# INSECTS ATTACKING CARAGANA AND THEIR CONTROL IN THE PRAIRIE PROVINCES

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A thesis

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# CHAPTER I

## INTRODUCTION

Caragana is a comparatively hardy plant in the prairie provinces and normally does not suffer seriously from insect attacks. However a fairly large percentage of seeds are destroyed every year and sometimes the plants are severely defoliated by insects.

### The problem

The purpose of the study was (1) to ascertain the life history and habits, and if possible a satisfactory method of artificial control of the caragana seed chalcid, Eurytoma n. sp.[1], (2) to review the literature on other insects attacking caragana and obtain information on their biology and control.

### Importance of the study

Caragana is grown widely in the prairie provinces for farmstead shelter belts, field shelter belts, and for hedges in towns and cities. Historically it is of interest that the seed of caragana was imported from Russia by the Experimental Farms Service in 1887 (Cram, 1950). In 1911 seedlings of Caragana arborescens Lam. constituted 1.5 per cent of the

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[1] Order Hymenoptera, Family Eurytomidae. At time of writing, this insect is being described by Dr. O. Peck, Systematic Entomology, Division of Entomology, Department of Agriculture, Ottawa. Dr. Peck has suggested that the description will appear in the Canadian Entomologist.

total broad-leaved trees distributed by the Dominion Forest Nursery Station, Indian Head, Saskatchewan. By 1948 this figure had increased to 26 per cent. In 1951, 6,425,054 broad-leaved trees were distributed and of these, 4,126,279 or 64.2 per cent were caragana.

The caragana seed chalcid destroys a large amount of caragana seed every year and interferes very seriously with the caragana breeding program being carried out by Dr. W. H. Cram. The caragana aphid also affects caragana seed production by feeding on the plant juices in the seed pods and often causes severe defoliation. Leaf-eating insects such as blister beetles and grasshoppers have been reported to cause damage of a local nature and are especially destructive to caragana transplants which are becoming established.

## Location of the study

The laboratory work was done at the Dominion Entomological Laboratory, Indian Head, Saskatchewan. Much of the field study was carried out on the Dominion Forest Nursery Station, Indian Head. Material for studying distribution was obtained from different localities throughout the prairie provinces.

## Organization of the thesis

The body of the thesis is divided into two chapters.

A study of the biology along with experiments on control of the caragana seed chalcid, Eurytoma n. sp. is presented in Chapter II. This work was carried out during the years 1948-51. Chapter III deals with work done on the control of the caragana aphid, Macrosiphum caraganae (Cholod.)[2] along with a review of literature on this and other insects that attack caragana in the prairie provinces. Blister beetles[3], grasshoppers[4], the caragana plant bug[5], and a species of Lecanium scale[6] are discussed. At the conclusion of the thesis is a list of the literature cited.

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[2]Order Homoptera, Family Aphididae.

[3]Order Coleoptera, Family Meloidae.

[4]Order Orthoptera, Family Acrididae.

[5]Order Hemiptera, Family Miridae.

[6]Order Homoptera, Family Coccidae.

# CHAPTER II

## CARAGANA SEED CHALCID
## EURYTOMA N. SP.

### History

The caragana seed chalcid was first encountered at Indian Head, Saskatchewan by Dr. W. H. Cram in the summer of 1947. While carrying out a breeding improvement program on caragana he found that a large percentage of seed was being destroyed by an insect. This insect proved to be a new species belonging to the genus Eurytoma.

### Distribution

Surveys made throughout the prairie provinces show that the caragana seed chalcid occurs throughout the agricultural region. The infestation is usually more severe in Manitoba decreasing in intensity through Saskatchewan and Alberta. In 1948 a number of collections from Alberta were found to contain no infested seeds, but all samples from Manitoba were infested. The insect probably occurs in areas outside the prairie provinces where caragana is grown but the present study did not extend beyond these provinces.

### Hosts

The caragana seed chalcid infests the seeds of common caragana, Caragana arborescens Lam., the Russian pea shrub,

Caragana frutescens DC. and pygmy caragana, Caragana pygmaea DC.

## Description of the stages of the insect

The adult male caragana seed chalcid is from 2.5 to 3.0 mm. in length. The female is larger and measures from 3.0 to 3.5 mm. The general body color is black. The proximal portions of the femora and tibiae are black, and the distal portions are brownish-yellow. Fig. 7, page 24 shows a female caragana seed chalcid.

The egg (Fig. 1, page 6) is very small and can hardly be seen with the naked eye. The overall length is only 0.85 mm. The body of the egg is 0.28 mm. long and 0.15 mm. wide, while the tail is 0.57 mm. long. It is extremely delicate and almost colorless.

The larva is a small, white, legless, fat-bodied grub. It is about 3.0 mm. long and 1.5 mm. wide when fully grown. It has black, slightly curved mandibles.

The pupa (Fig. 2, page 7) is approximately the same size as the adult. During development it changes in color from white to black.

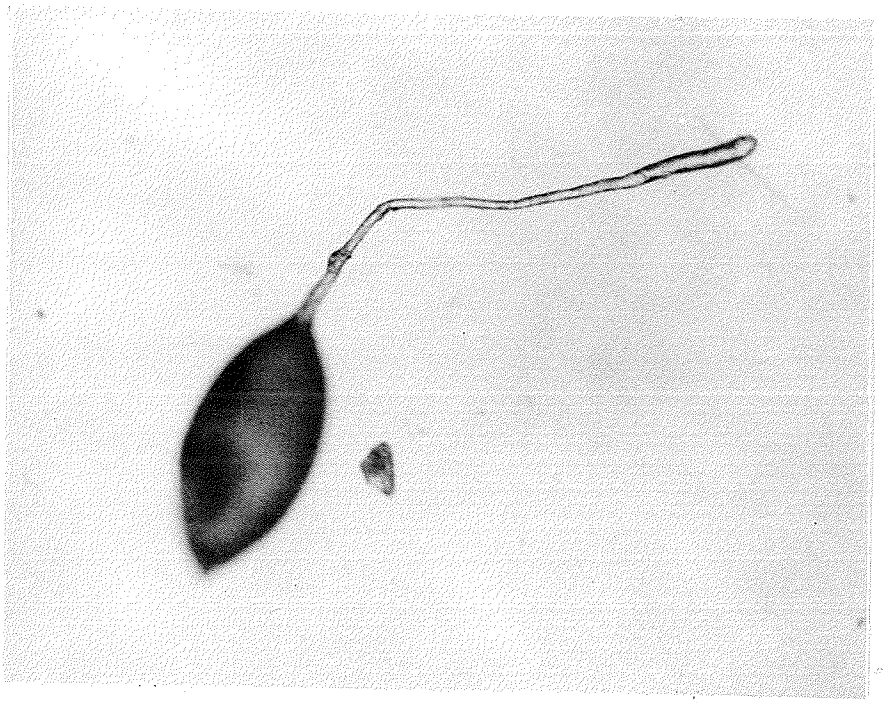

Figure 1. Egg of caragana seed chalcid. 123X[1]

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[1]This and subsequent magnifications are approximate only.

Figure 2. Pupa of caragana seed chalcid. 30X

Figure 3. Emergence cages.

## Methods and Techniques

### I Adult stage

#### Emergence

Emergence cages made of 30-30 mesh brass riddle cloth wire were used (Fig. 3, page 8). The top, sides and back were made of the brass wire, and the front consisted of a wooden frame supporting a sliding glass window. They were one foot high, one foot wide and one and one-half feet long. The sides were made from a continuous piece of screen which was curved around to form the back. This eliminated several sharp corners and facilitated collecting adults from the cages.

Infested caragana seeds were obtained by passing a large sample of seed, in which a number of infested seeds were present, through a fanning mill. Because the infested seeds are very light in weight they were separated from the heavier normal seeds and were collected with the chaff.

In the fall two samples of these infested seeds were placed in an unshaded area on the ground and in the spring they were covered with emergence cages. Three samples were spread on the ground in a shaded area and before emergence commenced they were also covered with cages. Observations were made daily to observe and record adult emergence.

Oviposition

To obtain data on oviposition in the field, cheesecloth bags, two feet long by six inches wide, were placed over branches bearing caragana seed pods at regular intervals during the oviposition period (Fig. 4, page 11).

To determine the commencement of the oviposition period bags were placed on five branches of Caragana frutescens twice each week during the period June 4 to July 12.

To determine the period during which maximum oviposition occurs, 60 bags were placed on branches of C. frutescens on June 8. Following this date, five bags were removed twice each week. Each time one group of bags was removed, the branches which had been exposed the previous time were again enclosed in bags. In this way caragana seed pods were exposed for different known periods of time during adult chalcid activity.

To determine the time at which oviposition ceases, 60 bags were placed on branches of C. arborescens on June 8. Following this date five bags were removed twice each week and the branches were left exposed for the remainder of the oviposition period.

In the above experiments all branches under observation were labelled. When the pods reached maturity

Figure 4. Cheesecloth bags on caragana

they were collected and the seeds were examined to determine the extent of infestation.

A study was carried out to determine the time at which oviposition commences, in relation to seed and pod size. On July 4, five of the longest pods on one branch of each of 35 C. arborescens trees were measured. The diameter of one seed in each pod was also measured. These data were recorded. To insure that no further oviposition occurred each of the branches bearing the pods from which the data had been obtained, was enclosed in a cheesecloth bag. When they had reached maturity the pods were collected from each branch. The seeds obtained from each branch were examined to determine the extent of infestation. These results were compared with the data obtained previously on pod and seed size.

Different types of caragana were studied to determine if there is a relationship between caragana type and chalcid infestation. Three trees of each of the following types were included in the study: (a) early blooming, (b) late blooming, (c) early leafing, (d) late leafing and (e) pendulous type. Branches of each of these types were enclosed in cheesecloth bags at regular intervals during the oviposition period. When the pods had reached maturity they were collected and the seeds examined to determine the extent of infestation.

## Longevity

Eighteen male and nine female chalcids were observed,

to determine longevity. These insects were reared individually from the larval stage in gelatin capsules (16 mm. x 6 mm.) and were kept in the capsules under laboratory conditions.

Effect of temperature and light on adult activity

Nine adults were placed in a glass jar in which a thermometer was suspended. Insect activity was observed as the temperature was increased slowly from 50 degrees F. to 106 degrees F.

