RESEARCH BULLETIN 980 JANUARY 1966

Life History and Control of the JUNIPER TIP MIDGE, *Oligotrophus apicis* Appleby and Neiswander

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CONTENTS

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AGDEX 276/612-606

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Life History and Control of the JUNIPER TIP MIDGE, *Oligotrophus apicis* Appleby and Neiswander[1]

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INTRODUCTION

Until a few years ago, the cause of the browning of branchlet tips of juniper trees and shrubs was unknown. In 1952, many trees of Canaert Redcedar in Lake County, Ohio, had a brown appearance due to numerous dead branchlet tips (Figure 1). Many yellow-orange midge larvae were found in these tips. Adults from these larvae were reared from the branches and sent to the U. S. National Museum, where Dr. Richard Foote identified the midges as an undescribed species of *Oligotrophus*.

The number of Ohio nurseries reporting *Oligotrophus* sp. injury has increased since 1952. In 1962, 88 Ohio nurseries reported such damage. Nurseries in Illinois, Indiana, Michigan, Oregon, and Pennsylvania also have reported *Oligotrophus* sp. injury to junipers.

Midge damage also occurred in propagation cuttings of juniper in greenhouses. The midge caused death of the new growth, resulting in stunted plants.

Neiswander (11) reported that a parasite, *Platygaster* sp. (Hymenoptera: Eulophidae), was important in controlling the midge population. Control studies by English (7) and Schuder (12) indicate that certain systemic insecticides, applied as a foliar spray or to the soil, are particularly effective in control of the midge.

The midge was described as *Oligotrophus apicis* Appleby & Neiswander (2). An illustrated key to the species of *Oligotrophus* found in the United States accompanies the species description.

The following study was initiated in 1961. It is primarily concerned with the life history and control of *O. apicis*.

LIFE HISTORY

In Ohio, *O. apicis* overwinters on juniper as a light-yellow larva in the branchlet tip enclosed by the terminal leaves. The larvae pupate in April and the first adults emerge during late April in southern Ohio and early May in northern Ohio.

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[1]Part of a dissertation presented to the Graduate School of The Ohio State University by the senior author in partial fulfillment of the Doctor of Philosophy degree.

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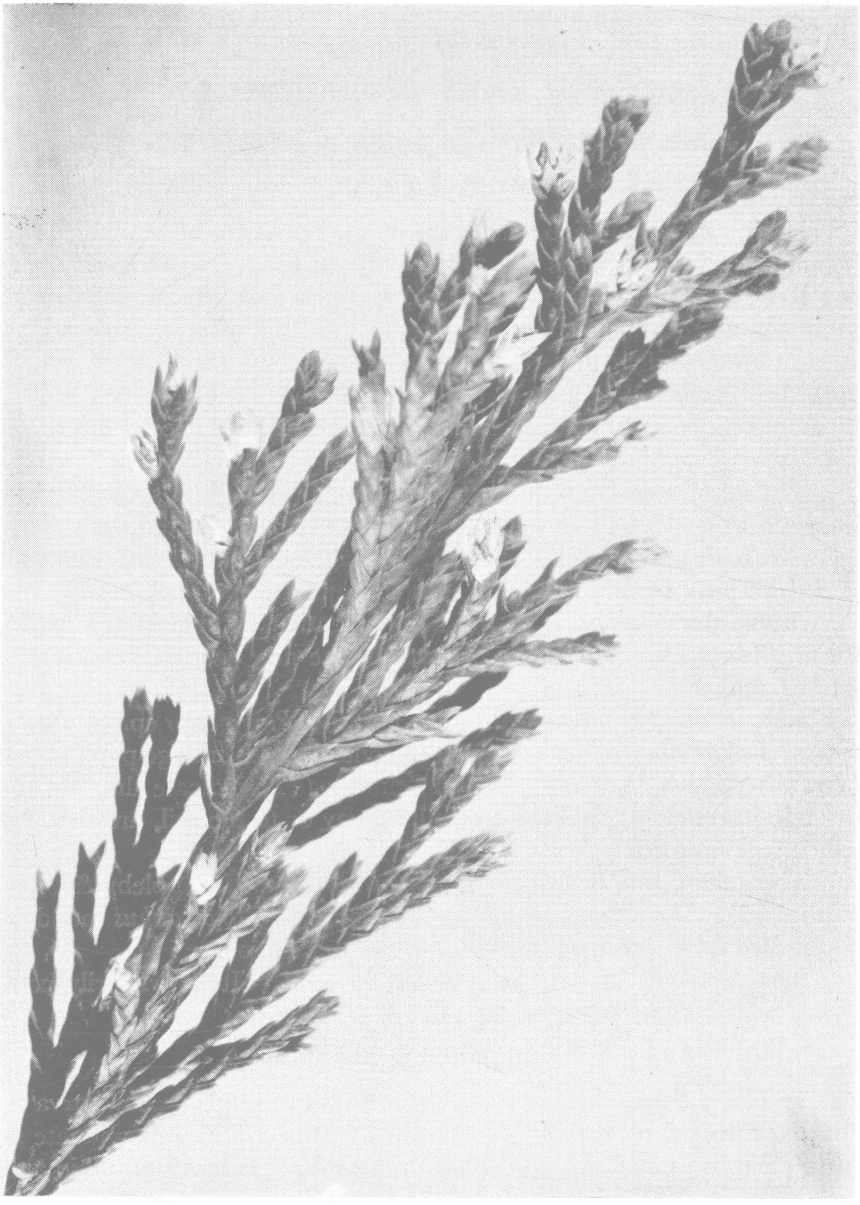

Fig. 1.—Tips of Canaert Redcedar branchlets injured by O. apicis.

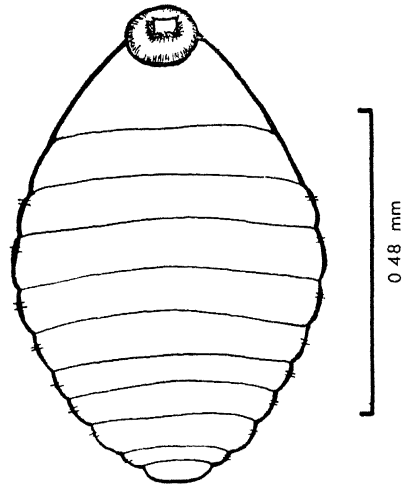

Fig. 2.—Drawing of a mature O. apicis larva, ventral view.

