This is to certify that the

thesis entitled

THE BIONOMICS AND CONTROL OF CLIMBING CUTWORMS ATTACKING GRAPES IN MICHIGAN

presented by

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has been accepted towards fulfillment of the requirements for

Master's degree in Entomology

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Date November 21, 1979

THE BIONOMICS AND CONTROL OF CLIMBING CUTWORMS ATTACKING GRAPES IN MICHIGAN

By

Frederick Walters Marmor

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Entomology

1979

ABSTRACT

THE BIONOMICS AND CONTROL OF CLIMBING CUTWORMS
ATTACKING GRAPES IN MICHIGAN

By

Frederick Walters Marmor

A complex of six species of climbing cutworms was identified inhabiting vineyards in southwestern Michigan, damaging the developing buds in early spring. Amathes c-nigrum L., Agrotis badinodis Grote, Amathes smithii Snellen, Rynchagrotis cupida (Grote), Euxoa messoria Harris and Spaelotis clandestina (Harris) were identified.

A laboratory rearing method was developed for Amathes c-nigrum L. and reared continuously through five consecutive generations.

Detection of cutworm larvae was best accomplished by nightly inspection of vineyards in the spring and by using a sweep net on the ground cover in the vineyards after dark.

Larvae of Euxoa messoria Harris were strongly attracted to a blacklight suspended above the ground.

The efficacy of various insecticides was tested in vineyards and microplots. Synthetic pyrethroids, chlorpyrifos, monocrotophos and various baits were effective in cutworm control.

ACKNOWLEDGMENTS

To my major professor, Dr. Angus Howitt, I would like to extend my thanks for his friendship, guidance and support, and for the opportunity to work at the Trevor Nichols Complex.

To my committee members, Dr. Stan Howell and Dr. Gary Simmons, I am grateful for their important inputs.

The grape growers of Berrien and Van Buren counties have been very cooperative and provided me with an excellent background in viticultural practices, and it is greatly appreciated.

The author is grateful to Robert Van Vleck, Gordon Brown, Robert Rogers, Ed Oxley, Dwight Brown, Cecil Bethe, William Streeter and William Cronenwett for the use of their vineyards and other facilities during the course of this study.

A very special thanks is extended to Gordon Brown and Robert Rogers and their families for providing housing for me during the research project.

I am indebted to the field staff of National Grape Cooperative for the initial introduction to the cutworm problem in grapes and for their help and guidance. The Van Buren and Berrien County Cooperative Extension Service provided help and guidance throughout the project.

To Deb, my wife, I would like to thank for her patience, understanding and encouragement which made the completion of this endeavor a reality.

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INTRODUCTION

Production of grapes has been a major horticultural enterprise in Michigan for over 100 years. Grapes were first planted in Michigan's Van Buren county in 1867 by Charles Lawton. The first recorded commercial harvest was in 1878 with thirty tons of grapes harvested (Thomas, personal communication). Michigan currently ranks fourth in total grape production only to be exceeded by California, New York and Washington. In 1977, Michigan produced a total of 33,000 tons of grapes with a production value of 6.5 million dollars. The 1978 grape crop produced 67,500 tons, of which, 60,000 tons were Concord. Utilization of the 1978 crop was as follows: fresh--2,100, wine--4,200, juice--60,300 and other--900 tons. Since 1973, Michigan has seen a decrease in grape acreage from 16,878 to 12,155 which is a 23 percent reduction. Nearly 99 percent of Michigan's grape acreage as reported in 1973 is located in Berrien, Kalamazoo and Van Buren counties in southwestern Michigan (Figure 1).

Grapes thrive in many soil types, and the Concord has a great adaptability to a wide range of soils. A good soil for grapes is a well-drained, deep, naturally fertile, gravelly or sandy loam with a subsoil that is not so heavy that it holds water (Shoemaker, 1978). Light soils are more easily worked, prepared for planting earlier in the spring, are tilled at less expense than clay soils and promote earlier ripening and higher sugar content of the grapes than do heavy soils (Childers, 1973).

Grapes are attacked by a variety of insect and disease pests. Common insect pests include rose chafers, flea beetles, leafhoppers and grape berry moth with black rot, Eutypa, downy mildew and powdery mildew being common grape diseases. One of the major and most destructive pests of grapes in Michigan are cutworms.

Damage to grapes by various species of cutworms includes feeding on developing buds, cluster damage pre-bloom, foliage feeding on new shoots and destruction of the apical meristem of shoots at or below the ground level. Since the larvae are nocturnal feeders, feeding is not frequently observed.

The investigations reported in this thesis were designed to understand certain aspects of the biology and control of climbing cutworms with respect to the production of grapes in Michigan. These investigations include studies to: (1) identify the cutworm complex attacking grapes, (2) understand the biology of the cutworms, (3) investigate the feeding behavior of the larvae, and (4) develop efficacy information for chemical control of cutworms.

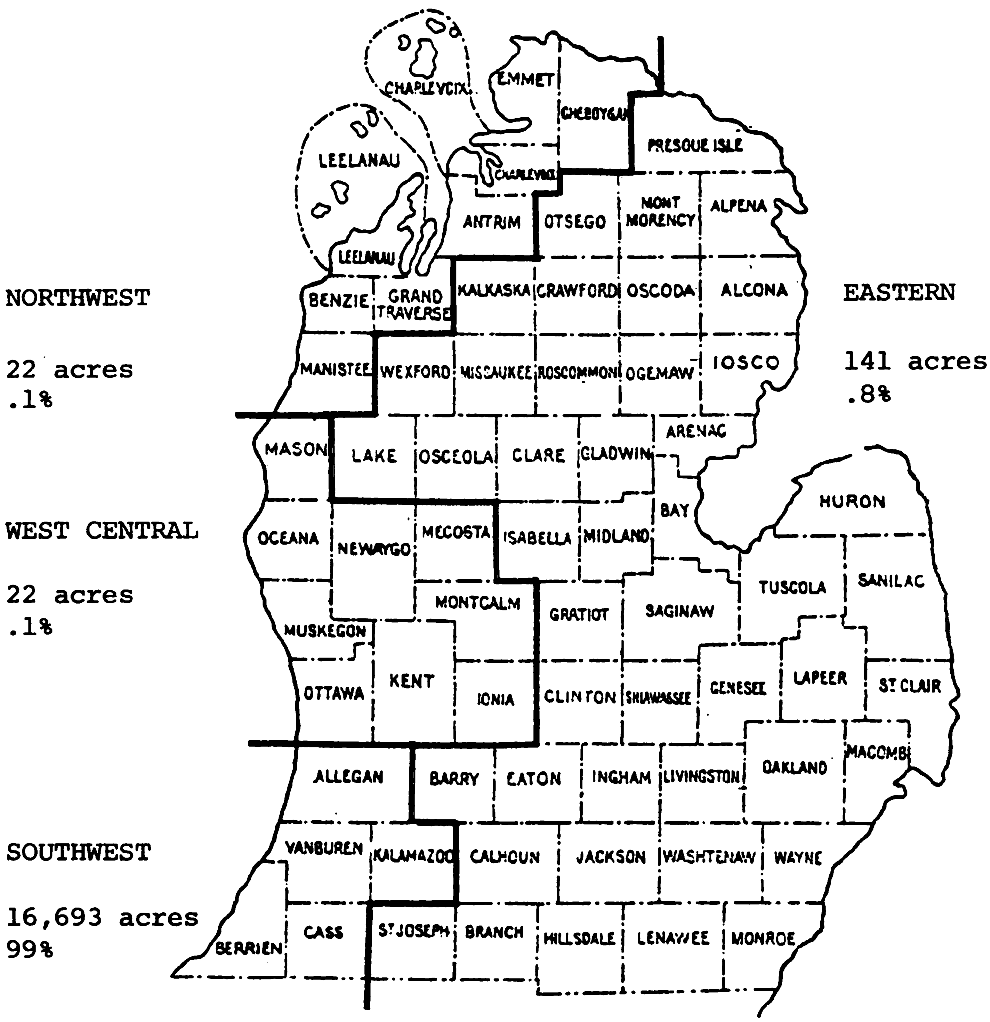


Figure 1. Distribution of Grape Acreage throughout Michigan with Acreage Reported for Each District

LITERATURE REVIEW

LITERATURE REVIEW

European literature of the early 1800's contains several accounts of cutworms climbing grapevines and doing much damage to the buds and leaves (Slingerland, 1895). The earliest reference to climbing cutworms in America is found in the Massachusetts Ploughman for June 28, 1851. This article reported that naked caterpillars came out of the ground in the night, and crawling up the trunks of the fruit tree, devoured the leaves and returned to conceal themselves in the ground before morning. In 1866, Riley gave a detailed account of the operations of three different species on the buds of fruit trees and grapevines in Illinois.

Cutworms may be grouped into categories based on the feeding habits of the larvae. The categories are: subterranean, tunnel makers, surface feeders, climbers and borers. Climbing cutworms are so termed due to the habit of the larvae to climb the host plant and feed on the stems, buds, foliage, flowers or seeds.

Slingerland (1895) reports that probably no cutworms assume the climbing habit when there are plenty of low-growing grasses and weeds at hand. Trees in grass or clover are rarely attacked by cutworms, while those in fields kept free from other vegetation by cultivation always suffer the most, as the worms have to either climb or starve. He also states that all cutworms prefer light, loose soils. Light, loose soils and a scarcity of low-growing succulent vegetation are conditions that may induce cutworms to assume the climbing habit.

The moths, nocturnal in habit, rest during the day in sheltered locations on trees, fences and other suitable localities. The moths feed on the nectar of flowers and other plant exudates. As a general rule, the moths are of a dull gray or brown color with their wings obscurely marked. The moths' nocturnal habits and the fact that often when in obscurity their eyes shine very brightly, led to their common name, owlet moths.

Life histories vary considerably and identification of the larvae is often very difficult. There are many keys available for cutworm identification (Crumb, 1929, 1932, 1956; Frost, 1955; Rings, 1976, 1977a, 1977b). Each contains a brief description of biology, damage and distribution.

Cutworms are naturally controlled by parasites, disease, predators and environmental conditions. Crumb (1929) reported that the control of many multiple-brooded species is largely effected in the fall and winter by environmental conditions, and he observed that the rate of mortality from parasites and disease is not as high in multiple-brooded species as in the single-brooded. Insect parasites and disease are characterized by the fact that by initiating the destruction of the insect, a provision is made for the possible destruction of a larger number in the future. Therefore, a disease which kills a single larva may develop enough reproductive bodies sufficient to infest a very large number and a single host may produce enough parasites to destroy large numbers of larvae in the next generation.

Environmental conditions of cold, heat, rain and drought are selective in their effectiveness for cutworm control due to the varying resistance which the species are able to offer. Single-brooded species in general are resistant to cold in all of their life stages whereas most multiple-brooded species are only resistant to cold when they reach the pupal stage (Crumb, 1929).

Cook (1934) suggests that the best way to prevent the ravages of cutworms is clean cultivation, thus eliminating sites for the larvae to overwinter. Ditching (Crumb, 1929) and fall plowing (Cook, 1934; Crumb, 1929) have also been recommended as possibilities for cutworm control.

Chemicals have been widely used for cutworm control. Inorganic insecticides such as Paris green, lead arsenate and zinc ortho-arsenite were commonly recommended. Paris green and lead arsenate were mixed with bran and sweeteners to serve as poison baits (Cook, 1934; Crumb, 1929; Walkden, 1950). The choice of compounds for use in baits was limited to the insecticidal value of the compound, and some compounds had their value impaired by the repellent action they had on the cutworms. The introduction of the chlorinated hydrocarbon insecticides, e.g., DDT, dieldrin and endrin, resulted in more effective cutworm control. Recently developed pyrethroid insecticides show promise for control of some agricultural pests. Their activity in the soil is limited (Harris and Turnbull, 1978) but their high toxicity to lepidopterous larvae (Harris and Turnbull, 1975; Schuster and Clark, 1977) suggests that they might have potential for cutworm control.

BIOLOGY

BIOLOGY

IDENTIFICATION OF CUTWORM COMPLEX

Introduction

Cutworms belong to a large group of insects in which the larvae have many characteristics in common. Species of different genera are sometimes so much alike that they can scarcely be identified in the larval stage. Positive identification of the species present is necessary so that an understanding of the biology of the species can be gained. Many different species may inhabit the same area so it is important to identify those species which attack the crop and those which cause no damage to the crop but occupy the same area. This study was initiated to determine what species of climbing cutworms cause damage to the grapes in the spring.

Methods and Materials

Inspections were made of vineyards in Berrien and Van Buren counties for the presence of cutworms. Vineyards selected were those which had a history of previous cutworm damage and also abandoned and neglected vineyards were monitored for cutworm activity.

Vineyard inspection began in the spring as the grape buds first showed signs of development. Canes were visually checked for the presence of cutworms or cutworm damage. Sweep net samples were taken in the vineyards sweeping the cover crop and other vegetation. All cutworm specimens collected were preserved in KAA and later transferred to 70% alcohol.

Larvae specimens collected while they fed on grape buds were sent to the U.S.D.A. Insect Identification Laboratory in Beltsville, Maryland, for positive identification.

Results and Discussion

Vineyard inspections made during the spring of 1978 and 1979 identified the following complex of cutworms causing damage to the grapes:

Amathes c-nigrum L.	Spotted cutworm
Spaelotis clandestina (Harris)	W-marked cutworm
Euxoa messoria Harris	Dark-sided cutworm
Agrotis badinodis Grote	Spotted-sided cutworm
Rhynchagrotis cupida (Grote)	Brown cutworm
Amathes smithii Snellen	No common name

The spotted cutworm and the spotted-sided cutworm are the most predominant species causing bud damage. The dark-sided cutworm, since it overwinters in the egg stage, attacks the grapes later in their development by feeding on the clusters pre-bloom.

The insect museum at Michigan State University has specimens and Michigan records for those species caught in blacklight traps throughout the state (Figure 2).

Spotted Cutworm, *Amathes c-nigrum* L.

(Lepidoptera: Noctuidae)

The spotted cutworm was originally described by Linnaeus in 1758. Since its description, it has undergone several changes in its genus,

Figure 2. Insect Museum Records of Species Caught in Blacklight Traps in Michigan

from the original placement in Noctua, followed by Agrotis (Crumb, 1929) then to Graphiphora (Crumb, 1956) and finally to the genus presently used, Amathes.

Distribution

This species is found throughout the east and west width of the United States and across Ontario and Quebec as far north as James Bay. The southern border for this species is the southern boundaries of North Carolina, Tennessee, Missouri, Kansas, Colorado and Utah. Alaska, Europe and Asia are also included in the range of this insect (Crumb, 1929; Rockburne and Lafontaine, 1976).

Food Plants

The spotted cutworm is described as a very general feeder on most field, garden and orchard crops. Walkden (1950) describes it as one of the most destructive cutworms in its range of abundance. A list of host plants is found in Appendix A1.

Description of Stages

Egg. The egg is white, spheroidal, slightly wider (0.65mm) than high (0.55mm) and is distinctly ribbed. There are 29-35 strong ribs with many conspicuous crossribs present (Salkeld, 1973). Soon after deposition the eggs become entirely pink, later turning nearly black before they hatch.

Larva. The larva is dull gray-brown, the summer brood sometimes dull olive, with faint pale dorsal and subdorsal lines and a broad subspiracle stripe. It has a series of black trapezoidal wedges on posterior segments, growing larger towards the rear, the last one on the eighth abdominal segment. The head is reticulated with brown (Figure 3A). The mandible has four prominent outer teeth and one inner tooth. The skin is smooth. First instar larva have a head capsule .35mm broad with a body 2-4mm long and .5mm wide while seventh instar larva head capsules measure 3mm broad and a body 30-36mm long and 6.5mm broad (Forbes, 1954; Crumb, 1929).

Pupa. Pupae are about 18mm long and 6mm broad. The maxillary palpi are visible, labrum not emarginate, cremaster with four hooked spinules, and the spines are rather long (Crumb, 1929).

Adult. The head and thorax are dark gray, almost blackish with the basal half or more of collar and shoulders contrastingly pale. The forewing is dark brown with the antimedial and terminal areas contrastingly blackish. Subterminal costal spot is triangular and conspicuous (Figure 3B). The hind wing is gray, shading to darker grayish-brown in veins and at the margin. Wingspread is 30-40mm (Rings, 1977a).

Life History

The spotted cutworm passes the winter as larvae, usually nearly mature in size. Eggs laid by the last brood adults produce the overwintering larvae. These larvae feed and develop in the fall with most of the larvae in the fourth instar by winter. These larvae overwinter in various locations providing protection from the winter.

Crumb (1929) reported that there were three flights of adults in Clarksville, Tennessee; the first in late April and early May, the second in July and the third in early September. In Illinois, Forbes (1954) found but two flights of adults. Moths emerged the latter part of May and early June. The second brood moths begin to appear in July and continued to emerge to the middle of August. In Michigan, the seasonal history is very much like that reported by Forbes except that the second brood moths emerge in early August and continue to mid-September.

W-marked Cutworm, Spaelotis clandestina (Harris)

(Lepidoptera: Noctuidae)

The W-marked cutworm was described and named by Harris in 1841. The cutworm was not definitely described until 1869 when its climbing habits were first recorded by Fitch (Slingerland, 1895).

Distribution

This species is a northern cutworm occurring throughout the east and west width of the United States and in Canada as far north as James Bay. The southern limits of this species are approximately Kentucky, Missouri, Kansas, Colorado, Utah, Nevada and California (Crumb, 1929).

Food Plants

This species is described as a general feeder on trees, shrubs and a great variety of herbaceous plants. A list of known food hosts is given in Appendix A2.

Description of Stages

Larva. Mature larvae have a head capsule measurement of 2.7mm broad with a body about 28mm long and 5mm broad. The skin is smooth with the color varying from pale gray to dark gray.

The dorsal area is sharply defined. There is a slender, broken pale mid-dorsal line. A series of black subdorsal spots tend to be present on all abdominal segments, becoming wedge-shaped on segments seven and eight. The two spots on each segment form a more or less definite W-shaped figure (Crumb, 1929). A distinct white or yellow subdorsal line broadened posteriorly is found on each segment. Spiracles are pale yellowish or white. The head is pale, brownish with black submedian arcs and reticulation (Figure 3C).

Pupa. Pupae are about 16mm long and 5mm wide, maxillary palpi visible, labrum not emarginate, movably linked abdominal segments. Cremaster with hooked accessory spinules with the spines set close together.

Adult. The deep brown collar is unicolorous with the thorax, outline of orbicular spot and inner margin of reniform spot is black, which color may also connect the two spots and extend somewhat past the orbicular towards the base of the wing. Hind wings are whitish (Figure 3D). Wingspread is 40-45mm.

Life History

The W-marked cutworm is a univoltine species having a period of retarded development following the emergence of the moths. This period is chiefly occupied by the egg stage, and possibly to some extent by an unusually long preoviposition period. The winter is passed as partially mature larvae. The moth when at rest folds its wings so closely and flatly over its back that it is enabled to get into very narrow crevices (Slingerland, 1895).

Figure 3. Climbing Cutworm Species Attacking Grapes. Spotted cutworm larva (A), spotted cutworm adult (B), W-marked cutworm larva (C), W-marked cutworm adult (D), dark-sided cutworm larva (E), dark-sided cutworm adult (F).

A

B

C

D

E

F

Dark-sided Cutworm, *Euxoa messoria* Harris

(Lepidoptera: Noctuidae)

The dark-sided cutworm was originally described by Harris in 1841. Dyar (1902) placed this species in the *Paragrotis* genus and lists the following synonyms: *spissa* Guenee, *cochrani* Riley, *repentis* Grote and Robinson, *displiciens* Walker, *reticens* Walker, *ordinata* Walker, *inextricata* Walker, *indirecta* Walker, *septentrionalis* Walker, and *inducta* Walker.

Distribution

The dark-sided cutworm has a North American distribution. It occurs throughout the width of the United States and as far south as Tennessee, California, Arizona and New Mexico (Cheng, 1973). This species is prevalent throughout Ontario and Quebec.