## II Egg stage

### Incubation period

Before oviposition had commenced, cheesecloth bags were placed over branches of caragana. When the pods had developed sufficiently to be attractive to the female chalcid, adult insects were placed in the bags. They were left for a period of 24 hours after which they were liberated. The bags were then replaced to insure that no further oviposition could take place. Pods were collected daily from the bags, and the seeds examined for the presence of eggs or larvae.

## III Larval stage

### Feeding habits

Infested caragana seeds were collected at regular

intervals during the summer. These were examined to determine the feeding habits of the larva during its development.

Effect of larval feeding on weight of infested seeds

Seeds of C. arborescens were collected at time of dehiscence. A comparison was made between the weight of normal seeds and that of infested seeds.

Larval dispersal

To obtain information on the dispersal of larvae by dehiscence of the seed pods, trays were placed at different distances from the bases of caragana trees. The trays were two feet long and one foot wide. They radiated from the bases of the trees to a distance of 17 feet from the base, with six trays in each line. A total of 270 trays were used. The C. arborescens trees included in the study ranged in height from 6 ft. 9 in. to 11 ft. 3 in. and the C. frutescens from 5 ft. 6 in. to 7 ft. 6 in. All the caragana seeds which fell into the trays were collected and examined.

Regional distribution

Seed pods were collected from a number of localities in the prairie provinces to determine the distribution of the chalcid and the extent to which it infests caragana seeds.

Natural mortality

Infested samples of seed which were received for distribution and population studies were observed to be parasitized.

Infested C. arborescens seeds which had overwintered under normal conditions were examined. A number of larvae were observed to have died.

## IV Pupal stage

Duration

In order to ascertain the duration of the pupal stage 105 larvae were removed from infested seeds before commencement of pupation. These insects were reared individually in small (16 mm. x 6 mm.) gelatin capsules. Daily observations were made and records were kept.

## V Artificial control

Ground sprays

An experiment was carried out to obtain information on the effects of aldrin, BHC and DDT applied as sprays to infested seeds prior to the emergence of the adult chalcids. Samples of seed which had been kept outside during the winter were spread on the ground in the spring and then treated. Each insecticide was applied to individual samples

at rates of 0.04 oz. and 0.08 oz. of active material per sq. ft. Following the treatment each sample was covered with a small emergence cage of fine mesh screen. Observations were made daily to collect the adults which emerged.

Foliage sprays

To investigate the possibility of preventing oviposition, insecticidal sprays were applied to the foliage of C. arborescens trees. Aldrin, BHC, and DDT were applied at the rate of two pounds and five pounds, pyrenone at one and one-half pounds and three pounds, and Pestox III at two pints and four pints, in 100 imperial gallons of water. Each concentration except the heavier application of Pestox III was applied to four trees. The latter was applied to only two trees. All treatments were made on July 4. On this date, when the insecticides had been applied cheesecloth bags were placed on two branches of each tree to insure that no further oviposition occurred in pods on these branches. When they had reached maturity the pods within the bags were collected and the seeds examined to determine whether oviposition had occurred prior to the time of spraying. Samples of pods were collected from all treated and check trees and the seeds were examined.

Cultural control

In an attempt to obtain information on the possibility

of controlling the chalcid by burying the larvae, three samples of infested seeds were spread on the ground in the spring before pupation had taken place. The first was covered with a layer of loose soil one inch thick and the second with a layer one-half inch thick. The third sample was left uncovered to serve as a check. A cage of fine mesh screen was placed over each sample to trap emerging adults.

## Life history and habits

### I Adult stage

#### Emergence

Table I, page 18 shows the daily adult emergence for the caragana seed chalcid during the 1951 season. The number of adults which emerged from the different cages is not significant since no exact check was made as to the number of infested seeds placed in each. From these data it it can be seen that:

(a) adult emergence commenced June 12 and ceased July 25. This is a period of six weeks and two days;

(b) female chalcids did not commence to emerge as early as males but continued to emerge in greater numbers until a later date;

(c) the ratio of males to females was 41 to 59;

(d) peak emergence occurred at an earlier date in the

TABLE I

DAILY EMERGENCE OF ADULT CHALCIDS, 1951

| Date | Unshaded Sites | | | | | | Shaded Sites | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cage 1 | | | Cage 2 | | | Cage 3 | | | Cage 4 | | | Cage 5 | | |
| | M. | F. | Total | M. | F. | Total | M. | F. | Total | M. | F. | Total | M. | F. | Total |
| June 12 | 5 | 0 | 5 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | - | - | - |
| 14 | 19 | 4 | 23 | 13 | 5 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | - | - | - |
| 15 | 20 | 10 | 30 | 7 | 4 | 11 | 6 | 0 | 6 | 1 | 0 | 1 | 2 | 0 | 2 |
| 16 | 10 | 5 | 15 | 7 | 2 | 9 | 1 | 0 | 1 | 2 | 0 | 2 | 1 | 0 | 1 |
| 17 | 20 | 6 | 26 | 19 | 6 | 25 | 9 | 0 | 9 | 3 | 0 | 3 | 3 | 0 | 3 |
| 18 | 32 | 13 | 45 | 18 | 12 | 30 | 10 | 2 | 12 | 1 | 3 | 4 | 4 | 1 | 5 |
| 19 | 21 | 23 | 44 | 25* | 11 | 36* | 7 | 5 | 12 | 9 | 0 | 9 | 3 | 0 | 3 |
| 21 | 28 | 14 | 42 | 11 | 12 | 23 | 10 | 1 | 11 | 4 | 0 | 4 | 5 | 0 | 5 |
| 22 | 19 | 27* | 46 | 13 | 19 | 32 | 13 | 7 | 20 | 11 | 6 | 17 | 9 | 6 | 15 |
| 23 | 34* | 26 | 60* | 20 | 10 | 30 | 23* | 10 | 33 | 4 | 3 | 7 | 6 | 6 | 12 |
| 26 | 17 | 27* | 44 | 3 | 20* | 23 | 7 | 12 | 19 | 1 | 4 | 5 | 4 | 8 | 12 |
| 27 | 1 | 14 | 15 | 2 | 12 | 14 | 9 | 34* | 43* | 7 | 9 | 16 | 5 | 9 | 14 |
| 30 | 4 | 22 | 25 | 4 | 12 | 16 | 2 | 17 | 19 | 0 | 5 | 5 | 5 | 8 | 13 |
| July 2 | 3 | 4 | 7 | 0 | 7 | 7 | 10 | 17 | 27 | 2 | 4 | 6 | 3 | 7 | 10 |
| 3 | 2 | 8 | 10 | 2 | 4 | 6 | 6 | 21 | 27 | 1 | 6 | 7 | 3 | 7 | 10 |
| 4 | 0 | 2 | 2 | 0 | 1 | 1 | 9 | 15 | 24 | 2 | 2 | 4 | 0 | 2 | 2 |
| 5 | 1 | 2 | 3 | 0 | 5 | 5 | 9 | 7 | 16 | 3 | 6 | 9 | 3 | 2 | 5 |
| 6 | 1 | 7 | 8 | 0 | 7 | 7 | 5 | 17 | 22 | 0 | 5 | 5 | 3 | 5 | 8 |
| 7 | 2 | 4 | 6 | 0 | 1 | 1 | 5 | 23 | 28 | 4 | 2 | 6 | 3 | 15 | 18 |
| 9 | 2 | 1 | 3 | - | - | - | 3 | 17 | 20 | 3 | 10 | 13 | 9 | 13 | 22 |
| 10 | - | - | - | - | - | - | 6 | 6 | 12 | 5 | 5 | 10 | 11 | 16 | 27 |
| 11 | - | - | - | - | - | - | 12 | 16 | 28 | 10* | 11 | 21 | 13 | 18 | 31 |
| 12 | - | 3 | 3 | 0 | 1 | 1 | 5 | 34* | 39 | 5 | 15 | 20 | 12 | 24 | 36 |
| 13 | - | 1 | 1 | 0 | 1 | 1 | 12 | 28 | 40 | 7 | 13 | 20 | 14* | 34* | 48* |
| 14 | - | 1 | 1 | - | - | - | 7 | 22 | 29 | 9 | 9 | 18 | 10 | 32 | 42 |

TABLE I (continued)

DAILY EMERGENCE OF ADULT CHALCIDS, 1951

| Date | Unshaded Sites | | | | | | Shaded sites | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cage 1 | | | Cage 2 | | | Cage 3 | | | Cage 4 | | | Cage 5 | | |
| | M. | F. | Total | M. | F. | Total | M. | F. | Total | M. | F. | Total | M. | F. | Total |
| July 16 | - | - | - | - | - | - | 5 | 13 | 18 | 7 | 16* | 23* | 10 | 27 | 37 |
| 17 | - | - | - | - | - | - | 5 | 8 | 13 | 2 | 4 | 6 | 9 | 9 | 18 |
| 18 | - | - | - | - | - | - | 7 | 31 | 38 | 7 | 14 | 21 | 11 | 23 | 34 |
| 19 | - | - | - | - | - | - | 8 | 14 | 22 | 6 | 10 | 16 | 5 | 10 | 15 |
| 20 | - | - | - | - | - | - | 5 | 17 | 22 | 5 | 6 | 11 | 4 | 8 | 12 |
| 21 | - | - | - | - | - | - | 2 | 19 | 21 | 1 | 2 | 3 | 3 | 18 | 21 |
| 23 | - | - | - | - | - | - | 3 | 9 | 12 | 2 | 2 | 4 | 2 | 6 | 8 |
| 24 | - | - | - | - | - | - | 0 | 5 | 5 | 0 | 3 | 3 | 2 | 4 | 6 |
| 25 | - | - | - | - | - | - | 2 | 7 | 9 | 0 | 1 | 1 | 0 | 7 | 7 |

*Maximum emergence for single day during emergence period.

exposed cages. The percentage of total emergence which occurred during the month of June for each of cages 1, 2, 3, 4 and 5 was 90.5, 90.2, 28.2, 24.6 and 16.9 respectively.

When the adult chalcid emerges it bores a small hole (Fig. 5, page 21) through which it makes its exit.

Mating

Adults have been observed to mate on the day of emergence. Before mating, the male approaches the female meanwhile rubbing the ventral surface of his abdomen from side to side on the surface on which he is standing. He then mounts the female and moves his antennae up and down vigorously, rubbing the ends against the ends of those of the female. He crawls to the side of the female and copulation which is of only a few seconds duration, takes place. The pair separate soon after mating.

