OVICIDAL ACTIVITY OF METHOMYL ON EGGS OF PEST AND BENEFICIAL INSECTS AND MITES ASSOCIATED WITH APPLES IN VIRGINIA

by

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INTRODUCTION

The variegated leafroller, *Platynota flavedana* Clemens, and the tufted apple budmoth, *Platynota idaeusalis* (Walker), are important pests of apples in Virginia (Thomas 1976). The two species have very similar life cycles and for control purposes are managed as a complex, referred to herein as *Platynota* spp. Currently, *P. flavedana* is believed to be the predominent species of the complex in Virginia (Bobb 1972, Thomas 1976).

Bobb (1972) made observations of the biology and control of *P. flavedana* in the Piedmont area of Virginia. He found that between 30 to 75% of the apples in three orchards, totaling more than 250 acres, were injured by this leafroller. Bobb conducted field studies on chemical control of 1st generation larvae and found that none of the insecticides being used by orchardists (phosalone, phosmet, TEPP, mevinphos, azinphosmethyl, lead arsenate) were effective for larval control when used according to current recommendations. He also tested numerous compounds in the laboratory for efficacy as larvicides or ovicides and found that only one commercially available insecticide, parathion 15 wp at 0.3 lbs ai/100 gal, showed much promise.

Thomas (1976) conducted basic biological studies of *P. flavedana* in Winchester, Virginia and found that this leafroller damaged 47% of the untreated apples in one experimental orchard during 1974. He evaluated a series of commercially available and experimental compounds and found that none of the standard orchard insecticides (parathion, azinphosmethyl, chlordimeform, diazinon, phosalone, phosmet) provided adequate control. However, he found that formulations of *Bacillus thuringiensis* Berliner provided good control. In 1979, after conducting extensive studies using *B. thuringiensis*, Thomas concluded that the material could provide satisfactory control of infestations of this leafroller if applied at high rates and with proper timing. The degree of control provided by methomyl (Lannate-L) and *B. thuringiensis* were similar but inferior to that obtained with methyl-parathion in his tests. However, due to its high price and the limited degree of control obtained, *B. thuringiensis* was not recommended in Extension spray schedules designed for direct control of pest problems. The most probable acceptable use of *B. thuringiensis* would be as late season or harvest sprays for control of second generation leafroller larvae (Thomas 1979).

Horsburgh et al. (1980) conducted preliminary tests in 1979 using methomyl as an ovicide to control *P. flavedana*. The results indicated that this material had potential for use in this manner and had only moderate detrimental effects on two beneficial species--*Orius insidiosus* (Say) and *Leptothrips mali* (Fitch). In 1980, I decided to further evaluate methomyl with respect to its ovicidal properties on pest and beneficial species of insects and mites and its potential for inclusion in integrated pest management programs for apples in Virginia.

My research explored the following areas: 1) the effect of methomyl on the eggs of various pest insect and mite species associated with apples; 2) methomyl's effect on the eggs of beneficial insect species found on apples; 3) the efficacy of methomyl used as an ovicide against *Platynota* spp. compared with several promising experimental and standard pesticide compounds. An additional area of study was added in 1981 after reviewing the research results of 1980; namely, monitoring the seasonal activity of *P. flavedana* and *P. idaeusalis* in relation to accumulated degree-days in an effort to more precisely time applications of ovicidal sprays.

II. LITERATURE REVIEW

Ovicides in General

Numerous pesticides have been evaluated for their activity on the eggs of various insect and mite species (Ebeling and Pence 1954; Cole 1955; Mehrotra and Smallman 1957; Brazzel and Gaines 1959; Kerr and Brazzel 1960; Henneberry et al. 1961; Bartlett 1964; Zschintzsch et al. 1965; Dittrich 1967; Swenson et al. 1969; Mitri and Kamel 1970; Hartman 1972, 1973; Tysowsky and Gallo 1977; Streibert and Dittrich 1977; Ascher et al. 1978; Singh et al. 1978; Bry et al. 1980; Faragalla et al. 1980; Heinrichs and Valencia 1981). Very few insecticides which are commercially available have been developed for use as an ovicide. The ovicidal activity of insecticides has generally been discovered by accident after their introduction for other specific purposes. Of all the stages of an insect's life cycle, the egg is probably the least studied as a target for specific control measures (Smith and Salkeld 1966). One possible reason for this suggested by Smith and Salkeld (1966) is the long-standing problem of obtaining adequate numbers of eggs for experimental purposes. These authors believe this difficulty is being overcome by improvements in rearing techniques.

Smith and Salkeld (1966) list three prerequisites for effective use of ovicides:

> "(a) The egg must be in an exposed location where lethal concentrations of toxicant can be directed to it. (b) The egg must be susceptible to the toxic effect of the chemical.

(c) A sufficient proportion of the population must be exposed in the egg stage to justify treatment."

These prerequisites are sound and should be considered before a control program using ovicidal materials is considered.

Ovicides differ in their modes of action (Smith and Salkeld 1966) and eggs of different species vary in susceptibility to toxicants over time (Salkeld and Potter 1953). Mode of action and varied susceptibility over time are beyond the realm of this thesis and were not investigated. Under field situations, eggs of a species or several species are deposited over a period of time, resulting in the presence of eggs of varied ages at any given time. From a practical standpoint, ovicide sprays must be stage specific, i.e., egg--rather than stage and age specific.

Ovicides Used for Deciduous Fruit Pests

Traditionally materials exhibiting ovicidal activity such as dinitro-o-cresol, dinitro-o-cyclo-hexylphenol, dinitro-o-secondary butyl phenol, parathion, and petroleum oils either alone or in combination have been used as dormant or delayed-dormant (green-tip) sprays. These sprays have been used to control overwintering eggs of the European red mite, *P. ulmi*, apple aphid, *Aphis pomi* DeGeer, rosy apple aphid, *Dysaphis plantaginea* (Passerini), fruittree leafroller, *Aschips argyrospilus* (Walker), the spring generation eggs of the pear psylla, *Psylla pyricola* Forster, and the redbanded leafroller, *Argyrotaenia velutinana* (Walker), with results depending upon the rate and time of application (Hough 1939, Chapman and Avens 1948, Chapman and Pearce 1949, Mundinger 1952, Kurtz and Fullmer 1959, Smith and Salkeld 1966). Dinitro-oil sprays were objectionable because of their caustic nature which was not only annoying to the applicator, but severely burned any cover crop present at the time of application. This led to the use of phosphate-oil combinations such as ethion and oil (Kurtz and Fullmer 1959).

Currently, the Virginia Tech Extension Service recommends[1] superior oil plus an organophosphate insecticide (chlorpyrifos, carbophenothion, ethion, or parathion mix applied in a prebloom spray (green-tip) and a second spray (7 days after the first spray but before the first pink is visible) to control aphids, mites, redbanded leafrollers in the egg stage, and San Jose scale, Quadraspidiotus perniciosus (Comstock). Since applying superior oil after the pink stage can be phytotoxic, if an ovicide is required after this time another material must be used. The recent escalation of the price of petroleum products has made superior oil sprays increasingly more expensive and less economically attractive to growers.

Organophosphates have exhibited ovicidal activity against some fruit pests. Smith and Aven (1954) investigated the ovicidal activity of parathion for control of the peach tree borer, Synanthedon exitiosa (Say). They found that age of the residue and duration of exposure of the eggs to the residues were important. Parathion exhibited a

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[1] 1981 Virginia Spray Bulletin for Commercial Tree Fruit Growers. Publ. 219. Ext. Div., VPI & SU, Blacksburg, Va.

fumigant effect; a single application of the material (2 lbs of 15% formulation per 100 gallons) provided a toxic residue for over 13 days following application. Exposures of 2 to 6 days were required to cause mortality of eggs deposited on the sprayed surface. The authors observed that in all cases where mortality occurred the embryological development was "apparently" normal to the point of hatch but the insect failed to emerge. This phenomenon appears to be characteristic of organophosphate, chlorinated hydrocarbon, dinitro, or carbamate insecticides that exhibit ovicidal properties (Smith and Salkeld 1966).

Hagley (1975) and Pree (1977) tested various organophosphate compounds for their ovicidal activity aginst eggs of L. pomonella and the apple maggot, Rhagoletis pomonella (Walsh), respectively. Hagley found that azinphosmethyl and phosmet exhibited ovicidal activity, but phosalone did not. Pree observed that fenthion, azinphosmethyl, and phosalone completely inhibited hatch of apple maggot eggs whereas phosmet and dimethoate did not. Pree and Hagley (1977) conducted laboratory studies on the toxicity of azinphosmethyl, phosmet, and permethrin to eggs of the oriental fruit moth, Grapholitha molesta (Busck) and L. pomonella. They found egg age influenced susceptibility in L. pomonella but not in G. molesta and that all materials tested were moderately ovicidal to eggs of both species, but were not likely to provide adequate commercially acceptable control in the field. These results support the findings of Burnson (1960) who also observed that eggs of G. molesta were susceptible to several organophosphate and carbamate compounds. Hoying and Riedl (1980) also found that as eggs of L. pomonella neared hatch they exhibited decreased susceptibility to the growth regulator, diflubenzuron.

Bobb (1972) tested various insecticides against the eggs of *P. flavedana* and found parathion and carbofuran to be ovicidal, providing 84 and 100 percent egg mortality, respectively. Travis et al. (1981) evaluated several insecticides on the eggs of *P. idaeusalis* and found, in his tests, that azinphosmethyl was most effective in preventing emergence of 1st-instar larvae from the egg.