Food Plants

Walkden (1950) reports that the climbing habit has been well developed in this species so it has a wide range of host plants. This species has been reported causing damage to trees and shrubs, corn, onions, vineyards and sweet potatoes (Crumb, 1929; Walkden, 1950). A list of host plants is found in Appendix A3.

Description of Stages

Egg. The egg is circular in outline, .62mm wide and .43mm high with about forty-five slightly elevated ribs. The eggs are white after deposition and change to light brown and finally dark brown when the larva is fully developed.

Larva. The general color is pale brown dorsally with the subventral and ventral area whitish. A pale, narrow mesal stripe is bordered by an irregular, black stripe on each side. A broad, pale subdorsal stripe which includes two darkly pigmented tuberacles on each thoracic and abdominal segments is present. There is a dark brown supraspiracular stripe for which the species is named (Figure 3E). The head is pale brown with clusters of dark brown, round spots near the cervical shield and above and behind the ocelli. The skin is smooth and spiracles are dark brown (Rings, 1977b). First instars have a head capsule .28mm wide with a body 2.3mm long and .43mm wide, while sixth instars have a head capsule 3.2mm wide and a body about 30-37mm long and 5mm wide. Crumb (1929) reports only six instars for this species while Cheng (1973) reports seven.

Pupa. Pupae are about 17mm long and 6mm wide, maxillary palpi visible and there is callus present on the prothorax before the mesothoracic spiracles. The creamaster has two pairs of straight accessory spinules, the spines are short, weak, convergent at the tips and set on the tip of the abdomen without a basal process (Crumb, 1929).

Adult. The wing patterns of this species are extremely variable. The fore wing is usually light, powdery, grayish-brown. The orbicular and reniform are filled with ground color and finely outlined in black. Antimedial and postmedial lines are double and wavy. Hind wings are grayish-white and darker on the outer margin and on the veins (Figure 3F). Wingspread is 30-35mm (Rings, 1977a).

Life History

The dark-sided cutworm is univoltine. Moths emerge in late July. Moths may be found during the day resting under plants, leaves, boards or other objects which keep them protected from the sun. This species overwinters in the egg stage which is laid in the fall at a depth of 1-2cm in the soil. Eggs complete their embryonic development before winter and hatch the next spring (Cheng, 1972). The distribution of the larvae in the field was found to be seldom uniform, mostly because moths lay their eggs in groups in the soil (Cheng, 1971; Jacobson and Peterson, 1965).

Cheng (1973) showed that early instars fed near the leaf tips of food plants while later instars frequently cut the plants off at ground level or ate the growing points or leaves. The depth at which larvae rested during the day was regulated by soil moisture.

Spotted-sided Cutworm, *Agrotis badinodis* Grote
(Lepidoptera: Noctuidae)

The spotted-sided cutworm was originally described by Grote in 1874. The literature is filled with various genus names beginning with *Agrotis* (Grote, 1874), *Anicla* (Walkden, 1950), *Graphiphora* (Crumb, 1956) and *Agrotis* where it presently stands.

Distribution

Crumb (1929) reports the range of this species includes the Atlantic coast from New York to North Carolina and extends westward to Iowa, Kansas and Texas. Specimens have also been collected from southern and eastern Ontario and western Quebec.

Food Plants

The spotted-sided cutworm has been described to show a decided food preference for dock (Rumex) and chickweed (Stellaria), (Crumb, 1929). Rings (1977) states that the species is generally of minor importance in the North Central states but occasionally attracts attention as a climbing cutworm in orchards. A list of host plants is found in Appendix A4.

Description of Stages

Egg. The egg is white, circular in outline, strongly, bluntly subconical in profile, .63mm broad and .54mm high. About twenty-five strongly elevated ribs are present with the micropyle set in a depression (Crumb, 1929). The second day after deposition a very distinct belt of pink appears on the micropyle.

Larva. This species is pale gray in color with a subdorsal series of triangular black spots at least posteriorly and oblique black spots just above the spiracles (Figure 4A). The mandible is provided with a characteristic large bidentate internal tooth. The skin is smooth. First instars have a head capsule measurement of .36mm broad with a body about 3mm long and .41mm wide. Seventh instars have head capsules 2.5-2.7mm wide with larvae 25-32mm long and 5mm wide (Crumb, 1929).

Pupa. The pupae are about 16mm long and 5.5mm wide. There is a row of large circular pits on the anterior margin of movably linked abdominal segments. The cremaster is without spinules, spines short, outcurved, set on a long subconical process (Crumb, 1929).

Adult. The head and thorax are pale brown with the upper half of collar shading into black. The fore wing is light brown with a violaceous tinge. Antimedial and postmedial lines are prominent, pale brown and edged with black. The space between the orbicular and reniform is filled with dark brown scales (Grote, 1874). Wingspread is 28-35mm (Figure 4B).

Life History

There is but one generation annually of this species. The adults are short-lived; only about two weeks of the life cycle are occupied by this stage. Moths emerge September to October. Eggs are deposited soon after the females emerge and hatch in about two weeks. The larvae feed to some extent in the fall and pass the winter as third or fourth instars (Walkden, 1937). The summer is passed in the pupal stage within an earthen cell.

Brown Cutworm, *Rhynchagrotis cupida* (Grote) (Lepidoptera: Noctuidae)

This species was originally described as *Rhynchagrotis anchocelioides* by Guenee with Dyar (1902) listing *cupida* as a synonym to this species.

Distribution

The brown cutworm is generally distributed in the eastern part of the United States, north of the southern boundaries of North Carolina, Tennessee, Missouri and Kansas (Crumb, 1929). This species also occurs across southern and eastern Ontario northward to Sudbury and in Quebec from Kazabazua to Forestville (Rockburne and Lafontaine, 1976).

Food Plants

Crumb (1932) reported this species as feeding on the buds and newer growth of apple, grape and peach. A complete list of food hosts is listed in Appendix A5.

Description of Stages

Egg. The eggs are pale lemon-yellow, .50mm high and .60mm wide. There are 28-33 distinct ridges radiating from the micropylar area. Eggs become pink in color a few days after deposition. The underside of the egg is smooth and not adhaesive (Rings, 1972).

Larva. The general color is brown varying sometimes to gray. The middorsal pale line is broad, broken and diffuse. A segmental series of elongate black spots anterior to setigerous tubercle D_2 are somewhat diffuse on their dorsal margins, more distinct and wedge-shaped on abdominal segments seven and eight (Crumb, 1929). The head is pale brown reticulated with black and black submedial arcs. The cervical shield is pale brown reticulated with black. Sixth instars have a length of 31-40mm and 5.4mm wide (Figure 4C).

Pupa. Pupal length is 16-21mm with a width of 7mm. They are shining light brown, impunctate. A quadruple row of rounded pits on dorsum of fifth abdominal segment is present (Rings, 1972). The cremaster is distinct, blunt, rounded and heavily pigmented; laterally bearing three pairs of setae.

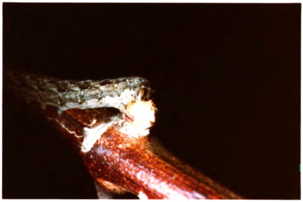
Adult. Ground color of fore wing is grayish or brownish. Anti-medial and postmedial lines are faint, dark and double, prominent at the costa. Subterminal lines are luteous, sometimes punctiform or obsolete, almost always preceded by a dark, triangular marking

Figure 4. Climbing Cutworm Species Attacking Grapes. Spotted-sided cutworm larva (A), spotted-sided cutworm adult (B), brown cutworm larva (C), brown cutworm adult (D), *Amathes smithii* larva (E), *Amathes smithii* adult (F).

A

B

C



D

E

F

extending to the costa. Orbicular is small and rounded, covered with scales, slightly darker than ground color (Rings, 1977). Hind wings are fuscous; fringes are tricolored (Figure 4D). Wingspread is 32-40mm.

Life History

Rings (1972) reported collecting wild, gravid females from June to October, but they did not oviposit until the end of September. Crumb (1929) explained this retardation as an evolutionary mechanism to keep single-brooded species on a univoltine schedule. Single-brooded species of cutworms tend to be of northern distribution in the United States.

Eggs were laid singly and hatched about four weeks after deposition. Larvae feeding probably continued through October and November when air and soil temperatures were above 7°C (Rings, 1972).

Larvae overwinter as third or fourth instars. In early spring, feeding is resumed after dark when temperatures are favorable. After the larvae enter the fifth and sixth instars, they develop a strong tendency to climb. At first, larvae eat the fruit and leaf buds and later the foliage. Prepupal chambers are formed about 1-5cm below the surface.

Marten (1880) offers the following description of this species and its feeding habits: "The larva of this species is of a greenish color, and may be found at night depredating upon grapevines. It crawls along the vines until it reaches a bud, when it stops and devours it; commencing its depredations as soon as the buds begin to start."

Amathes smithii Snellen

(Lepidoptera: Noctuidae)

This species was originally described by Snellen in 1896. It occurs generally in the United States north of the latitude of the Ohio River and in all adjacent provinces of Canada and in Alaska.

Description of Stages

Larva. General color is usually brown varying to gray, skin smooth. A segmental series of brown or blackish shield-shaped markings are present dorsally on abdominal segments, bordered laterally by a strong distinct subdorsal white line. Spiracles are pale yellowish to brown. The head is a bright brown with black submedial arcs (Figure 4E).

Adult. The fore wings vary from gray-brown to red-brown. Transverse lines are a little darker than the ground color. The traverse posterior line is evenly bent, with a row of small black dots outside. Hind wings are fuscous (Figure 4F). Wingspread is 36-40mm (Beuten, 1901).

Life History

The larvae hatches in the fall, hibernates half-grown, feeds up rapidly in the spring and then aestivates for a month or more in the soil before pupating. During this period it can stand very wet conditions but it is more sensitive to drying of the soil. Forbes (1954) describes this species as sometimes injurious in vineyards in the spring, when the weeds which are its autumn food are cultivated out.

REARING TECHNIQUES

Introduction

Development of a rearing technique for the mass production of various life stages of an insect is important. Large numbers of insects are necessary for laboratory screening tests, biology studies and for use in artificially infesting plots for economic injury studies. The technique should be one that would provide the greatest number of insects for the amount of input with a minimum amount of mortality through time.

Methods and Materials

Establishment of Colony

Larvae of the spotted cutworm were collected from the vineyards of Robert Rogers in Van Buren county in November 1978. One hundred and fifty larvae were collected as they remained protected and fed within the folds of fallen grape leaves. These larvae were taken back to the cereal leaf beetle greenhouse at Michigan State University for rearing.

Moths

Emerging moths were removed from the pupal containers and transferred to mating and egg-laying cages. These cages (40x25x45cm) were constructed of plexiglass sides and top with 4cm holes covered with 16-mesh screen for ventilation. The front, back and bottom were made of plywood. A door (18x21cm) provided access to the cage. Twenty moths were placed in each cage. Cages were maintained at 25±1°C and a 16-hour photophase. Food was provided daily by filling 9/16 ounce plastic cups with a 10% honey solution and inserting a cotton ball to serve as a wick. Folded paper towelling and pots of clipped barley provided cover for the moths and sites for oviposition (Figures 5A-B).

Eggs

Eggs were collected daily and placed in pint plastic containers with triangular sections of the plastic lid replaced with 16-mesh screen (Figure 5C). No attempt was made to remove eggs from the paper towelling except to cut large egg masses from it. Eggs laid on the barley were clipped off at the soil surface and placed in the pint plastic containers. Egg containers were maintained at 25±1°C, 50% RH with a 16-hour photophase. Eggs may be stored at 5°C and 70% RH for up to fourteen days until adequate numbers are available.

Larvae

Newly emerging larvae were fed clipped barley leaves which were placed in the egg containers. Larvae require little attention during the first week after emerging. Larvae were reared in the egg containers until they reach the fourth instar when they were transferred into two-ounce plastic containers with slits made in the lids to prevent a build-up of moisture (Figure 5D). These small plastic containers contained two larvae in each and were used to prevent cannibalism which takes place in the pint containers when the larvae reach fifth instar. Larvae were fed daily and the containers were changed every third day to prevent excessive build-up of feces and conditions favorable for the development of diseases. Larvae were allowed to pupate within the containers.

Figure 5. Equipment used for Rearing Amathes c-nigrum in the Laboratory. Mating and oviposition cages (A), barley and paper towelling oviposition sites (B), egg and young larvae containers (C), larvae containers for instars 4-6 (D), pupae container (E).

A

B

C

D

E

Pupae

Pupae were removed from the larvae containers daily and were placed in eight-ounce waxed paper ice cream cartons half filled with moist, sterilized soil. Five to ten pupae were placed in each container and covered with a plastic lid to prevent escape of the moth when it emerged (Figure 5F). These pupal containers were kept covered with cardboard sheets to eliminate light from the containers.

Larvae Food Sources

Barley

Barley was grown in eight-ounce ice cream cartons three-fourths filled with sterilized soil, barley seed and enough soil to cover the seed. These containers were placed in a greenhouse maintained at 21±2°C with an 18-hour photophase. The barley was watered and allowed to grow for seven to ten days before being used. The barley was clipped into 2-4cm sections and fed to the larvae.

Artificial Diet

The artificial diet used was obtained from Dr. Ring Cardé. The ingredients and preparation of the diet is described in Appendix B. After preparation, the diet was placed into the two-ounce larvae containers so that each container was approximately half full (40-50 gm). A plastic lid was placed on the cup with no slits to avoid exposure of the diet to contaminants in the air. After the larvae were placed on the diet, the lid was removed only to clean the containers of excess feces (Figure 5E).

Results and Discussion

Collection of a large number of larvae from the field provided a continuous supply of various life stages of the spotted cutworm through the winter and spring. Larvae collected from the field began to pupate fifteen days after being brought back to the rearing room and all of the larvae had pupated twenty-eight days after collection. The culture started in 1978 has been reared through five successive generations. Barley provided a constant food source for the larvae and a honey-water solution was supplied for the adults. Eggs and fourth and fifth instars have been kept for short periods of time in a 5°C refrigerator. Eggs have been stored for fourteen days and fourth and fifth instars for thirty days with low mortality rates. A complete generation took approximately seventy-five days at 25°C.

Females would oviposit on paper towelling, barley leaves, soil, walls of the cage and on any other object which did not have a smooth surface. Egg production would increase as the humidity within the cage increased. Fertilized eggs could be distinguished from those unfertilized three days after oviposition by the change in color from pale yellow to pink.

The first two instars could be found hanging from a silken thread from the top of the larvae containers. These young instars would feed on the upper surface of the leaves, never feeding through the lower epidermis. Later instars would consume the entire leaf.

The duration of various life stages is summarized in Table 1. All of the observations were taken in the rearing room maintained at 25±1°C, 50% RH and a 16-hour photophase. The somewhat shorter duration of the larva stage of those larvae reared on the artificial diet as compared to those larvae reared on barley may be due to the food occasionally being limited in the barley-reared containers while those on the diet always had a constant supply. The additional handling which the barley-reared larvae were subjected to may have disrupted them slightly.

Table 1. Time Required for Development of Life Stages of the Spotted Cutworm, *Amathes c-nigrum*

Life Stage	Time in Days			Number Observed
	Min.	Max	Mean	
Egg	5	11	6.5	901
Larva-barley	25	38	30.2	425
Larva-diet	25	34	27.8	309
Pupa	11	18	14.1	516

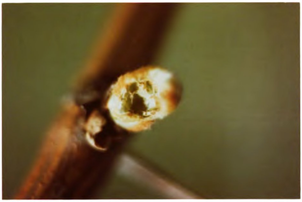
LARVAL FEEDING BEHAVIOR

Introduction

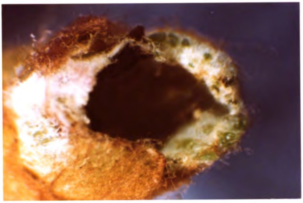
Damage to the developing grape buds in the spring by climbing cutworms can seriously affect the yield if the area is heavily damaged. Field observations show the cutworms exhibiting an observable preference of certain developmental stages, to others. Bud damage varies from the complete bud being eaten to those buds which the cutworm has fed on for only a short period of time (Figure 6). Damage done by the dark-sided cutworm includes feeding on developing clusters and damage to sucker growth both above and below ground level (Figure 6).

Figure 6. Cutworm Damage to Grapes. Bud damage (A-C), cluster damage (D), damage to sucker growth (E-F).

A



B



C

D

E

F

two-ounce plastic container filled with sand which was placed with its lip flush with the sand surface in the center of the bucket. This arena allowed the cutworms to emerge naturally during the night.

The experiments were run at the Michigan State University Horticultural Farm in a cooler room maintained at 8°C; the light was adjusted to 100 lux to simulate full moonlight. Continuous observations were made on each bucket and the movements of each larva were traced on a sheet of paper corresponding to that bucket.

Long Cane Experiments

Single node canes and canes with three nodes were forced in the mist bed. Groups of canes were joined together with a piece of wire inserted into the cortex of each of the canes. The canes were arranged in a manner to simulate natural development of the buds in the field and also rearrangements of bud placement to measure its effect on bud preference.

These canes were placed in a sand bed and a 10-ounce paper drink cup with its bottom removed was placed over the cane and pushed into the sand 3cm. This cup served as an arena for releasing the larvae. Each of the canes were checked at two-hour intervals, and room temperature was kept at 21°C.

Results and Discussion

Bucket Experiments

A total of forty-five different trials were made utilizing this design. Of these trials, twelve never received any bud damage at all. In replicates where bud damage occurred, no significant differences were observed between the developmental stage and bud damage (χ^2, P = .05). Table 2 summarizes the results of the bucket experiments. Various groupings of the developmental stages and bud damage never showed any significant differences.

Long Cane Experiments

Results from the long cane feeding tests for randomness of larvae feeding showed that they deviated significantly from random (χ^2, P = .05). Table 3 summarizes the results of the long cane experiments. Since the feeding behavior was not random, more damage can be expected in certain bud developmental stages. Various groupings of the damage data e.g. small buds, groups X, 1 and 2; and large buds, groups 3 and 4; removal of the X developmental stage still showed strong significant differences. Only when comparisons between stages 3 and 4 were made were there no significant differences in damage (χ^2, P = .05).

The long cane experiments gave a more accurate representation of a grape cane in the field than did the bucket experiment.

Table 2. Results of Bud Preference Feeding Tests for the Spotted Cutworm Using the Bucket Design

Trial	Dev. Stage	# Buds Damaged	# Buds Not Damaged	# of Trials	# of Buckets With No Damage	χ^2	Significance Level
A	1	0	9	15	6	4.98	.173
	2	3	6				
	3	3	6				
	4	4	5				
B	1	1	10	15	4	3.82	.282
	2	3	8				
	3	4	7				
	4	5	6				
C	1	1	12	15	2	7.137	.067
	2	6	7				
	3	4	9				
	4	7	6				

Table 3. Results of Bud Preference Feeding Tests for the Spotted Cutworm Using the Long Cane Design

Trial	Dev. Stage	# Buds Damaged	# Buds Not Damaged	# of Trials	# of Canes With No Damage	χ^2	Significance Level
A	X	0	21	18	3	19.87	.001<P
	1	2	30				
	2	6	14				
	3	3	5				
	4	14	20				
B	X	0	40	22	5	42.22	.001<P
	1	1	23				
	2	0	5				
	3	10	5				
	4	7	13				
C	X	0	4	25	12	66.14	.001<P
	1	1	55				
	2	1	6				
	3	9	1				
	4	15	4				

SURVEY AND SAMPLING TECHNIQUES

Grape Grower Questionnaire Survey

Introduction

Information and observations which growers have accumulated during their years of farming is often very keen and useful. Growers are willing to share their knowledge and to help researchers and extension personnel in any way that they can. The use of a survey form is a way to contact a large number of growers and to gain background information on the severity and distribution of the problem. Information on current practices used by growers and other factors which may add to or decrease the severity of the problem may also be gathered.

Methods and Materials

A questionnaire form was prepared and sent to grape growers which were on the county extension mailing lists of Berrien and Van Buren counties. Growers were sent a questionnaire packet which included the following items (Appendix C):

1. an introductory letter stating the purpose of the questionnaire and the objectives of the ensuing research;
2. general farm information form;
3. two blank field questionnaire forms;
4. a completed field form example; and
5. a self-addressed stamped return envelope.