Oviposition

Females were observed to oviposit readily when placed in a Petri dish with fresh caragana seed pods. A female that is preparing to oviposit investigates the pod thoroughly, usually walking along it several times before selecting a site. A position quite near to but on either side of the dorsal suture of the pod is selected. The abdomen is then drawn forward and the tip placed against the surface of the pod (Fig. 6, page 22). A sharp jab starts the tip of the

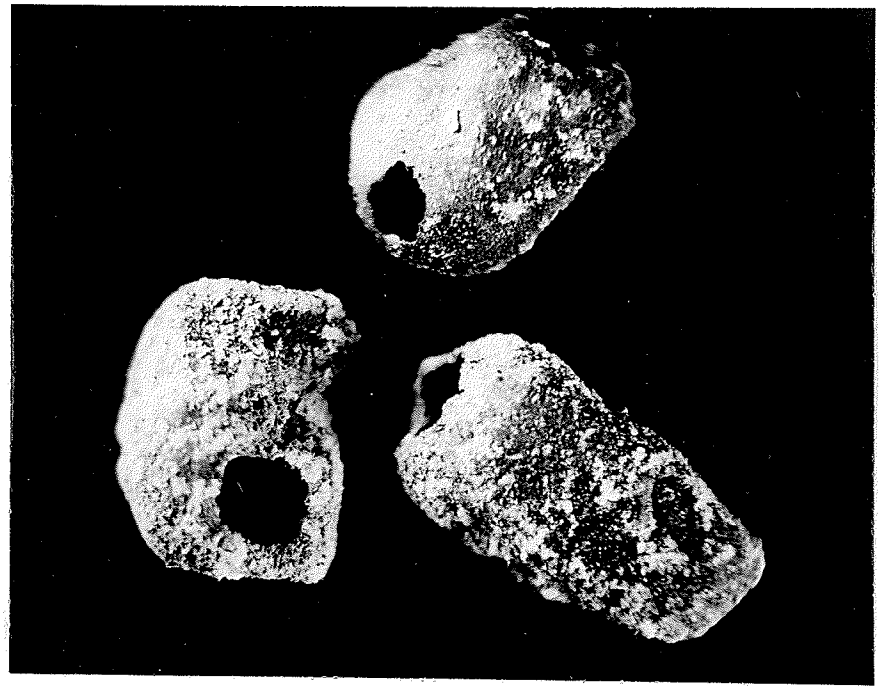

Figure 5. Caragana seeds from which chalcids have emerged.

Figure 6. A female caragana seed chalcid selecting an oviposition site. 17X

ovipositor into the pod. The abdomen then resumes its normal positionwhich is at right angles to the ovipositor (Fig. 7, page 24). The body is pumped slowly up and down gradually forcing the ovipositor deeper into the pod. When the desired depth is reached an egg is deposited and the ovipositor withdrawn. An egg is not necessarily deposited however, each time the ovipositor is inserted. One female was observed to insert her ovipositor into a single seed 45 times. Further investigation showed that no eggs had been deposited.

Seeds which have been punctured during oviposition are usually scarred. These scars are always in the vicinity of the micropyle.

When infested seeds were dissected it was found that there was usually only one egg in each seed. Thirty-four eggs were removed from infested seeds, 82 per cent of which were found singly in the seed and 18 per cent were in pairs.

The oviposition period extends for approximately one month. Table II, page 25 shows that oviposition commenced during the period June 11 to June 14. Similarly Table III, page 26 shows maximum oviposition to have occurred during the period July 2 to July 5. Table IV, page 27 shows that no oviposition occurred after July 9. Combining the information obtained from Table II and Table IV it can be seen that the oviposition period extended from June 11 to

Figure 7. A female caragana seed chalcid ovipositing. 17X

TABLE II

OVIPOSITION DATA OBTAINED BY ENCLOSING BRANCHES OF *C. FRUTESCENS* IN CHEESECLOTH BAGS AT REGULAR INTERVALS FROM JUNE 4 TO JULY 12, 1949

| Date of bagging | No. seeds obtained | Seeds infested | |
|---|---|---|---|
| | | No. | Per cent |
| June 4 | 8 | 0 | 0.0 |
| 8 | 143 | 0 | 0.0 |
| 11 | 117 | 0 | 0.0 |
| 14 | 99 | 16 | 16.2 |
| 18 | 151 | 32 | 21.2 |
| 21 | 90 | 16 | 15.5 |
| 25 | 166 | 74 | 44.6 |
| 28 | 58 | 53 | 91.4 |
| July 2 | 384 | 275 | 72.1 |
| 5 | 202 | 149 | 73.8 |
| 9 | 331 | 248 | 74.9 |
| 12 | 539 | 398 | 73.8 |

TABLE III

OVIPOSITION DATA OBTAINED BY ENCLOSING BRANCHES OF C. FRUTESCENS IN CHEESECLOTH BAGS AND EXPOSING THEM FOR INTERVALS DURING THE OVIPOSITION PERIOD, 1949

| Date bag removed | Date bag replaced | No. seeds obtained | Seeds infested | |
|---|---|---|---|---|
| | | | No. | Per cent |
| Not enclosed | June 11 | 14 | 0 | 0.0 |
| June 11 | 14 | 175 | 35 | 20.0 |
| 14 | 18 | 125 | 4 | 3.2 |
| 18 | 21 | 67 | 10 | 14.9 |
| 21 | 25 | 39 | 1 | 2.6 |
| 25 | 28 | 15 | 5 | 33.3 |
| 28 | July 2 | 0* | - | - |
| July 2 | 5 | 11 | 4 | 36.4 |
| 5 | 9 | 0* | - | - |
| 9 | 12 | 11 | 0 | 0.0 |
| 12 | 19 | 0* | - | - |
| 19 | | 14 | 0 | 0.0 |

*Seed pods failed to develop.

TABLE IV

OVIPOSITION DATA OBTAINED BY ENCLOSING BRANCHES OF C. ARBORESCENS IN CHEESECLOTH BAGS AND EXPOSING THEM AT REGULAR INTERVALS FROM JUNE 11 TO JULY 16, 1949

| Date bag removed | No. seeds obtained | Seeds infested | |
|---|---|---|---|
| | | No. | Per cent |
| Not enclosed | 185 | 17 | 9.2 |
| June 11 | 384 | 40 | 10.4 |
| 14 | 421 | 41 | 9.7 |
| 18 | 377 | 21 | 5.7 |
| 21 | 317 | 12 | 3.8 |
| 25 | 147 | 7 | 4.7 |
| 28 | 327 | 49 | 15.0 |
| July 2 | 208 | 17 | 8.2 |
| 5 | 173 | 10 | 5.8 |
| 9 | 194 | 0 | 0.0 |
| 12 | 274 | 0 | 0.0 |
| 16 | 178 | 0 | 0.0 |

July 9.

The female chalcid usually deposits its eggs in caragana seeds which are in the early stages of development and in which the cotyledons have just started to form. Eggs and young larvae have been observed in seeds which are more advanced and in which the cotyledons are already quite well developed but when this is the case the small larva is unable to devour the cotyledons as rapidly as they expand. It is forced to remain in a small hole in the seed because of inability to eat the hard cotyledons, or is sometimes forced to eat its way out through the seed coat.

Table V, page 29 suggests the approximate pod length and seed diameter of C. arborescens preferred by the chalcid for oviposition. These data show that oviposition commenced when the pods were on the average greater than 5.0 and less than 5.4 cm. in length and the seeds more than 0.25 and less than 0.33 cm. in diameter.

The data in Table VI, page 30 would seem to indicate that there is a definite relationship between the time of blooming and chalcid infestation, with the early blooming trees being more severely infested. The pendulous type appears to offer more attraction to the chalcid than does the upright type.

TABLE V

A COMPARISON OF CARAGANA POD AND SEED SIZES WITH CHALCID INFESTATION, JULY 4, 1950

| Collections of uninfested seeds | | Collections of infested seeds | |
|---|---|---|---|
| Pod length (cm.) | Seed diameter (cm.) | Pod length (cm.) | Seed diameter (cm.) |
| 4.0 | 0.10 | 4.5 | 0.25 |
| 4.0 | 0.20 | 4.5 | 0.25 |
| 4.0 | 0.30 | 4.5 | 0.28 |
| 4.5 | 0.10 | 4.5 | 0.35 |
| 4.5 | 0.30 | 5.0 | 0.35 |
| 4.5 | 0.32 | 5.0 | 0.40 |
| 4.5 | 0.35 | 5.2 | 0.30 |
| 4.8 | 0.15 | 5.2 | 0.32 |
| 5.0 | 0.20 | 5.2 | 0.35 |
| 5.0 | 0.30 | 5.2 | 0.40 |
| 5.5 | 0.25 | 5.5 | 0.20 |
| 5.5 | 0.30 | 5.5 | 0.20 |
| 5.5 | 0.32 | 5.5 | 0.30 |
| 5.5 | 0.32 | 5.5 | 0.40 |
| 5.5 | 0.35 | 6.5 | 0.48 |
| 6.0 | 0.25 | 6.6 | 0.38 |
| 6.0 | 0.30 | 7.2 | 0.40 |
| 6.5 | 0.38 | | |
| Average: 5.0 | 0.25 | 5.4 | 0.33 |

TABLE VI

OVIPOSITION IN RELATION TO PLANT DEVELOPMENT AND PENDULOUS TYPE OF GROWTH AS INDICATED BY CARAGANA BRANCHES ENCLOSED IN CHEESECLOTH BAGS AT REGULAR INTERVALS FROM JUNE 8 TO JULY 9, 1948

| Tree type | Date of bagging | Number of seeds obtained | Seeds infested | |
|---|---|---|---|---|
| | | | No. | Per cent |
| C1-2 | June 8 | 157 | 0 | 0.0 |
| Early blooming | 11 | 0* | 0 | 0.0 |
| | 18 | 0* | 0 | 0.0 |
| | 25 | 33 | 0 | 0.0 |
| | July 2 | 36 | 6 | 18.2 |
| | 9 | 169 | 25 | 14.8 |
| C6-3 | June 8 | 74 | 0 | 0.0 |
| Early blooming | 11 | 40 | 0 | 0.0 |
| | 18 | 141 | 0 | 0.0 |
| | 25 | 70 | 0 | 0.0 |
| | July 2 | 5 | 0 | 0.0 |
| | 9 | 21 | 1 | 4.8 |
| C1-10 | June 8 | 71 | 0 | 0.0 |
| Early blooming | 11 | 89 | 0 | 0.0 |
| | 18 | 100 | 1 | 1.0 |
| | 25 | 115 | 3 | 2.6 |
| | July 2 | 187 | 12 | 6.4 |
| | 9 | 214 | 14 | 6.5 |
| C21-14 | June 8 | 23 | 0 | 0.0 |
| Late blooming | 11 | 8 | 0 | 0.0 |
| | 18 | 22 | 0 | 0.0 |
| | 25 | 0* | 0 | 0.0 |
| | July 2 | 11 | 0 | 0.0 |
| | 9 | 49 | 0 | 0.0 |
| C21-22 | June 8 | 42 | 0 | 0.0 |
| Late blooming | 11 | | | |
| | 18 | 71 | 0 | 0.0 |
| | 25 | 41 | 0 | 0.0 |
| | July 2 | 59 | 0 | 0.0 |
| | 9 | 66 | 0 | 0.0 |