Many compounds have been evaluated in the laboratory for their ovicidal activity, but few are commercially used as ovicides for the control of deciduous tree-fruit pests. The ovicidal activity of some standard insecticides such as azinphosmethyl or parathion enhances the control achieved and can lessen the degree of accuracy required in timing sprays against specific pests. Sprays are rarely applied specifically to take advantage of ovicidal activity.

Methomyl Used as an Ovicide

Chalfant et al. (1979) tested methomyl and other compounds for their ovicidal action on cabbage looper, *Trichoplusia ni* (Hübner) eggs. Their results indicated that methomyl exhibited ovicidal activity. However, they found that to be effective the eggs must be covered by the spray material, since methomyl has little or no fumigant activity. Pitts and Pieters (1980) evaluated eight insecticides, including methomyl, against tobacco budworm, *Heliothis virescens* (F.), eggs and concluded that methomyl was consistently more effective than other chemicals tested as ovicides including the standard, chlordimeform.

Herzog (unpublished data) observed similar results in his tests using methomyl against *H. virescens* and the bollworm, *Heliothis zea* (Boddie). Currently, methomyl is registered for use as an ovicide/larvicide against *H. virescens* and *H. zea* on cotton. In Australia, Waite (1981) demonstrated that methomyl at reduced rates is an effective ovicide for controlling *Heliothis punctiger* Wallengren and *Heliothis armiger* (Hübner) on cotton.

Horsburgh et al. (1980) demonstrated that methomyl has potential for use as an ovicide against orchard pests, specifically *P. flavedana* while the material had only moderate effects on two beneficial species-- *O. insidiosus* and *L. mali*. These tests also demonstrated the importance of good coverage in obtaining satisfactory control with the ovicide. When eggs were placed on the periphery of the tree canopy, significantly greater mortality resulted than was obtained when egg masses were located throughout the canopy, which is where they occur naturally in fruit orchards.

Use of Degree-Days to Predict Seasonal Activity

In the past, tree phenology, bud development in particular, has been used to predict insect and mite development on fruit trees. The use of this method as an index for timing sprays has not been found to be totally reliable (Herne and Trottier 1975). Consequently seasonal activity of a variety of fruit pests has been monitored in terms of accumulated degree-days for predictive purposes. Among fruit pests, the seasonal activity of the apple maggot (Reissig et al. 1979), codling moth (Riedl et al. 1976, Riedl and Croft 1978, Cranhan 1980, Jorgensen et al. 1979, Croft et al. 1980), two cherry fruit fly species (Jubb and Cox 1974), western cherry fruit fly (AliNiazee 1976, 1979), spotted tentiform leafminer and its parasite--*Apanteles ornigis* Weed (Johnson et al. 1979), tufted apple budmoth (Hogmire and Howitt 1979), oriental fruit moth (Bailey 1980, Rice et al. 1982a), San Jose scale (Jorgensen et al. 1981, Rice et al. 1982b), and the European red mite (Trottier and Herne 1979) have been monitored in relation to elapsed degree-days. Cumulative degree-days have been found by the aforementioned authors to be the most accurate method for predicting insect or mite phenology resulting in the ability to more accurately time sprays against specific pest spcies. This improved efficiency helps eliminate excessive, costly sprays which are environmentally deleterious and adversely affect pest management programs. Furthermore, the degree of pest control obtained with a specific pesticide application is improved.

III. OVICIDAL ACTIVITY OF METHOMYL ON EGGS OF INSECT AND MITE PESTS ASSOCIATED WITH APPLE IN VIRGINIA

Introduction

Ovicidal activity of methomyl has been demonstrated against eggs of several pest species such as cabbage-looper, *T. ni* (Chalfant et al. 1979), tobacco budworm, *H. virescens* (Pitts and Pieters 1980), and *H. punctiger* and *H. armiger* (Waite 1981). Horsburgh et al. (1980) demonstrated that the compound has potential for use as an ovicide against orchard pests, specifically *P. flavedana*. The study reported in this thesis was undertaken to assess the effects of methomyl, in the laboratory, against eggs of six pest insect and mite species associated with apple in Virginia.

Materials and Methods

LC_{50} Values for Methomyl on Eggs of Pest Species

Experiment 1

Apples containing *L. pomonella* larvae were collected from an abandoned orchard located in Winchester, Va., during June, 1981, and placed in 3.78 ℓ jars, containing strips of corrugated cardboard ca. .25 cm wide. The larvae pupated within the cells of the cardboard strips. The strips (containing the pupating larvae) were then transferred to 3.78 ℓ jars lined with waxed paper. The adults emerged and after a preoviposition period, oviposited on the waxed paper.

Sections (7 mm diameter) of the paper with egg(s) in situ were removed with a paper punch and affixed to double-coated Scotch(R) tape on a microscope slide, a modification of the acaricide-testing technique (Anon. 1968). Ten eggs were stuck to each of three slides that constituted each treatment. The slides were dipped in the respective treatment solutions which ranged from 100.4 to 538.9 μg ai methomyl/ℓ water plus a water control. Data were recorded (number of hatched eggs) when eclosion for the control treatments ceased.

Experiment 2

Apple leaves bearing eggs of *P. ulmi* were collected from a research orchard in Winchester, Va., on August 4, 1981 and were transported to the laboratory. Irregular-sized leaf sections bearing 10 mite eggs in situ were affixed to double-coated Scotch(R) tape stuck on a microscope slide. A treatment procedure similar to that described in Experiment 1 was followed. Treatment rates ranged from 538.9 to 4856.0 μg ai methomyl/ℓ water; a water control was utilized.

Experiment 3

Egg masses laid by summer generation *Platynota* spp. (*P. flavedana* and *P. idaeusalis* mix) females were collected on August 18, 1981 from a commercial orchard in Nelson County, Va., and taken to the laboratory for experimentation. The leaf clusters bearing the egg masses (Figure 1) were dipped in the respective treatment solutions which ranged from 34.3 to 269.5 μg ai methomyl/ℓ water plus a water control. Leaf clusters were maintained in 50-dram clear plastic vials until egg hatch. One egg mass was used per vial and four, one-vial replicates were used

Fig. 1. Egg mass of Platynota spp. in situ on apple leaf.

per treatment. Data were recorded as number of hatched eggs.

In all three experiments, log-dose mortality was analyzed by probit analysis (Helwig and Council 1979).

Effects of Methomyl at Varied Concentrations on Eggs of Pest Species

The treatment rates of methomyl (Lannate L 1.8) (kg ai/378.5 ℓ water) applied to the eggs of the codling moth, *L. pomonella*; European red mite, *P. ulmi*; the *Platynota* spp.; and the aphid complex (*Aphis* spp., and rosy apple aphid, *D. plantaginea*) were: 0.204, 0.179, 0.153, 0.128, 0.102, 0.076, 0.051, plus a water control. For the red-banded leafroller, *A. velutinana*, the treatment rates (kg ai/378.5 ℓ water) were: 0.204, 0.102, 0.051, 0.026, 0.013, and a water control.

Experiment 4

Eggs of *L. pomonella* were collected and processed in a manner similar to that described in Experiment 1.

Experiment 5

Apple leaves bearing summer eggs of *P. ulmi* were collected from the research orchard in Rockbridge County, Va. on July 9, 1980. Eggs were processed as described in Experiment 2 and a treatment procedure similar to that described in Experiment 1 was followed.

Experiment 6

On March 5, 1981, apple twigs bearing overwintering *P. ulmi* eggs were collected from the research orchard at Steeles Tavern, Va., and brought to the laboratory for processing. Twigs were cut in 2.54 cm sections. Each twig section bore a variable number of eggs ranging from 10 to 35. The sections were affixed to double-stick Scotch(R) tape on a microscope slide (Figure 2). One section was used per slide and four replicates were used per treatment. The slides were processed as described in Experiment 1.

Experiment 7

Leaf clusters bearing egg masses laid by summer generation *Platynota* spp. females were collected on August 5, 1980 from Red Delicious trees in a commercial apple orchard in Nelson County, Va. and returned to the laboratory for study. A similar procedure as that described in Experiment 3 was used to process the egg masses except five replicates were used per treatment.

Experiment 8

Egg masses of *A. velutinana*, laid in April, were located and sprayed in situ to runoff with a 9.5 ℓ compressed-air sprayer with the respective concentrations of insecticide on April 18, 1980 in an abandoned orchard in Winchester, Va. One egg mass was used per replicate and a variable number of replicates (7-10) were used per treatment. Egg masses were caged with screen-topped, 60 ml plastic jelly cups after treatment and allowed to hatch in the field. When hatching ceased, the bark sections containing the egg masses were removed and brought to the laboratory for microscopic examination.

Experiment 9

Apple twigs bearing eggs of *Aphis* spp. and *D. plantagenia* were collected on March 5, 1981 from the research orchard in Rockbridge

Fig. 2. Microscope slide bearing 2.54 cm apple twig section.

County, Va. The eggs were processed using the same procedure as described in Experiment 6. The number of eggs per section ranged from 12 to 43 with five replicates per treatment.

Analysis of variance (ANOVA) and Duncan's Multiple Range Test ($P = .05$) were used to determine differences between treatments in Experiments 4-9.

Results and Discussion

LC_{50} Values for Methomyl on Eggs of Pest Species

Table 1 contains the results of Experiments 1-3. Differences in susceptibility of eggs to methomyl were observed between species. Eggs of *Platynota* spp. and *L. pomonella* were highly susceptible to methomyl treatments. Methomyl appears to be a promising ovicide for *Platynota* spp. and *L. pomonella*. *P. ulmi* eggs were not susceptible to methomyl at the rates tested.

Test populations were collected from areas which had received repeated insecticide applications over several years and the individuals may have exhibited various levels of tolerance of methomyl as indicated by the 95% fiducial limit (Table 1). Some individuals of the population may have been more tolerant of methomyl than were others. This phenomenon may become of greater importance with continued use of this material.