This packet was then mailed to 917 grape growers on the county mailing lists. An appeal was made to growers attending the Michigan

Grape Day meetings in March of 1978, to return the questionnaire forms if they had not already done so.

Results and Discussion

Of the 917 questionnaire forms mailed out in February, 132 were returned by those growers receiving them. The returned questionnaires accounted for 14.4 percent of the total mailed out. Of those returned, thirteen were not used for various reasons, e.g. no longer grow grapes, backyard gardener, etc. With these responses omitted, the returned questionnaires accounted for a total of 2,298.5 acres or 19 percent of Michigan's 12,155 acres of grapes. Results of the questionnaire pertaining to chemical control will be discussed in a later chapter on chemical control.

Distribution of Grape Acreage and Cutworm Damage

Counties represented from the questionnaires returned included Berrien and Van Buren reporting 96.3 percent of the acreage and Allegan, Cass and Kalamazoo counties reporting the remainder of the acreage.

From the returned questionnaires, the top five grape-growing townships are Antwerp, Bainbridge, Keeler, Porter and Royalton reporting 96.10 percent, 90.68 percent, 100 percent, 85.21 percent and 76.27 percent of their acreage damaged by cutworms respectively (Table 4). These five townships contain 64 percent of the grape acreage reported from the questionnaires.

The soil type in Antwerp township reporting cutworm damage is predominately Chelsea sand. The largest percentage of this soil is used for fruits, mostly grapes. The main limitations of this soil for farming are susceptibility to erosion, low soil moisture and low fertility. It is moderately suited to fruit from a soils standpoint but it is well suited because of topographic position (Austin and Lietzke, 1972).

Table 4. Grape Acreage and Number of Fields by Township and Cutworm Damage as Reported from Questionnaires

Township	Cutworm Damage					
	None Reported		Reported		Totals	
	No. of Acres	No. of Fields	No. of Acres	No. of Fields	No. of Acres	No. of Fields
Almena	0	0	10	1	10	1
Antwerp	16.6	3	409	19	425.63	22
Arlington	9	1	3	1	12	2
Bainbridge	11.4	3	111	18	122.4	21
Baroda	29.75	6	38.5	4	68.25	10
Benton	15	1	0	0	15	1
Berrien	44.08	6	0	0	44.08	6
Chikaming	0	0	24	1	24	1
Coloma	0	0	12	2	12	2
Covert	7.7	2	0	0	7.7	2
Decatur	0	0	99.5	6	99.5	6
Ganges	18	1	0	0	18	1
Geneva	0	0	3	1	3	1
Hager	2	1	6	2	8	3
Hartford	0	0	15	1	15	1
Keeler	0	0	241	4	241	4
Lake	65.3	3	6	1	71.3	4
Lincoln	10	1	18	4	28	5
Oronoko	90	7	16.5	4	106.5	11
Oshtemo	.1	1	0	0	.1	1
Paw Paw	52	3	124	6	176	9
Pipestone	2	1	26.25	3	28.25	4
Porter	76	2	438	10	514	12
Royalton	40.76	4	131	7	171.76	11
Silver Creek	0	0	12	1	12	1
Texas	0	0	10	1	10	1
Wayne	47	1	0	0	47	1
Weesaw	8	2	0	0	8	2
	1,753.75	97	544.69	49	2,298.44	146

Vineyard Age

The age distribution of vineyards indicates that fewer new vineyards are being established. Of the fields reported, 67.12 percent were greater than twenty years old with only 4.11 percent of the vineyards being less than five years old (Table 5). Vineyards have the capability of continually being renewed by providing a layer from a plant which in turn will root and establish a vine in approximately three years, with the old, less productive vine being removed. New trunks may also be established by allowing a sucker to grow for several years and later removing the old trunk (Rogers, personal communication). Therefore, once established, a vineyard can be renewed as vines become less productive or after being damaged so the vines will be of various ages within the vineyard.

Weed Problems

The presence of uncontrolled weeds in the vineyards was reported in forty-one (36.28 percent) of the fields reporting no cutworm damage as opposed to twenty (17.70 percent) of the fields reporting heavy cutworm damage (Table 6). A significant difference was observed between cutworm damage and the presence of uncontrolled weeds in the vineyard ($\chi^2_{36} = 58.19$, $.01<P<.025$). This significant relationship may indicate that the weeds within the vineyard may serve as alternate food hosts for the cutworms and limit damage to the grapes.

Adjacent Crops

Vineyards were most commonly bordered by tree fruit plantings, open fields, wooded areas and county roads, 16.54 percent, 16.36 percent, 13.49 percent and 11.79 percent respectively (Table 7).

Table 5. Grape Vineyard Age Distribution in Relation to Cutworm Damage Rating as Reported from Questionnaires

Vineyard Age	Cutworm Damage				Total No. of Fields	% of Total Fields	Cumulative %
	None	Light	Moderate	Heavy			
1 - 5	2	4	0	0	6	4.11	4.11
6 - 10	5	4	2	3	14	9.59	13.70
11 - 15	3	8	1	1	13	8.90	22.60
16 - 20	3	4	1	1	9	6.16	28.76
More than 20	22	37	21	18	98	67.12	95.88
Not reported	2	2	1	1	6	4.12	100.00

Table 6. Cutworm Damage and Uncontrolled Weed Problems as Reported from Questionnaires

Weed	Cutworm Damage				Total
	None	Light	Moderate	Heavy	
Dock	2	0	3	0	5
Grasses	8	7	6	7	28
Asparagus	6	2	3	0	11
Sumac	2	2	2	0	6
Milkweed	8	3	1	5	17
Morning glory	1	3	0	0	4
Woody plants	2	3	0	2	7
Wild onion	2	6	0	4	12
Horse nettle	0	0	2	0	2
Lambs quarter	0	0	1	1	2
Rag weed	0	2	0	0	2
Poison ivy	7	4	0	0	11
None	3	2	1	1	7
	41	34	19	20	114

Table 7. Cutworm Damage and Adjacent Crops to the Vineyard as Reported from Questionnaires

Surrounding Habitat	Cutworm Damage				Total	% of Total
	None	Light	Moderate	Heavy		
Corn	20	14	2	2	38	6.62
Open	21	41	18	14	94	16.38
Woods	14	21	17	26	78	13.59
Grapes	9	22	9	16	56	9.76
Tree fruits	24	39	19	13	95	16.55
Grain	4	10	5	1	20	3.84
Road	15	26	15	9	65	11.34
Pasture	1	4	1	2	8	1.39
Alfalfa	4	6	4	1	15	2.61
Asparagus	8	16	7	10	41	7.14
Buildings	8	17	5	2	32	5.57
Tomatoes	0	0	2	0	2	.35
Not reported	14	15	0	0	29	5.05

A significant relationship was observed between the crop land adjacent to the vineyard and the cutworm damage to the vineyard (χ^2_{36} = 83.53, P<.00001). These areas may contain necessary food plants for adult survival and for those species with a long adult stage, may provide shelter and protection for the moth during the extended preoviposition period. For multiple-brooded species, these areas may serve as a location for the summer generations to build their populations to a sufficient number for overwintering purposes.

Adult Sampling

Introduction

Insect light traps have proven useful in entomological surveys for determining the presence, abundance and time of occurrence of many species of insects. This information can be used in determining an estimate of time for egg hatch and occurrence of other life stages. Additional work is needed for population estimation from the relative trap catches.

Methods and Materials

Weekly Sampling

Adult cutworm flight activity was monitored with the use of Ellisco^R general purpose, 15-watt blacklight insect traps. Blacklight traps in 1977 were located at Fenn Valley Vineyards near Fennville in Allegan county and at the farms of Gordon Brown and Robert Van Vleck near Lawton in Van Buren county. The Brown blacklight trap was established on June 13, 1977, with the Van Vleck and Fenn Valley blacklight traps being established on July 8, 1977. Cyanogas^R (American Cyanamid

Corporation) was used as a killing agent. This material was placed in small paper bags in the bottom of the blacklight and was changed once every week.

In 1978, blacklight traps were operated in Berrien and Van Buren counties. The Cecil Bethe farm near Spinks Corners is where the Berrien county trap was located, and the traps in Van Buren county were all located near Lawton on the farms of Gordon Brown, Robert Rogers and William Streeter. The blacklight traps were established on May 20, 1978, for the Brown and Rogers traps with the Bethe and Streeter traps being established on June 14, 1978. Chloroform was used as a killing agent in 1978. The chloroform was placed in an 8-ounce glass bottle with a 7mm hole drilled in its plastic lid. Through the hole was inserted a 15cm piece of cotton plug which extended to the bottom of the bottle. This design allowed for the slow release of the chloroform into the blacklight collecting basket. The bottle was filled with chloroform as needed depending upon the previous weather conditions.

Pieces of crumpled paper towelling were added to the blacklight collecting basket to provide a place for the moths to die and also to help prevent damage to the moths by beetles entering the traps. The samples were collected from the blacklight traps on two-day intervals. The moth samples were dated, labeled and returned to the laboratory for sorting and identification of the specimens at a later date.

<u>Hourly Sampling</u>

Information on the hourly moth flight activity was obtained by removing the contents of the blacklight trap on hourly intervals from 10:00 P.M. to 6:00 A.M. This was done on three separate occasions during 1978, August 18, 25 and 31, for each of the three traps located in Van Buren county. The samples were collected and placed in labeled paper bags until the following day when they were sorted, sexed and counted.

Results and Discussion

Weekly Sampling

The blacklight trap catch for the spotted cutworm from Allegan and Van Buren counties for 1977 is shown in Figure 7. Spotted cutworm and dark-sided cutworm blacklight trap catches from Berrien and Van Buren counties for 1978 are shown in Figures 8 and 9. Initial moth catches for the spotted cutworm were taken on May 29 and 30, 1978, at the Rogers and Brown blacklight traps respectively. Second generation moths were taken on July 29, 1977, at the Van Vleck light trap and on August 5, 1978, at the Rogers trap. Figure 8 shows a ten-fold increase in blacklight trap catches between the first and second generations of spotted cutworm. This large increase in the summer generation could possibly provide a large number of larvae for overwintering purposes due to the high mortality of the overwintering larvae.

Dark-sided cutworm moths were initially taken on July 14 and 21, 1978, at the Rogers and Brown traps and on August 6 and 16, 1978, at the Bethe and Streeter traps respectively.

By changing the time axis from chronological time to degree-day-accumulations (°D), moth catch can then be plotted against physiological time (Figures 10 and 11). A base temperature of 10°C was used for calculating °D since the actual threshold temperature for flight was unknown. Degree-day accumulations were calculated from Michigan

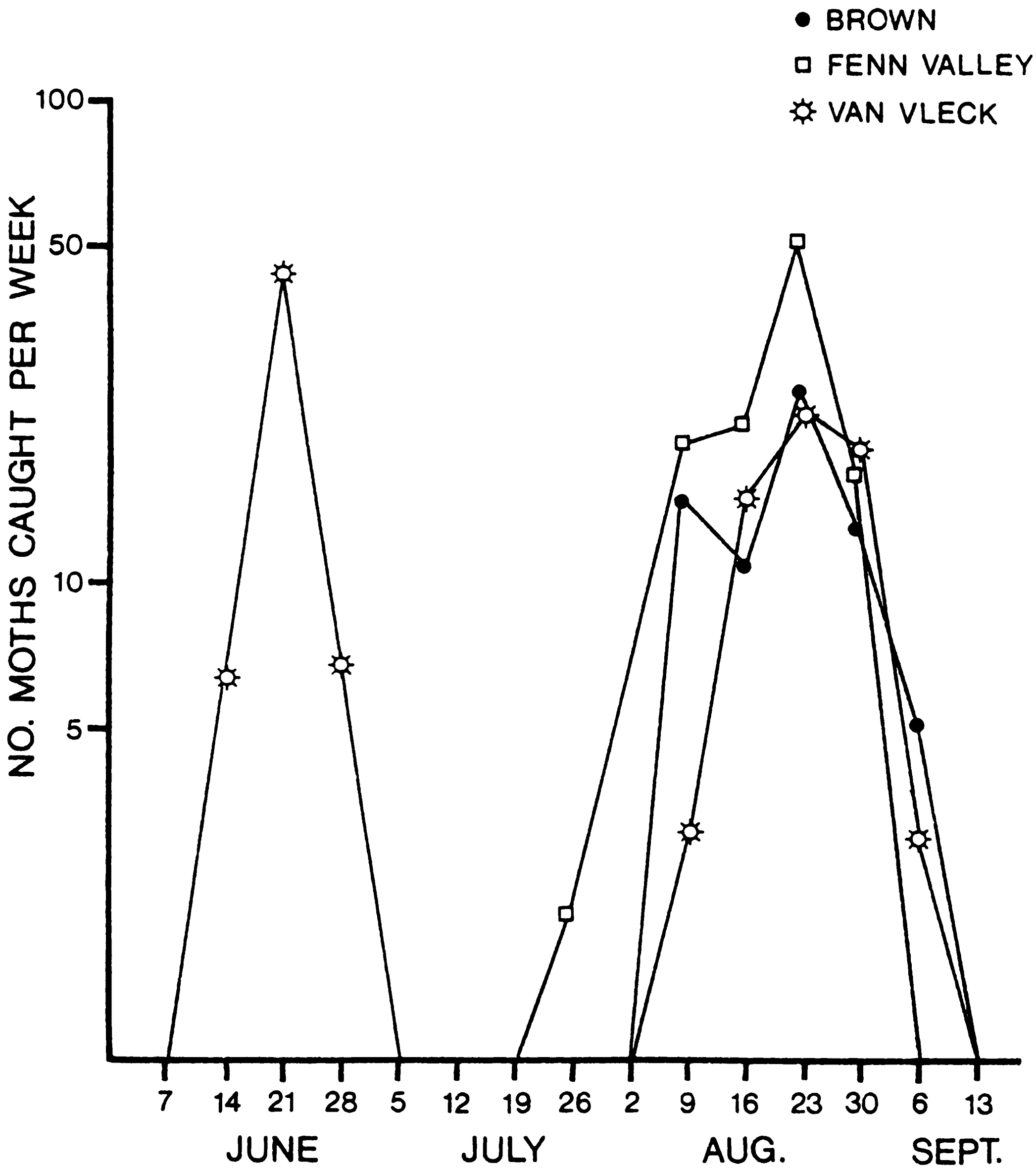


Figure 7. Blacklight Trap Catches of Spotted Cutworms from the Brown, Fenn Valley and Van Vleck Blacklight Traps (1977)

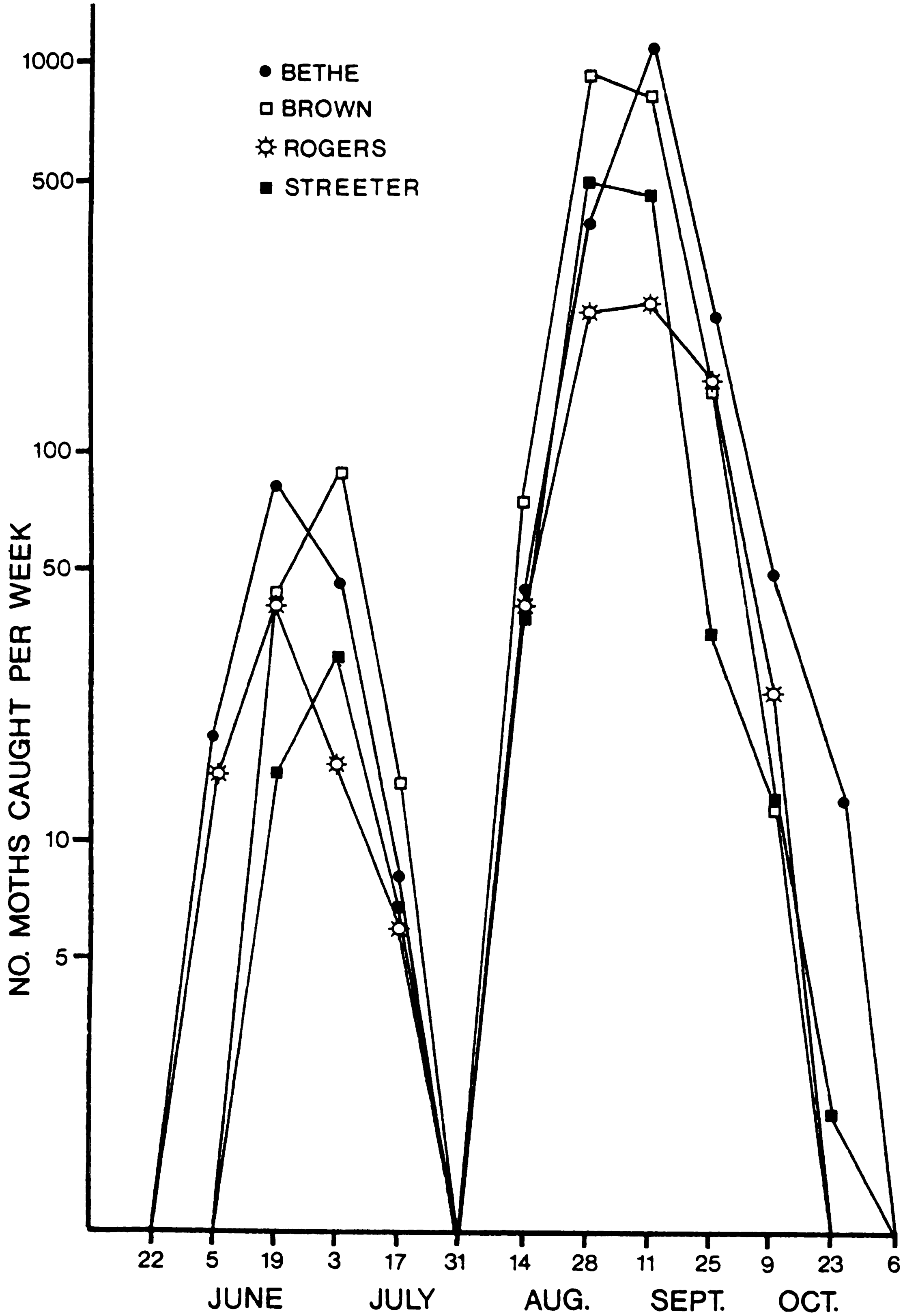


Figure 8. Blacklight Trap Catches of Spotted Cutworms from the Bethe, Brown, Rogers and Streeter Blacklight Traps (1978)