Both sexes are weak fliers. On days with little air current, adults can be seen flying several feet away from infested junipers. Adults mate shortly after emergence, with mating occurring while the female rests on the juniper foliage. Shortly after mating, eggs are deposited on the new foliage, usually along the space between overlapping leaves. Branchlet tips may appear red due to the large number of eggs.

Eggs deposited in early May begin hatching in mid-May. Upon emerging, the larvae crawl to the branchlet tips and move between the leaves, eventually reaching the central cavity of the growing tip. Several larvae may enter a tip but only one larva completes development.

By early June, the eggs have hatched and the larvae are within the tips. Adults are again numerous in late June, early August, and mid-September. Eggs deposited during the summer months hatch within 4-5 days. From August until October, all life stages of the midge can be found. The average adult life is 1 to 2 days.

EGGS

The eggs are red-orange, shiny, elongate, and tapering at the ends. They are 0.27 millimeters in length and 0.09 mm at greatest width. The red-orange eggshells remain attached to the leaf for a short time after the larvae emerge.

LARVAE

The larvae are very sluggish after feeding begins. The light-yellow color of the larva in early stages is intensified as the larva matures. The fully developed larva (Figure 2) is 0.75 mm in length, 0.51 mm in height, and 0.57 mm at greatest width. The breast plate on the ven-

tral side of the prothorax, characteristic of the larvae of many cecidomyiids, is absent. Paired spiracles are present on abdominal segments 1 through 9.

PUPAE

Pupation occurs within the juniper tip (Figure 3). During early development, the pupa (Figure 4) is entirely light orange. Later the head, antennae, legs, and wing pads turn dark brown to nearly black. The abdomen of the male is deep yellow-tan, with the terminal appendages the same color as the head. The female pupa is similar except the entire abdomen is dark red and more robust.

The average length of the female pupa is 1.17 mm and the greatest width is 0.77 mm. The male is slightly smaller. For a short time

Fig. 3.—Some of the scale-like leaves removed from the branchlet tip of Canaert Redcedar, exposing an O. apicis **pupa.**

after adult emergence, the pupal exuvium remains projecting from between the terminal leaves of the juniper branchlet.

ADULTS

Adults of *O. apicis* are small, delicate, mosquito-like insects (Figure 5), slightly more than 1.5 mm or 1/16 inch in length. The males are easily distinguished by the straw-brown abdomen and the clasping ap-

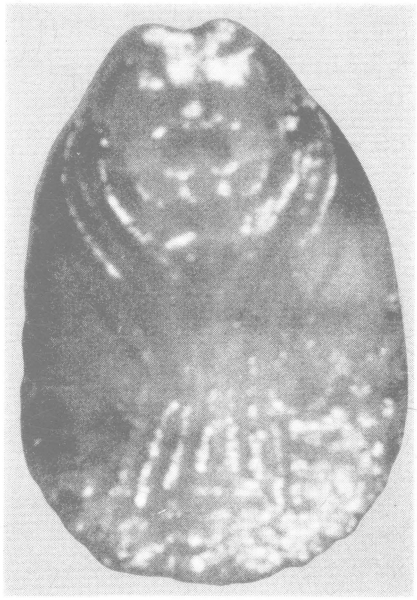

Fig. 4.—Ventral view of an O. apicis **pupa.**

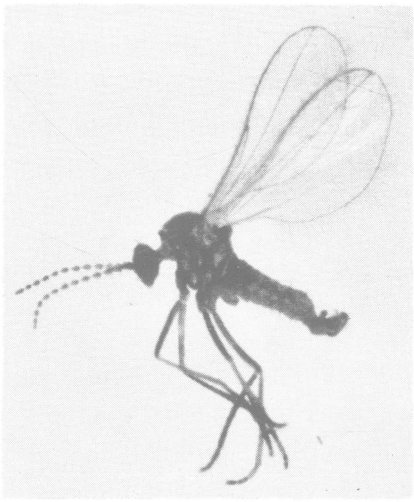

Fig. 5.—Lateral view of an adult O. apicis, **male.**

pendages or dististyles on the end of the abdomen. The abdomen of the female is dark red when full of eggs. It tapers to the end, with a paired flap-like structure on the posterior of the abdomen. Dissected virgin females contained an average of 125 eggs.

HOST PLANTS

Junipers are common evergreen plants in landscape plantings throughout most of Ohio. They have the quality of being able to grow well in city plantings where similar plants would fail. Wyman (13) indicated that nurserymen are offering more than 170 species and cultivars, about 93 of which are recommended for general planting.

Junipers vary in form from the columnar and pyramidal to bush-like growth typical of the pfitzers. Others are low, creeping plants used as ground covers.

Unfortunately, junipers are susceptible to certain diseases, especially juniper blight and cedar-apple rust. They are also attacked by such arthropod pests as scales, aphids, bagworms, mites, and midges.

The most important midge species injurious to junipers in Ohio are the common juniper midge, *Contarinia juniperina* Felt, and the juniper tip midge, *O. apicis*. The latter has been found infesting the following junipers[4] in Ohio: Canaert Redcedar, *Juniperus virginiana* 'Canaertii'; Dundee Redcedar, *J. v. pyramidalis* 'Hilli'; Andorra Juniper, *J. horizontalis* 'Plumosa'; Cypress Eastern Redcedar, *J. v. cupressifolia;* North Eastern Redcedar, *J. v. crebra;* Goldtip Eastern Redcedar, *J. v.* 'Elegantissima'; Globe Eastern Redcedar, *J. v.* 'Globosa'; Weeping Eastern Redcedar, *J. v. pendula;* Schott Redcedar, *J. v.* 'Schottii'; Alpine Creeping Juniper, *J. h. alpina;* Smith Redcedar, *J. v.* 'Smith'; 'Blue Heaven', *J. scopulorum*. Severe infestations of *O. apicis* have been found on the first four varieties mentioned.

INSECTARY REARINGS

Beginning in late April and continuing until October, five or six juniper branches of 8 to 10 inches in length were cut for each of five containers. These were cut at intervals of 7 to 10 days from Canaert Redcedar trees in a nursery planting at the Ohio Agricultural Research and Development Center.