TABLE VI (continued)

OVIPOSITION IN RELATION TO PLANT DEVELOPMENT AND PENDULOUS TYPE OF GROWTH AS INDICATED BY CARAGANA BRANCHES ENCLOSED IN CHEESECLOTH BAGS AT REGULAR INTERVALS FROM JUNE 8 TO JULY 9, 1948

| Tree type | Date of bagging | Number of seeds obtained | Seeds infested | |
|---|---|---|---|---|
| | | | No. | Per cent |
| C16-28 | June 8 | 20 | 0 | 0.0 |
| Late blooming | 11 | 0* | 0 | 0.0 |
| | 18 | 124 | 0 | 0.0 |
| | 25 | 0* | 0 | 0.0 |
| | July 2 | 37 | 0 | 0.0 |
| | 9 | 23 | 0 | 0.0 |
| C1-4 | June 8 | 110 | 0 | 0.0 |
| Early leafing | 11 | 114 | 0 | 0.0 |
| | 18 | 104 | 0 | 0.0 |
| | 25 | 68 | 0 | 0.0 |
| | July 2 | 80 | 5 | 6.2 |
| | 9 | 121 | 8 | 6.6 |
| C6-4 | June 8 | 100 | 0 | 0.0 |
| Early leafing | 11 | 139 | 0 | 0.0 |
| | 18 | 9 | 0 | 0.0 |
| | 25 | 9 | 0 | 0.0 |
| | July 2 | 8 | 0 | 0.0 |
| | 9 | 19 | 3 | 15.8 |
| C6-5 | June 8 | 7 | 0 | 0.0 |
| Early leafing | 11 | 4 | 0 | 0.0 |
| | 18 | 39 | 0 | 0.0 |
| | 25 | 0* | 0 | 0.0 |
| | July 2 | 14 | 1 | 7.1 |
| | 9 | 44 | 6 | 13.6 |
| C1-6 | June 8 | 4 | 0 | 0.0 |
| Late leafing | 11 | 16 | 0 | 0.0 |
| | 18 | 17 | 0 | 0.0 |
| | 25 | 36 | 0 | 0.0 |
| | July 2 | 17 | 1 | 5.9 |
| | 9 | 16 | 2 | 12.5 |

TABLE VI (continued)

OVIPOSITION IN RELATION TO PLANT DEVELOPMENT AND PENDULOUS TYPE OF GROWTH AS INDICATED BY CARAGANA BRANCHES ENCLOSED IN CHEESECLOTH BAGS AT REGULAR INTERVALS FROM JUNE 8 TO JULY 9, 1948

| Tree type | Date of bagging | Number of seeds obtained | Seeds infested | |
|---|---|---|---|---|
| | | | No. | Per cent |
| C6-13 Late leafing | June 8 | 79 | 0 | 0.0 |
| | 11 | 0* | 0 | 0.0 |
| | 18 | 154 | 0 | 0.0 |
| | 25 | 26 | 0 | 0.0 |
| | July 2 | 30 | 3 | 10.0 |
| | 9 | 75 | 3 | 4.0 |
| C6-22 Late leafing | June 8 | 37 | 0 | 0.0 |
| | 11 | 106 | 0 | 0.0 |
| | 18 | 210 | 0 | 0.0 |
| | 25 | 0* | 0 | 0.0 |
| | July 2 | 92 | 0 | 0.0 |
| | 9 | 95 | 4 | 4.2 |
| Pendula A | June 8 | 0* | 0 | 0.0 |
| | 11 | 16 | 0 | 0.0 |
| | 18 | 88 | 0 | 0.0 |
| | 25 | 71 | 1 | 1.4 |
| | July 2 | 30 | 4 | 1.3 |
| | 9 | 24 | 2 | 8.3 |
| Pendula B | June 8 | 251 | 0 | 0.0 |
| | 11 | 253 | 0 | 0.0 |
| | 18 | 141 | 3 | 2.1 |
| | 25 | 75 | 3 | 4.0 |
| | July 2 | 19 | 1 | 5.2 |
| | 9 | 110 | 10 | 8.4 |
| Pendula 451 | June 8 | 21 | 0 | 0.0 |
| | 11 | 14 | 0 | 0.0 |
| | 18 | 9 | 0 | 0.0 |
| | 25 | 15 | 0 | 0.0 |
| | July 2 | 76 | 40 | 52.6 |
| | 9 | 43 | 11 | 25.6 |

*Pods failed to develop.

Feeding

When the female chalcid has withdrawn her ovipositor she can be observed to back up slightly and suck some of the liquid which has exuded from the oviposition wound in the pod. This has been observed both in the laboratory and in the field. The male has been observed, under laboratory conditions only, to suck juices from wounds in the seed and pod.

Longevity

Table VII, page 34 shows the survival period for nine female and eighteen male chalcids. The average period for the 27 insects was 10.7 days. The average for the females and males was 12.0 and 10.2 days respectively. The minimum and maximum periods for females was seven and 16 days; for males five and 14 days.

Effect of temperature and light on adult activity

Adult activity appears to be directly influenced by heat and light. In a cool insectary or in the field on cool days movement was observed to be very sluggish. As temperature or light intensity increased, activity also increased. Nine adults which were observed under increasing temperatures were very sluggish at 50 degrees F. Activity gradually increased and at 68 degrees F. some of the adults commenced to fly. At 70 degrees F. one pair of insects was

TABLE VII

SURVIVAL PERIOD OF 18 MALE AND NINE FEMALE ADULT CHALCIDS REARED IN GELATIN CAPSULES, 1950

| Survival period (days) | No. individuals | | |
|---|---|---|---|
| | Male | Female | Total |
| 5 | 1 | 0 | 1 |
| 6 | 0 | 0 | 0 |
| 7 | 1 | 1 | 2 |
| 8 | 2 | 0 | 2 |
| 9 | 5 | 1 | 6 |
| 10 | 1 | 0 | 1 |
| 11 | 1 | 2 | 3 |
| 12 | 4 | 1 | 5 |
| 13 | 1 | 0 | 1 |
| 14 | 2 | 3 | 5 |
| 15 | 0 | 0 | 0 |
| 16 | 0 | 1 | 1 |

observed to mate. From 100 degrees F. up to 106 degrees F., although the insects were still very active they appeared to be uncomfortable. At all temperatures at which the insects were active a reduction in light intensity reduced the activity.

## II Egg Stage

### Incubation period

Table VIII, page 36 shows that the incubation period is highly variable. The minimum time recorded for incubation was seven days. However after 22 days incubation, eggs were still present. Since the percentage of viable eggs was not known the maximum period of incubation could not be determined.

## III Larval stage

### Duration

In 1949 larvae were first observed on June 20. In 1950 the earliest date on which pupae were observed was May 23. Therefore the larval period normally extends for approximately 11 months.

If conditions are not satisfactory the larvae instead of pupating will remain in the larval stage for at least one more year. Larvae infesting seeds were overwintered in 1949-1950 but did not pupate in the spring. They were overwintered

TABLE VIII

INCUBATION PERIOD, 1951

| Host | Date of oviposition | Incubation period* | Number of eggs | Number of larvae |
|---|---|---|---|---|
| C. arborescens | July 20 | 5 | 1 | 0 |
| " | 14 | 6 | 1 | 0 |
| " | 17 | 7 | 0 | 1 |
| C. frutescens | 3 | 9 | 1 | 1 |
| " | 3 | 11 | 0 | 2 |
| " | 3 | 12 | 0 | 2 |
| " | June 28 | 14 | 0 | 1 |
| " | 28 | 15 | 0 | 1 |
| " | 28 | 16 | 0 | 2 |
| " | 25 | 16 | 0 | 2 |
| " | 25 | 18 | 5 | 2 |
| " | 22 | 19 | 2 | 0 |
| " | 25 | 19 | 5 | 2 |
| " | 28 | 19 | 1 | 3 |
| " | 22 | 20 | 0 | 1 |
| " | 22 | 21 | 8 | 5 |
| " | 25 | 22 | 2 | 8 |

*Period between the time at which oviposition occurred and examination was made.

again in 1950-51. When they were brought into the insectary in the spring pupation took place. Nine male and thirteen female adults emerged during the period June 15 to June 23.

## Feeding habits

As soon as the egg hatches the young larva begins to feed on the tender, growing cotyledons. Fig. 8, page 38 shows larval damage in the early stage. The seed coats have been removed to reveal the partly devoured cotyledons. Normally the larva continues to feed until the cotyledons are entirely destroyed.

Occasionally more than one egg is deposited in a single seed resulting in competition between larvae. In one study in which 87 larvae were obtained, 73 appeared singly in the seeds, eight were in pairs and six were present in threes. However not more than one mature larva has been observed in a single seed.

## Effect of larval feeding on appearance and weight of infested seeds

After the egg has hatched and the larva has been feeding for several weeks, the seed is often marked with a dark-brown patch on the seed coat immediately outside the point at which the larva is feeding. This discolored patch is quite soft and spongy.

When the caragana seed pods dehisce, the infested seed

Figure 8. Early stages of larval damage to caragana seeds. 30X

is quite dry and hard but the seed coat is not smooth and round as on a normal seed. It is usually flattened or dented on one or both ends and often on the sides giving the seed a rectangular shape. It is usually dull-brown in color.

A number of normal and infested seeds weighed at the time of dehiscence (Table IX, page 40) showed the average weight of one normal seed to be 28.8 mgm. and that of one infested seed to be only 11.9 mgm.