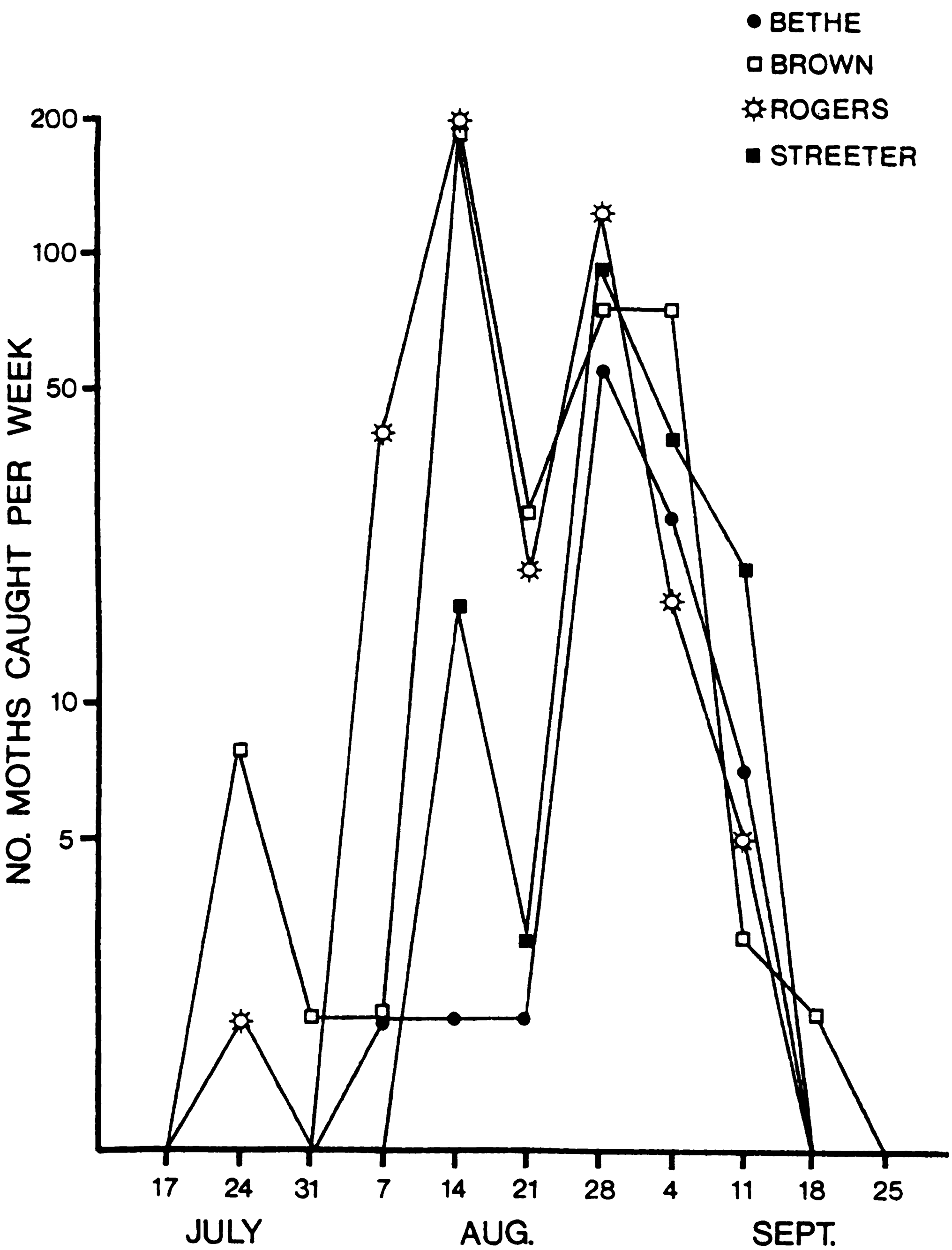


Figure 9. Blacklight Trap Catches of Dark-sided Cutworms from the Bethe, Brown, Rogers and Streeter Blacklight Traps (1978)

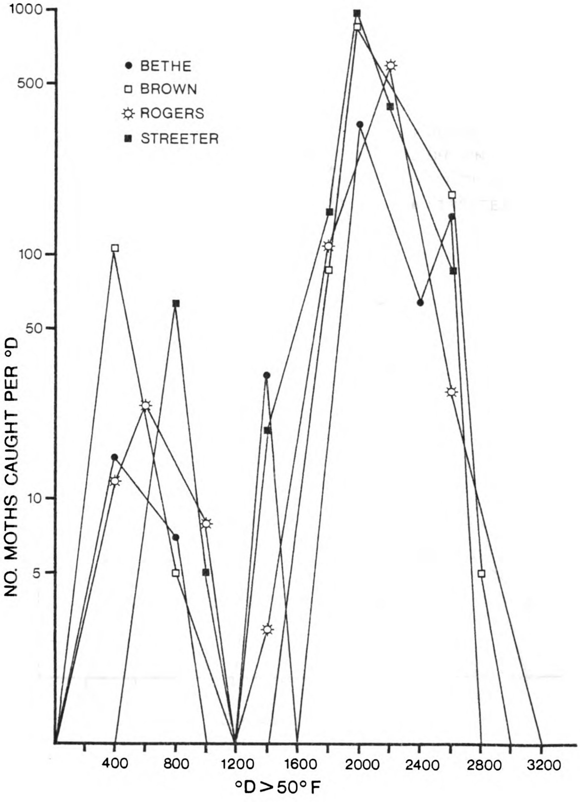


Figure 10. Blacklight Trap Catches of Spotted Cutworms Per Degree-day from the Bethe, Brown, Rogers and Streeter Traps in 1978

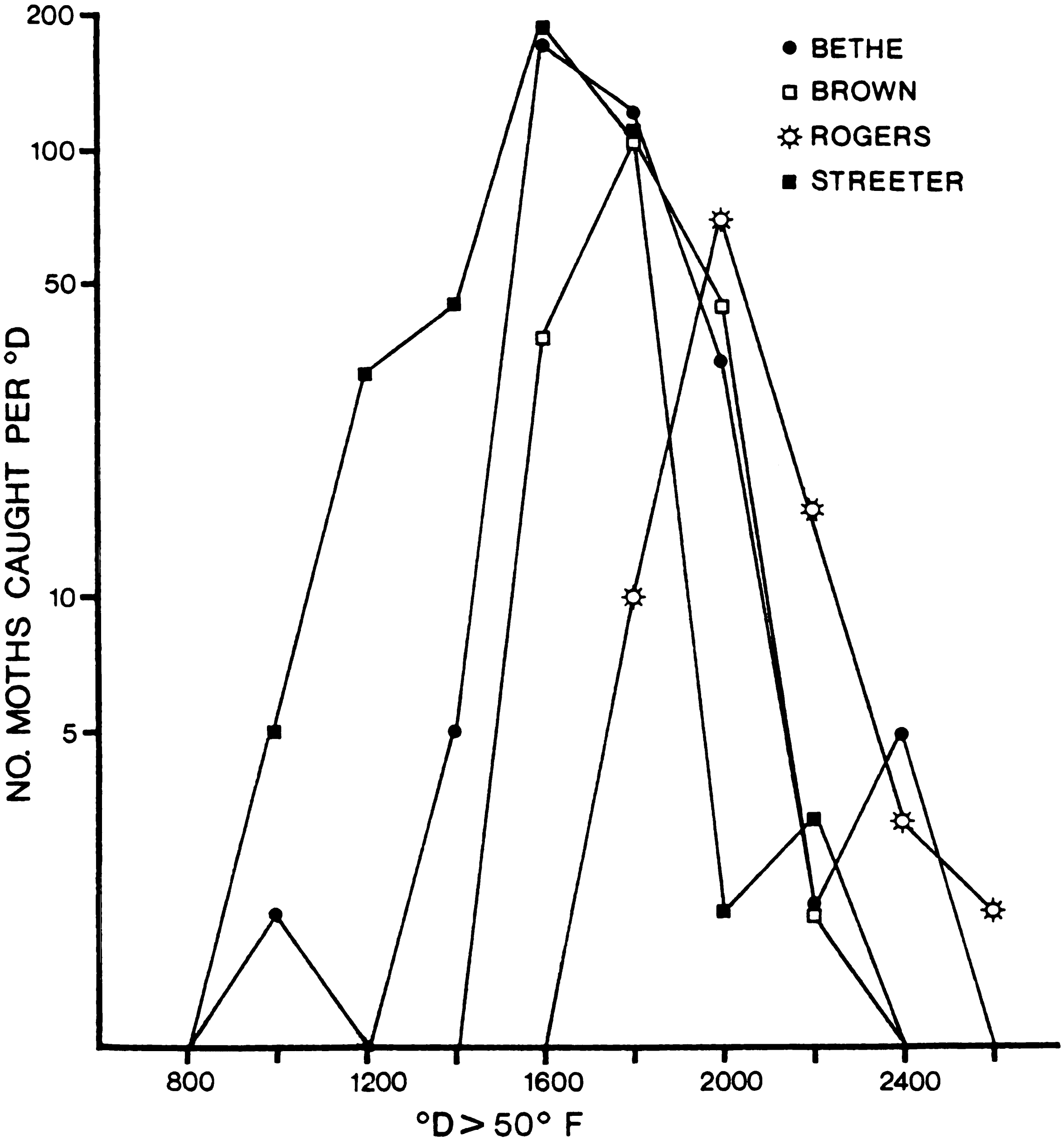


Figure 11. Blacklight Trap Catch of Dark-sided Cutworms Per Degree-day from the Bethe, Brown, Rogers and Streeter Traps in 1978

weather stations which were in Fennville, Paw Paw and Sodus, Michigan. This change in the axis removes much of the variations in the flight curves between trapping locations.

Light traps are probably the most widely used insect traps, and there are many references to them (Cook, 1928; Frost, 1953). The variation in the efficiency of the trap from insect to insect, from night to night and from site to site is extremely great because light traps are entirely artificial and rely upon the disturbance of normal flight behavior to function. Light traps take fewer insects on nights of full moon due to the fall in the efficiency of the trap (William, Singh and El Ziady, 1956). Cook (1928) discussed the relative trap catch of moths at light traps and those visiting flowers. He reported that the dark-sided cutworm is not readily attracted to light traps with less than 1 percent of the total moth catch being taken at the light trap.

These variations in trapping efficiency may explain the low blacklight trap catches for *Amathes smithii*, the spotted-sided cutworm and the brown cutworm.

Hourly Sampling

An estimate of the hourly flight activity of cutworm moths as attracted by a blacklight trap is shown in Figures 12 through 19. Male activity of the spotted cutworm indicates a flight which reaches its first peak between 12:00 P.M. and 1:00 A.M., slowly decreasing in activity and reaching a second peak between 5:00 A.M. and 6:00 A.M. Female flight activity increased rapidly with its peak activity occurring between 10:00 P.M. and 11:00 P.M. and declining rapidly by 12:00 P.M. and remained low the rest of the night. Females became

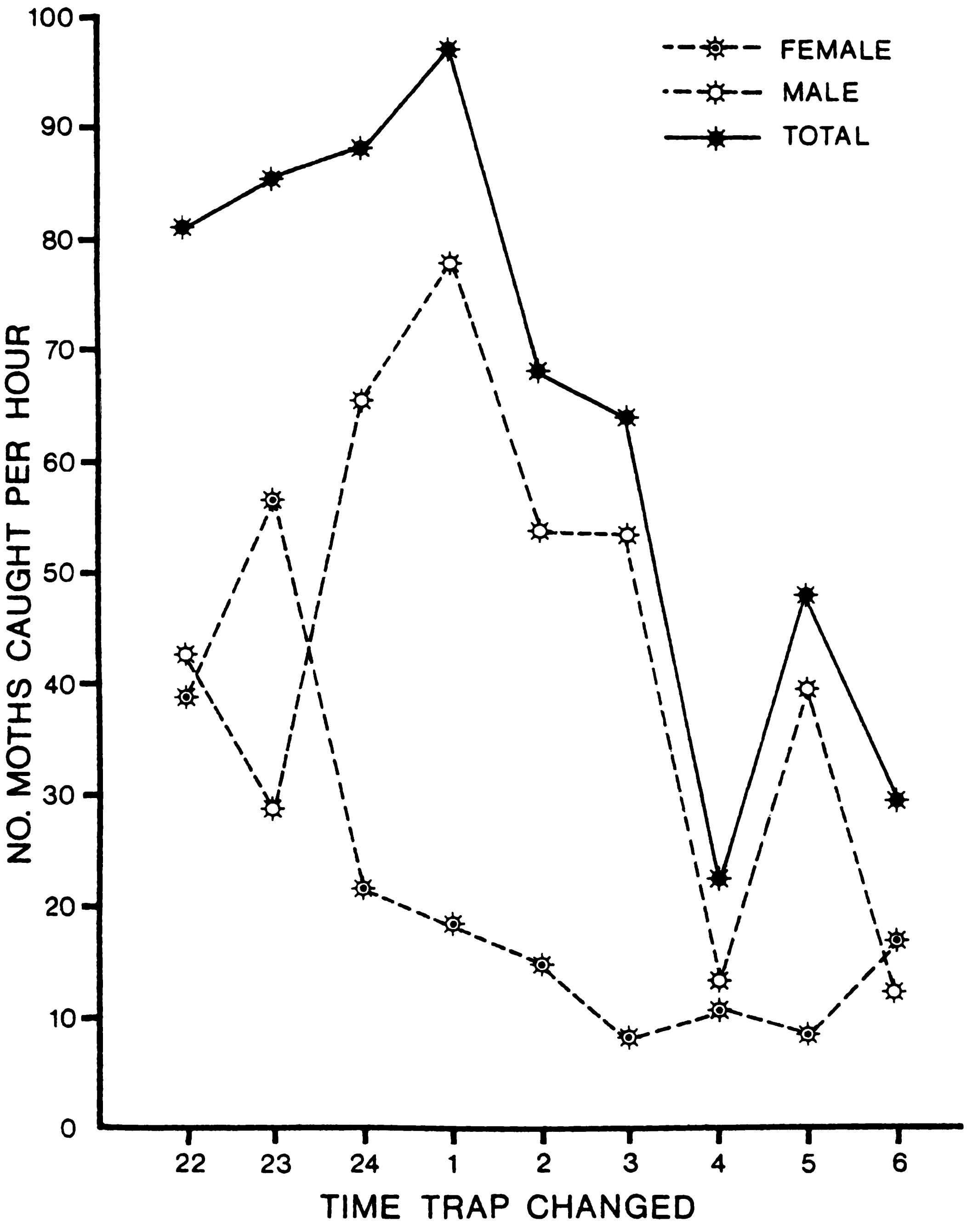


Figure 12. Total Hourly Spotted Cutworm Moth Catch from the Brown, Rogers and Streeter Blacklight Traps for August 18, 25 and 31, 1978

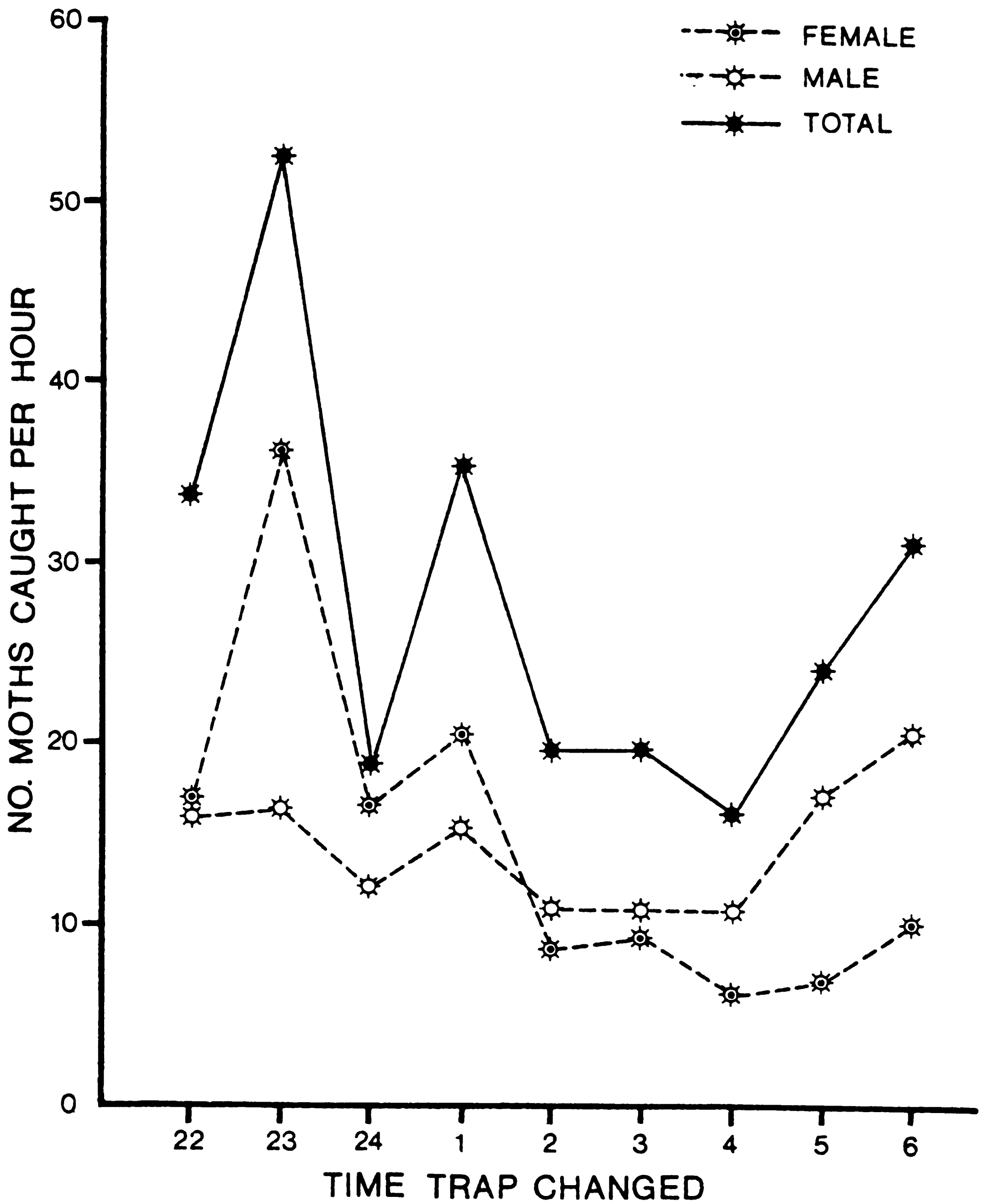
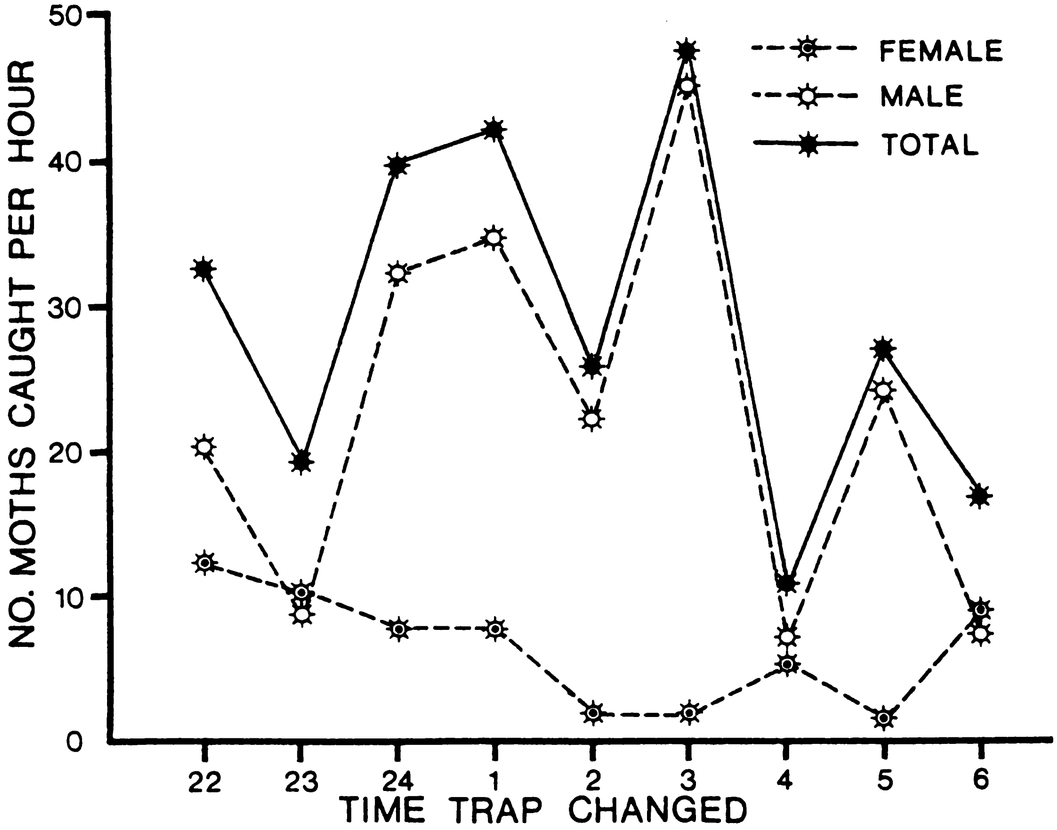


Figure 13. Total Hourly Dark-sided Cutworm Moth Catch from the Brown, Rogers and Streeter Blacklight Traps for August 18, 25 and 31, 1978

Figure 14. Hourly Spotted Cutworm Moth Catch from the Brown Blacklight Trap for August 18, 25 and 31, 1978

