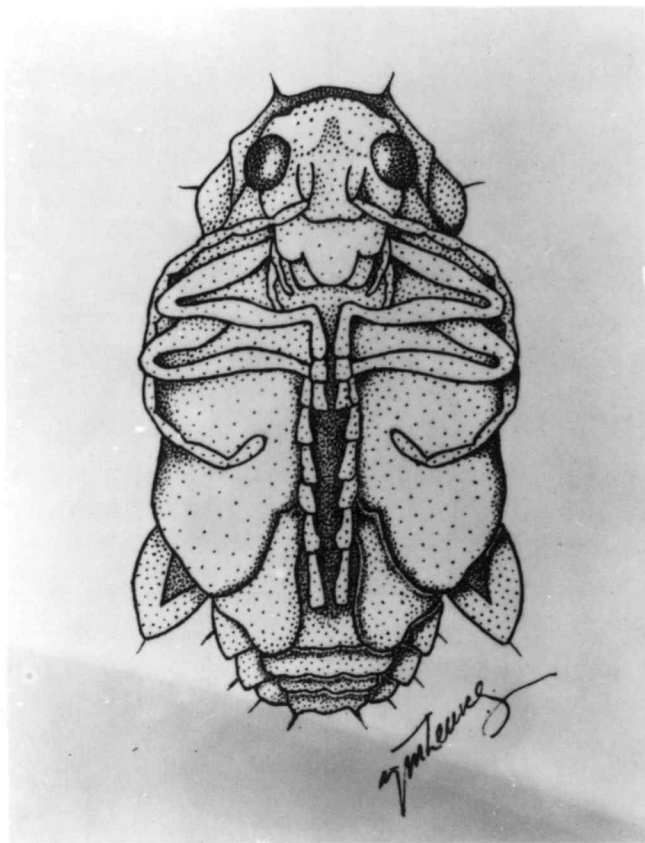
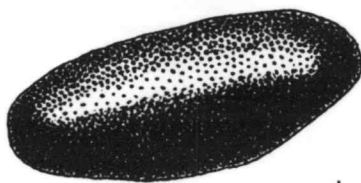
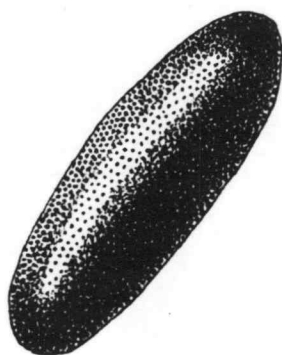


Plate 3

Full grown pupa, L. waterhousei



*Wm. Lewis*

Plate 4

Eggs of L. waterhousei

Plate 5

Damage on roots



A. Larva tunneling in main root



B. Larval damage on small rootlets

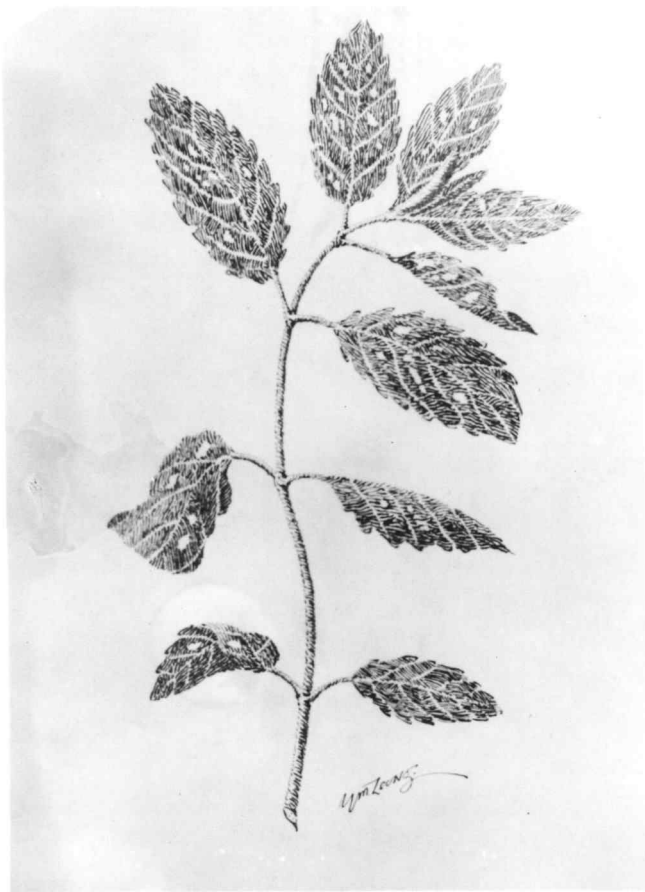


Plate 6

Damage on leaves by adults



Plate 7

Healthy plant (left) and infested plant (right)