Effects of Methomyl at Varied Concentrations on Eggs of Pest Species

No significant differences ($P < .05$) were observed between means for treatments of *L. pomonella* (Table 2). Significant ($P < .05$) differences were observed between the means for all treatments, except

Table 1. LC_{50} values for methomyl[1] on eggs of pest species.

Species Tested	LC_{50}[2]	(95% Fiducial Limits of LC_{50})[2]	Slope	LC_{90}[2]
L. pomonella	203.4	(103.0 - 285.3)	0.26	892.9
P. ulmi	> 4856.0	---	--	---
Platynota spp.	31.7	(10.6 - 47.6)	0.41	76.6

[1]Lannate 1.8 L formulation.

[2]μg ai/ℓ water.

the 0.102 kg ai/378.5 ℓ rate, and the control. Eggs of L. pomonella appear to be moderately susceptible to methomyl.

For both overwintering and summer generation P. ulmi eggs no significant differences (P > .06 and P > .28, respectively) were observed between means for the methomyl treatments and the control. Methomyl does not exhibit significant ovicidal activity against P. ulmi eggs at any rate that would be commercially acceptable (0.204 kg ai/378.5 ℓ or less).

Eggs of the Platynota spp. complex appear to be highly susceptible to methomyl. Significant differences (P < .01) were observed between means for treatments and control (Table 2). There were no significant differences (P < .01) between means for treatments 0.204 to 0.076 kg ai/378.5 ℓ. The mean for the 0.051 kg ai/378.5 ℓ treatment, however, differed significantly (P < .01) from the means for the other treatments and the control. These results indicate that methomyl has potential for controlling the Platynota spp. using reduced rates of the material, i.e., less than 0.204 kg ai/378.5 ℓ.

The eggs of the Platynota spp., as well as those of other lepidopterous pests studied, which were killed contained highly developed embryos which failed to emerge (Figure 3) or possessed larvae which had partially emerged through the chorion (Figure 4) and then died. Lepidoptera eggs have been shown to be more easily killed just before eclosion using organophosphate and carbamate insecticides than are other less developed eggs (Smith and Salkeld 1966).

Significant differences (P < .01) between means for treatments and between means for treatments and control (except for the 0.013 kg ai/

Fig. 3. Eggs of <u>Platynota</u> spp. treated with methomyl, from which the larvae failed to hatch.

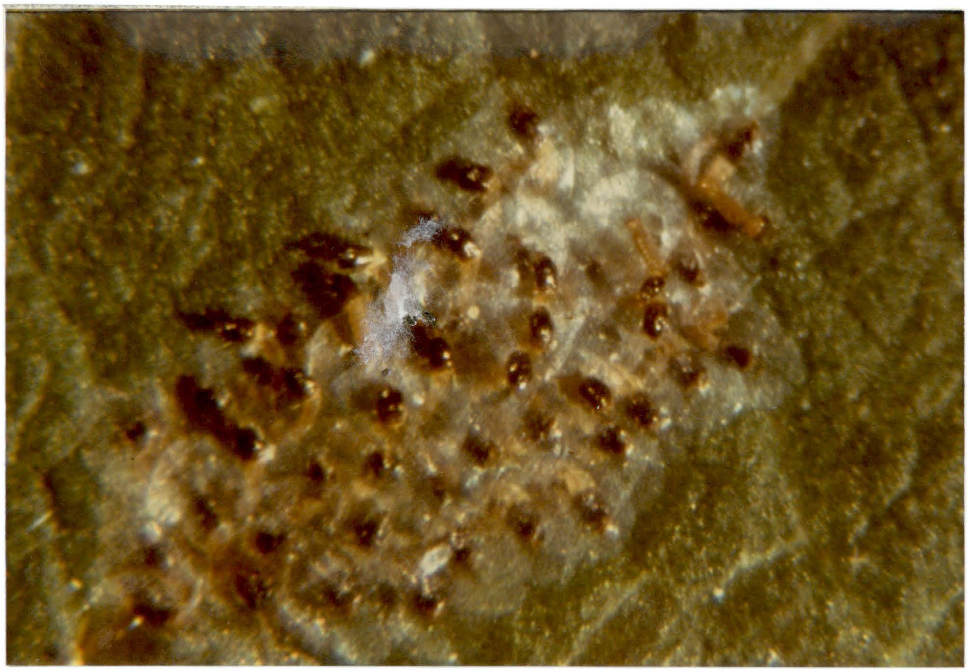

Fig. 4. Eggs of <u>Platynota</u> spp. treated with methomyl where larvae succumbed after partially emerging from egg.

378.5 ℓ rate) for A. velutinana were observed (Table 2). Of the rates tested, only the 0.204 kg ai/378.5 ℓ rate provided a high level of control.

Methomyl appears to be highly toxic to eggs of Aphis spp. and D. plantaginea. Significant differences ($P < .01$) were observed between means for treatments and the control. No significant differences between means for treatments were observed as 100 percent mortality occurred in all (Table 2). Methomyl may have potential for use as an ovicide against aphid eggs during the silver-tip to green-tip stage of bud development. However in tests conducted during 1981, David et al. (1982) illustrated that concentrate sprays of methomyl applied at extremely low rates of 0.25 kg ai/HA (0.03 kg ai/378.5 ℓ) or lower with an air-blast sprayer did not provide commercially acceptable control of aphids.

Methomyl appears to be ovicidal, even at reduced rates, against all species tested, except P. ulmi. It shows promise for use in this manner in commercial spray programs. However, care should be taken in extrapolating these results to field conditions. As illustrated by Horsburgh et al. (1980), optimal control depends on good coverage. Chalfant et al. (1979) observed that methomyl must come in contact with the insect eggs to be effective because no fumigant activity was demonstrated. In all probability, the degree of control obtained in the field will be less than that observed in the laboratory using comparable tank concentrations of the pesticide. Consequently, further evaluation of the material under a commercial application procedure is

Table 2. Ovicidal activity of methomyl[1] on eggs of pest species.

	$\bar{X}$ % Mortality			
Kg ai/378.5 ℓ	*L. pomonella*[2]	*Platynota* spp.[3]	*A. velutinana*[3]	Aphididae[3]
0.204	84.28 a	100.00 a	100.00 a	100.00 a
0.179	70.33 a	100.00 a	NT	100.00 a
0.153	83.26 a	99.34 a	NT	100.00 a
0.128	78.27 a	100.00 a	NT	100.00 a
0.102	46.14 ab	98.74 a	50.18 b	100.00 a
0.076	54.72 a	99.37 a	NT	100.00 a
0.051	56.84 a	72.98 b	25.30 b	100.00 a
0.026	NT	NT	32.69 b	NT
0.013	NT	NT	0.25 c	NT
Control	6.70 b	0.11 c	2.05 c	19.50 b

NT = not tested.

[1]Lannate 1.8 L formulation

[2]Means in the same column followed by the same letter are not significantly different ($P < .05$); Duncan's Multiple Range Test. Data were transformed using arcsin ($\sqrt{x}$) for analysis.

[3]Means in the same column followed by the same letter are not significantly different ($P < .01$); Duncan's Multiple Range Test. Data were transformed using arcsin ($\sqrt{x}$) for analysis.

in progress at the Winchester Fruit Research Laboratory as a direct result of this study.

IV. OVICIDAL ACTIVITY OF METHOMYL ON EGGS OF BENEFICIAL INSECTS ASSOCIATED WITH PESTS OF APPLES IN VIRGINIA

Introduction

Horsburgh et al. (1980) found that *P. flavedana*, one of the most important pests of apples in Virginia, was highly susceptible to methomyl (Lannate-L) treatments applied during the egg stage. They also observed that eggs of two beneficial insect species, namely *O. insidiosus* and *L. mali*, were only moderately susceptible to the toxicant. The objective of this study was to assess the effects of methomyl, in the laboratory, on eggs of beneficial insects associated with pests of apples in Virginia.

Materials and Methods

LC_{50} Values of Methomyl on Eggs of Beneficial Insects

Experiment 1

Chrysopa spp. eggs were collected in Winchester, Va. from a research orchard on May 26, 1981 and brought back to the laboratory for experimentation. Eggs were removed from the leaf surface and affixed to double-coated Scotch$^{(R)}$ tape on a microscope slide (Anon. 1968). Ten eggs were affixed to each slide and three replicates were used per treatment. Slides were dipped in treatment solutions which ranged from a rate of 269.5 to 4856.0 μg ai methomyl/ℓ of water. A water control was included. Data were recorded as number of hatched eggs when eclosion ceased.

Experiment 2

O. insidiosus oviposits its eggs within the midvein of apple leaves. On July 10, 1981 adults were allowed to oviposit in green bean pods to protect the eggs from tissue shrinkage that occurs when apple leaves are excised. Green bean pods do not shrink badly and consequently the eggs are not damaged (McCaffrey 1981). Three pods were used per treatment; each pod contained a variable number of eggs. The range was from 7 to 40. Rates used in the treatments ranged from 404.2 to 1619.6 μg ai methomyl per ℓ of water; a water control was added. The treated pods were allowed to dry and then were placed in empty styrofoam cups until eclosion. The number of eggs per pod and the number of unhatched eggs were recorded.

Experiment 3

Eggs of S. punctum were collected from a research orchard in Winchester, Va. on July 17, 1981 and processed in a manner similar to that described in Experiment 1. Treatment rates ranged from 7.9 to 134.7 μg ai of methomyl per ℓ of water plus a water control.

In all three experiments, log-dose mortality was analyzed by probit analysis (Helwig and Council 1979).