Figure 15. Hourly Dark-sided Cutworm Moth Catch from the Brown Blacklight Trap for August 18, 25 and 31, 1978


FEMALE
MALE
TOTAL
NO. MOTHS CAUGHT PER HOUR
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10
20
30
40
50
22
23
24
1
2
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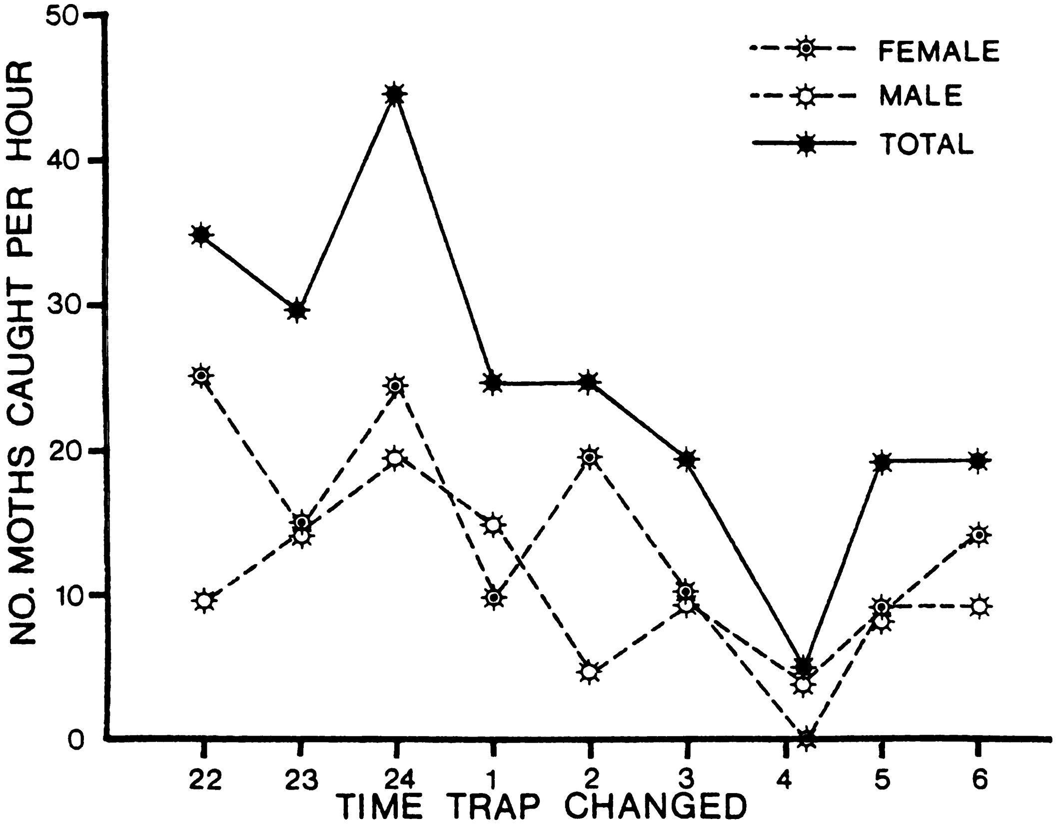
5
6
TIME TRAP CHANGED


FEMALE
MALE
TOTAL
NO. MOTHS CAUGHT PER HOUR
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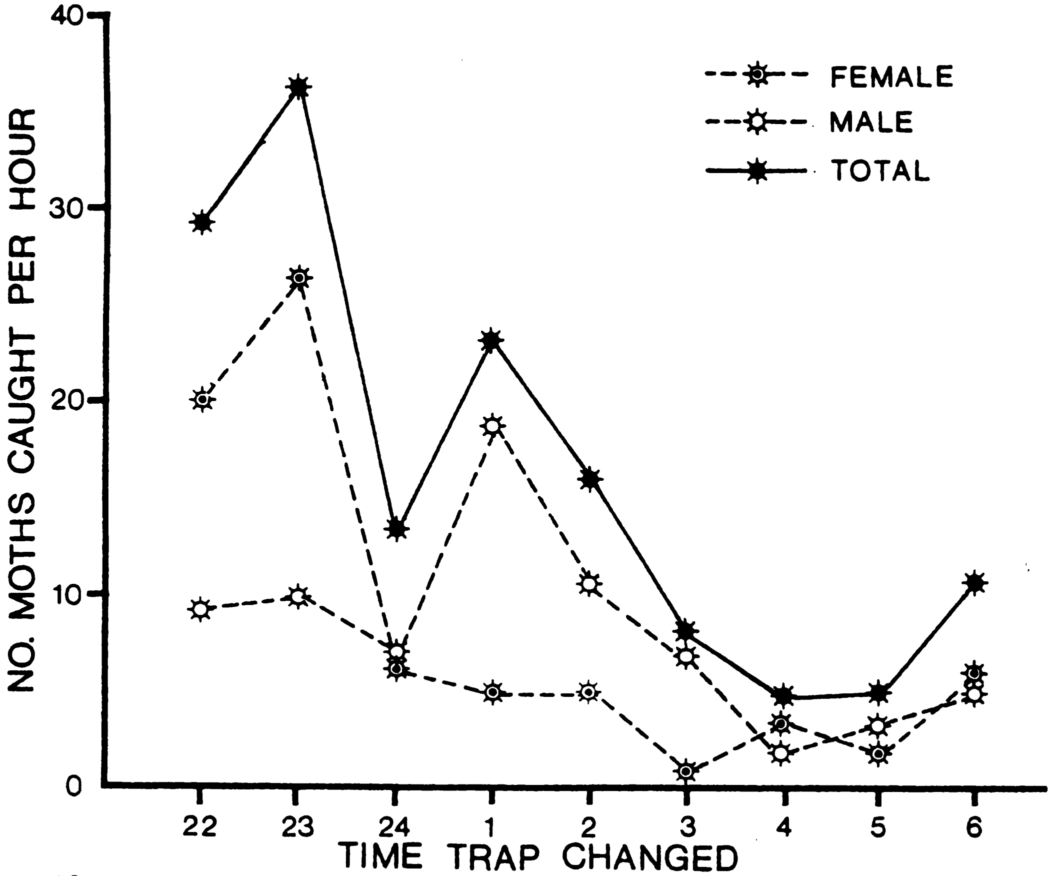
4
5
6
TIME TRAP CHANGED

Figure 16. Hourly Spotted Cutworm Moth Catch from the Rogers Blacklight Trap for August 18, 25 and 31, 1978

Figure 17. Hourly Dark-sided Cutworm Moth Catch from the Rogers Blacklight Trap for August 18, 25 and 31, 1978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NO. MOTHS CAUGHT PER HOUR
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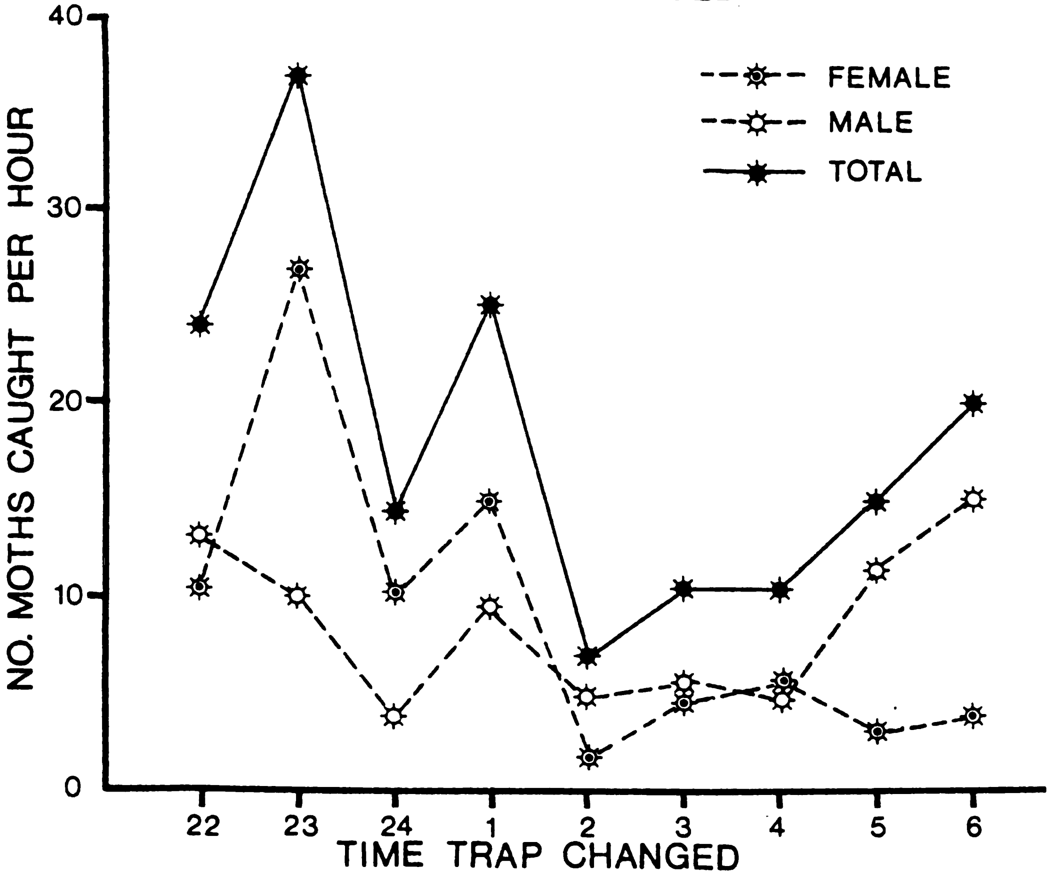
6
TIME TRAP CHANGED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NO. MOTHS CAUGHT PER HOUR
FEMALE
MALE
TOTAL
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2
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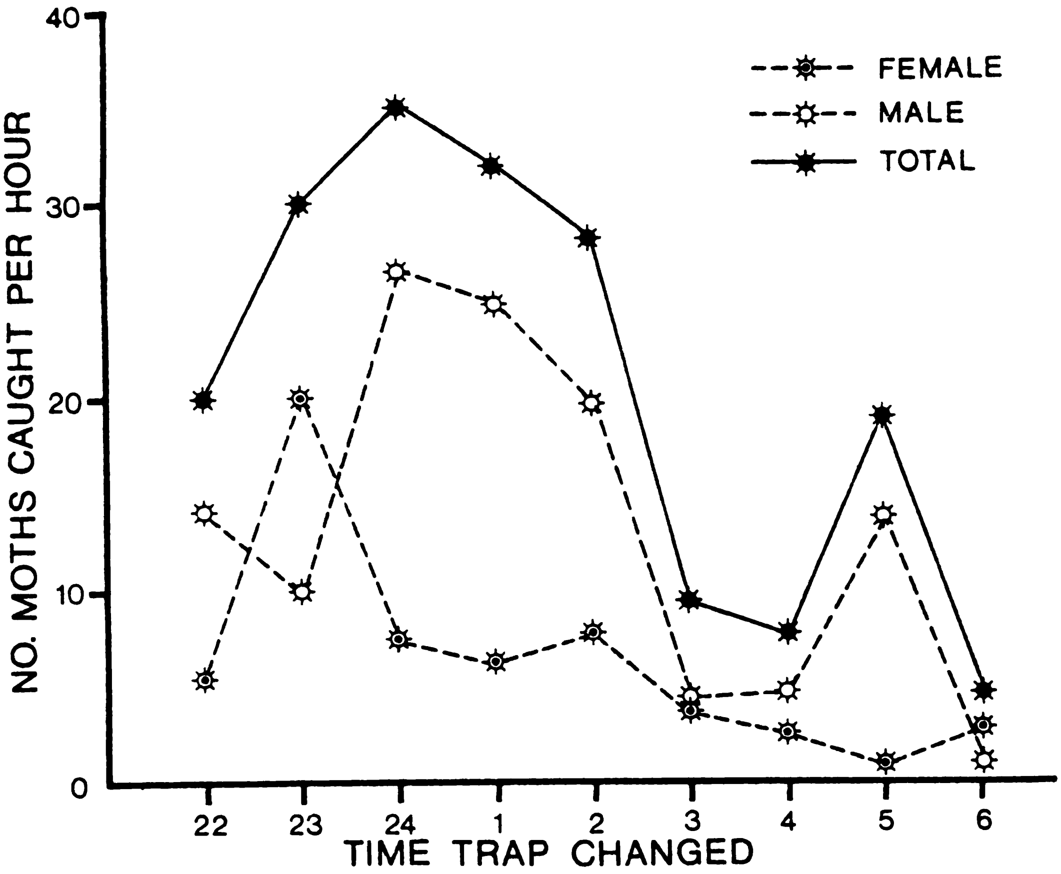
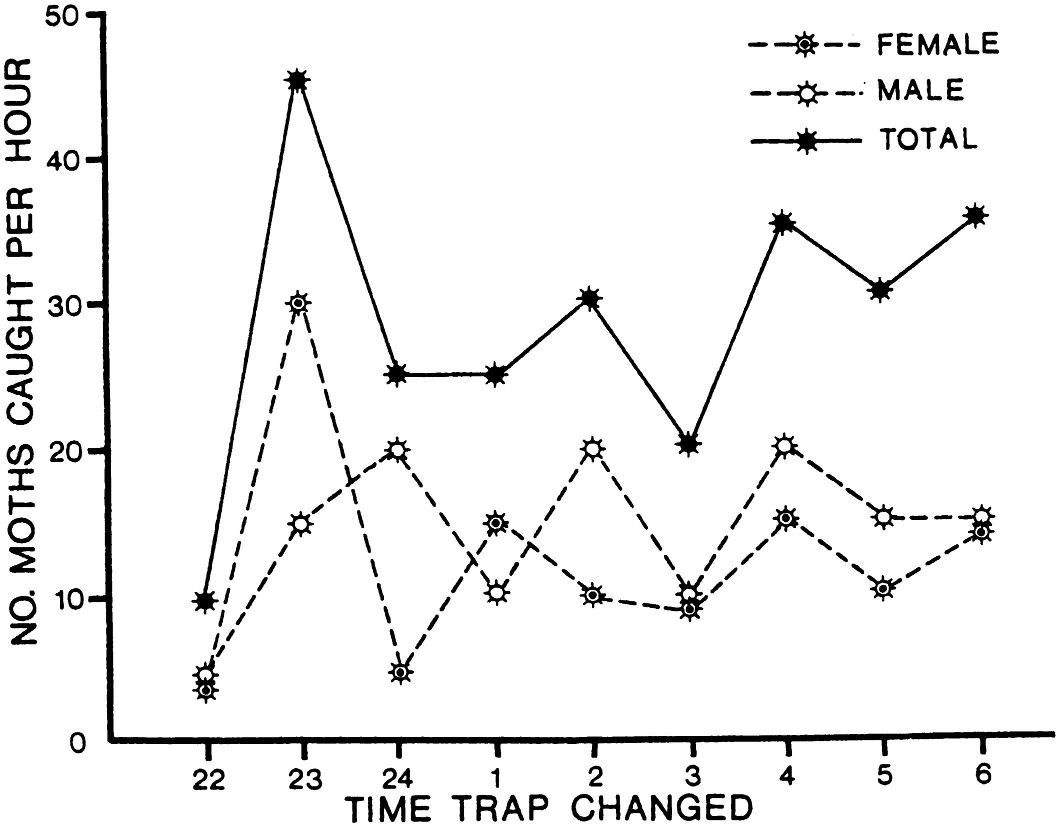
6
TIME TRAP CHANGED

Figure 18. Hourly Spotted Cutworm Moth Catch from the Streeter Blacklight Trap for August 18, 25 and 31, 1978

Figure 19. Hourly Dark-sided Cutworm Moth Catch from the Streeter Blacklight Trap for August 18, 25 and 31, 1978



40
30
20
10
0
NO. MOTHS CAUGHT PER HOUR
FEMALE
MALE
TOTAL
22
23
24
1
2
3
4
5
6
TIME TRAP CHANGED



50
40
30
20
10
0
NO. MOTHS CAUGHT PER HOUR
FEMALE
MALE
TOTAL
22
23
24
1
2
3
4
5
6
TIME TRAP CHANGED

active at the blacklight trap earlier in the evening than did males with male activity reaching its peak shortly after midnight and another peak prior to dawn.

Dark-sided cutworm activity indicates that male flight activity reaches its peak between 5:00 A.M. and 6:00 A.M. with a consistent catch prior to its peak. Female activity increased rapidly with its first peak between 11:00 P.M., rapidly decreasing and reaching another peak between 1:00 A.M. and 2:00 A.M. After the second peak, female activity declined to a low level and remains there throughout the rest of the night. Activity of females reached its peak near midnight with a second peak shortly after midnight. Male activity remained level throughout the night until early morning when their activity reached its peak.

Tables 8 and 9 summarize the hourly trap catches for the spotted cutworm and the dark-sided cutworm respectively.

Table 8. Summary of Total Spotted Cutworm Moths Caught Per Hour from the Brown, Rogers and Streeter Blacklight Traps for August 18, 25 and 31, 1978

Time	Hourly Catch			Percent of Hourly Catch		Percent of Total Catch		
Hours	Female	Male	Both	Female	Male	Female	Male	Both
22	38	42	80	47.50	52.50	6.48	7.17	13.65
23	56	29	85	65.88	34.12	9.56	4.95	14.51
24	21	66	87	24.14	75.86	3.58	11.26	14.84
1	19	77	96	19.79	80.21	3.24	13.14	16.38
2	15	53	68	22.06	77.94	2.56	9.04	11.60
3	8	56	64	12.50	87.50	1.36	9.56	10.92
4	11	13	24	45.83	54.17	1.88	2.22	4.10
5	9	41	50	18.00	82.00	1.53	7.00	8.53
6	18	14	32	56.25	43.75	3.07	2.39	5.46
	195	391	586					

Table 9. Summary of Total Dark-sided Cutworm Moths Caught Per Hour from the Brown, Rogers and Streeter Blacklight Traps for August 18, 25 and 31, 1978

Time	Hourly Catch			Percent of Hourly Catch		Percent of Total Catch		
Hours	Female	Male	Both	Female	Male	Female	Male	Both
22	17	16	33	51.51	48.49	6.64	6.25	12.89
23	36	16	52	69.23	30.76	14.06	6.25	20.31
24	16	12	28	57.14	42.86	6.25	4.69	10.94
1	20	15	35	57.14	42.86	7.81	5.86	13.67
2	8	10	18	44.44	55.56	3.12	3.90	7.02
3	9	10	19	47.37	52.03	3.52	3.90	7.42
4	6	10	16	37.50	62.50	2.34	3.90	6.24
5	7	17	24	29.17	70.83	2.73	6.64	9.37
6	10	21	31	32.26	67.74	3.90	8.20	12.10
	129	127	256					

Larval Sampling

Introduction

The development of a sampling program suitable for certain life stages of an insect must be based on the distribution and life cycle of the insect involved. A sampling technique suitable for one insect may not be suitable for another; there is no universal sampling method. A study was undertaken to evaluate different larval sampling techniques for their effectiveness in cutworm sampling.

Methods and Materials

Attraction to Blacklight

A general purpose Ellisco[R], 15-watt blacklight trap was disassembled using only the light and starting mechanism box. In 1978, the light was suspended 45.7cm above ground level on the outside row of a vineyard in Van Buren county. Five days after the establishment of the light, it was noticed that large numbers of dark-sided cutworms had congregated under the light. Counts of numbers of cutworms present were made on the fifth night using a 45.7cm square frame. Counts were made directly under the light and at a distance of 3 meters from the light in north, south, east and west directions. In 1979, a similar light was set up on the edge of a vineyard which had been removed one week earlier. Samples were taken by using a .91 meter square frame and digging to a depth of six inches directly below the light, 1.8, 2.74 and 7.6 meters from the light in north, south, east and west directions. The samples were taken at establishment of the light, five and eight days after establishment. At the end of each sampling period, the larvae were removed from the area and the instars determined.

Visual Inspection

Vineyards were selected in 1978 and 1979 for visual sampling of the vines at night for cutworm presence. In each vineyard selected, four randomly selected areas were chosen and in each of these areas 30.5 meters of row was examined. The trunk, canes and wire in this 30.5 meters were closely examined for cutworms. Specimens found were collected and labeled for identification the following morning. Samples were sorted and counted and the number of each species recorded.