Larval dispersal

When the seed pods dehisce the normal and infested seeds are dispersed. The data in Table X, page 41, show that:

(a) a very high percentage of the normal and infested seeds are not dispersed more than five feet from the bases of the trees, i.e. for C. arborescens 93 per cent normal and 84 per cent infested and for C. frutescens 85 per cent normal and 81 per cent infested;

(b) infested seeds although less than one-half the weight of the normal seeds have a pattern and range of dispersal similar to that of the normal seeds;

(c) very few seeds were dispersed as far as 17 feet from the bases of the trees.

TABLE IX

A COMPARISON OF WEIGHTS OF NORMAL AND INFESTED SEEDS AT TIME OF DEHISCENCE, 1948

| | Normal seeds | | Infested seeds | |
|---|---|---|---|---|
| | No. | Wt. (mgm.) | No. | Wt. (mgm.) |
| | 138 | 3,305 | 41 | 427 |
| | 9 | 252 | 2 | 12 |
| | 4 | 90 | 7 | 62 |
| | 46 | 1,140 | 12 | 114 |
| | 71 | 1,769 | 31 | 351 |
| | 100 | 2,594 | 25 | 317 |
| | 100 | 2,338 | | |
| Total | 468 | 13,488 | 108 | 1,283 |
| Average | | 28.8 | | 11.9 |

TABLE X

SEED DISPERSAL BY DEHISCENCE OF SEED PODS, 1948

| Species of caragana | Dist. from tree (ft.) | Total no. seeds | Normal seeds | | Infested seeds | |
|---|---|---|---|---|---|---|
| | | | No. | Per cent | No. | Per cent |
| C. arborescens | 0 - 2 | 2370 | 2167 | 41.0 | 203 | 65.8 |
| | 3 - 5 | 2830 | 2775 | 52.5 | 55 | 17.8 |
| | 6 - 8 | 216 | 191 | 3.6 | 25 | 8.1 |
| | 9 - 11 | 102 | 87 | 1.5 | 15 | 4.7 |
| | 12 - 14 | 62 | 51 | 1.0 | 11 | 3.6 |
| | 15 - 17 | 15 | 15 | 0.4 | 0 | 0.0 |
| C. frutescens | 0 - 2 | 414 | 86 | 65.7 | 328 | 66.5 |
| | 3 - 5 | 98 | 25 | 19.2 | 73 | 14.8 |
| | 6 - 8 | 46 | 8 | 6.2 | 38 | 7.8 |
| | 9 - 11 | 32 | 6 | 4.7 | 26 | 5.2 |
| | 12 - 14 | 28 | 5 | 3.4 | 23 | 4.7 |
| | 15 - 17 | 6 | 1 | 0.8 | 5 | 1.0 |

Regional distribution and host preference

The data in Table XI, page 44, show that the caragana seed chalcid is widely distributed and occurs in all of the prairie provinces. The degree of infestation varies considerably and is greater in Manitoba and Saskatchewan than in Alberta. The average infestations based on C. arborescens, C. frutescens and C. pygmaea in Manitoba were 38 per cent, in Saskatchewan 29 per cent, and in Alberta 3 per cent. A few seed samples of C. sinica, C. sophoraepholia, C. brevispina, C. microphylla, C. spinosa, C. lobergi and C. boisi were examined. These samples were all free from infestation with the exception of one sample of C. boisi seed from Morden, Man. One per cent of the seed in it was infested.

Natural mortality

Parasitism was observed to occur in infested samples of caragana seed from some localities. In 1949, 26.7 per cent of the chalcids in C. pygmaea and 21.4 per cent in C. frutescens seed from Scott, Sask. were parasitized. Parasitism also occurred in infested C. pygmaea seed from Sutherland, Sask. and C. frutescens seed from Brandon, Man. These parasites were identified as Amblymerus sp. and Habrocytus sp. Table XII, page 45 shows the daily parasite emergence in 1950. Emergence occurred during the period

June 14 to July 10 with the maximum for a single day occurring on June 23. Fig. 9, page 46 shows the holes in caragana seeds through which adult parasites emerged. Fig. 10, page 47 shows a female parasite ovipositing into an infested caragana seed.

Infested seeds were examined after overwintering normally. Of a total of 664 larvae studied, 159 or 24 per cent, had died. Many of the seeds containing dead larvae were infected with a fungus. This fungus was determined as Fusarium sp. but it is not known whether it was responsible for the death of the larvae.

## IV Pupal stage

### Duration

Of the 105 larvae placed singly in gelatin capsules for rearing only 34 pupated and emerged as adults. Fifty-eight of the insects died in the larval stage (some because of physical injury during removal from the seed coat), five died in the pupal stage and eight of the larvae did not pupate. The data concerning the 34 pupae which emerged as adults are shown in Table XIII, page 48. Pupation occurred during the period May 23 to June 19. The average duration of the pupal stage for 23 males was 15.9 days and for 11 females was 17.0 days.

TABLE XI

REGIONAL DISTRIBUTION, 1948

| Province | Locality | Per cent seeds infested | | | |
|---|---|---|---|---|---|
| | | C. arborescens | C. frutescens | C. pygmaea | Species unknown* |
| Man. | Morden | 0.2 | 7.9 | 38.9 | |
| | Lyleton | 12.8 | | | |
| | Stonewall | 15.1 | | | |
| | Pilot Mound | 19.4 | | | 3.9 |
| | Dand | 26.2 | | | |
| | Boissevain | 26.3 | | | |
| | Ninga | 29.1 | | | 9.5 |
| | Killarney | 33.9 | | | |
| | Souris | 43.7 | | | |
| | Carroll | 50.0 | | | 70.5 |
| | Hartney | 64.3 | | | |
| | Brandon | 90.0 | 99.8 | | |
| Sask. | Vanguard | 0.0 | | | |
| | Aneroid | 0.3 | | | |
| | Indian Head | 5.5 | 79.0 | | |
| | Sutherland | 11.2 | | 29.6 | |
| | Melfort | 16.8 | | 70.0 | |
| | Kenaston | 18.7 | | | |
| | Conquest | 25.2 | | | |
| | Scott | 29.8 | 0.7 | 79.7 | |
| | Snowden | 68.3 | | | |
| Alta. | Brooks | 0.0 | | | |
| | Lethbridge | 0.0 | 0.0 | 0.0 | |
| | Lacombe | 0.0 | | 4.6 | |
| | Athabasca | 0.0 | | | |
| | Beaverlodge | 0.0 | | 0.0 | |
| | Edmonton | 0.3 | | | |
| | Hanna | 6.9 | | | |
| | Provost | 18.6 | | | |

*Species of caragana was not recorded when pods were collected.

TABLE XII

DAILY EMERGENCE OF PARASITES FROM INFESTED *C. PYGMAEA* SEED, 1950

| Date | Emergence | | |
|---|---|---|---|
| | Male | Female | Total |
| June 14 | 9 | 0 | 9 |
| 16 | 4 | 0 | 4 |
| 17 | 6 | 0 | 6 |
| 18 | 6 | 0 | 6 |
| 19 | 6 | 0 | 6 |
| 20 | 9 | 0 | 9 |
| 21 | 11 | 0 | 11 |
| 22 | 8 | 1 | 9 |
| 23 | 14 | 2 | 16 |
| 24 | 6 | 5 | 11 |
| 26 | 6 | 3 | 9 |
| 27 | 2 | 0 | 2 |
| 28 | 4 | 4 | 8 |
| 29 | 1 | 1 | 2 |
| 30 | 1 | 2 | 3 |
| July 1 | 0 | 3 | 3 |
| 3 | 0 | 7 | 7 |
| 5 | 0 | 1 | 1 |
| 6 | 0 | 3 | 3 |
| 7 | 0 | 2 | 2 |
| 10 | 0 | 4 | 4 |

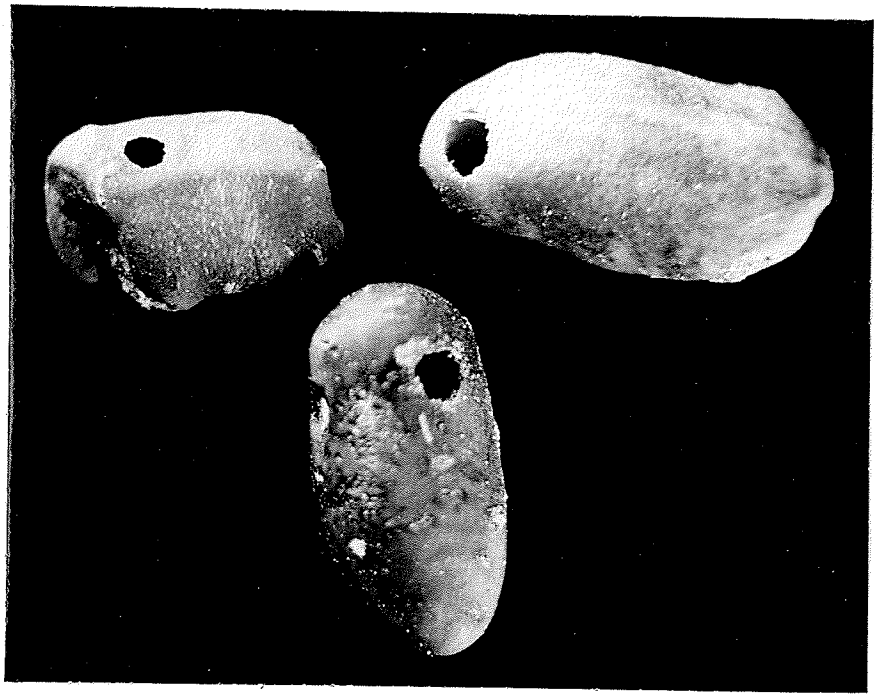

Figure 9. Infested caragana seeds from which adult parasites have emerged. 10X

Figure 10. A parasite of the caragana seed chalcid ovipositing into an infested seed. 27X

TABLE XIII

PUPAL PERIOD OF 23 MALE AND 11 FEMALE CHALCIDS REARED IN GELATIN CAPSULES, 1950

| Pupal period (days) | Male | Female | Total |
|---|---|---|---|
| 11 | 2 | 0 | 2 |
| 12 | 0 | 1 | 1 |
| 13 | 3 | 0 | 3 |
| 14 | 0 | 1 | 1 |
| 15 | 2 | 1 | 3 |
| 16 | 5 | 0 | 5 |
| 17 | 6 | 2 | 8 |
| 18 | 3 | 3 | 6 |
| 19 | 1 | 2 | 3 |
| 20 | 1 | 1 | 2 |

### Color changes

During its development the pupa gradually changes in color from white to black. These changes are shown in Table XIV, page 50.