Effects of Methomyl at Varied Concentrations on Eggs of Beneficial Insects

Seven treatments plus a water control were used in Experiments 4-9. The treatment rates (kg ai/378.5 ℓ water) were: (1) 0.204, (2) 0.179, (3) 0.153, (4) 0.128, (5) 0.102, (6) 0.076, (7) 0.051, (8) water control.

Experiment 4

Syrphid fly eggs were collected from a commercial orchard in Nelson County, Va. on June 16, 1980. Sections (7 mm diameter) of apple leaves with egg(s) in situ were removed with a paper punch and affixed to double-coated Scotch$^{(R)}$ tape on a microscope slide (Figure 5). Prepared slides were processed in a manner similar to that described in Experiment 1.

Experiment 5

On June 28, 1980, eggs of Aphidoletes aphidimyza (Rondani), an aphidophagous cecidomyiid, were collected from the Shenandoah Valley Research Station orchard located in Rockbridge County, Va. A procedure similar to that outlined in Experiment 4 was followed to prepare the slides and insecticide was applied using the methods outlined in Experiment 1. Data were recorded as number of larvae present since the larvae apparently consume the egg chorion during or after eclosion.

Experiment 6

L. mali adults were collected in an abandoned apple orchard located in Augusta County, Va., on July 11, 1980 and placed for 6 days

Fig. 5. Microscope slide bearing 7 mm diameter leaf sections.

in rearing cages containing mite infested leaves (McCaffrey 1981). On July 17, the eggs laid along the leaf midvein were teased out and processed in a manner similar to that described in Experiment 1. Due to the paucity of eggs, treatment 2 was omitted.

Experiment 7

Eggs of Stethorus punctum (LeConte) were collected on July 30, 1980, from a commercial apple orchard located in Nelson County, Va. The eggs were processed using a similar procedure as that described in Experiment 3.

Experiment 8

Chrysopa spp. eggs were collected from a Nelson County, Va. commercial apple orchard on July 31, 1980. The eggs were processed following the procedure similar to that described in Experiment 1.

Experiment 9

On August 8, 1980, using the method described in Experiment 2, eggs of O. insidiosus were obtained from field-collected adults. A variable number of eggs ranging from 10 to 64 was used per one-pod replicate. Egg-bearing pods were processed in a manner similar to that described in Experiment 2.

Analysis of variance (ANOVA) and Duncan's Multiple Range Test (P = .05) were used to determine differences between treatments in Experiments 4-9.

Results and Discussion

LC_{50} Values of Methomyl on Eggs of Beneficial Insects

Table 3 contains the results of the first three experiments. Differences in susceptibility of eggs to methomyl were observed between species. Eggs of *S. punctum* were highly susceptible to methomyl treatments. *O. insidiosus* eggs were moderately susceptible and eggs of *Chrysopa* spp. were susceptible only at extremely high rates of methomyl.

Test populations were collected from areas which had received repeated insecticide applications over several years and the individuals may have exhibited various levels of tolerance of methomyl as indicated by the 95% fiducial limit for *S. punctum*, in particular. Some individuals of the population may have been more tolerant of methomyl than were others. A phenomenon which could become of increasing importance with continued use of this compound.

Effects of Methomyl at Varied Concentrations on Eggs of Beneficial Insects

There was significantly ($P < .01$) more mortality of syrphid fly eggs treated with methomyl than in the water control (Table 4). Significant differences between means for several methomyl treatments were observed. However, even the low concentration in treatment 7 (0.051 kg ai/378.5 ℓ) resulted in 87% egg mortality. Syrphid fly eggs are highly susceptible to methomyl even at reduced rates (less than 0.204 kg ai/378.5 ℓ).

Eggs of *A. aphidimyza* were also highly susceptible to the methomyl treatments. Significantly ($P < .01$) less egg hatch resulted

Table 3. LC_{50} values for methomyl[1] on eggs of beneficial insects.

Species Tested	LC_{50}[2]	(95% Fiducial Limits of LC_{50})[2]	Slope	LC_{90}[2]
Chrysopa spp.	4655.2	(3165.1 - 9638.0)	0.05	84774.1
O. insidiosus	496.7	(396.3 - 578.6)	0.36	1133.4
S. punctum	60.8	(21.1 - 1585.2)	0.26	398.9

[1] Lannate 1.8 L formulation.

[2] μg ai/ℓ water.

in the methomyl treatments compared to the water control (Table 4). There were significant differences among several methomyl treatments, but mortality was relatively high for all treatments.

There were no significant ($P < .01$) differences between means for the methomyl treatments on eggs of L. mali as 100% mortality was observed in all (Table 4). A significant difference betwen means was found between the treatments and the control. Horsburgh et al. (1980) found that when eggs were treated in situ on the apple leaf, 64.9 percent mortality resulted using the 0.204 kg ai/378.5 ℓ rate. In both cases, L. mali appears to be highly susceptible to methomyl, but its natural location on the apple leaf affords it some protection. This phenomenon probably holds true for the other species tested and the mortality in the field is expected to be less than that observed in the laboratory.

S. punctum eggs were susceptible to methomyl treatments. No significant differences ($P < .01$) between methomyl treatment means were observed (Table 4). Significant differences between the means for the treatment and control groups were observed. Colburn (1976) found that S. punctum adults were highly susceptible to methomyl. From these results, it appears that in ongoing pest management programs using S. punctum as the primary predator of P. ulmi, such as the Pennsylvania program (Asquith and Hull 1979), methomyl will have a disruptive effect. Consequently, its use cannot be recommended in such a system.

In the study of eggs of Chrysopa spp., no significant ($P > .07$) differences in egg mortality were observed between means for the methomyl treatments and the control. Twenty-four of the eggs were parasitized by Trichogramma minutan Riley[1] and 92 percent of the parasites emerged. The parasitized eggs were randomly distributed among the treatment and control groups. Bartlett (1964) found that eggs of Chrysopa carnea Stephens were notably tolerant to all of the 57 pesticides tested except oil. It appears that Chrysopa spp. eggs survive methomyl applications reasonably well, a phenomenon that could be of use in designing integrated pest management programs.

O. insidiosus proved to be only moderately susceptible to the methomyl treatments in this experiment. Significant ($P < .01$) differences between means for several treatments and between means for the treatments and control were observed (Table 4). In the tests conducted by Horsburgh et al. (1980), they found that O. insidiosus eggs were not susceptible to methomyl at the 0.204 kg ai/378.5 ℓ rate. Their preliminary test involved a sample of 20 eggs and was not replicated.

O. insidiosus oviposits its eggs in plant tissue with only the operculum exposed, probably affording its eggs some protection from the toxicant. Many predatory mirids also oviposit in plant tissue and similar tolerance to methomyl might be expected. However, further studies need to be conducted to see if this extrapolation is valid.

Eggs of syrphid flies, A. aphidimyza, L. mali, and S. punctum were highly susceptible to methomyl, but eggs of Chrysopa spp. and O. insidiosus exhibited little or only moderate susceptibility to the toxicant. Consequently, it appears that methomyl has little promise

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[1]Identified by E. E. Grissell, Systematic Entomology Laboratory, USDA, Washington, D.C.

Table 4. Ovicidal activity of methomyl[1] on eggs of beneficial insects.

	$\bar{X}$ % Mortality				
Kg ai/378.5 ℓ	Syrphidae[2]	*A. aphidimyza*[2]	*L. mali*[2]	*S. punctum*[2]	*O. insidiosus*[2]
0.204	100.00 a	100.00 a	100.00 a	100.00 a	57.61 a
0.179	100.00 a	100.00 a	NT	100.00 a	54.57 a
0.153	98.85 a	100.00 a	100.00 a	95.47 a	22.50 bc
0.128	97.63 abc	100.00 a	100.00 a	100.00 a	39.39 ab
0.102	77.85 c	100.00 a	100.00 a	84.65 a	11.93 cd
0.076	97.63 abc	73.80 b	100.00 a	86.99 a	19.65 bc
0.051	86.99 bc	77.85 b	100.00 a	90.00 a	24.96 bc
Control	6.70 d	4.53 c	8.76 b	10.84 b	1.41 d

NT = not tested.

[1]Lannate 1.8 L formulation.

[2]Means in the same column followed by the same letter are not significantly different ($P < .01$); Duncan's Multiple Range Test. Data were transformed using arcsin ($\sqrt{x}$) for analysis.

for use in an orchard under an integrated pest management (IPM) program, such as those described by Asquith and Hull (1979), because of its high toxicity to most beneficial insects. However, if applications of the material can be timed for periods when susceptible predators are not present or when their eggs are protected within the plant tissue, this problem may be partially overcome. Sprays of methomyl in the dormant stage of bud development can be very effective in controlling certain pest species, such as aphids, which are in the egg stage. Otherwise, methomyl sprays should be applied in an orchard under an IPM program only when less toxic materials cannot adequately control pest populations.

V. METHOMYL USED AS AN OVICIDE TO CONTROL THE *PLATYNOTA* SPP. COMPLEX IN VIRGINIA APPLE ORCHARDS

Introduction

The *Platynota* spp. complex, *P. flavedana* and *P. idaeusalis*, is a serious threat to apples grown in Virginia. The primary damage results from the larvae feeding on and disfiguring the fruit during mid and late season. None of the insecticides commonly used by orchardists in Virginia effectively suppress the larval stage of this pest (Bobb 1972; Thomas 1976, 1979; Hill and Cobb 1980; Cobb and Poe 1981) so as to maintain fruit injury at harvest below the 1% economic injury level (Croft 1975).