Pitfall Traps

Pitfall traps were set out in thirteen vineyards in Berrien and Van Buren counties during 1978. Pint containers constructed of wax-coated cardboard were placed in holes made with a golf course hole cutter. The traps were set with their lips flush with the soil surface. Two types of traps were used: (1) baited with Hopkins[R] 5% carbaryl apple-pomace bait, and (2) unbaited, containing two ounces of ethylene glycol to serve as a preservation agent. A .63cm plywood cover supported with nails 7.6 centimeters above the trap provided a cover for each trap to prevent rain from entering the traps.

The pitfall traps were randomly placed throughout the vineyard in locations in and between the rows. Vineyards used consisted of both those with a cover crop planted and those which had a semi-permanent cover of grasses.

Shingle Traps

Shingles were utilized as a trapping method in ten vineyards in Berrien and Van Buren counties in 1978. The shingles (30.5x45.7 centimeters) were held in place on the ground with two pole barn spikes. The traps were randomly placed in the vineyards and the vegetation under the trap was thinned if the traps did not sit firmly on the soil. Locations of the shingle traps were marked with colored plastic flagging placed on the trellis system.

Spatial Distribution

The study of the distribution of the climbing cutworms was done in five locations in Van Buren county in 1979. A site in the vineyard was selected and a 3x3 meter square area was marked out. This area was carefully checked for the presence of cutworms by removing the vegetation as needed. The soil was checked to a depth of 10 centimeters. As the larvae were found, a stick with a corresponding piece of colored ribbon indicating the species of the cutworm was used to mark its location. After all of the larvae had been removed and their position marked, measurements were taken so that their location could be mapped out at a later date.

Results and Discussion

Attraction to Blacklight

The use of the blacklight has been shown to be a powerful attractant for many different orders of insects. Olson and Rings (1969) found that the spotted cutworm responded photopositively for instars one through three while instars four through seven responded photonegatively to various intensities and wavelengths of light. The attraction of the dark-sided cutworm larvae to the blacklight is shown in Table 10. After five days of operating the blacklight in 1978, an area 45.7 centimeters square was sampled yielding 475 dark-sided cutworm larvae (Figure 20). In 1979, the blacklight was placed in a recently removed vineyard. After eight nights of operation, the trap attracted 167 dark-sided cutworm larvae within the .91 meter area sampled beneath the light. This number of larvae is a 167 fold increase over the number present when sampled prior to the operation of the light.

The blacklight could possibly be used to monitor population levels of the dark-sided cutworm larvae in the spring and to concentrate larvae in one area for purposes of collecting larvae to establish a colony, aid in the release and establishment of parasites and possibly as a means of aiding in control in some circumstances. This response of the attraction of the dark-sided cutworm to the blacklight was not observed with any of the other species of cutworms attacking grapes.

Visual Inspection

This type of sampling technique allowed for a large number of vineyards to be inspected each night. A summary of the species of cutworms collected and abundance of each species in the vineyards sampled is found in Table 11. Sampling of this nature gives a qualitative determination of what species are present within an area.

Pitfall Traps

The results of the pitfall trapping study indicates that early in the season the cutworms are attracted to the pitfall traps in a limited degree (Table 12). The baited pitfall traps caught more cutworms than

Table 10. Attraction of Dark-sided Cutworm Larvae to the Blacklight

Location Sampled	Date Sampled			# Increase
	6/1/79	6/5/79	6/8/79	
At light	1	134	33	166
1.8 meters--N	3	62	2	61
1.8 meters--S	1	50	7	56
1.8 meters--E	0	14	12	26
1.8 meters--W	0	29	5	34
2.74 meters--N	0	8	1	9
2.74 meters--S	6	43	3	40
2.74 meters--E	0	4	0	4
2.74 meters--W	4	37	3	36
7.6 meters--N	2	2	1	1
7.6 meters--S	2	0	0	-2
7.6 meters--E	1	2	0	1
7.6 meters--W	5	1	0	-4

Figure 20. Dark-sided Cutworm Larvae under Blacklight in Vineyard, 1978

Table 11. Number of Each Species Collected Per 122 Meters of Vineyard Row During Visual Inspections

Location	No. of Each Species Found Per 122 Meters of Row					
	Brown Cutworm	*Amathes smithii*	Spotted Cutworm	Spotted-sided Cutworm	W-marked Cutworm	Total
1978						
Abandoned	0	1	3	35	0	39
Oxley #1	19	1	6	0	0	26
Slevatz	11	0	0	2	0	13
Brown #1	0	0	2	0	0	2
Brown #2	0	1	0	0	0	1
Glavin	0	0	0	0	0	0
Cronenwett	0	0	4	1	0	5
Rogers #1	0	0	3	0	0	3
Ryan	0	2	5	11	0	18
Wrona	1	0	1	8	0	10
Total	31	5	24	57	0	117
1979						
Rogers #1	0	0	13	1	0	14
Rogers #2	0	0	4	0	0	4
Oxley #2	0	0	5	1	0	6
Slevatz	0	0	0	0	2	2
Cronenwett	0	1	1	0	0	2
Brown, D.	0	0	0	0	0	0
Abandoned	1	1	0	2	3	7
Brown #1	1	0	6	0	0	7
Brown #2	0	0	8	0	0	8
Ryan	3	0	10	22	0	35
	5	2	47	26	5	85

Table 12. Results of Baited and Unbaited Pitfall Traps as a Detection Tool for Climbing Cutworms

Location & Trap No.**	Number of Cutworms Caught Per Trap*						Total
	4/18	4/22	4/26	4/30	5/4	5/8	
b1-1	0	0	0	0	0	0	0
b1-2	0	0	0	0	0	0	0
u1-3	0	0	0	0	0	0	0
u1-4	0	0	0	0	0	0	0
b2-1	0	0	0	0	0	0	0
b2-2	0	0	0	0	0	0	0
u2-3	0	0	0	0	1	0	1
u2-4	0	0	0	0	0	0	0
b3-1	0	0	0	0	0	0	0
u3-2	0	0	0	0	0	0	0
u3-3	0	0	0	0	0	0	0
b4-1	0	0	0	0	0	0	0
u4-2	0	0	0	0	0	0	0
b5-1	0	0	0	0	0	0	0
b5-2	0	0	0	0	0	0	0
u5-3	0	0	0	0	0	0	0
u5-4	0	0	0	0	0	0	0
b6-1	0	0	0	0	0	0	0
b6-2	0	1	0	0	0	0	1
u6-3	0	0	0	0	0	0	0
u6-4	0	0	0	0	0	0	0
b7-1	0	1	0	0	0	0	1
b7-2	0	0	0	0	0	0	0
u7-3	0	2	0	0	0	0	2
u7-4	0	0	0	0	0	0	0
b8-1	0	0	0	0	1	0	1
b8-2	0	0	0	0	0	0	0
u8-3	0	0	0	0	0	0	0
u8-4	0	0	0	0	0	0	0
b9-1	0	0	0	0	0	0	0
b9-2	0	0	0	0	0	0	0
b9-3	0	0	0	0	0	0	0
u9-4	0	0	0	0	0	0	0
u9-5	0	0	0	0	0	0	0
u9-6	0	0	0	0	0	0	0
b10-1	0	0	0	0	0	0	0
b10-2	0	0	0	0	0	0	0
u10-3	0	0	0	0	0	0	0
u10-4	0	0	0	0	0	0	0
b11-1	0	0	0	0	0	0	0
b11-2	0	0	0	0	0	0	0
u11-3	0	0	0	0	0	0	0
u11-4	0	0	0	0	0	0	0
b12-1	0	0	0	0	0	0	0

Table 12. Continued.

Location & Trap No.**	Number of Cutworms Caught Per Trap*						Total
	4/18	4/22	4/26	4/30	5/4	5/8	
b12-2	0	1	0	0	0	0	1
b12-3	0	0	0	0	0	0	0
u12-4	0	0	0	1	0	0	1
u12-5	0	0	0	0	0	0	0
u12-6	0	0	0	2	0	0	2
u12-7	0	0	0	0	0	0	0
u12-8	0	0	0	0	0	0	0
b13-1	0	0	0	0	0	0	0
b13-2	0	0	0	0	0	0	0
u13-3	0	0	0	0	0	0	0
u13-4	0	0	0	0	0	0	0
b13-5	0	0	0	0	0	1	1
b13-6	0	0	0	0	0	0	0
u13-7	0	0	0	0	0	0	0
u13-8	0	0	0	0	0	0	0
b13-9	0	0	0	0	0	0	0
b13-10	0	1	0	0	0	0	1
u13-11	0	0	0	0	0	0	0
u13-12	0	0	0	0	0	0	0
b13-13	0	0	0	0	0	0	0
b13-14	0	0	0	0	0	0	0
u13-15	0	0	0	0	0	0	0
u13-16	0	0	0	0	0	0	0
b13-17	0	0	0	0	0	0	0
b13-18	0	0	0	0	0	0	0
u13-19	0	0	0	0	0	0	0
u13-20	0	0	0	0	0	0	0
b13-21	0	0	0	4***	0	0	4
b13-22	0	0	0	0	0	0	0
u13-23	0	0	0	0	0	0	0
u13-24	0	0	0	1	0	0	1
b13-25	0	0	0	1	0	0	1
b13-26	0	0	0	2	0	0	2
u13-27	0	0	0	0	0	0	0
u13-28	0	0	0	0	0	0	0
b13-29	0	0	0	0	0	0	0
b13-30	0	0	0	0	0	0	0
	0	6	0	11	2	1	20

*All of the cutworms caught were the spotted cutworm unless otherwise indicated.
**b = baited, u = unbaited.
***3 spotted-sided cutworms, 1 spotted cutworm.

did the unbaited traps. The apple-pomace bait used may have served as a strong enough attractant to lure the cutworms to the trap.

Due to the presence of a cover crop in the vineyard, food is generally readily available and movement of the cutworm is rather limited. After the initiation of bud feeding, oftentimes cutworms never return to the ground during the day but rather conceal themselves under pieces of loose bark on the vine. Movement between vines is often accomplished on the wire of the trellis system.

Shingle Traps

During the course of this study, the shingle traps were completely ineffective as a detection method for climbing cutworms as no cutworms were captured in the traps. Walkden (1943) describes using burlap sacks for sampling cutworms in the prairie with good success. With the amount of ground cover present in many of the vineyards, enough protection could be gained under the plant material without seeking protection elsewhere.

Spatial Distribution

The distribution of cutworm larvae in the 3x3 meter square sampled plots is shown in Figures 21 and 22 for two of the vineyards sampled. These figures show that the distribution was aggregated. The variance to mean ratio is a test based on the equality of the variance and mean in a Poisson series and the inequality of both parameters in a regular and contagious distribution. The variance to mean ratio is calculated by the following formula,

$$I = \frac{s^2}{x} = \frac{(x - x)^2}{x\ (n - 1)}$$

where s^2 = variance, x = arithmetic mean and n = number of sampling units. The departures from unity can be assessed by using a χ^2 table (Elliott, 1977).

$$\chi^2 = I\ (n - 1) = \frac{s^2\ (n - 1)}{x} = \frac{(x - x)^2}{x}$$

if I>1, contagious distribution is suspected, I = 1 a random distribution and I<1 a continuous distribution is suspected. The calculated I value for the sampled plots and the χ^2 value are given below:

$$I = 17.53 \qquad \chi^2 = 70.15$$

Since the χ^2 value is greater than the expected χ^2 value, a contagious distribution is suspected.

Table 13 summarizes the 3x3 meter plots sampled.

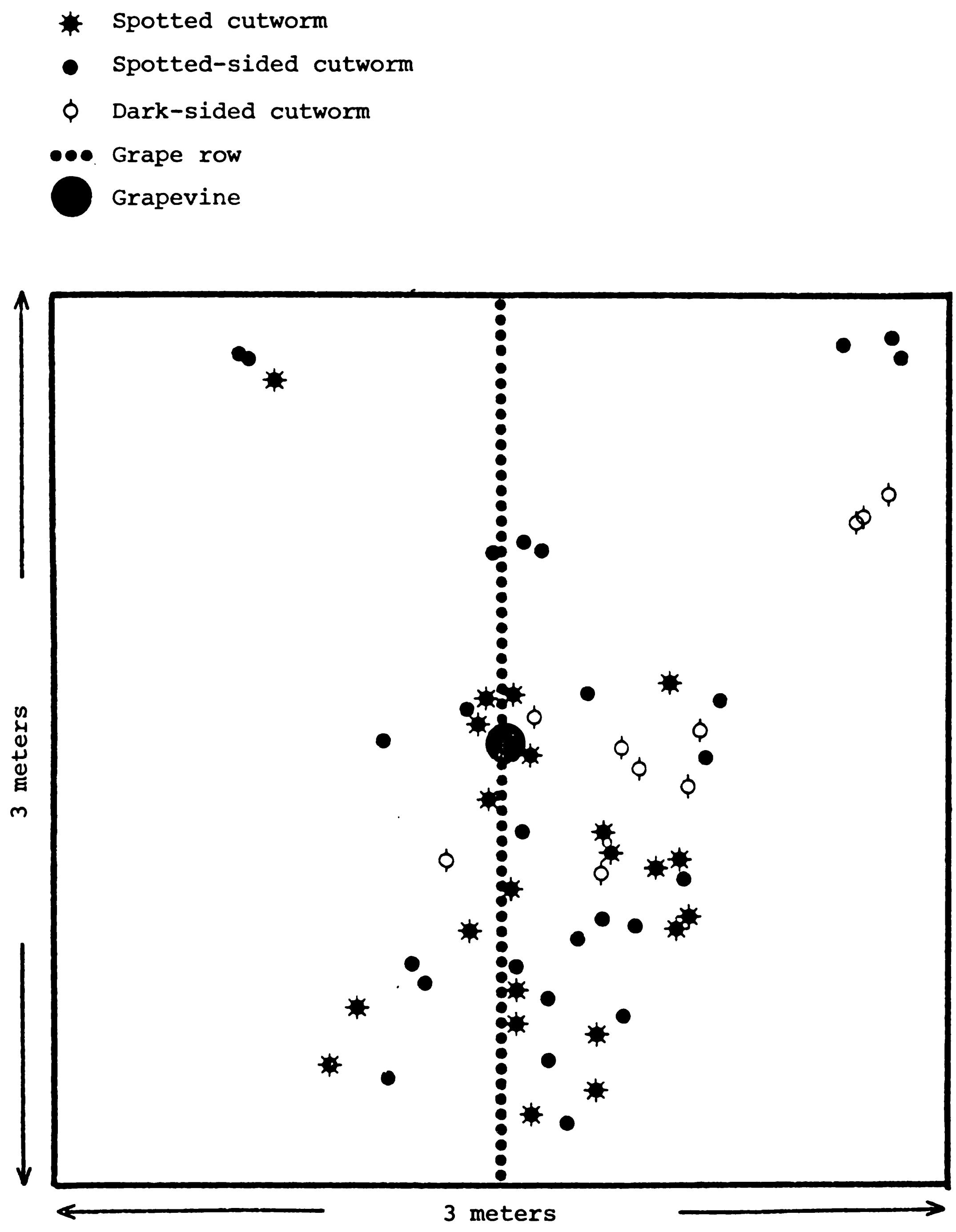


Figure 21. Distribution of Cutworm Larvae in Vineyard (Ryan #1)

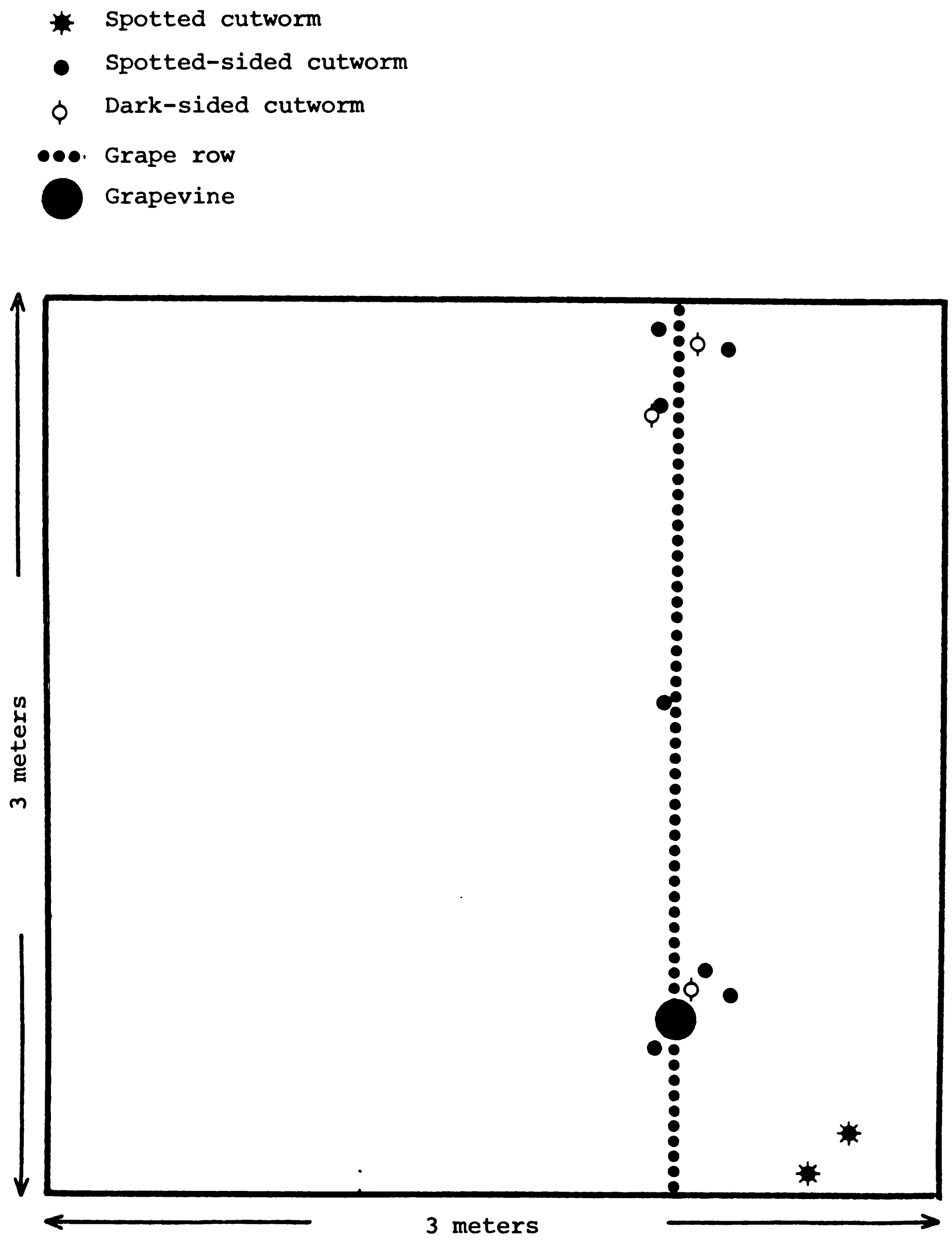


Figure 22. Distribution of Cutworm Larvae in Vineyard (Brown)

Table 13. Summary of Cutworm Species Located During 3x3 Meter Plot Sampling

Location	Number of Each Species			Total
	Spotted	Spotted-sided	Dark-sided	
Ryan #1	22	26	10	58
Ryan #2	2	7	5	14
Brown	2	7	3	12
Rogers	5	2	1	8
Oxley	7	9	5	21

CONTROL

CONTROL

CHEMICAL CONTROL

Introduction

Research on the efficacy of insecticides in controlling insect pests must be done so that growers will have a chemical available for their use in controlling pest problems attacking their crops. There are constantly new compounds being developed by companies which show promise as insecticides and these must be field evaluated for their effectiveness.

Control of climbing cutworms is complicated by the following factors:

1. The recent loss of chlorinated hydrocarbon insecticides e.g. DDT, dieldrin, chlordane.

2. The average nightly temperature during cutworm activity is 45-55°F which limits the use of temperature-dependent insecticides.