## Artificial control

### Ground sprays

The data in Table XV, page 51 show that BHC gave excellent control, aldrin gave very good control and DDT was relatively ineffective. When all emergence had ceased some of the seeds from each cage were examined. In seeds treated with BHC and with aldrin, insects were observed to have died in the adult stage within the seed. This did not occur in seeds treated with DDT or in untreated seeds.

### Foliage sprays

The results of applying sprays to the foliage of *C. arborescens* to prevent chalcid oviposition are shown in Table XVI, page 52. These data show that of the 38 trees which were treated, 17 were infested prior to the time of treatment. The 21 trees which were apparently not infested at time of treatment, became infested at a later date. Therefore these results did not yield any satisfactory information on control of the chalcid.

TABLE XIV

COLOR CHANGES OF 30 MALE AND EIGHT FEMALE PUPAE DURING DEVELOPMENT, 1950

| Color | Average days from pupation | |
|---|---|---|
| | Male | Female |
| Entirely white | 2.2 | 2.7 |
| Body white, eyes yellow | 5.6 | 6.5 |
| Body white, eyes and ocelli orange | 7.3 | 9.5 |
| Dorsal abdomen and ventral thorax turning black | 9.1 | 11.0 |
| Body black, eyes dull red | 12.2 | 14.5 |
| Emerged | 15.9 | 17.0 |

TABLE XV

RESULTS OBTAINED FROM THE APPLICATION OF SPRAYS TO INFESTED CARAGANA SEEDS ON THE GROUND, 1950

| Insecticide | Concentration actual chemical in oz./sq. ft. | Emergence | | |
|---|---|---|---|---|
| | | Male | Female | Total |
| BHC - 6% gamma isomer | 0.04 | 0 | 0 | 0 |
| " " | 0.08 | 0 | 0 | 0 |
| Aldrin - 25% w.p. | 0.04 | 1 | 0 | 1 |
| " " | 0.08 | 2 | 0 | 2 |
| DDT - 50% w.p. | 0.04 | 49 | 4 | 53 |
| " " | 0.08 | 37 | 4 | 41 |
| Check | | 70 | 16 | 86 |

TABLE XVI

RESULTS OBTAINED FROM THE APPLICATION OF SPRAYS TO THE FOLIAGE OF C. ARBORESCENS TREES, 1950

| Insecticide | Conc. | Seeds examined | | | Per cent infested prior to spraying |
|---|---|---|---|---|---|
| | | No. | No. infested | Per cent infested | |
| DDT | 2 lb./100 gal. | 739 | 49 | 6.6 | 28.1 |
| " | " | 425 | 19 | 4.4 | 1.8 |
| " | " | 554 | 4 | 0.4 | 1.7 |
| " | " | 583 | 17 | 2.9 | 1.4 |
| Check | | 433 | 3 | 0.7 | |
| DDT | 5 lb./100 gal. | 446 | 6 | 1.3 | 0.0 |
| " | " | 683 | 8 | 1.2 | 0.1 |
| " | " | 723 | 3 | 0.4 | 3.0 |
| " | " | 239 | 2 | 0.8 | 0.0 |
| Check | | 60 | 1 | 1.6 | |
| BHC | 2 lb./100 gal. | 330 | 1 | 0.3 | 0.0 |
| " | " | 529 | 11 | 2.1 | 1.4 |
| " | " | 0 | | | 0.0 |
| " | " | 384 | 16 | 4.1 | 3.2 |
| " | 5 lb./100 gal. | 875 | 6 | 0.7 | 1.2 |
| " | " | 237 | 8 | 3.3 | 0.0 |
| " | " | 428 | 3 | 0.7 | 0.0 |
| " | " | 999 | 49 | 4.9 | 1.0 |
| Check | | 921 | 21 | 2.2 | |
| Aldrin | 2 lb./100 gal. | 889 | 9 | 1.0 | 0.0 |
| " | " | 0 | | | 0.0 |
| " | " | 421 | 11 | 2.6 | 0.0 |
| " | " | 835 | 10 | 1.1 | 5.0 |
| Check | | 215 | 5 | 2.3 | |
| Aldrin | 5 lb./100 gal. | 429 | 4 | 0.9 | 0.8 |
| " | " | 426 | 6 | 1.4 | 0.0 |
| " | " | 431 | 21 | 4.9 | 0.0 |
| " | " | 457 | 7 | 1.5 | 1.9 |
| Pyrenone | 1.5 lb./100 gal. | 317 | 7 | 2.2 | 0.0 |
| " | " | 424 | 14 | 3.3 | 0.0 |
| " | " | 443 | 13 | 2.9 | 1.7 |
| " | " | 555 | 25 | 4.5 | 3.7 |
| Check | | 255 | 30 | 13.3 | |

TABLE XVI (continued)

RESULTS OBTAINED FROM THE APPLICATION OF SPRAYS TO THE FOLIAGE OF C. ARBORESCENS TREES, 1950

| Insecticide | Conc. | Seeds examined | | | Per cent infested prior to spraying |
|---|---|---|---|---|---|
| | | No. | No. infested | Per cent infested | |
| Pyrenone | 3 lb./100 gal. | 614 | 24 | 3.9 | 17.4 |
| " | " | 0 | | | 0.0 |
| " | " | 250 | 1 | 0.4 | 2.6 |
| " | " | 490 | 10 | 2.0 | 0.0 |
| Check | | 478 | 17 | 3.5 | |
| Pestox | 2 pt./100 gal. | 0 | | | 0.0 |
| " | " | 0 | | | 0.0 |
| " | " | 625 | 5 | 0.8 | 0.0 |
| " | " | 457 | 2 | 0.4 | 0.0 |
| " | 4 pt./100 gal. | 564 | 4 | 0.7 | 0.0 |
| " | " | 632 | 12 | 3.6 | 0.0 |

Cultural control

The data in Table XVII, page 55 show that the emergence of adults from infested seeds covered with soil followed a pattern very similar to that from uncovered seeds.

## Summary

1. Caragana is a very important plant in the prairie provinces. It is used more extensively in shelter belts than any other single species of tree.

2. The caragana seed chalcid was first encountered at Indian Head, Sask. in 1947.

3. The insect occurs quite generally throughout the prairie provinces.

4. Investigations showed that it destroys a high percentage of the seed of C. arborescens, C. frutescens and C. pygmaea. It is of economic importance in connection with caragana breeding work and seed production.

5. Table XVIII, page 56 shows the approximate periods of the year during which the different stages of the chalcid are present. Adults emerge over a period of about six weeks during June and July, and live for slightly less than two weeks. The eggs are laid soon after the adults emerge and hatch in five days or more. The larvae are present from the latter half of June until the latter half of May the following spring, a period of approximately 11 months. The pupal

TABLE XVII

DAILY EMERGENCE OF CHALCIDS FROM INFESTED SEEDS COVERED WITH SOIL, 1951

| Date | Check | | | Covered with one inch soil | | | Covered with one-half inch soil | | |
|---|---|---|---|---|---|---|---|---|---|
| | M. | F. | Total | M. | F. | Total | M. | F. | Total |
| June 14 | 5 | 0 | 5 | | | | 4 | 0 | 4 |
| 15 | 4 | 1 | 5 | 0 | 4 | 4 | 3 | 0 | 3 |
| 16 | 5 | 2 | 7 | 1 | 2 | 3 | 6 | 0 | 6 |
| 17 | 0 | 3 | 3 | 5 | 0 | 5 | 7 | 0 | 7 |
| 18 | 14 | 4 | 18 | 7 | 2 | 9 | 5 | 2 | 7 |
| 19 | 12 | 6 | 18 | 15 | 3 | 18 | 10 | 4 | 14 |
| 21 | 10 | 5 | 15 | 7 | 2 | 9 | 6 | 4 | 10 |
| 22 | 3 | 16 | 19 | 5 | 5 | 10 | 5 | 11 | 16 |
| 23 | 14 | 7 | 21 | 8 | 1 | 9 | 16 | 10 | 26 |
| 26 | 4 | 9 | 13 | 1 | 1 | 2 | 16 | 8 | 24 |
| 27 | 5 | 15 | 20 | 1 | 2 | 3 | 2 | 10 | 12 |
| 30 | 6 | 12 | 18 | 0 | 3 | 3 | 3 | 6 | 9 |
| July 2 | 4 | 7 | 11 | 1 | 5 | 6 | 2 | 8 | 10 |
| 3 | 4 | 4 | 8 | 3 | 6 | 9 | 5 | 16 | 21 |
| 4 | 0 | 2 | 2 | 1 | 0 | 1 | 3 | 10 | 13 |
| 5 | 1 | 2 | 3 | 3 | 3 | 6 | 2 | 13 | 15 |
| 6 | 1 | 3 | 4 | 2 | 9 | 11 | 5 | 19 | 24 |
| 7 | 4 | 8 | 12 | 2 | 9 | 11 | 2 | 9 | 11 |
| 9 | 2 | 4 | 6 | 3 | 15 | 18 | 1 | 5 | 6 |
| 10 | 2 | 6 | 8 | 3 | 7 | 10 | 1 | 2 | 3 |
| 11 | 3 | 2 | 5 | 1 | 4 | 5 | 1 | 4 | 5 |
| 12 | 1 | 7 | 8 | 2 | 7 | 9 | 1 | 1 | 2 |
| 13 | 1 | 3 | 4 | 0 | 1 | 1 | 0 | 2 | 2 |
| 14 | 0 | 2 | 2 | 1 | 0 | 1 | | | |
| 16 | 0 | 1 | 1 | 0 | 0 | 0 | | | |
| 17 | 1 | 0 | 1 | 0 | 0 | 0 | | | |
| 18 | 0 | 2 | 2 | 1 | 0 | 1 | | | |

TABLE XVIII

APPROXIMATE PERIODS OF THE YEAR DURING WHICH THE DIFFERENT STAGES OF THE CARAGANA SEED CHALCID ARE PRESENT

| Stage | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | March | April | May |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Adult | ——— | —— | | | | | | | | | | |
| Egg | —— | ——— | | | | | | | | | | |
| Larva | — | ——— | —— | ——— | —— | —— | —— | —— | —— | ——— | ——— | — |
| Pupa | ——— | —— | | | | | | | | | | —— |

stage lasts for a period of slightly more than two weeks.