Horsburgh et al. (1980) in preliminary tests demonstrated that methomyl can effectively prevent egg hatch if good spray coverage is achieved. David et al. (1981) illustrated that methomyl effectively prevented egg hatch, in the laboratory, when used at rates as low as 0.076 kg ai/378.5 ℓ water. The objective of this experiment was to evaluate methomyl (Lannate 1.8 L) as an ovicide and to compare it with several experimental and registered larvicides for control of the *Platynota* complex under field conditions.

Materials and Methods

Insecticides were applied to mature, standard York trees replicated four times in single tree plots in a randomized block design in a commercial orchard located in Winchester, Va. Sprays were applied to runoff with a handgun on August 31, 1981, which coincided with the peak egg deposition of the second generation of *Platynota* spp.; and on September 10, 1981 when larvae were in the early instars. Treatments were applied with a Bean 132.5 litre/min. hydraulic pump operating at 21.1 kg/cm^2. Insecticides used in the experiment were methomyl (Lannate L 1.8), FMC 45806 (Ammo), permethrin (Ambush), *Bacillus thuringiensis* (Dipel wp). The check treatment was unsprayed.

Fruit was harvested on September 19, 1981 by randomly selecting 200 apples per tree (800/treatment) and was checked for late season damage by the *Platynota* spp. complex (Figure 6). Analysis of variance (ANOVA) and Duncan's Multiple Range Test ($P = .05$) were used to determine differences between treatments.

Results and Discussion

Control obtained by all materials tested differed significantly ($P < .01$) from the unsprayed check (Table 5). No significant ($P < .01$) differences were observed between the means for the treatments. Methomyl at the 946.24 and 473.12 ml/378.5 ℓ of water rates provided the best control, but not statistically better than the other materials. FMC 45806 at the 18.92 ml and 22.68 gm/378.5 ℓ of water rates provided good control. Leafroller damage to the fruit in all treatments, except the 473.12 ml/378.5 ℓ rate of methomyl, exceeded the 1% economic injury level.

Fig. 6. Damage to apple caused by _Platynota_ spp. larvae.

Table 5. Comparison of methomyl with other experimental and registered pesticides for *Platynota* spp. complex[1] control.

Material and Amount per 378.5 ℓ	Mean % Apples Damaged by *Platynota* spp.[2,3]
Methomyl (Lannate 1.8 L) 236.59 ml	1.48 b
Methomyl (Lannate 1.8 L) 473.12 ml	0.93 b
Methomyl (Lannate 1.8 L) 946.24 ml	1.06 b
FMC 45806 (Ammo 2.5 E) 18.92 ml	1.94 b
FMC 45806 (Ammo 25 W) 22.68 gm	1.28 b
Permethrin (Ambush 2 E) 189.25 ml	3.23 b
Bacillus thuringiensis (Dipel WP) 5.44 BIU	3.56 b
Check - unsprayed	12.39 a

[1]Consisting of *P. flavedana* and *P. idaeusalis*.

[2]Means followed by the same letter in the same column are not significantly different ($P < .01$); Duncan's Multiple Range Test. Data were transformed to arcsin $\sqrt{x}$ for analysis.

[3]200 apples/one tree replicate, 4 replicates/treatment, sprays applied to runoff with a handgun on August 31 and September 10 with a Bean 132.5 ℓ/min hydraulic pump operating at 21.1 kg/cm^2 to mature, standard York trees.

These data indicate that methomyl applied as an ovicide and larvicide for early instars can effectively control the Platynota complex under field conditions in Virginia. Studies using air-blast applied concentrate sprays should be conducted to determine if similar results can be obtained. Further testing to determine if the ovicidal application alone would provide adequate control is in progress at the Winchester Fruit Research Laboratory. Results can then be incorporated in recommendations for the best use of this material by commercial fruit growers in the state.

VI. A PRELIMINARY STUDY OF THE SEASONAL ACTIVITY OF PLATYNOTA FLAVEDANA CLEMENS AND PLATYNOTA IDAEUSALIS (WALKER) IN VIRGINIA APPLE ORCHARDS

Introduction

Populations of the variegated leafroller, *Platynota flavedana* Clemens, and a closely related species the tufted apple budmoth, *Platynota idaeusalis* (Walker), (together referred to as the *Platynota* complex) in Virginia commercial apple orchards consistently cause fruit damage at harvest which exceeds the 1% economic injury level set by Croft (1975) despite orchardists' efforts to control this pest (Bobb 1972; Thomas 1976, 1979). *P. flavedana* is believed to be the predominant species in Virginia (Bobb 1972, Thomas 1976). Control measures for this pest complex must be directed at the egg or first instar larval stages because the older larvae are protected in leafrolls making control extremely difficult (Thomas 1976, 1979). Consequently, proper timing of sprays against the *Platynota* complex is extremely important. Past methods utilizing calendar dates or tree phenology as an index for timing sprays have not been found to be totally reliable for the *Platynota* spp. or other fruit pests (Herne and Trottier 1975). Phermone traps have been used to detect the presence or absence of *P. flavedana* and *P. idaeusalis* in orchards, but not as a tool for timing sprays. The objective of this preliminary study, undertaken during the 1981 growing season, was to determine if the seasonal activity of *P. flavedana* and *P. idaeusalis* could be related to cumulative degree-days allowing the development of a phenology model to assist growers in timing sprays against the pests.

Materials and Methods

Seven orchards (4 in Frederick County, 1 in Madison County, 1 in Rockbridge County, 1 in Nelson County) were sampled weekly for P. flavedana and P. idaeusalis. Male moth flights were monitored using Zoecon Corp. Pherocon(R) 1C sticky traps baited for P. flavedana with 5.0 mg of the company's 1981 sex phermone formulation #1298152 on a plastic cap and for P. idaeusalis with Zoecon's sex phermone formulation trans-11-tetradecenyl alcohol plus trans-11-tetradecenyl acetate on a plastic cap. Phermone caps were changed every 6 weeks and trap bottoms were changed after ca. 70 moths were caught in the traps. Fifteen trees per orchard were randomly selected and tagged during the dormant stage of bud development. These trees were sampled weekly for Platynota spp. egg masses [(egg masses of P. flavedana and P. idaeusalis are indistinguishable in the field) (see Figure 2)] using a 3 minute visual search of the foliage per tree to a height of 3.6 m above ground using a 5 m tall orchard ladder. Egg hatch was monitored by observing tagged egg masses.

A modified Stevenson Screen weather station containing a Bendix(R) hygrothermograph was placed in each orchard on January 1. Degree-days were calculated from daily minimum and maximum temperatures according to the sine-wave method described by Baskerville and Emin (1969). A developmental threshold of 48°F (8.9°C) was used for

P. idaeusalis (Hogmire and Howitt 1979). Due to lack of developmental data for *P. flavedana* it is assumed that it too has a developmental threshold of 48°F (8.9°C).

Results and Discussion

P. flavedana and *P. idaeusalis* populations during the 1981 season were small compared to previous years. Low population levels of these leafrollers during the 1981 season were also observed in Pennsylvania (Hull pers. comm.) and West Virginia (Hogmire pers. comm.) orchards. For the overwintering generation, variegated leafroller populations failed to develop in the Madison and one Frederick County orchard; as a result, these sites were dropped from the study. In the Rockbridge County orchard, hygrothermograph problems and low leafroller populations caused the deletion of this orchard from the study. Adequate population densities of the overwintering generation of *P. idaeusalis* were present in all sampled orchards except the Rockbridge County site. However, based on the importance given to *P. flavedana* in the work of Bobb (1972) and Thomas (1976) only the orchards possessing populations of *P. flavedana* were retained in the study.

Summer generation of *P. flavedana* populations developed in one Frederick County and the Nelson County study site. *P. idaeusalis* populations during the summer generation were present in the Frederick County orchards, but not numerous enough in the Nelson County orchard where *P. flavedana* was the predominent species. Overwintering and summer generation *Platynota* spp. egg deposition was extremely light in the orchards sampled.

The data from this study suggests that P. flavedana may not be the predominant species in Virginia. These data indicate that there is a mix of P. flavedana and P. idaeusalis in some orchards with P. flavedana being the predominant species in the Piedmont region of Virginia and P. idaeusalis being the predominant species in the upper Shenandoah Valley. However, further study of this phenomenon must be conducted before the actual distribution of these leafrollers can be defined. It appears that a phenology model of seasonal activity of the Platynota spp. in Virginia will have to incorporate both P. flavedana and P. idaeusalis for more accurate predictions of events such as egg deposition and hatch.

Tables 6 and 7 contain summaries of observed P. flavedana and P. idaeusalis activity for overwintering and summer generations, respectively. Riedl et al. (1976) noted that the reliability of physiological time models (degree-days) for forecasting decreases over time if reference to the actual population, which is naturally variable, is not made. Glenn (1922) and Shelford (1927) suggested the use of biological reference points (biofix points), such as first moth catch, and starting the accumulation of degree-days from these points for a more realistic prediction. Consequently, biofix points will be referred to in this study. Biofix I is defined as the first male P. flavedana moth(s) in the phermone trap with no significant interruption in catches thereafter. Biofix II is defined similarly, but for the summer generation P. flavedana activity.

Table 6. Summary of observations of seasonal activity of overwintering generation *P. flavedana* and *P. idaeusalis*, 1981.

Event	Ave. No. DD_{48} ± 1SD
P. flavedana[1]	
1st male moth catch	620.7 ± 32.3[3] (Biofix I)
50% male moth catch	918.8 ± 69.8[3]
P. idaeusalis[2]	
1st male moth catch	584.7 ± 114.2[3]
50% male moth catch	885.8 ± 131.6[3]
Platynota spp.[4]	
1st oviposition	836.3[5]
50% oviposition	1231.0[5]
1st egg hatch	1044.3[5]

[1]Based on four orchards.

[2]Based on six orchards.

[3]From Jan. 1.