3. The period of bud susceptibility to cutworm damage may be shortened or lengthened due to the temperature during this time. If the period is lengthened, insecticide residues may diminish and necessitate additional reapplications of an insecticide.

4. There is very little surface area available for the insecticide to impinge upon limiting the amount of area for larvae to contact the insecticide.

5. Often during periods of cutworm activity, environmental conditions are not favorable for insecticide applications.

Methods and Materials

Laboratory Studies

These studies were conducted under the direction of Dr. Ronald Harris at the Research Institute, Agriculture Canada, London, Ontario. Screening tests were conducted with fifteen insecticides on the fall armyworm, *Spodoptera frugiperda*, and with two insecticides on the dark-sided cutworm, *Euxoa messoria*. All larvae used were in the third instar. Concentrations of .001, .01, .1 and 1.0% insecticide solutions were used at each concentration. Solvent (19:1 acetone: olive oil) controls were included in all tests. Treated insects were placed in waxed paper cups, supplied with clover for food, covered with a glass petri dish and held at 26±1°C, 60% RH and continuous light for twenty hours. Mortality data for a given concentration were averaged.

Field Evaluations in Established Vineyards

1978

The field plots were located in Van Buren county near Lawton on the farms of Gordon Brown and Dwight Brown in vineyards of the Concord variety with the vineyard age being greater than fifty years. Both vineyards were pruned to a 4-cane kniffen training system. The plots were sprayed with a four-tank hydraulic sprayer fitted with two vertical booms, one on each side of the row. A canvas hood was fitted behind each boom and three feet to each side of the boom to eliminate spray drift to the other plots. The sprayer was set at a pressure of

150 PSI and was calibrated to deliver 200 gallons of finished spray material to the acre (Figure 23). Treatments were replicated five times with each replicate consisting of five grapevines; only the middle three were utilized for evaluating damage.

Plots were evaluated for bud damage at given intervals. Damaged buds were marked with a black permanent felt tip on the cane surrounding the bud. Prior to application of chemical treatments, the plots were evaluated for damage.

<u>1979</u>

Field tests for this study were conducted in Van Buren county near Lawton on the Robert Rogers farm. Grapes were of the Concord variety, pruned to a 4-cane kniffen system and were planted more than fifty years ago. Sprays were applied with the same sprayer as described in the 1978 field evaluations with the pressure being reduced to 125 PSI and recalibration of the sprayer to deliver sixty gallons of finished spray material to the acre. Treatments were replicated four times with each replicate consisting of five grapevines; only the middle three were utilized for evaluating damage. Precounts and marking of damaged buds was done the same as described earlier.

Field Evaluations in Non-producing Vineyards

<u>1978</u>

Young one-year-old grapevines were utilized in this evaluation in Van Buren county near Lawton on the William Cronenwett farm. An area 45.7 centimeters square was sampled around each plant to a depth of 15 centimeters. All of the cutworms found within this area were removed and counted. A total of ten dark-sided cutworms were placed back into the area and the soil was returned. A .91 meter square area was treated with each of the candidate chemicals with a Hudson[R] knapsack sprayer. Approximately eight ounces of finished spray material was applied to each plot (equivalent to 300 gallons per acre). The high gallonage was used to completely wet the foliage and cover the soil surface and thereby test the efficacy of the insecticide and not the application method. Baits were applied at a rate of forty pounds per acre. Treatments were replicated five times, each replicate consisting of one grapevine.

Plots were evaluated at one-, three- and five-day intervals after treatment. Evaluations on days one and three consisted of removing dead cutworms from the surface of each plot and recording these numbers. On day five, dead cutworms were removed from the soil surface and each plot was dug to a depth of 15cm to locate cutworms (dead and alive) below the soil surface.

1979

This study was conducted in Van Buren county near Lawton on the William Cronenwett farm. Strips of 26-gauge sheet metal, 3.05 meters long and .3 meters wide, were forced into the soil to a depth of 5-7 centimeters forming a circle with a diameter of 1 meter. These circles were used to surround one grape plant and existing vegetation. Any vegetation extending over the top of the barrier was removed to prevent escape of the cutworms. Treatments were applied with a Hudson[R] knapsack sprayer with each plot receiving three ounces of spray material. This rate would be equivalent to 144 gallons per acre of a broadcast application. Each treatment was replicated four times with each replicate consisting of one tin circle (Figure 24).

Evaluations were made at one- and six-day intervals after treatment. Day-after evaluations consisted of examining each plot for cutworms disturbing the plot as little as possible. All cutworms found were removed and counted. Evaluations made on the sixth day after treatment were made by removing all visible cutworms and then removing all existing vegetation from the plot. Each plot was then treated with one gallon of water to which two tablespoons of pyrethrin had been added. This solution brought to the surface any live cutworms within the plot. The solution was allowed to work for twenty minutes prior to digging of the plot. The soil was examined to a depth of 10 centimeters to locate any remaining cutworms. Counts were then made of dead cutworms and on the number of live cutworms found within each plot.

Residual Activity

In the vineyard utilized for 1979 chemical evaluations, a separate study was initiated to determine the residual activity of the chemical treatments. Following application of the chemical treatments, ten sheet metal cages were forced into the ground beneath the grapevines with two cages being randomly placed in each of the five treatments. The cages were constructed of 26-gauge sheet metal, .3 meters wide and 3.05 meters long. The sheet metal was shaped to form a circle with a diameter of 1 meter. The cages were forced into the soil to a depth of 5-7 centimeters. An application of Tanglefoot^{R} was made to the top of each cage to prevent escape of the cutworms. Care was taken

Figure 23. Hooded Boom Sprayer Used for Chemical Application to Grapes

Figure 24. Micro Plots in Young Vineyard

when placing the cages not to disturb the soil and debris within the cage.

The efficacy of chemical treatments was determined by placing ten fifth instar, field collected, spotted cutworm larvae in each of the cages. Cutworms were placed in five of the cages one day after the first chemical application with the other cages being infested five days after the initial chemical treatment. Each of the cages was evaluated three days after the cutworms were introduced. After the second application of chemicals, ten more cages were randomly placed in the vineyard and the study was repeated.

Results and Discussion

Present control programs for climbing cutworms are aimed at controlling the larvae. Chlorinated hydrocarbon insecticides were widely used in the past for cutworm control, but of these, none is currently available or recommended for use (Flore, Jones and Olsen, 1979). Many of the newer insecticides are being evaluated for cutworm control with several showing potential for use. Laboratory screening techniques provide an effective method for determining a compounds potential for control of an insect pest before taking the compound to the field for evaluation. Field testing of compounds allows for evaluation of efficiency under natural conditions and under application methods similar to those of growers.

Grape Grower Questionnaire Survey

Results from the grower survey indicated that the insecticides most frequently used for cutworm control are parathion and carbaryl, representing 35.84 percent and 17.70 percent of the grower responses respectively. Other insecticides used for cutworm control include chlordane (12.39 percent), dieldrin (10.67 percent), azinphosmethyl (4.87 percent) and tanglefoot (1.33 percent). Table 14 summarizes insecticide usage for cutworm control.

Table 14. Cutworm Damage and Insecticide Usage as Reported from Questionnaires

Insecticide	Cutworm Damage				Total
	None	Light	Moderate	Heavy	
None	13	8	4	1	26
Chlordane	2	11	3	12	28
Dieldrin	2	6	10	6	24
Parathion	14	33	15	18	80
Carbaryl	4	19	12	5	40
Azinphosmethyl	3	6	1	1	11
Tanglefoot	0	0	2	1	3
Not reported	5	4	0	0	9
	43	87	47	44	221

During the growing season, the insecticides used most frequently for insect control are parathion and carbaryl. Grape berry moth and grape leafhoppers are the main target pests of these insecticide applications.

The season of chemical application for cutworms is most commonly the spring (Table 15). The actual time of application during the spring is almost evenly divided between day and night applications. This even division could possibly be due to the fact that many grape growers hold other jobs of employment and must do their farming during their off hours. Many growers understand the importance of enhancing their insecticide application for cutworm control by spraying in the late evening and night when the cutworms are active.

Table 15. Cutworm Damage and Time of Insecticide Applications as Reported from Questionnaires

Time of Application	Cutworm Damage				Total
	None	Light	Moderate	Heavy	
None	12	7	4	0	23
Spring	15	46	23	21	105
Fall	1	1	1	0	3
Not reported	10	5	0	0	15
Day	6	22	10	9	47
Night	6	16	12	11	45
Not reported	4	9	2	1	16

Laboratory Studies

Fifteen insecticides were evaluated for control of third instar fall armyworms and two insecticides for third instar dark-sided cutworms (Tables 16 and 17). Fall armyworm larvae were utilized for this experiment due to the low availability of dark-sided cutworm larvae. The fall armyworm reacts very similar to the dark-sided cutworm in its toxicological response (Harris, personal communication). FMC 45498, permethrin, WL 43467, chlorpyrifos and methomyl showed good activity for the control of the fall armyworm. Chlorpyrifos showed a decrease in effectiveness in the control of the dark-sided cutworm. This decrease in efficiency is probably due to differences between species.

Table 16. Direct Contact Toxicity of Fifteen Insecticides to Third Instar Fall Armyworm Larvae

Insecticide	Average % Mortality at % Insecticide Solution Indicated				
	.0001	.001	.01	.1	1.0
Permethrin*		0	100	100	100
WL 43467		0	100	100	---
WL 43775		0	0	100	---
FMC 45498	0	100	100	100	---
Pyrethrin		0	0	25	100
Chlorpyrifos		0	100	100	---
Acephate		0	10	95	100
Fonofos		0	0	25	100
Methomyl		0	65	85	100
Endosulfan		0	0	10	100
Azinphosmethyl		0	0	90	100
Carbofuran		0	0	27	60
Endrin		0	0	95	---
DDT		0	5	70	---
Carbaryl		0	0	0	5

*Ambush

Table 17. Direct Contact Toxicity of Two Insecticides to Third Instar Dark-sided Cutworm Larvae

Insecticide	Average % Mortality at % Insecticide Solution Indicated		
	.01	.1	1.0
Permethrin*	75	95	100
Chlorpyrifos	10	85	100

*Ambush

Field Evaluations in Established Vineyards

Eight insecticides were selected for evaluation in field trials for 1978 and 1979 for control of climbing cutworms attacking the young, developing buds (Tables 18, 19 and 20). The average nightly temperature during the period of cutworm activity in 1978 was 11 C. Field results show that fenvalarate and permethrin were highly effective in controlling cutworm damage. Chlorpyrifos, UC 51762, acephate and monocrotophos showed moderate control of cutworms.

The cool temperatures during the period of cutworm activity may have limited the effectiveness of many of the compounds evaluated. Harris and Kinoshita (1977) report that the pyrethroid insecticides (fenvalerate and permethrin) have a negative temperature coefficient of toxicity against insects. This negative temperature coefficient is also exhibited by DDT while compounds like endosulfan, diazinon and carbaryl respond with positive coefficients (Kinoshita, 1976). Pyrethroid insecticides are strongly inactivated on incorporation into the soil and they are inactivated in dry soils as are most insecticides (Harris and Turnbull, 1978).

Table 18. Efficacy of Six Insecticides in Controlling Climbing Cutworms Attacking Grape Buds (1978)

Insecticide	Rate (Form)	# of Good Buds	# of Buds Damaged on Dates Listed 5/9/78	5/15/78	5/18/78	5/22/78	Total # of Damaged Buds	% of Buds Damaged
Monocrotophos 5E	192ml	925	6	18	5	0	29ab	3.13
Chlorpyrifos 4E	946ml	832	15	13	9	0	37ab	4.45
Permethrin* 2E	48ml	950	7	0	3	2	12 b	1.26
UC 51762 75W	142gm	918	21	14	2	0	37ab	4.03
Fenvalarate 2.4E	20ml	903	14	1	2	0	17ab	1.88
Methomyl 1.8L	237ml	845	9	24	22	0	55ab	6.51
Control	---	775	15	32	22	1	70a	9.03

Chemical treatments were applied on 5/6 and 5/18/78.

Totals followed by the same letter are not significantly different at the 5% level, Duncan's multiple range analysis.

*Ambush

Table 19. Efficacy of Five Insecticides in Controlling Climbing Cutworms Attacking Grape Buds (1978)

Insecticide	Rate (Form)	# of Good Buds	# of Buds Damaged on Dates Listed 5/15/78	5/18/78	5/22/78	Total # of Damaged Buds	% of Buds Damaged
Monocrotophos 5E	96ml	597	17	3	8	28 bc	4.69
Fenvalarate 2.4E	10ml	721	1	7	1	9 c	1.25
Permethrin* 2E	24ml	770	1	2	1	4 c	.52
Acephate 75S	142gm	654	11	20	11	42abc	6.42
UC 51762	70gm	704	24	29	8	61ab	8.66
Control	---	711	34	15	31	80a	11.25

Chemical treatments were applied on 5/10 and 5/18/78.

Totals followed by the same letter are not significantly different at the 5% level, Duncan's multiple range analysis.

*Ambush

Table 20. Efficacy of Four Insecticides in Controlling Climbing Cutworms Attacking Grape Buds (1979)

Insecticide	Rate (Form)	# of Good Buds	# of Buds Damaged on Dates Listed 4/28/79	4/30/79	5/2/79	5/5/79	Total # of Damaged Buds	% of Buds Damaged
Permethrin* 3.2E	29ml	504	0	0	3	0	3 b	0.59
Fenvalarate 2.4E	20ml	504	0	0	4	0	4 b	0.79
Permethrin** 2E	48ml	450	0	2	0	1	3 b	0.66
Carbaryl 80W	180gms	529	3	6	6	3	18a	3.40
Control	---	508	3	7	8	8	26a	5.12

Chemical treatments were applied on 4/27 and 5/13/79.

Totals followed by the same letter are not significantly different at the 5% level, Duncan's multiple range analysis.

*Pounce

**Ambush

Field Evaluations in Non-producing Vineyards

Control of the dark-sided cutworm attacking young grape plants was evaluated in 1978 and 1979 using fourteen insecticides (Tables 21 and 22). Permethrin, fenvalerate and chlorpyrifos were all effective in the control of this species. Carbaryl and the high rate of fenamiphos showed fair control. Both of the baits used in 1978 showed good effectiveness in cutworm control. The plots in 1978 did not have any type of border around them and there was considerable emigration and immigration in the sprayed plots. The micro plots utilized in 1979 eliminated this movement of the larvae. The use of the micro plots and pyrethrin solution for sampling the live larvae within each plot provided an absolute measure of the cutworm population and mortality for each treatment.

Harris, Svec and Chapman (1978) suggest that the dark-sided cutworm can be controlled in early April by treating the cover crop grown in rotation with vegetables and tobacco.

Insecticide toxicity is affected by temperature (Dustan, 1947; Guthrie, 1950; Harris, 1971). Larvae of overwintering cutworms appear early in the spring when it is normally cool. Cutworm feeding activity has been observed under field conditions with an ambient temperature of 8°C while cutworms in the laboratory have continued to feed when kept in a refrigerator at 4°C.

In Michigan, most vineyards are sown to a cover crop of rye, wheat or oats in August to prevent erosion, help add organic matter to the soil and aid in harvest operations in the fall. The cover crop remains in the vineyard throughout the winter until the following spring when it is tilled under. In the spring, before initiating their

Table 21. Efficacy of Eleven Insecticides in Controlling the Dark-sided Cutworm Attacking Young Grape Plants (1978)

Insecticide	Rate (Form)	# of Dead Cutworms		6/5/78		Total	
		6/1/78	6/3/78	Alive	Dead	Alive	Dead
Monocroptophos 5E	15ml	127	42	0	5	0	174ab
Fenvalarate 2.4E	15ml	33	14	0	8	0	55cde
Permethrin* 2E	4ml	95	41	0	5	0	141bc
Acephate 75S	115gms	128	61	5	17	5	206ab
Chlorpyrifos 4E	76ml	131	55	0	19	0	205ab
UC 51762 75W	11.5gms	24	25	3	8	3	57cde
Methomyl 1.8L	19ml	64	48	17	5	17	117bcd
Fonofos 4E	19ml	20	13	2	4	2	37de
FMC 35001 4E	4.8ml	18	6	7	0	7	24de
Control	---	0	0	15	0	15	0e
Fenvalarate Bait	---	60	69	0	20	0	149abc
Carbaryl Bait	---	82	125	0	41	0	248a

Totals followed by the same letter are not significantly different at the 5% level, Duncan's multiple range analysis.

*Ambush

Table 22. Efficacy of Seven Insecticides in Controlling Dark-sided Cutworms Attacking Young Grape Plants (1979)

Insecticide	Rate (Form)	5/27/79		6/1/79		Total		% Mortality
		Alive	Dead	Alive	Dead	Alive	Dead	
Permethrin* 2E	10ml	5	145	0	26	5a	171a	97.70
Fenvalarate 2.4E	8ml	2	110	0	22	2a	132ab	98.50
Permethrin** 3.2E	6ml	1	77	0	9	1a	86abc	98.80
Chlorpyrifos 4E	25ml	5	104	4	41	9a	145ab	94.10
Methomyl 1.8L	25ml	12	13	89	7	101b	20c	16.50
Control	---	3	0	203	1	206b	1c	00.48
Carbaryl 80W	36gms	15	43	25	30	40a	73abc	64.60
Fenamiphos 3E	32ml	1	6	30	47	31a	56bc	63.10
Fenamiphos 3E	96ml	6	13	56	25	62a	38a	38.00
Fenamiphos 3E	320ml	20	78	12	25	32a	103abc	76.30

Tables in each column followed by the same letter are not significantly different at the 5% level, Duncan's multiple range analysis.

*Ambush

**Pounce

climbing behavior, cutworms feed on this cover crop. An early broadcast application of an insecticide to this vegetation may prove to be a reliable method of cutworm control. An application to this vegetation would provide a greater surface area for the cutworms to come in contact with the insecticide.

Residual Activity

The residual activity of the insecticides evaluated in 1979 for control of climbing cutworms is summarized in Table 23. Since the cutworms are present over a long period of time, insecticides used for their control should remain effective for a seven- to ten-day period so repeat applications will not be necessary. The residual activity of the compounds is reduced five days after its initial application for most of the compounds evaluated. Fenvalerate showed strong residual activity five days after application and the activity of carbaryl reduced only slightly.

BIOLOGICAL CONTROL

Methods and Materials

Parasites

Larvae of the various species of climbing cutworms which were visually parasitized by various parasites were brought to the laboratory for rearing. Larvae brought to the laboratory for other purposes often died due to a parasite which in turn were reared to maturity. Emerged adults were preserved and identified at a later date.

Table 23. Mortality of the Spotted Cutworm Due to Residual Activity of Chemical Treatments in the Vineyard

Insecticide	Days After Chemical Treatment Before Introduction of Larvae					
	1			5		
	Dead	Alive	% Mortality	Dead	Alive	% Mortality
Permethrin* 3.2E	20	0	100	7	13	35
Fenvalarate 2.4E	19	1	95	17	3	85
Permethrin** 2E	19	1	95	11	9	55
Carbaryl 80W	13	7	65	11	9	55
Control	1	19	5	2	18	10

*Pounce

**Ambush

Disease

An *Entomophora* sp. fungus was found causing larvae mortality in several vineyards. Larvae from fields with mortality due to the fungus were brought to the laboratory for evaluation. Larvae were collected during the day as they remained concealed under the vegetation in the vineyard. Larvae were placed in individual containers for rearing. Fifty larvae from each of four different vineyards were evaluated. Barley was provided as a food source and mortality counts were made at four and seven days after being collected.

Results and Discussion

Parasites

Of the 150 spotted cutworm larvae brought to the laboratory for purposes of establishing a colony, five of the resulting pupae were parasitized by a Hymenopterous wasp, *Therion circumflexum* (L.). Three males and two females emerged and attempts were made for further parasitism of larvae with no success.

Parasitism of other species of cutworms collected during 1978 and 1979 which could be reared to maturity for identification are shown in Table 24. A list of the known natural enemies of the climbing cutworm species attacking grapes is found in Appendix D.