6. Artificial control measures have been carried out in an attempt to prevent infestation and destruction of caragana seeds. BHC and aldrin applied as sprays to infested seeds on the ground gave good control of the chalcid. Sprays applied to caragana foliage to prevent adult oviposition have not yielded satisfactory results.

# CHAPTER III

## OTHER INSECTS ATTACKING CARAGANA

### Caragana aphid, Macrosiphum caraganae (Cholod.)[1]

From reports in the Canadian Insect Pest Review it is apparent that the caragana aphid occurs generally on caragana throughout the prairie provinces. Patch (1938) reports that the aphid feeds on Caragana arborescens and C. pygmaea. The writer has observed it feeding on these species and also on C. frutescens.

Strickland and Hocking (1950) say "Nearly every year a close examination of caraganas will show that they are lightly infested with small green plant-lice. Occasionally conditions are such that these become excessively numerous by mid-June. A heavy infestation results in all of the leaves falling from the bushes, which remain for the rest of the summer as bare as they were in winter. Fortunately, this causes no permanent damage; in the following year the bushes will resume their normal luxuriance of growth and foliage." The aphids seem to prefer to feed on tender young pods and foliage as shown in Figs. 11 and 12, page 59.

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[1]Order Homoptera, Family Aphididae.

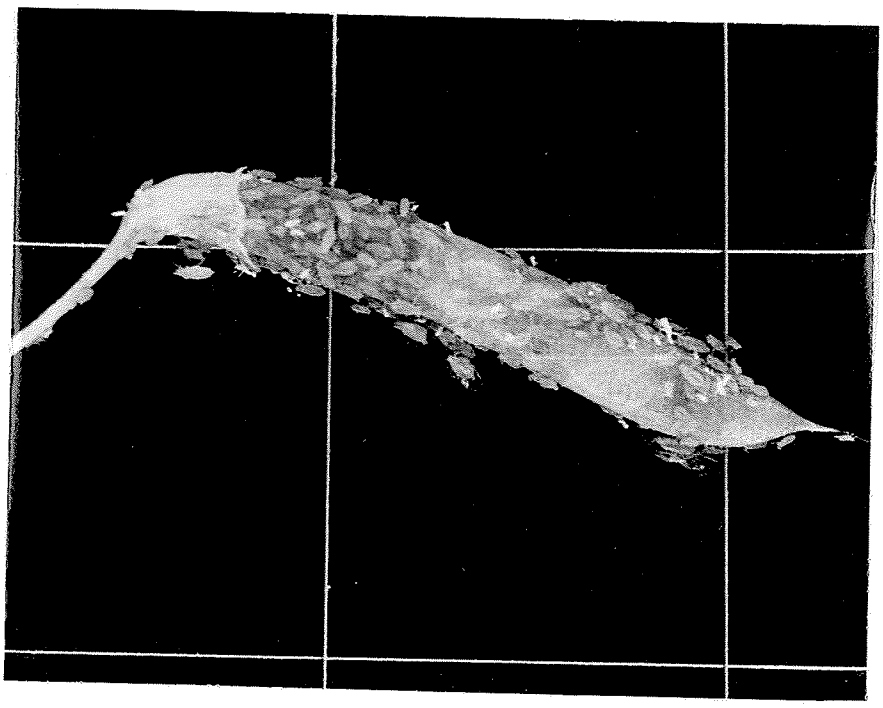

Figure 11. Aphids on a caragana pod

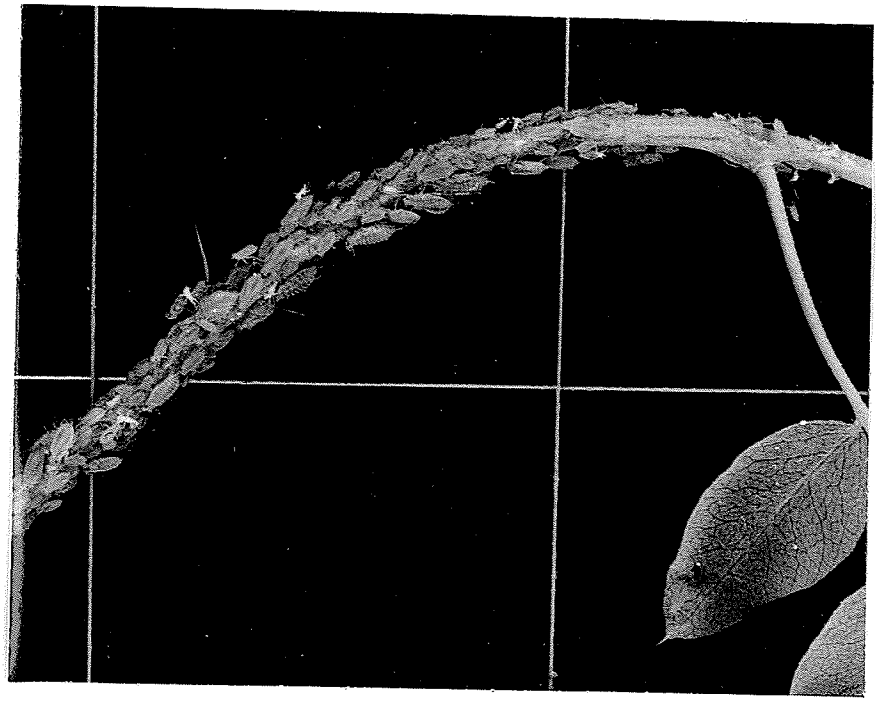

Figure 12. Aphids on new growth of caragana

According to Strickland and Hocking (1950) it is thought that aphids infesting caragana do not require an alternate host.

Natural control

Larvae and adults of the convergent lady beetle, Hippodamia convergens Guer. have been observed to feed freely on the aphids. Fig. 13, page 61 shows a larva of this species feeding on caragana aphids. The two-spotted lady beetle, Adalia bipunctata (L.) is also predacious on the aphid but was not observed to be present in as large numbers as the convergent lady beetle.

Artificial control

The results of artificial control experiments carried out at Indian Head, Sask. (data unpublished) are shown in Table XIX, page 62. These data show that parathion (15 per cent wettable powder) used at the rate of 5.3 ounces in 40 gal. of water, or TEPP (40 per cent emulsifiable concentrate) used at the rate of five fluid ounces in 40 gal. of water gave satisfactory control.

## Blister beetles[2]

Predatism of the larvae of blister beetles on eggs of

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[2]Order Coleoptera, Family Meloidae.

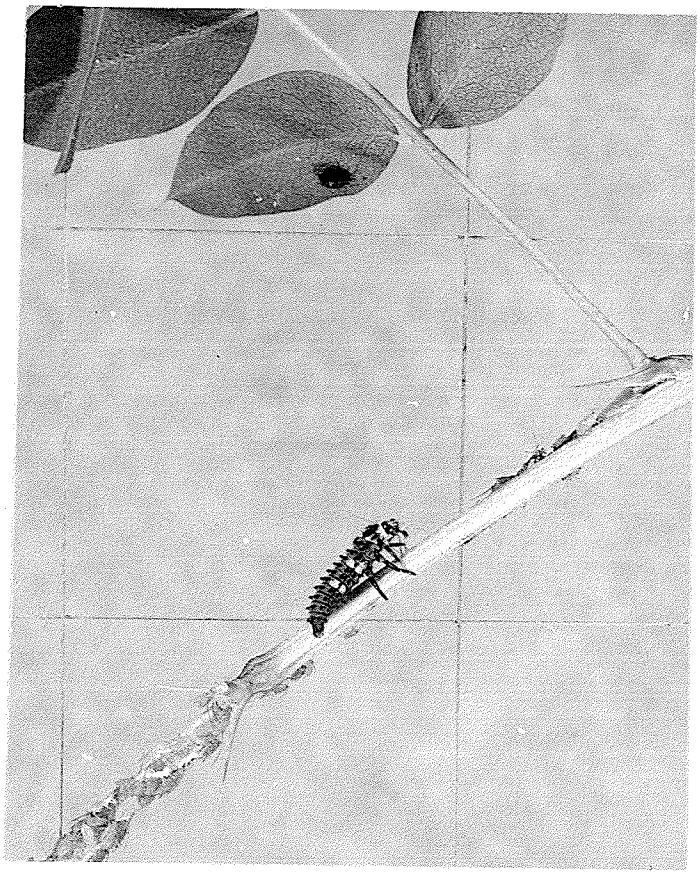

Figure 13. A larva of Hippodamia convergens feeding on caragana aphids.

TABLE XIX

INSECTICIDES USED AGAINST THE CARAGANA APHID AND RESULTS OBTAINED, 1951

| Insecticide | Amt. used in 40 imperial gal. water | Results* |
|---|---|---|
| DDT 25% emul. conc. | 20 fl. oz. | not effective |
| Parathion 15% w.p. | 10.7 oz. | mortality over 98% |
| " " | 5.3 oz. | " " " |
| " " | 2.7 oz. | not effective |
| " " | 1.7 oz. | " " |
| TEPP 40% emul. conc. | 5 fl. oz. | mortality over 98% |
| " " | 3 fl. oz. | " " " |
| " " | 2 fl. oz. | mortality near 98% |
| Nicotine sulphate 40% | 6.7 fl. oz. | not effective |

*98% kill used as standard for effective control.

grasshoppers indicates that they are beneficial in this stage. From observations made by Horsfall (1943) it was found that about 25 per cent of egg masses were destroyed where grasshopper eggs were abundant. However in the adult stage the insects feed voraciously on plant foliage and flowers, and are responsible for considerable damage. They appear in large swarms in localized areas causing considerable damage within the area in which they are feeding, but do not usually cause much damage over large areas.

Host plants

Manson (1948) says that blister beetles feed on a wide variety of broad-leaved plants, with some species showing a greater range of hosts than others. "The chief plants damaged are potatoes and legumes, but the food plants may vary from cabbage to ash trees and include alfalfa, clover, beans, peas, potato, tomato, sugar beet, squash, aster, calendula, sunflower, honeysuckle, caragana, ash, wild lettuce, Russian thistle, mullein, and many others." Milliken (1921) says the beetles may feed only on the petals and pollen of the host plants. On many plants however they devour the foliage and when present in large numbers, may completely defoliate the plants. Twinn (1938) says that several species of blister beetles including Lytta nuttallii Say and Macrobasis subglabra Fall "interfered considerably with the successful

establishment of caragana shelter belts" in the prairie provinces.