The cut ends of the branches were inserted into small jars filled with water so the cut ends were covered to a depth of about 2 inches. The containers were placed in glass lantern globes which were covered at the top with cheesecloth. The containers were then placed in the insectary.

[4]Nomenclature according to Wyman (13).

Over a 3-year period, daily records were kept of the number and kinds of insects emerging from the branches.

A nylon mesh cage was placed over a juniper tree in a nursery planting. Insect emergence records were taken for a 2-year period during the same time that insectary emergence records were being taken.

In comparing records between cage and insectary emergence, it was decided the latter presented a more accurate indication of actual emergence. Data on the number of adult midges and their parasites reared in the insectary are summarized in Figures 6-8.

The emergence data indicate there are four generations of *O. apicis* a year. For two consecutive years, the largest number of midges emerged in the spring generation. In 1963, however, midges of the third generation were the most numerous.

Emergence of midge parasites *Tetrastichus* spp. (Hymenoptera: Eulophidae) occurs somewhat later than that of *O. apicis*. *Tetrastichus* spp. and a phytophagous species of *Rhopalicus* (Hymenoptera: Pteromalidae) emerged in large numbers. Several *Torymus* sp. (Hymenoptera: Tormyidae) emerged from the juniper branches.

PARASITES OF OLIGOTROPHUS APICIS

Although parasites have been a contributing factor in the control of *O. apicis,* it appears that parasites alone are not capable of keeping populations below the level of economic importance.

A summary of the total parasitism for a year is given in Table 1. A decrease in the number of adult midges in the spring generation of 1963 can probably be attributed in part to the high rate of parasitism in 1962. Nevertheless, the population of the third generation of midges in 1963 was comparatively high. The most numerous parasites were of the genus *Tetrastichus.*

Studies by Neiswander (11) showed that parasites of the genus *Platygaster* were at least one factor which reduced the midge population below the level of economic importance in 1952. However, species of *Torymus* and *Platygaster* were of little importance in control of the midge during 1961-1963.

TABLE 1.—Annual Percent Parasitism of O. apicis **Based on Insectary Rearings.**

Year	Number of Midge Adults	Number of Parasite Adults	Percent Parasitization
1961	315	222	70
1962	375	329	88
1963	328	82	25

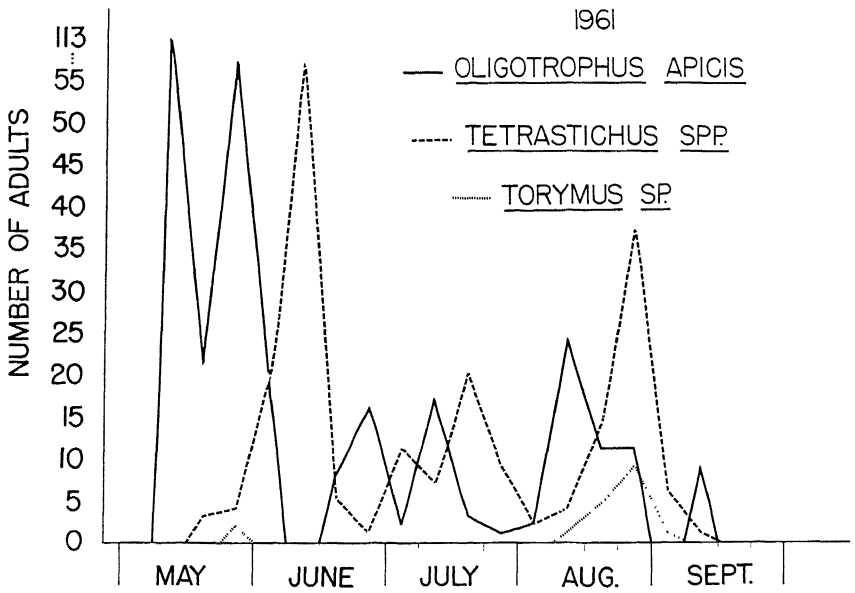

Fig. 6.—Emergence of O. apicis, Tetrastichus **spp., and** Torymus **sp. in 1961 from insectary rearings.**

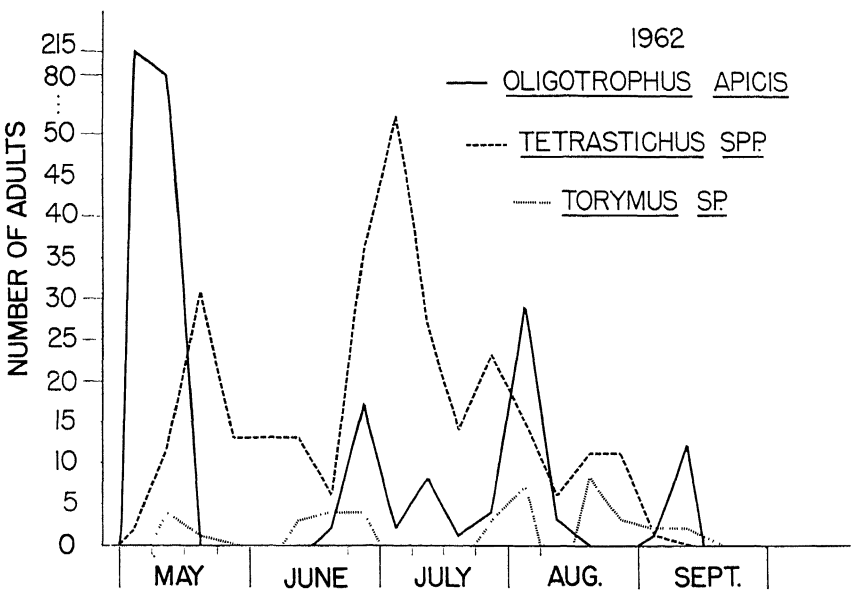

Fig. 7.—Emergence of O. apicis, Tetrastichus **spp., and** Torymus **sp. in 1962 from insectary rearings.**