[4]Mix of *P. flavedana* and *P. idaeusalis*.

[5]From biofix I (1st male moth(s) in trap with no significant interruption in catch thereafter) based on Nelson Co. orchard data.

Table 7. Summary of observations of seasonal activity of summer generation P. flavedana and P. idaeusalis, 1981.

Event	Ave. No. DD_{48} ± 1SD
P. flavedana[1]	
1st male moth catch	2069.4 ± 120.6[3] (Biofix II)
50% male moth catch	3210.6 ± 127.8[3]
P. idaeusalis[2]	
1st male moth catch	2077.1 ± 105.9[3]
50% male moth catch	2931.6 ± 354.4[3]
Platynota spp.[4]	
1st oviposition	916.0 ± 228.4[5]
50% oviposition	1112.1 ± 318.7[5]
1st egg hatch	1102.8 ± 233.5[5]

[1]Based on two orchards.

[2]Based on three orchards.

[3]From Jan. 1.

[4]P. flavedana and P. idaeusalis mix.

[5]From biofix II (1st male moth(s) in trap with no significant interruption in catch thereafter) based on two orchards.

P. flavedana male moth catches for overwintering and summer generations were based on data from four and two orchards, respectively. Male moth catches of *P. idaeusalis* for overwintering and summer generations were based on data from six and three orchards, respectively. Weekly moth catches were converted to cumulative percent catch per generation per species. When the cumulative percent moth catches per generation per species for the locations were plotted against degree-day accumulations, the relationship between the two variables followed a sigmoid curve. To develop a predictive equation for moth emergence per generation per species the data from all study sites were pooled. The percentage values were transformed to probits to linearize the sigmoid emergence curves. Using these data regression equations were computed using the General Linear Models (GLM) procedure of Statistical Analysis System (SAS) which utilizes the principle of least squares to fit linear models (Helwig and Council 1979).

These equations are of the form $Y = a + bx$ where "Y" is the probit of the cumulative emergence or deposition estimate, "a" is the intercept of the regression line of the Y axis, "b" is the regression coefficient, and "x" is the cumulative number of degree-days from January 1 except for the summer-generation egg deposition equation where "x" is the cumulative number of degree-days from biofix II. Table 8 contains the regression equations for both the overwintering and summer generation *P. flavedana* and *P. idaeusalis* male moth flights and summer generation *Platynota* spp. egg deposition.

From these data, it appears that seasonal activity of *P. flavedana* and *P. idaeusalis* can be predicted in terms of accumulated degree-days.

Table 8. Regression equations relating probits of cumulative percents of (1) overwintering and summer generation moth flights of *P. flavedana* and *P. idaeusalis* and (2) summer generation egg deposition of *Platynota* spp.[1] to degree-day accumulations, 1981.

Event	Regression Equation	SE of Regression Coefficient	r^2
	P. flavedana		
Overwintering generation male moth flight[2,4]	y = 0.51022 + 0.00465x	0.00027	.91
Summer generation male moth flight[2,5]	y = -1.98762 + 0.00224x	0.00025	.76
	P. idaeusalis		
Overwintering generation male moth flight[2,6]	y = -21.74514 + 9.15049x	0.89425	.69
Summer generation male moth flight[2,7]	y = -38.81534 + 12.74218x	2.97015	.42
	Platynota spp.		
Summer generation egg deposition[3,5]	y = -27.68291 + 11.23152x	9.56625	.22

[1] *P. flavedana* and *P. idaeusalis* mix.

[2] y = probits of cumulative % emergence estimate; x = cumulative number of DD_{48} from Jan. 1.

[3] y = probits of cumulative % emergence estimate; x = cumulative number of DD_{48} from biofix II.

[4] Date were pooled from 4 sites.

[5] Data were pooled from 2 sites.

[6] Data were pooled from 6 sites.

[7] Data were pooled from 3 sites.

These data (Table 8) suggest that *P. flavedana* activity may be predicted more accurately than the activity of *P. idaeusalis*. Also, it appears that overwintering generation activity for each species can be more accurately predicted than the summer generation activity. This conclusion differs from that observed by Hogmire and Howitt (1979) for *P. idaeusalis* populations in Michigan. They noted a higher degree of accuracy in predicting 1st generation (= summer generation) adult male populations than spring generation (= overwintering generation) male flight activity. The authors suggested that this phenomenon was probably due to greater temperature fluctuation typically encountered in the spring.

Variablity in the phenology of *P. flavedana* and *P. idaeusalis* may be additive over the two generations. The variability of the spring generation could adversely affect the predictability of the activity of the summer generation. Consequently, male moth flights and egg deposition of *P. flavedana* and *P. idaeusalis* may be more difficult to predict during the summer generation.

This study included only one environmental parameter, air temperature, but as Hogmire and Howitt (1979) suggest, other parameters such as soil temperature and rainfall may greatly influence the development of these leafrollers especially during the fall and spring when the larvae inhabit leaf litter on the orchard floor. There may also be a high limiting temperature occurring during the summer above which physiological development ceases. Furthermore, predictability of seasonal activity can be influenced by the accuracy of temperature monitoring instruments. Undetected inaccuracy on these instruments can introduce a degree of variability into the data which can become significant as the season progresses if cumulative degree-day values are used instead of degree-day accumulations from a biofix point.

Egg deposition and hatch periods have considerable variability (ca. 7-10 days and 1-4 days, respectively) associated with them. This is probably a result of overlapping generations of P. flavedana and P. idaeusalis (the latter occurs ca. 7-14 days earlier than the former), complicated by the indistinguishable appearance of egg masses of the two species which occur concurrently. Consequently, a phenology model may only be able to give growers a reliable starting point at which they should begin monitoring for Platynota spp. egg deposition in their orchards rather than a precise date for spray applications. This starting point will be of considerable assistance to growers because it will serve as an alert that the oviposition period is near. But, considerably more research input into developing such a model is necessary. The ability to distinguish between egg masses of P. flavedana and P. idaeusalis would greatly improve the precision of such a model as would more accurate egg sampling schemes and species distribution information.

These data presented here are preliminary in nature and will have to be validated in future experimentation before any definite conclusions or management decisions can be made concerning the seasonal activity of P. flavedana and P. idaeusalis. However, it appears that with additional research input, seasonal activity of these species can be predicted in terms of accumulated degree-days. The author recommends that a more detailed bionomic study of P. flavedana and

P. idaeusalis be conducted in an effort to develop phenology models for the species and expand knowledge of the biology of these important pests in Virginia apple orchards.

SUMMARY

Methomyl has been evaluated for its ovicidal activity against eggs of *Trichoplusia ni*, *Heliothis virescens*, *Heliothis zea*, *Heliothis punctiger*, and *Heliothis armiger*, with promising results. Currently, methomyl is registered for use as an ovicide/larvicide against *H. virescens* and *H. zea* on cotton. Studies were undertaken during 1980 and 1981 to evaluate the effect of methomyl (Lannate 1.8 L) on eggs of pest and beneficial insects and mites associated with apples in Virginia.

Methomyl at the 0.051, 0.076, 0.102, 0.128, 0.153, 0.179, and 0.204 kg ai/378.5 ℓ water rates was evaluated against eggs of *Lasperyresia pomonella*, *Panonychus ulmi*, *Platynota* spp. (*P. idaeusalis* and *P. flavedana* mix), and the aphid complex (*Aphis* spp. and *Dysaphis plantaginea* combination) in the laboratory. Eggs of the *Platynota* spp. and aphids were highly susceptible to methomyl at the lowest rates tested. For aphids, 100% mortality was observed in all methomyl treatments, while average percent mortality for the *Platynota* spp. ranged from 72.98 to 100 for the 0.051 and 0.204 kg ai/378.5 ℓ treatments, respectively. *L. pomonella* eggs were moderately to highly susceptible to methomyl treatments with average percent mortality for the 0.051 and 0.204 kg ai/378.5 ℓ rates being 56.84 and 84.28, respectively. Neither overwintering or summer generation eggs of *P. ulmi* were susceptible to the toxicant.

The susceptibility of eggs of Argyrotaenia velutinana to methomyl was evaluated at the 0.013, 0.026, 0.051, 0.102, 0.204 kg ai/378.5 ℓ water rates. These eggs also proved to be highly susceptible to methomyl treatments with average percent mortality varied from 0.25 to 100 for the 0.013 and 0.204 kg ai/378.5 ℓ water treatments, respectively.

Seven concentrations of methomyl, 0.051, 0.076, 0.102, 0.128, 0.153, 0.179, 0.204 kg ai/378.5 ℓ water, were evaluated, in the laboratory, against eggs of seven beneficial insect species associated with pests of apples. These insects were: Syrphid flies, Aphidoletes aphidimyza, Leptothrips mali, Stethorus punctum, Chrysopa spp., and Orius insidiosus. O. insidiosus eggs, which are imbedded within plant tissue, were only moderately susceptible to the material with average percent mortality for the 0.051 and 0.204 kg ai/378.5 ℓ water rates being 24.96 and 57.61, respectively. Eggs of syrphid flies, A. aphidimyza, L. mali, and S. punctum were all highly susceptible to methomyl with average percent mortality for the 0.051 kg ai/378.5 ℓ water rate being 86.99, 77.85, 100, and 90, resepctively. Chrysopa spp. eggs appear to be highly tolerant of the material with average percent mortality not differing statistically from the control.