General biology

Blister beetles have a developmental history different from and more complex than that of other beetles. The complexities of the life cycle have occasioned the name hypermetamorphosis for this type of development.

According to Horsfall (1943) all the common species lay their eggs in narrow tubular cavities in the soil. The cavities are made in firm soil about one inch deep and the diameter varies with the size of the beetle constructing the tube. The female lays from 50 to 300 eggs in the bottom of the tube and then covers the eggs with soil and tamps it down with its head.

The time spent in the egg stage varies with different species. With some the average time is nine days while with others it may be as much as 80 days. Most of the eggs in a single mass hatch within a few hours and the young are called triungulin larvae. These larvae come to the surface of the ground and run about searching for an entrance to a grasshopper egg pod. Within a few days of the commencement of feeding in an egg pod the larva undergoes its first moult. The insect completes its development in seven instars which include three different phases (Horsfall, 1943). The

first phase is a feeding period in which gradual changes occur throughout five instars. Some changes in body shape occur but the morphological changes are slight. The second phase is that in which the coarctate larva (sixth instar) remains dormant. It remains overwinter in this stage and occasionally over two winters. The third phase also consists of only one instar and resembles a larva of the fifth instar so much that it is hard to differentiate between them. This active non-feeding larva changes to a pupa.

Ash-gray blister beetle, Epicauta fabricii (Lec.)

Gilbertson and Horsfall (1940) describe the adult as having "an ash-gray color all over the body, including legs and head. The underlying color is black with a covering of minute whitish hairs. There are no marks such as lines or spots." The original description given by Leconte in 1853 was published in the Proceedings of the Academy of Natural Science, Philadelphia VI, page 343.

Leng (1920) says that Macrobasis unicolor (Kby.) and M. cinerea (Fab.) are synonyms of Epicauta fabricii (Lec.). Brown (1940) says the insect has been referred to in literature as Lytta cinerea Fab., Cantharis cinerea (Fab.), Lytta Fabricii Lec. and Lytta debilis Lec.

Brown (1940) says that "most of the references to unicolor in the literature of economic entomology apply to

this species which occurs from North Dakota and Massachusetts to New Mexico and Georgia. In Canada it is abundant in the most southern parts of Alberta, Saskatchewan, and Manitoba, but it is known in the east only from the Lake Erie district of Ontario."

Black blister beetle, Epicauta pennsylvanica (Deg.)

Horsfall (1943) quotes Blatchley in describing the adult as "Elongate, slender. Uniform black, opaque, clothed with fine, short, prostrate black hairs." This species was originally described by De Geer in 1775 and the description published in Memoirs pour servir a l'histoire des Insectes, Stockholm V, 1775. Leng (1920) lists the following synonyms which exist: Epicauta atrata (Fab.), E. coracina (Ill.), E. nigra (Woodh.) and E. morio Lec.

Caragana blister beetle, Macrobasis subglabra Fall

Brown (1940) says "This species may be recognized by its truly black color and very indistinct vestiture." This species was first described by Fall (1922) from a series taken from Edmonton, Alta. and Redvers, Sask.

With regard to its distribution in Canada Brown (1940) says "the insect is abundant in Alberta, Saskatchewan and Manitoba, extending as far north as Edmonton, the type locality, in Alberta and to Berens River in Manitoba."

In literature this species has also been referred to as Macrobasis murina (Lec.).

Nuttall blister beetle, Lytta nuttallii Say

This species was described by Say and the description published in the Journal of the Academy of Natural Science, Philadelphia III, 1823. Leng (1920) says that Lytta fulgifer (Lec.) is a synonym of this species.

The insect is quite common and some years it is very numerous and destructive. Twinn (1934) says it is "the most conspicuous and important species" in the prairie provinces, and attacks "caragana hedges, beans and other legumes."

De Gryse (1924) describes the adult as "a large, handsome beetle with plum coloured wing-covers glossed with gold. The head, thorax and abdomen are metallic green, the antennae black, the legs dark purple."

Control

A number of different insecticides have been tried against blister beetles. Although some authors still recommend their use, it appears that the arsenicals do not give good control. Dietz and Zeisert (1934) found that barium fluosilicate "when used one part by weight and diluted with four parts by weight of flour, talc, or clay gave a uniformly high percentage of kill in as short a time as 24

hours." They found that lime used as a diluent decreased the toxicity of the barium fluosilicate and that neither lead arsenate nor calcium arsenate "approached barium fluosilicate in insecticidal efficiency against blister beetles." Lead arsenate applied as a spray at four pounds in 100 U.S. gallons of water, and as an undiluted dust was "ineffective in killing or preventing from feeding." Gilbertson and Horsfall (1940) found that barium fluosilicate dust gave good control but say that better results are obtained when it is applied in such a way as to hit the beetles as well as the foliage.

Brown (1951) says "the fluorine poisons, cryolite and barium fluosilicate, in 25 per cent dusts applied at 25 lb./acre are able to give quick control."

West and Campbell (1950) found that a spray of 0.4 per cent suspension of a five per cent DDT powder gave 93.3 per cent kill of Epicauta on potatoes after three days. A lead arsenate spray of the same concentration gave 6.6 per cent kill after three days. A three per cent DDT dust applied at 20 pounds per acre gave good control.

Smith and Sullivan (1940) found that the most effective spray against the black blister beetle was "one containing pyrethrum extract (pyrethrins 1:5000) and derris powder (rotenone 1:4000) which killed 91.6 per cent of the

beetles." When the derris powder was used alone it killed only 11.1 per cent of the beetles.

Dustan (1940) says "in Saskatchewan it has been found that a solution of epsom salts and water (three tablespoonfuls to one gallon) acts as a deterrent to Nuttall's blister beetle when sprayed on the foliage of plants on which these insects are feeding." In Alberta a "dust composed of one part of paris green, one part of derris (4 per cent rotenone) and 10 parts of hydrated lime, by volume, has given most satisfactory control of blister beetles."

Manson (1948) says DDT and chlordane can be used effectively as five per cent dusts at 20 to 25 pounds per acre. They also give good control as sprays when 1.5 pounds of the 50 per cent wettable powder is used in 40 gallons of water.

## Grasshoppers

### Importance

Grasshoppers are world wide in distribution and are found in all the provinces of Canada. The most destructive species occurring in the prairie provinces are: lesser migratory grasshopper, Melanoplus mexicanus mexicanus (Sauss.)[3]; two-striped grasshopper, M. bivittatus (Say)[3], and the clear-

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[3]Order Orthoptera, Family Acrididae.

winged grasshopper Camnula pellucida (Scudd.)[4].

Records show that outbreaks of grasshoppers lasting for periods of four or five years, have occurred in the prairie provinces at intervals of 11 years since 1895. At times they have been reported to cause fairly considerable damage to the foliage of caragana.

Life history

The life histories of the economic species of grasshoppers are very similar, although there is some difference in habit. The winter is passed in the egg stage and hatching commences towards the end of May or early June. The nymphs complete their development in about six weeks and during this period they moult five times. The adult stage is reached in early July, when mating takes place and the overwintering eggs are deposited in pods in the soil.

The lesser migratory grasshopper oviposits chiefly in stubble fields. The two-striped grasshopper prefers oviposition sites such as ditches, ridges or banks sheltered from the wind and facing the sun. However eggs of this species may be found in almost any of the locations selected by other species. The clear-winged grasshopper deposits its eggs in "egg-beds" in short-grass areas along roadsides, headlands and fence lines.

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[4]Order Orthoptera, Family Acrididae.

Control

If it is necessary to exercise artificial control, aldrin applied at the rate of two ounces per acre is recommended as giving very good control. Wood et al. (1950) say the spray should be applied to the plant foliage on which the insects are feeding.

Where it is not practical to spray, grasshopper baits can be used. The formula for the bait used in the grasshopper control campaign in Saskatchewan in 1950 according to Arnason and McDonald (1950) is:

| | |
|---|---|
| sawdust | 50 gal. |
| millfeed | 3 gal. |
| chlordane concentrate | ½ pint |

The bait should be spread evenly on the ground at the rate of not more than 20 pounds per acre.

## Caragana plant bug, Lopidea dakota Knight[5]

This insect was described by Knight (1923) in Entomological News. Knight says the male is 6.4 mm. long and 2.5 mm. wide and the female 6.9 mm. long and 2.4 mm. wide. The female is more robust than the male but similar in form and coloration. The body color is bright red. The insect was named after the Dakota Indians.

The Canadian Insect Pest Review reports its occurrence as being quite general throughout the prairie provinces and

[5]Order Hemiptera, Family Miridae.

British Columbia. It is reported as occurring on caragana, raspberries, and strawberries, but is not usually present in sufficiently large numbers to warrant carrying out artificial control measures.

## Scale Insects, Lecanium sp.[6]

Scale insects of the genus Lecanium have been reported to attack caragana. Manson (1936) reporting from Lethbridge says the "scale frequently appears on caragana but has seldom caused injury to the affected trees". Professor A. V. Mitchener reports that the insects occur on caragana in Winnipeg.

## Summary

1. The caragana aphid is a common pest of caragana and is present to some extent nearly every year. It may cause serious defoliation but this does not appear to cause permanent damage.

2. Coccinellid larvae and adults aid in controlling the aphid population. Hippodamia convergens Guer. was observed to be more plentiful than other species.

3. Parathion and TEPP sprays are effective in controlling the aphid. Parathion is applied at the rate of

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[6] Order Homoptera, Family Coccidae.

5.3 ounces of 15 per cent wettable powder in 40 gal. of water; TEPP at five ounces of 40 per cent emulsifiable concentrate in the same amount of water.

4. The blister beetles Epicauta fabricii (Lec.), E. pennsylvanica (Deg.), Macrobasis subglabra Fall and Lytta nuttallii Say have been reported in the Canadian Insect Pest Review as causing damage to the foliage of caragana. They may appear suddenly in large numbers on caragana within limited areas. Because of their voracious feeding habits they will cause considerable damage if prompt control measures are not exercised.

5. A number of insecticides have been used against blister beetles, but the most effective appears to be barium fluosilicate applied as a dust in such a way that it strikes the beetles as well as the foliage.

6. Grasshoppers are not common pests of caragana but have been reported to have caused damage.

7. The caragana plant bug is reported as commonly occurring on caragana in the prairie provinces but is not usually present in large numbers.

8. A Lecanium scale has been reported on caragana.

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