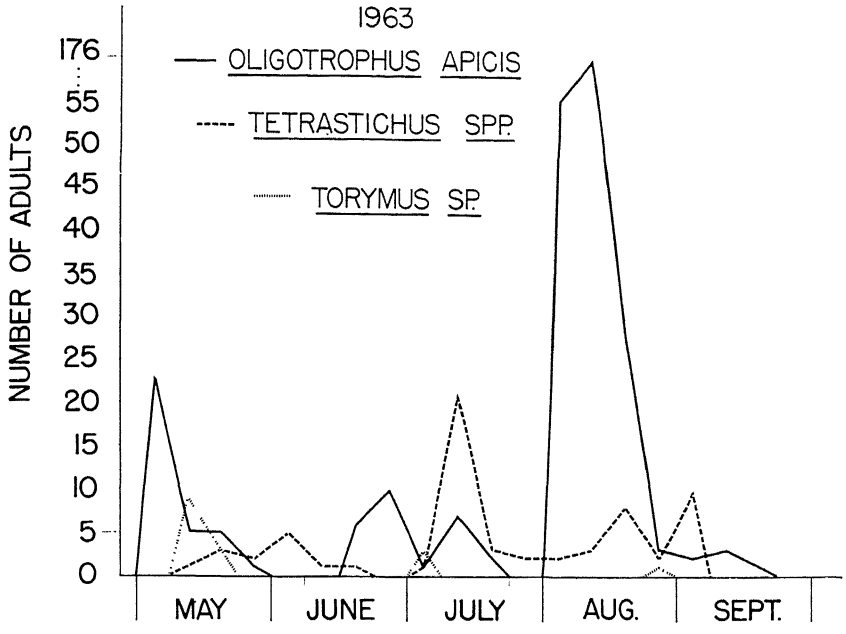

Fig. 8.—Emergence of O. apicis, Tetrastichus **spp., and** Torymus **sp. in 1963 from insectary rearings.**

Parasites and a pteromalid species were sent to Dr. B. D. Burks, U. S. National Museum, who made the determinations. The determinations were given U. S. National Museum Lot No. 61-16260 on August 22, 1961.

FAMILY EULOPHIDAE

Tetrastichus juniperi **(Crawford)**

Crawford (5) described the female from 11 specimens reared from berries of *Juniperus virginiana*. These were sent to him by S. Marcovitch with information that the species was phytophagous.

Marcovitch (9) studied the life history. In a single juniper berry, he found as many as 8 to 10 larvae. In observing larval development, he noticed they lived in tight fitting burrows which gradually became larger as the larvae fed and grew. He concluded from this fact that the species was phytophagous. A description of the male is included in his work.

The adult female of *Tetrastichus juniperi* (Figure 9) is mostly yellow. The compound eyes and three ocelli are bright red. The antennae are straw-brown, as are the four tarsal segments of the first and second pair of legs and the last two tarsal segments of the hind legs. The

dorsum of the abdomen has five or six brown bands extending horizontally, giving it a striped appearance. Total length, excluding antennae, is about 1.14 mm. A more detailed description is given by Crawford (5).

Enclosed by the terminal leaves of the juniper branchlet tip, the parasite overwinters in the larval stage on the larva of *O. apicis*. The larva is yellow-orange, smooth, without setae, rather inactive, and measures about 1.06 mm in length.

The larvae pupate in early May. The pupa is light yellow with red-brown compound eyes and ocelli. Later the wing pads and abdom-

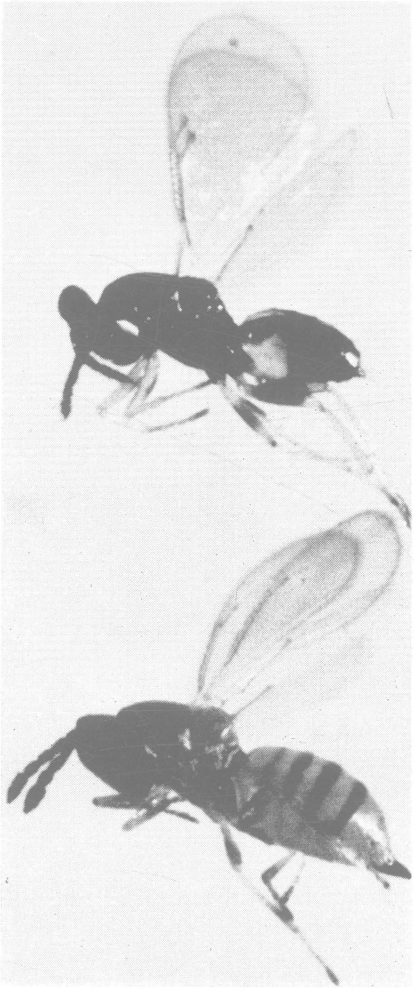

Fig. 9.—Lateral view of adults of Tetrastichus juniperi; **upper specimen is male, lower is female.**

inal markings become dark gray. The first adults emerge in mid-May and are found until mid-September.

From June to September, the parasite can be found as an external larva on the larval and pupal stages of *O. apicis* and as a hyperparasite on other *Tetrastichus* species. The parasite was easily reared on the host in the laboratory.

The top specimen in Figure 9 was considered by Burks as the possible male of this species. The male description given by Marcovitch (9) states it is mostly lemon-yellow but much darker than the female. A small area on the prosternum and dorsum of the abdomen is brown except for the anterior and posterior extremities. Specimens of males emerging from juniper tips did not conform to this description. Such specimens were brown except for a small, light yellow-tan area on the dorsal and ventral areas at the base of the abdomen and the legs.

The male overwinters as a small external parasite on *O. apicis*. Appearance of the male larva is the same as the female. The pupa is light yellow with red eyes. Later the eyes become dark red and the entire pupa becomes a shiny gray-black. The parasitic habits and emergence are similar to that of the female.

FAMILY EULOPHIDAE

Tetrastichus marcovitchi (Crawford)

Crawford (6) described both sexes from one male and three females sent by S. Marcovitch. Marcovitch (9), who reared the specimens from berries of *Juniperus virginiana,* stated they overwinter as larvae and are hyperparasitic on other *Tetrastichus* species.

Dr. B. D. Burks determined the female *T. marcovitchi* but was not certain of the males. Except for red eyes, the head and thorax of the female are black. The first three tarsal segments are light tan to white. The fourth tarsal segment and the remaining leg segments are dark brown. The abdomen is rather robust and dark brown. The female is parasitic on *Rhopalicus* sp. (Pteromalidae) larvae and pupae and occasionally on *O. apicis.*

FAMILY TORYMIDAE

Torymus sp.