Values for the LC_{50} of methomyl on eggs of Platynota spp., L. pomonella, O. insidiosus, Chrysopa spp., and S. punctum were generated. Eggs of Platynota spp. and S. punctum exhibited a high degree of susceptibility to the toxicant, as indicated earlier, yielding LC_{50} values of 31.7 and 60.8 μg ai/ℓ water, respectively. L. pomonella and O. insidiosus eggs were less susceptible to methomyl yielding LC_{50}

values of 203.4 and 496.7 kg µg/ℓ water, respectively. With an LC_{50} value of 4655.2 µg ai methomyl/ℓ water, eggs of Chrysopa spp. appear to be highly tolerant to this pesticide. Eggs of P. ulmi were found to have an LC_{50} value in excess of 4856.0 µg ai methomyl/ℓ water.

Methomyl, used an an ovicide, was evaluated in the field for its control of the Platynota spp. complex in Virginia apple orchards, and was compared to several experimental and registered larvicidal compounds. The materials and rates per 378.5 ℓ water applied to runoff with a handgun to mature, standard York trees were: methomyl (Lannate 1.8 L) at 236.59 ml, 473.12 ml, 946.24 ml; FMC 45806 (Ammo 2.5 E) 18.92 ml; FMC 45806 (Ammo 25 W) 22.68 gms; permethrin (Ambush 2 E) 189.25 ml; and Bacillus thuringiensis (Dipel wp) 5.44 BIU. Fruit damage caused by the summer generation Platynota spp. was evaluated at harvest for all treatments. In the unsprayed control, an average of 12.39% fruit damage was recorded. In all treatments, except the 473.12 ml rate of methomyl, leafroller damage to the fruit exceeded the 1% economic injury level. Methomyl at the 946.24 and 473.12 ml rates provided the highest degree of control.

Methomyl, used as an ovicide, shows promise for use in controlling some of the more important and destructive pests found in Virginia apple orchards, namely--the aphid complex, Platynota spp. complex, A. velutinana, and L. pomonella. But, the material is highly toxic, even at reduced rates (less than 0.204 kg ai/378.5 ℓ water), to several important beneficial insects including syrphid flies, A. aphidimyza, L. mali, and S. punctum. Use of this highly toxic material may have a deleterious effect on beneficial species in orchards utilizing the aforementioned predatory insects for biological control of phytophagous pest species. Consequently, materials which are less toxic to beneficial species should be used to control fruit pests in these orchards. However, if applications of the material can be timed for periods when predators are not present or when eggs are protected within plant tissue, such as during the dormant stage of bud development, the sprays can be very effective in controlling certain pest species such as aphids, or A. velutinana. In orchards where growers decide not to utilize beneficial insect and mite species to control phytophagous pest species, accurately timed methomyl sprays should provide acceptable chemical control of aphids, Platynota spp. complex, A. velutinana, and L. pomonella, in the egg stage or as young immatures.

Proper timing of sprays to control the Platynota spp. complex is extremely important for optimal results. Past methods using tree phenology and calendar dates as indices for timing sprays proved to be extremely unreliable. A preliminary study was undertaken during 1981 to determine if seasonal activity of P. flavedana and P. idaeusalis could be related to cumulative degree-days allowing the development of a phenology model to assist growers in timing sprays against these pests.

The results of this study suggested that seasonal activity of P. flavedana and P. idaeusalis adult males could be predicted in terms of accumulated degree-days. It appears that seasonal activity of P. flavedana male moths can be more accurately predicted in terms of accumulated degree-days than P. idaeusalis adult males. Overwintering generation activity for both species can be more accurately predicted than summer generation activity. Egg deposition and hatch periods for the *Platynota* spp. is difficult to predict due to the indistinguishable superficial appearance of the egg masses of the two species. Consequently, a phenology model may serve to give growers a reliable starting point at which they should begin monitoring for *Platynota* spp. egg deposition in their orchards rather than provide a precise date for spray application against eggs of each individual species.

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APPENDICES

Appendix 1. Average temperature and relative humidity recorded during methomyl lab tests.

Experiment Number	Ave. Temperature (°C) ± 1SD	Ave. Relative Humidity (%) ± 1SD
	Pest Species	
1	24.0 ± 6.3	66.1 ± 19.0
2	24.0 ± 6.3	66.1 ± 19.0
3	25.6 ± 1.4	76.3 ± 7.9
4	25.3 ± 0.9	75.6 ± 9.7
5	24.8 ± 1.2	87.1 ± 1.9
6	NR	NR
7	26.2 ± 1.2	67.0 ± 5.5
8	NR	NR
9	NR	NR
	Beneficial Species	
1	21.3 ± 5.9	82.3 ± 16.1
2	23.9 ± 7.0	67.2 ± 18.9
3	24.5 ± 6.7	68.2 ± 19.6
4	19.3 ± 1.1	68.5 ± 10.5
5	24.1 ± 1.1	88.5 ± 3.0
6	26.9 ± 1.2	85.4 ± 9.9
7	27.1 ± 1.3	65.7 ± 3.7
8	27.0 ± 1.4	66.1 ± 3.6
9	26.1 ± 1.8	59.9 ± 4.1

NR = not recorded.

APPENDIX 2

Maximum and Minimum Temperatures Recorded in Orchards

Used in Seasonal Activity Study, 1981

Maximum and minimum temperature (°F) recorded in Nelson County orchard.

	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.	
Date	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	46	29	49	19	64	42	70	50	70	48	82	56	78	58	84	52	83	69	85	49	66	47
2	45	24	50	14	54	34	81	48	66	43	72	66	75	62	85	55	78	67	58	42	76	42
3	48	20	28	8	52	28	83	42	80	36	82	65	70	61	90	62	72	65	64	32	72	48
4	20	13	34	8	46	24	78	56	90	49	81	67	82	61	92	70	67	62	71	32	74	44
5	38	16	35	16	44	36	64	48	84	56	91	67	86	59	96	66	72	62	84	48	70	46
6	42	23	50	21	48	34	54	32	80	45	89	69	80	64	74	65	80	63	82	55		
7	42	8	49	27	45	30	64	27	71	36	86	62	90	62	84	64	74	61	67	42		
8	26	11	51	25	54	30	75	34	71	38	88	68	96	70	84	66	76	59	68	36		
9	33	18	46	16	52	26	62	50	73	52	92	69	99	71	89	60	77	51	66	34		
10	34	6	50	26	52	26	72	51	60	60	90	69	94	66	88	62	80	46	59	36		
11	28	8	58	17	54	28	84	68	79	54	87	58	91	66	89	66	88	52	54	46		
12	28	7	32	10	59	33	88	62	72	38	86	58	91	64	84	58	92	58	56	45		
13	30	16	42	9	68	34	88	54	78	48	90	64	92	62	84	54	88	56	60	36		
14	50	26	58	23	50	32	48	43	84	55	95	70	96	56	86	56	90	58	70	30		
15	42	26	63	26	68	28	72	38	76	50	96	65	86	62	88	60	81	62	72	38		
16	40	22	64	49	58	31	70	30	68	46	96	68	73	62	91	66	75	61	72	48		
17	32	16	62	46	60	31	71	51	78	49	92	56	88	60	76	46	70	51	65	32		
18	54	25	72	45	44	32	66	52	60	47	85	62	88	61	80	54	70	48	62	40		
19	64	36	57	50	42	24	70	48	50	46	94	64	90	68	72	54	67	46	53	26		
20	54	37	59	50	46	18	64	32	62	48	88	67	94	66	80	55	78	45	64	24		
21	41	28	65	50	54	34	64	32	78	53	95	59	93	66	78	49	79	50	76	32		
22	58	31	60	50	46	27	74	54	88	64	92	62	85	64	77	52	84	48	74	39		
23	50	24	51	28	52	34	76	52	88	52	88	58	83	64	84	46	69	44	58	52		
24	54	24	54	30	61	32	67	42	90	58	88	64	67	62	92	55	76	38	58	34		
25	57	26	62	34	62	32	66	31	91	58	94	62	79	62	84	58	76	40	53	29		
26	65	42	62	32	66	30	78	52	88	61	92	46	89	68	82	52	80	46	53	41		
27	60	33	72	38	68	40	84	49	81	64	81	54	96	68	86	52	84	48	61	53		
28	54	27	76	38	68	31	92	52	78	62	86	47	92	70	89	58	76	46	67	48		
29	50	25			76	37	79	62	81	61	90	50	86	63	80	54	72	38	74	41		
30	38	12			68	50	68	56	85	57	84	56	80	53	78	63	76	46	63	47		
31	44	13			84	49			89	62			84	51	86	65			53	38		

Maximum and minimum temperature (°F) recorded in Madison County orchard, 1981.

	Jan.		Feb.		Mar.		Apr.		May		June		July	
Date	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	46	29	49	19	62	38	67	49	64	46	62	56	66	54
2	45	24	50	14	54	34	78	49	66	43	69	58	70	57
3	48	20	28	8	52	30	84	44	74	40	80	63	72	58
4	20	13	34	8	48	23	78	59	84	46	79	65	80	59
5	38	16	35	16	42	33	71	54	82	52	89	63	80	59
6	42	23	48	26	42	36	54	33	77	51	87	67	76	58
7	42	8	45	22	46	30	64	31	68	38	82	58		
8	26	11	46	27	55	43	76	38	69	39	88	54		
9	33	18	60	22	56	44	66	48	72	46	88	69		
10	34	6	42	26	50	32	71	38	65	56	88	66		
11	28	8	54	36	51	31	80	51	77	53	84	60		
12	28	7	59	14	53	34	80	50	71	50	85	61		
13	30	16	34	13	62	34	49	41	74	51	91	66		
14	50	26	38	21	66	32	70	46	81	52	92	69		
15	42	26	54	28	58	30	65	36	74	57	94	67		
16	40	22	62	50	68	30	71	32	68	50	95	69		
17	32	16	63	44	52	30	71	52	78	47	93	63		
18	54	25	72	48	38	28	81	57	58	49	84	60		
19	64	36	58	48	40	19	72	42	50	45	91	63		
20	54	37	56	50	45	21	64	48	71	43	86	66		
21	41	28	62	48	50	30	61	30	78	41	92	60		
22	58	31	54	52	48	26	67	33	82	60	88	56		
23	50	24	56	39	50	33	78	52	81	54	82	56		
24	54	24	52	36	60	32	66	47	86	56	84	57		
25	57	26	54	36	58	31	57	41	89	56	90	61		
26	65	42	54	36	64	32	74	32	84	60	77	61		
27	60	33	66	36	65	43	82	49	78	64	81	46		
28	54	27	72	40	66	32	90	50	77	62	81	49		
29	50	25			77	56	80	62	80	60	82	57		
30	38	12			69	56	66	54	85	56	79	55		
31	44	13			82	46				80	60			

Maximum and minimum temperatures (°F) at Frederick County (farm) orchard, 1981.