Disease

The mortality counts of larvae collected from vineyards with *Entomophora* dead larvae present are given in Table 25. An examination of dead larvae in the field showed the average height of the dead larvae was 85cm above ground level with 75 percent of the dead larvae

Table 24. List of Parasites Reared from Climbing Cutworms Attacking Grapes from Field Collected Larvae in 1978 and 1979*

Parasite	Host
Diptera:	
Tachinidae	
Mericia ampelus (Walker)	Spotted-sided cutworm
Euphorocera claripennis (Macquart)	Dark-sided cutworm Spotted cutworm
Bombyliidae	Spotted-sided cutworm
Hymenoptera:	
Ichneumonidae	
Therion circumflexum (L)	Spotted cutworm

*Thanks to R. L. Fisher for the identification of the Hymenoptera and to F. W. Ravlin for Diptera identification.

Table 25. Mortality Counts of Dark-sided Cutworms Infected with Entomophora

Location	# of Larvae	Mortality on Day 4	Mortality on Day 7	Total Dead	Total Alive	% Mortality
Ryan	50	7	3	10	40	20
Brown, D.	50	31	11	42	8	84
Brown, G.	50	6	9	15	35	30
Moorman	50	13	18	31	19	62

assuming a head-down position. The most common site of attachment for the dead larvae was on the posts supporting the trellis system and over 50 percent of the larvae were on the east side of the object on which they died. All of the larvae infected with the fungus were dark-sided cutworms with no other species being observed to be infected.

CONCLUSION

CONCLUSION

The complex of climbing cutworms attacking grapes in Michigan is large, six species being identified during 1978 and 1979. The life histories of these species varies greatly as do their food hosts and habits. All of these factors complicate monitoring and control practices.

It is important that cutworms be detected in the field early in the season prior to bud damage. It became evident during this study that pitfall traps and shingle traps would not provide a reliable indication as to the presence of cutworms in a vineyard. The use of a sweep net in the cover crop and surrounding vegetation will provide this information. The dark-sided cutworm larva could possibly be monitored with the use of a blacklight.

Adult monitoring is done with blacklight traps yet they provide only information as to the time of occurrence and abundance of a species. There are many factors which dictate the efficiency of the traps which may vary nightly.

Cutworms have the potential of causing large amounts of damage in terms of yield loss by feeding on the developing buds and by reducing the growth of a young plant by feeding on the foliage and apical meristems of sucker growth. Presently, chemical control measures are necessary for control of the climbing cutworms in those vineyards receiving damage, necessitating control. Natural enemies are present in the vineyards, both commercial and abandoned, yet most occur in low densities.

Laboratory studies indicate a preference by the cutworms to certain developmental stages of the grape bud. These preferences are for the larger, more swollen buds. In the spring after bud development has started, extended periods of cool temperatures may keep the grape buds at a particular developmental stage and increase the amount of cutworm damage due to the natural preference which the cutworm shows.

APPENDICES

APPENDIX A

HOST RANGE OF THE CUTWORM COMPLEX

APPENDIX A

HOST RANGE OF THE CUTWORM COMPLEX

Table Al. Host Plants of the Spotted Cutworm as Reported in Published Literature

Common Name	Scientific Name	Reference
Alfalfa	Trifolium spp.	Tietz (1972)
Apple	Malus pumila	Crumb (1929)
Barley	Hordeum vulgara L.	Tietz (1972)
Beet	Beta vulgaris L.	Crumb (1929)
Cabbage	Brassica oleracea L. var. capitata	Crumb (1929)
Canada thistle	Cirsium arvense	Crumb (1929)
Carrot	Caucus carota var. sativa	Crumb (1929)
Cauliflower	Brassica oleracea var. botrytis	Crumb (1929)
Celery	Apium graveolens L.	Crumb (1929)
Chickory	Cichorium intybus	Crumb (1929)
Chickweed	Stellaria media (L)	Crumb (1929)
Clover	Trifolium spp.	Crumb (1929)
Corn	Zea mays	Crumb (1929)
Cranberry	Vaccinium macrocarpon Ait.	Tietz (1972)
Currant	Ribes sativum Syme.	Crumb (1929)
Dandelion	Taraxacum officinale Weber	Tietz (1972)
Dock	Rumex spp.	Tietz (1972)
Ferns		Crumb (1929)
Flax	Linum sulcatum Ridd.	Tietz (1972)
Goldenrod	Solidago spp.	Tietz (1972)
Gooseberry	Ribes hirtellum Michx.	Crumb (1929)
Grasses		Crumb (1929)
Henbit	Lamium spp.	Tietz (1972)
Lettuce	Lactuca sativa L.	Tietz (1972)
Maple	Acer spp.	Crumb (1929)
Mangel	Beta vulgaris L.	Crumb (1929)
Mullen	Verbascum spp.	Tietz (1972)
Oat	Avena sativa L.	Crumb (1929)
Pea	Pisum sativum	Crumb (1929)
Plantain	Plantago spp.	Tietz (1972)
Potato	Solanum tuberosum L.	Tietz (1972)
Rhubarb	Rheum rhaponticum L.	Crumb (1929)
Sunflower	Helianthus spp.	Crumb (1929)
Tobacco	Nicotiana tabacum L.	Crumb (1929)
Tomato	Solanum lycopersicum L.	Crumb (1929)
Turnip	Brassica rapa L.	Crumb (1929)
Wheat	Triticum aestivum L.	Crumb (1929)

Table A2. Host Range of the W-marked Cutworm as Reported in Published Literature

Common Name	Scientific Name	Reference
Apple	*Malus pumila*	Crumb (1929)
Asparagus	*Asparagus officinalis*	Crumb (1929)
Bean	*Phaseolus vulgaris*	Crumb (1929)
Box elder	*Acer negundo* L.	Crumb (1929)
Buckwheat	*Fagopyrun sagittatum*	Crumb (1929)
Cabbage	*Brassica oleracea* var. capitata	Crumb (1929)
Cauliflower	*Brassica oleracea* var. botrytis	Crumb (1929)
Celery	*Apium graveolens*	Crumb (1929)
Chickory	*Cichorium intybus*	Crumb (1929)
Clover	*Trifolium* spp.	Crumb (1929)
Corn	*Zea mays* L.	Crumb (1929)
Currant	*Ribes rubrum* L.	Crumb (1929)
Elm	*Ulinus* spp.	Tietz (1972)
Grape	*Vitis labrusca* L.	Tietz (1972)
Gooseberry	*Ribes hirtellum* Michx.	Crumb (1929)
Grasses		Crumb (1929)
Lettuce	*Lactuca sativa* L.	Crumb (1929)
Lindens	*Tilia* spp.	Tietz (1972)
Peach	*Prunum persica* L.	Crumb (1929)
Plantain	*Plantago major*	Crumb (1929)
Populars	*Populus* spp.	Tietz (1972)
Pumpkin	*Cucurbita pepo*	Crumb (1929)
Tobacco	*Nicotiana tabacum* L.	Crumb (1929)
Wheat	*Triticum aestivum* L.	Crumb (1929)
Wild endive	*Cichorium endivia* L.	Whelen (1935)
Willows	*Salix* spp.	Tietz (1972)

Table A3. Host Plants of the Dark-sided Cutworm as Reported in Published Literature

Common Name	Scientific Name	Reference
Apple	*Malus pumila*	Crumb (1929)
Bean	*Phaseolus vulgaris* L.	Tietz (1972)
Beet	*Beta vulgaris* L.	Tietz (1972)
Buckwheat	*Fagopyrun sagittatum*	Tietz (1972)
Clover	*Trifolium* spp.	Crumb (1929)
Corn	*Zea mays* L.	Crumb (1929)
Currant	*Ribes sativum* Syme.	Tietz (1972)
Flowering plants		Crumb (1929)
Grape	*Vitis labrusca* L.	Whelen (1935)
Lettuce	*Lactuca sativa* L.	Tietz (1972)
Onion	*Allium cepa* L.	Crumb (1929)
Peach	*Prunus persica* L.	Crumb (1929)
Pea	*Pisum sativum*	Crumb (1929)
Potato	*Solanum tuberosum* L.	Crumb (1929)
Radish	*Raphanus sativus* L.	Crumb (1929)
Shrubs		Crumb (1929)
Soft maple	*Acer rubrun* L.	Whelen (1935)
Spinach	*Spinaca oleracia* Mill	Tietz (1972)
Strawberry	*Fragaria chiloensis* L.	Crumb (1929)
Sugar beet		Crumb (1929)
Sweet potato	*Ipomoea batatas* L.	Crumb (1929)
Tobacco	*Nicotiana tabacum* L.	Crumb (1929)
Tomato	*Solanum lycopersicum* L.	Tietz (1972)
Turnip	*Brassica rapa* L.	Crumb (1929)

Table A4. Host Range of the Spotted-sided Cutworm as Reported in Published Literature

Common Name	Scientific Name	Reference
Alfalfa	*Medicago sativa*	Rings (1977)
Apple	*Malus pumila*	Rings (1977)
Cherry	*Prunus cerasus*	Rings (1977)
Chickweed	*Stellaria media*	Crumb (1929)
Clover	*Trifolium* spp.	Crumb (1929)
Crabapple	*Malus diversfolia* (Bong.)	Rings (1977)
Curled dock	*Rumex crispus* L.	Crumb (1929)
Hedge mustard	*Sisymbrium officinale* L.	Crumb (1929)
Many-flowered aster	*Aster erocoides* L.	Crumb (1929)
Pin oak	*Quercus palustris*	Rings (1977)
Tobacco	*Nicotiana tabacum* L.	Crumb (1929)
Wheat	*Triticum aestivum* L.	Rings (1977)

Table A5. Host Plants of the Brown Cutworm as Reported in Published Literature

Common Name	Scientific Name	Reference
Apple	*Malus pumila*	Tietz (1972)
Peach	*Prunus persica*	Tietz (1972)
Grape	*Vitis labrusca* L.	Tietz (1972)

Table A6. Host Plants of *Amathes smithii* as Reported in Published Literature

Common Name	Scientific Name	Reference
Alder		Crumb (1956)
Apple	*Malus pumila*	Crumb (1956)
Dock	*Rumex* spp.	Crumb (1956)
False-helleborne	*Veratrum californicum*	Crumb (1956)
Raspberry	*Rubus* spp.	Crumb (1956)
Salmonberry	*Rubus spectabilis*	Crumb (1956)
Strawberry	*Fragaria chiloensis* L.	Crumb (1956)
Violet	*Viola* spp.	Crumb (1956)

APPENDIX B

ARTIFICIAL DIET

APPENDIX B

ARTIFICIAL DIET

Table B1. Diet Used for Rearing Spotted Cutworms

	Ingredients	Quantity
A.	Pinto beans (dry)	427 gm
	Brewers yeast	64 gm
	Ascorbic acid	6 gm
	Methyl-P-hydroxybenzoate	4 gm
	Sorbic acid	2 gm
	Distilled water	615 ml
B.	Agar	26 gm
	Distilled water	615 ml
C.	Vitamin solution	50 ml
	Formaldehyde	4 ml
	Aureomycin (18% soluble)	3.5 gm
	Vitamin solution	
	Inositol	2.0 gm
	Niacin	.1 gm
	Riboflavin	.05 gm
	Pyridoxine HCl	.025 gm
	Calcium pantothenate	.1 gm
	Thiamine HCl	.025 gm
	Folic acid	.025 gm
	Biotin	.002 gm
	B_{12}	.002 gm
	Distilled water	100 ml

1. Blend A in a blender until smooth.

2. Heat B until all of the agar is dissolved and allow to cool.

3. Mix A, B and C together into a large container.

4. Pour into containers and cover.

APPENDIX C

GRAPE GROWER QUESTIONNAIRE SURVEY

APPENDIX C

GRAPE GROWER QUESTIONNAIRE SURVEY

COOPERATIVE EXTENSION SERVICE
MICHIGAN STATE UNIVERSITY and
U.S. DEPARTMENT OF AGRICULTURE COOPERATING

ENTOMOLOGY
NATURAL SCIENCE BUILDING

EAST LANSING · MICHIGAN · 48824

February 15, 1978

Dear Grape Grower:

As you know, the early grape insects, grape flea beetle (steely beetle) and climbing cutworms have been very damaging pests to vineyards in the past few years. The effective chemicals we have used in the past are gone, and currently available ones have limited effectiveness.

The Department of Entomology at Michigan State University with support of the Michigan Grape Research Council has started a program of cutworm research which should lead to more effective control of these pests. We would like grower cooperation in identifying areas of cutworm damage, finding vineyards to work in and determining the knowledge that growers have about climbing cutworms, their biology and control.

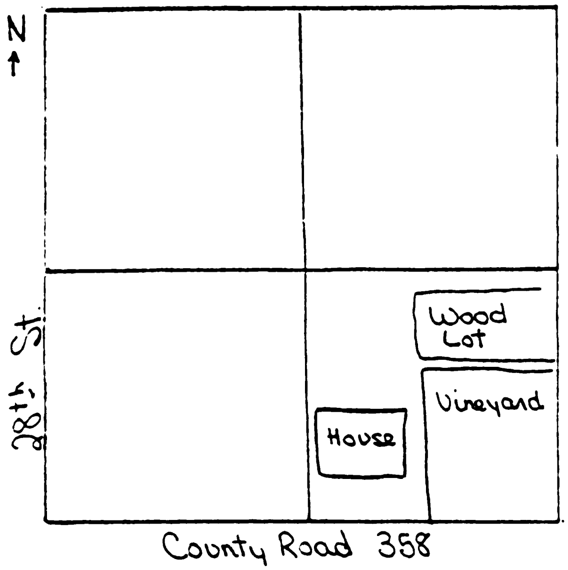
Your help in filling out the enclosed questionnaire and returning it in the enclosed envelope will help us develop for you better knowledge of the life-cycle, food sources, emergence timing and control measures for the cutworms. Several chemicals are being screened currently with the hope that a very effective chemical will be available for you in the next year or two.

The enclosed example sheet shows what data we need. Please draw in the location, as close as possible, of your vineyards. If you have more than one field on a section, please draw them on separate model sections. If you have more than three fields, we would appreciate you including them and answering the questions on another sheet of paper. Your time and effort on this matter will be greatly appreciated.

Jay F. Brunner	Angus J. Howitt	Fred W. Marmor
Extension Fruit Entomologist	Fruit Entomologist	Graduate Student

Enclosure

Please locate vineyards in relation to nearest roads.



Sec. # 27

Township ANTWERP

Acreage 43 ACRES

Age 17 YRS.

Varieties CONCORD

Niagara

Indicate spring bud feeding damage by cutworms:

None______ Light X

Moderate____ Heavy______

Please include any comments as to particular areas where cutworm damage has occured on a yearly basis or other observations which you have made. (e.g. section of vineyard consistently damaged like border rows, northern end of vineyard, southeatern corner, tops of hills, etc.)

At north end of vineyard near the woodlot.
Have also occured on the 6-10 ROWS near the house
Tops of hills and in sandy areas.
Damage is localized

List crops or other habitats which border your vineyard; for example,

Corn	Alfalfa	Open field
Grain	Grapes	Tree line
Asparagus	Road	House, buildings

N Wood lot

S Road C.R.-358

E GRAPES

W House

Name______________________________ Address____________________

Phone No.________________________ ___________________________

Check the insecticides and/or baits used for cutworm control:

Chlordane_____ Parathion_____ Sevin_____ Others_____

Dieldrin______ Penncap M_____ Baits_____ ___________

Did any of the insecticides or baits show favorable results for cutworm control?

Yes_____ Trade Name_________________

No______ ___________________________

What make, model and type of sprayer is used, and what method of spraying is used? (e.g. every row, alternate rows, etc.)

At what time are control measures generally taken for cutworm control?

Fall_______ Day_______

Spring_____ Night_____

If herbicides are used, check which ones:

None_______ Paraquat_____ Others_________

Karmex_____ Simazine_____ _______________

List any weed problems not controlled by herbicides or cultivation practices:

If a cover crop used in the fall, what type of crop is used and approximately what date is it planted?

Cover crop Yes_____ Type_________________

No______ Planting date________

Could I contact you for further information?

Yes_____ No_____

Please locate vineyards in relation to nearest roads.

Sec. #________________

Township________________

Acreage________________

Age________________

Varieties________________

____

____

Indicate spring bud feeding damage by cutworms:

None_______ Light_______

Moderate____ Heavy_______

Please include any comments as to particular areas where cutworm damage has occured on a yearly basis or other observations which you have made. (e.g. section of vineyard consistently damaged like border rows, northern end of vineyard, southeatern corner, tops of hills, etc.)

List crops or other habitats which border your vineyard; for example,

Corn	Alfalfa	Open field
Grain	Grapes	Tree line
Asparagus	Road	House, buildings

N____________________ S____________________

E____________________ W____________________

APPENDIX D

NATURAL ENEMIES OF CUTWORM COMPLEX

APPENDIX D

NATURAL ENEMIES OF CUTWORM COMPLEX

Table D1. List of Parasites and Diseases of the Spotted-sided Cutworm as Reported in Published Literature

Natural Enemy	Reference
Hymenoptera:	
Paniscus geminatus (Say)	Crumb (1929)
Diseases:	
Beauveria spp.	Crumb (1929)
Botrytis rileyi Farl	Crumb (1929)
Entomophora spp.	Crumb (1929)
Sorosporella uvella (Krass)	Crumb (1929)

Table D2. List of Parasites of the W-marked Cutworm as Reported in Published Literature

Natural Enemy	Reference
Diptera:	
Belvosia unifasciata R.-D.	Thompson (1945)
Wagneria rohweri Townsend	Thompson (1945)
Winthemia quadripustulata F.	Thompson (1945)
Hymenoptera:	
Amblyteles flavizonatus Cress	Thompson (1945)
Amblyteles suturalis Say	Thompson (1945)
Apanteles congregatus Say	Thompson (1945)
Apanteles militaris Walsh	Thompson (1945)
Enicospilus purgatus Say	Thompson (1945)
Haltichella perpulchra	Thompson (1945)

Table D3. List of Parasites and Diseases of the Spotted Cutworm as Reported in Published Literature

Natural Enemy	Reference
Diptera:	
Euphorocera claripennis (Macquart)	Crumb (1929)
Winthemia quadripustulata Fab.	Franklin and Lacroix (1904)
Winthemia rufopicta (Bigot)	Arnold (1978)
Hymenoptera:	
Amblyteles seminiger (Cress)	Franklin and Lacroix (1904)
Amblyteles comes (Cress)	Chittenden (1901)
Apanteles xylinus (Say)	Muesebeck (1921)
Apanteles yakutatensis Ashm	Muesebeck (1921)
Euplectrus bicolor Swed.	Franklin and Lacroix (1904)
Ophion bilineatum Say	Crumb (1929)
Diseases:	
Sorosporella uvella (Krass)	Crumb (1929)

Table D4. List of Parasites and Diseases of the Dark-sided Cutworm as Reported in Published Literature

Natural Enemy	Reference
Diptera:	
Aphria ocypterara Townsend	Crumb (1929)
Bonnettia compta (Fallen)	Crumb (1929)
Sarcophaga cimbicis Townsend	Crumb (1929)
Nowickia algens	Arnold (1978)
Hymenoptera:	
Berecynthus bakeri	Walkden (1950)
Meteorus vulgaris Cress	Walkden (1950)
Exetastes spp.	Walkden (1950)
Diseases:	
Bacillus cereus Franklin	Bucher and Cheng (1973)
Enterobacter cloacae (Jordan)	Bucher and Cheng (1973)
Enterobacter aerogenes (Krass)	Bucher and Cheng (1973)
Klebsiella pneumoniae (Scroeter)	Bucher and Cheng (1973)
Streptococcus faecalis (Andrewes)	Bucher and Cheng (1973)
Pseudomonas fluorescens Migula	Bucher and Cheng (1973)
Pseudomonas spp.	Bucher and Cheng (1973)
Bacillus sphaericus Neide	Bucher and Cheng (1973)
Achromobacter spp.	Bucher and Cheng (1973)
Sorosporella uvella (Krass)	Bucher and Cheng (1973)
Metarrhizium anisopliae Metsch	Walkden (1950)

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