Torymus (=*Callimome*) sp. was determined to be near *T. dasyneurae* (Huber). The mature larva overwinters inside the galls of *Rhopalicus* sp. Except for light brown mandibles, the larva is cream white. The body is stout, with numerous setae on the segments. The length is about 1.15 mm. The pupa changes from cream white to a shiny dark brown, nearly black. The eyes are very dark red. The female pupa can be recognized by the ovipositor, which is curved over the dorsum of the abdomen.

The first adults emerge in late May and are present throughout the summer (Figures 6, 7, 8). The adult male is a metallic, dark blue-green, with the abdomen slightly brown. The appearance of the female is similar to the male but the female has a long ovipositor. *Torymus* sp. is only an occasional parasite of *O. apicis*. It is a much more common parasite of *Rhopalicus* sp.

FAMILY PLATYGASTERIDAE

Platygaster **sp.**

As mentioned previously, work by Neiswander (11) showed that this species was very common during late August and that the parasite was important in reducing the midge population. During 1961-1963, the population of *Platygaster* sp. was very low and was not important in control of the midge.

The adult parasite is small and all black, with the 10-segmented antennae attached low on the face. Little is known about its life history, except that it is an internal parasite of *O. apicis* larvae.

A PTEROMALID GALL MAKER

FAMILY PTEROMALIDAE

Rhopalicus **sp.**

This insect is commonly found associated with Canaert Redcedar. There appear to be two or three generations a year (Figure 10). The immature larva overwinters at the tip of the juniper branchlet enclosed

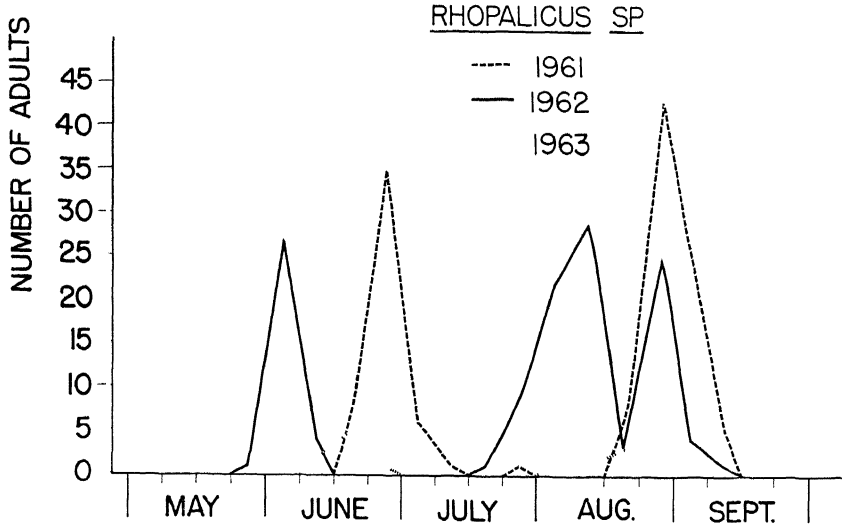

Fig. 10.—Emergence of Rhopalicus **sp. in 1961, 1962, and 1963 from insectary rearings.**

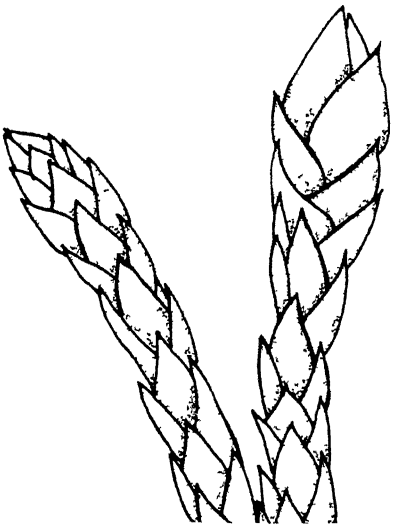

Fig. 11.—Drawing of a gall of Rhopalicus **sp. on Canaert Redcedar. Branchlet at right shows gall, branchlet at left is normal.**

by the terminal leaves. The gall (Figure 11) is similar to that of *O. apicis* except the leaves are slightly longer and wider, making this gall more conspicuous. During the time this study was conducted, the galls were never numerous enough to cause damage of economic importance.

The 10-segmented larva (Figure 12) is shiny white. The head is quite small in comparison to other segments. The first thoracic segment is wider and longer than the head and the second and third thoracic segments are very wide and long. The first abdominal segment is distinctly shorter in width and length and the remaining segments are progressively the same. The apex of the last abdominal segment is tapered into a long seta-like process, which is slightly curved The venter of the third thoracic and abdominal segments 1 to 6 have one pair of long setae arranged horizontally on each side of the median and curved toward the median.

When disturbed, the larva reacts by quickly rotating the abdomen in a circular motion.

The pupae of the first generation are found about the middle of May. The pupa is entirely dull black.

The head and thorax of the adult are a brilliant, metallic light green with a reddish-bronze tinge. The compound eyes are a light red and the abdomen is tan. The female is larger than the male, with the abdomen more robust and possessing an ovipositor on the venter of the abdomen.

English (7) includes *Rhopalicus* sp. as a parasite of *O. apicis*. During the present study, *O. apicis* and *Rhopalicus* sp. were never found in

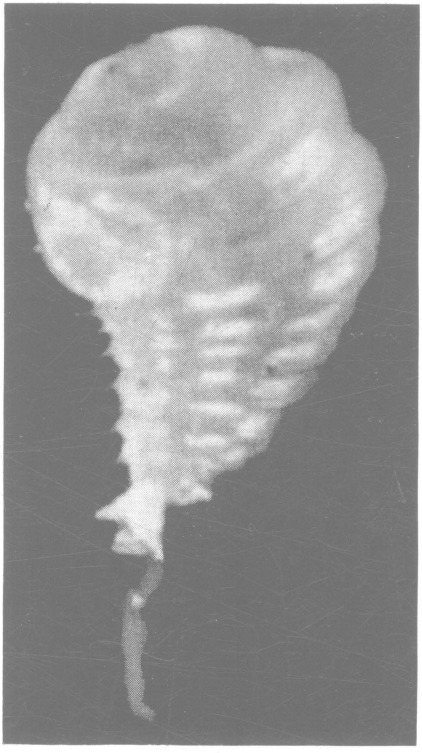

Fig. 12.—Rhopalicus **sp. larva, lateral view.**

the same gall. Although an occasional white egg was seen deposited between the apical leaves of juniper tips, all attempts to hatch eggs in the laboratory failed. Unlike the parasitic larvae which were easily reared in the laboratory when placed on midge larvae or pupae, *Rhopalicus* sp. died when such procedures were followed. It appears that *Rhopalicus* sp. is a phytophagous, gall-making pteromalid.

CHEMICAL CONTROL OF OLIGOTROPHUS APICIS

METHODS AND MATERIALS

In soil treatments, the amount of insecticide depended on the soil area covered by the tree canopy. In most tests, the area was 1 square yard.

Granular formulations were weighed and placed in a beaker which was marked to a given point. In the field, the granular material was poured into a beaker to the marked volume and, with the use of rubber gloves, the granules were distributed over the plot. The granules were worked into the soil with a rake.

Liquid formulations were measured, poured into a 2-gallon sprinkling can, and water added to fill the can. The can was then emptied

over the plot. Foliar treatments were applied with a 2-gallon compressed air sprayer unless otherwise indicated.

Each individual tree was considered a plot and each treatment had five or more replicates. Five branches about 6-7 inches in length were removed at random from each of five replicates. The branches were collected on April 30, June 19, July 18, and August 29 and placed in emergence containers in the insectary. The adult midges which emerged in the containers were counted and the percent control established by comparing the counts from treated and check plots.

1962 STUDIES

Studies at Columbiana, Ohio

A planting of Dundee Redcedar, *Juniperus virginiana pyramidalis* 'Hilli' at Columbiana, Ohio, served as the site for control studies. The planting consisted of about 500 6-ft. trees.

The trees were heavily infested with *O. apicis*. Midge parasites were not found in juniper tips previous to chemical applications on the plots. Parasites did not emerge in any of the insectary containers. Chemicals were sprayed on the plots on April 17, with subsequent applications throughout the spring and summer until August 13.

Insecticide Applications: On April 17, 12 insecticide treatments (Table 2) were applied to investigate their effects on the emergence of the midges when applied at the time the midges were in the larval stage. The insecticides were applied when the air temperature was 47° F.

Two additional treatments were applied April 24 when air temperature was 55° F. Of 100 infested tips examined, 11 percent of the midges were in the pupal stage. Cool temperatures during the time of application may account for the poor control results.

Another series of treatments was applied May 9 in an attempt to kill adult midges before large numbers of eggs were deposited and to kill larvae which may have emerged from eggs deposited previous to insecticide applications (Table 3). The air temperature was 47° F. in the morning and 59° F. by afternoon. Carbaryl was the most effective treatment.

On May 17, from ¼ to ½-inch of new growth was showing on the trees. Of 200 *O. apicis* eggs examined, 61 percent had hatched. A few larvae were found inside the tips but only under the cover of the outer leaf.

Insecticides were applied at this time to investigate the effects on the midge population at the time the eggs were hatching. All treatments applied on May 17 were effective (Table 4). Dimethoate, treatment No. 1, caused slight foliar burn which resulted in a yellowing of the new growth.

Adult midges or eggs were not seen when insecticides were applied on June 1 but numerous larvae were found inside the branchlet tips. Dimethoate applied on June 1 gave good control (Table 5) and did not cause foliar burn.

Midge eggs were abundant on the juniper foliage on June 29 and July 1. Midge adults, pupae, and mature larvae were also found.

A 15-gallon pressure sprayer was used to apply foliar treatments on June 29 and July 1 (Table 6). The percent control was compared to that obtained with Diazinon, treatment No. 8, as there were no check

TABLE 2.—Results from Application of Insecticides on April 17 and 24, 1962, for Control of O. apicis **on** J. virginiana pyramidalis.

Treatment No.	Date Applied, Treatment, and Rate	Percent Control	Total Number of Midges Emerged per Treatment
	April 17		
1	Diazinon 25E, 1 qt./100 gal.	94	79
2	Parathion 25WP, 2 lb./100 gal.	85	176
3	Dimethoate (Cygon) 4E, 1 qt./100 gal	83	205
4	Endosulfan (Thiodan) 2E, 1 qt./100 gal.	82	215
5	Guthion 2E, 3 pt./100 gal.	79	246
6	Demeton (Systox) 2E, 1 qt./100 gal.	58	492
7	Phorate (Thimet) 10% gran., 19 lb. actual/acre	44	661
8	Phosphamidon 4E, 1 pt./100 gal.	27	853
9	Ethion 4E, 1 pt./100 gal.	22	918
10	Malathion 57E, 1 qt./100 gal.	20	944
11	Lindane 20E, 1 pt./100 gal.	0	1166
12	Dichlorvos (DDVP) 4E, 1 qt./100 gal.	0	1174
	April 24		
13	Sumithion (American Cyanamid EI 47300) 4E, 1 pt./100 gal.	94	74
14	Naled (Dibrom) 8E, 1 pt./100 gal.	84	191
15	Check	—	1121

plots. Dimethoate, parathion, and a mixture of parathion and carbaryl were effective.

A dimethoate application applied August 13 with a 200-gal. truck-mounted sprayer was not as effective as previous applications of the insecticide in the spring and early summer. The poor control can probably be attributed to the higher percentage of the midge found as pupae and mature larvae in August. Results indicate that dimethoate probably does not kill these stages.

TABLE 3.—Results from Application of Insecticides on May 9, 1962, for Control of O. apicis **on** J. virginiana pyramidalis.

Treatment No.	Date Applied, Treatment and Rate	Percent Control	Total Number of Midges Emerged per Treatment
	May 9		
1	Carbaryl (Sevin) 50 WP, 2 lb./100 gal.	99	4
2	Carbophenothian (Trithion) 4 Fl, 1 qt./100 gal.	98	19
3	Endosulfan (Thiodan) 2E, 1 qt./100 gal.	96	82
4	Dieldrin 50 WP, 2 lb./100 gal.	95	101
5	DDT 50 WP, 2 lb./100 gal. and Diazinon 25E, 1 qt./100 gal.	95	108
6	Check	—	2097

TABLE 4.—Results from Application of Insecticides on May 17, 1962, for Control of O. apicis **on** J. virginiana pyramidalis.

Treatment No.	Date Applied, Treatment, and Rate	Percent Control	Total Number of Midges Emerged per Treatment
	May 17		
1	*Dimethoate (Cygon) 4E, 1 qt./100 gal.	99	2
2	Naled (Dibrom) 8E, 1 pt./100 gal.	99	3
3	Diazinon 25E, 1 qt./100 gal.	99	3
4	Guthion 2E, 3 pt./100 gal.	99	5
5	Parathion 25 WP, 2 lb./100 gal.	99	10
6	Check (same as in Table 3)	—	2097

*Foliar burning evident

TABLE 5.—Results from Application of Insecticides on June 1, 1962, for Control of O. apicis **on** J. virginiana pyramidalis.

Treatment No.	Date Applied, Treatment, and Rate	Percent Control	Total Number of Midges Emerged per Treatment
	June 1		
1	Dimethoate (Cygon) 4E, 1 qt./100 gal.	99	2
2	Diazinon 25E, 1 qt./100 gal	98	31
3	Parathion 25 WP, 2 lb./100 gal.	83	372
4	Naled (Dibrom) 8E, 1 pt./100 gal.	69	666
5	Check (same as in Table 3)	—	2097

TABLE 6.—Results from Application of Insecticides on June 29, July 1, and August 13, 1962, for Control of O. apicis **on** J. virginiana pyramidalis.

Treatment No.	Date Applied, Treatment, and Rate	Percent Control*	Total Number of Midges Emerged per Treatment
	June 29		
1	Dimethoate (Cygon) 4E,1pt./100 gal.	100	0
2	Dimethoate (Cygon) 2E, 1 qt./100 gal	99	2
3	Carbaryl (Sevin) 50 WP, 2 lb./100 gal. and Parathion 25 WP, 2 lb./100 gal.	99	3
4	Parathion 25 WP, 2 lb./100 gal.	99	4
5	Naled (Dibrom) 8E, 1 pt./100 gal.	98	16
6	Zectran 2E, 1 qt./100 gal.	96	29
7	Carbaryl (Sevin) 50 WP, 2 lb./100 gal.	52	395
	July 1		
8	Diazinon 25E, 1 qt./100 gal	—	812
	August 13		
9	Dimethoate (Cygon) 4E, 1 pt./100 gal.	98	20

*Percent control is in comparison to treatment No. 8.

Studies at Wooster, Ohio

At a Wooster, Ohio, residence, an Andorra juniper, *Juniperus horizontalis* 'Plumosa', hedge about 40 feet in length and 3 feet in width was heavily infested with *O. apicis*.

Spray applications of insecticides were applied to the foliage on May 8 when many eggs and a few adult midges were observed on the branchlets (Table 7). Each application was sprayed on three replicated plots, each of 1 square yard of hedge surface. Another insecticide application was made May 14, two days before the eggs began hatching. The carbaryl treatment was the most effective.

1963 STUDIES

Studies at Clyde, Ohio

At a nursery at Clyde, Ohio, about 100 Canaert Redcedar 6 feet in height were infested with *O. apicis* as well as its parasites and *Rhopalicus* sp. Insecticide applications were made in the same manner as in the 1962 studies.

On April 25, a few adult midges were seen and three different insecticides were applied (Table 8). Additional treatments were made on May 6 when the adult flies were abundant. Three insecticides were sprayed on the juniper foliage on May 15, when numerous midge eggs were noted but had not hatched.

Before adult emergence began, branches were pruned from one replicate of each of the nine treatments on June 19 and placed in emergence containers. On July 1, after the peak of adult emergence, branches from four replicates of each treatment were collected. The midges and parasites from replicates of the July 1 collection were divided by four and added to each of the June 19 samples. The data are summarized in Table 8.

TABLE 7.—Results from Application of Insecticides on May 8 and 14, 1962, for Control of O. apicis **on** J. horizontalis **'Plumosa', Andorra juniper.**

Treatment No.	Date Applied, Treatment and Rate	Total Number of Infested Tips from 10 Branches 6" in Length Cut June 15
	May 8	
1	DDT 50 WP, 2 lb./100 gal.	45
2	Carbaryl (Sevin) 50 WP, 2 lb./100 gal.	1
	May 14	
3	Parathion 25 WP, 2 lb./100 gal.	4
4	Check	166

TABLE 8.—Number of Adult O. apicis **and Parasites which Emerged from June 19 and July 1 Collections of Branches of** J. virginiana **'Canaertii', Canaert Redcedar Treated with Insecticides on April 25, May 6, and May 15, 1963.**

Treatment No.	Date Applied, Treatment, and Rate	Number of Adult Midges and Parasites Emerged per Treatment	
		Midges	Parasites
1	April 25 Carbaryl (Sevin) 50 % fl., 1 qt./100 gal. May 6 Carbaryl (Sevin) 50 % fl., 1 qt./100 gal.	139	71
2	April 25 DDT 25E, 1 qt./100 gal. May 6 DDT 25E, 1 qt./100 gal.	104	47
3	April 25 Baytex 4E, 1 qt./100 gal. May 6 Baytex 4E, 1 qt./100 gal.	6	21
4	May 6 Phorate (Thimet) 10 % gran., 19 lb. actual/acre, 2 gms./ sq. ft. of tree canopy	135	95
5	May 6 Dimethoate (Cygon) 4E, 20 lb. actual/ acre, 0.43 ml./ sq. ft. of tree canopy	40	135
6	May 15 Carbaryl (Sevin) 50 % fl., 1 qt./100 gal.	45	64
7	May 15 Dimethoate (Cygon) 4E, 1 pt./100 gal.	4	35
8	May 15 Naled (Dibrom) 8E, 1 pt./100 gal.	24	94
9	Check	13	161

TABLE 9.—Comparison of Number of Brown Tips of 10 Untreated and Dimethoate (Cygon) Treated Branches of J. horizontalis 'Plumosa', Andorra Juniper on July 1 after a Dimethoate Application on May 31, 1963.

Treatment	Number of Brown Tips										Total
Dimethoate (Cygon)	0	0	0	0	0	0	0	0	1	0	1
Check	64	65	70	75	84	91	99	104	113	165	930

Adult *Tetrastichus* sp. parasites began emerging during the second week of May. The first to emerge were those that overwinter as mature larvae. The decrease in the parasite populations on the treated trees during the latter part of June can probably be attributed to the residues of carbaryl, DDT, and Baytex on the foliage during the first few weeks of May (Table 8). Soil treatments of phorate and dimethoate had no apparent effect on the parasite population.

Applications of carbaryl, dimethoate, and naled in mid-May reduced the number of *Tetrastichus* sp. considerably in comparison to the check populations.

Studies at Wooster, Ohio

A foliar spray of dimethoate (Cygon) 4E at 1 pt. per 100 gal. was applied to an Andorra juniper, *J. horizontalis* 'Plumosa', hedge at Wooster, Ohio, on May 31. The *O. apicis* larvae were within the tips and about one-third grown.

On July 1, ten branches 10 to 12 inches in length were pruned at random from both the treated and untreated plants. The number of previously infested brown tips were counted. Excellent control resulted with the dimethoate spray, as shown in Table 9. In Figure 13, note the compactness of growth on the untreated branch as compared to the treated. The untreated branch had a brown appearance due to the many brown tips.

SUMMARY OF CHEMICAL CONTROL RESULTS

Insecticide treatments were ineffective in control of *O. apicis* when applied either before or at the beginning of adult emergence, although Baytex showed some promise. Phorate and dimethoate as soil treatments were ineffective.

Variable results were obtained with foliar sprays of carbaryl applied during the peak of adult emergence. In 1962, a spray application on Andorra juniper on May 8 gave good control (Table 7). However, a similar application on Canaert Redcedar on May 6, 1963, was ineffective (Table 8).

Foliar applications of dimethoate, naled, diazinon, and Guthion sprayed in mid-May when *O. apicis* eggs were hatching gave fairly good

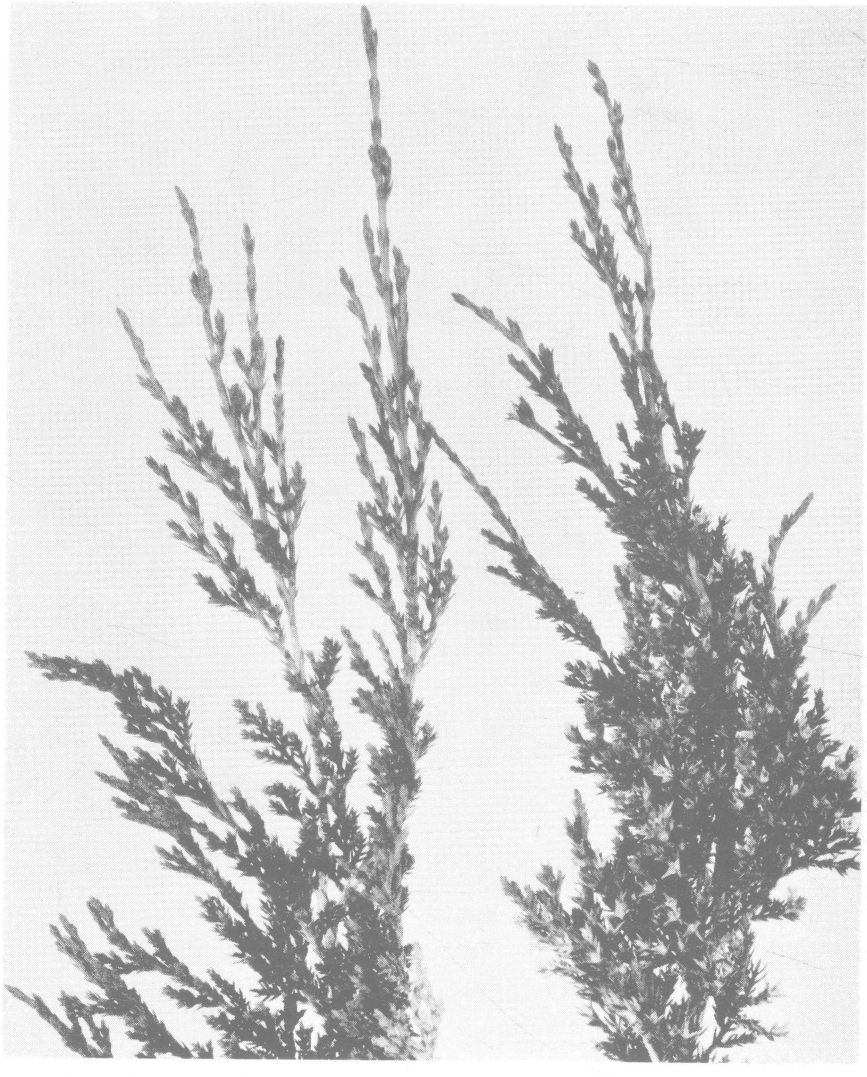

Fig. 13.—Branches of Andorra juniper; branch at left treated with dimethoate, branch at right not treated.

control. Best control results were obtained with dimethoate 4E at 1 pt. per 100 gal. or 2E at 1 qt. per 100 gal. sprayed on the foliage in late May or late June.

SUMMARY

Oligotrophus apicis Appleby & Neiswander overwinter as larvae in the branchlet tips of juniper. Adults emerge from the branchlets and are numerous in late April or early May, late June, early August, and mid-September. Eggs are deposited on the new juniper foliage soon after adult emergence. Adult life is about 2 days.

Natural control by parasites may reduce the midge population considerably. However, it appears that parasites alone are unable to keep the midge population in check for an extended period of time.

Dimethoate 2E at 1 qt. per 100 gal. applied as a spray to the infested junipers in late May gave the best control.

ACKNOWLEDGMENTS

The authors express sincere appreciation to Paul Suttle, Ivan Zuercher, Earl Howman, and Alvin Dilworth for their assistance; to Gwenn-Gary and Clyde Nurseries for cooperation in the chemical control studies; and to Donald Wyman for his suggestions in naming the juniper varieties.

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