	Jan.		Feb.		Mar.		Apr.		May		June		July	
Date	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	34	25	44	20	55	32	68	51	50	40	58	51	77	60
2	34	21	48	20	43	32	68	50	58	39	68	56	80	62
3	40	12	20	12	37	28	84	42	70	38	78	60	76	62
4	13	8	28	12	43	22	79	63	79	38	77	64	80	62
5	25	9	28	12	36	32	68	48	76	48	84	62	74	64
6	36	12	41	20	40	30	46	40	62	48	73	65	84	67
7	38	15	42	23	36	26	60	24	64	40	79	62	88	72
8	22	7	40	20	41	29	74	38	66	40	88	53	89	66
9	28	8	36	18	45	36	77	44	72	38	83	67	90	70
10	22	13	45	24	45	30	66	31	63	51	77	62	88	70
11	20	9	56	18	45	34	71	54	72	57	76	63	89	61
12	17	5	21	6	54	30	69	42	61	47	86	59	92	58
13	19	3	34	9	61	37	46	39	76	39	88	66		
14	30	16	50	19	38	25	62	42	84	54	88	68		
15	32	21	52	25	64	29	54	30	71	54	90	69		
16	37	21	59	31	43	26	67	26	60	50	96	67		
17	25	18	54	45	40	24	64	53	72	47	78	68		
18	36	18	68	44	31	22	73	52	52	46	84	54		
19	49	32	59	47	36	23	59	35	48	44	87	60		
20	50	38	53	48	40	22	70	46	69	44	78	64		
21	38	32	55	41	44	31	64	19	78	40	91	60		
22	49	32	51	45	48	26	76	26	80	61	88	65		
23	40	34	53	36	51	39	96	58	84	56	84	63		
24	42	27	43	32	52	34	73	44	84	58	88	58		
25	52	24	42	34	52	36	52	36	91	59	91	66		
26	54	40	44	33	63	30	82	32	86	62	72	58		
27	52	39	55	31	60	40	70	52	82	63	78	50		
28	46	31	57	38	65	34	82	43	76	60	82	46		
29	36	24			77	49	74	59	76	58	86	52		
30	28	17			65	54	61	47	86	56	82	62		
31	38	16			78	56			76	61				

Maximum and minimum temperatures (°F) at Frederick County (laboratory) orchard, 1981.

	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.	
Date	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	34	25	48	15	56	36	79	50	61	47	78	54	81	63	81	57	82	65	80	52
2	34	21	48	20	45	34	71	50	58	43	68	56	80	64	86	57	81	67	60	48
3	40	12	22	13	39	28	81	43	71	41	78	61	74	64	85	69	77	66	56	44
4	13	8	28	13	44	24	82	61	79	42	77	67	80	63	89	67	66	63	67	36
5	25	9	30	13	36	33	76	60	79	49	87	63	80	66	89	69	76	63	79	56
6	36	12	42	22	41	31	59	37	75	57	85	67	87	68	88	66	78	66	73	58
7	38	15	42	22	39	26	65	29	64	39	82	58	90	70	82	59	78	64	60	52
8	24	12	41	22	42	30	77	45	67	40	86	54	94	65	86	66	72	62	55	48
9	29	12	39	20	46	37	73	61	71	40	85	69	96	72	88	65	76	56	62	43
10	24	14	44	24	48	33	71	38	71	53	86	63	94	77	89	62	78	47	53	40
11	22	12	56	18	47	34	74	55	74	59	81	63	90	64	91	67	85	59	54	47
12	21	7	22	7	56	31	75	58	71	53	86	64	90	61	86	67	87	63	58	42
13	22	5	35	10	63	39	56	39	74	40	85	68	88	70	85	62	87	64	62	38
14	32	21	50	18	39	28	67	45	82	55	90	69	88	73	88	62	89	64	64	33
15	32	24	52	22	63	31	60	37	80	56	96	70	86	58	87	66	72	61	70	38
16	39	28	62	28	65	32	70	30	62	50	95	71	84	60	84	68	65	56	66	44
17	26	19	56	47	43	24	70	57	74	50	95	70	88	62	83	53	70	55	62	40
18	37	20	69	46	40	20	78	60	74	54	83	58	90	62	79	52	68	50	62	46
19	51	33	59	47	36	21	76	43	54	45	88	63	95	66	78	51	62	50		
20	52	40	54	44	42	20	62	48	70	45	85	66	95	75	81	54	61	55		
21	40	32	58	42	45	32	57	31	77	40	90	62	90	70	80	49	76	56		
22	50	32	52	46	49	24	66	35	84	61	89	66	80	68	76	59	78	57		
23	40	34	54	35	53	35	75	53	82	56	85	63	83	58	86	50	60	49		
24	44	29	45	32	56	32	71	56	81	58	86	60	81	62	87	60	67	50		
25	52	23	44	36	55	35	52	42	90	60	93	70	72	64	86	58	76	45		
26	55	37	47	34	64	28	69	35	88	62	91	62	89	68	83	54	78	55		
27	51	43	56	32	62	47	77	50	81	64	78	50	88	70	89	59	82	61		
28	49	28	56	37	65	32	87	51	76	63	81	48	87	65	89	61	69	55		
29	39	26			77	49	87	63	79	61	87	56	83	68	87	59	70	46		
30	31	18			67	56	78	53	85	58	84	65	82	51	83	67	70	66		
31	40	18			80	58			85	64			83	55	83	64				

Maximum and minimum temperatures (°F) at Frederick County (Wiggington) orchard, 1981.

	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.	
Date	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	34	25	44	10	54	30	77	48	58	43	76	53	80	63	79	55	80	64	81	47
2	34	21	45	20	42	30	70	46	56	40	67	56	80	62	84	56	80	65	78	46
3	40	12	21	12	39	24	80	40	70	40	77	60	75	63	83	67	76	63	56	46
4	13	8	28	8	42	20	80	60	77	39	76	66	79	60	88	67	64	60	68	31
5	25	9	28	10	34	31	74	57	78	46	86	60	78	63	89	67	76	61	79	53
6	35	6	42	16	37	20	56	34	74	56	85	66	85	66	86	66	77	64	76	52
7	34	12	40	16	36	25	62	26	63	32	80	55	88	69	80	58	76	62	72	46
8	22	7	38	20	42	28	73	40	66	33	84	52	93	65	85	67	71	59	56	43
9	28	5	36	17	45	32	70	60	70	36	84	68	95	70	88	64	74	51	63	37
10	21	11	44	20	46	28	70	33	69	50	85	61	94	76	87	60	77	45	61	34
11	20	6	54	17	45	30	71	52	71	54	80	62	90	63	90	66	83	57	53	41
12	20	2	20	6	54	29	73	54	70	50	84	62	89	60	86	67	86	60	60	43
13	20	2	32	6	62	38	53	34	71	33	83	67	86	68	83	60	87	61	62	36
14	31	18	49	14	39	24	66	43	80	50	88	66	87	70	85	61	86	62	64	29
15	31	21	50	18	63	26	59	34	78	52	91	68	84	54	86	65	87	56	69	34
16	36	20	60	24	63	30	66	26	60	46	90	68	84	57	83	67	70	52		
17	25	16	54	42	41	22	67	54	71	47	90	69	86	60	83	54	70	50		
18	36	18	68	40	40	20	74	57	72	51	83	56	89	60	76	51	70	46		
19	49	31	57	40	36	20	73	40	53	42	86	60	92	64	77	52	67	43		
20	52	38	51	42	40	18	60	44	68	42	84	62	91	70	79	52	60	50		
21	38	30	56	40	45	30	56	25	75	39	89	62	89	66	78	46	76	53		
22	48	30	50	42	46	24	63	30	80	60	88	64	84	59	75	56	78	54		
23	38	32	52	32	50	33	72	52	80	53	84	60	82	55	84	48	71	44		
24	41	23	43	31	54	30	70	54	79	54	85	60	69	58	86	56	66	46		
25	50	18	43	34	54	34	50	38	86	57	90	66	75	63	84	57	74	40		
26	53	30	46	33	60	26	66	31	84	60	89	61	88	70	80	55	78	51		
27	51	35	54	31	60	44	76	48	78	60	77	49	86	65	90	56	81	56		
28	47	24	56	33	64	30	85	47	73	61	80	48	84	66	91	57	80	55		
29	35	22			74	45	85	60	78	58	86	55	74	62	86	55	67	40		
30	29	16			75	53	76	52	80	57	84	63	81	48	82	63	68	53		
31	38	10			78	56			82	60			82	50	83	63				

Maximum and minimum temperatures (°F) at Frederick County (Brumback) orchard, 1981.

	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.	
Date	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	34	25	44	10	54	30	66	42	48	39	56	46	73	58	82	53	82	66	80	45
2	34	21	45	20	42	30	67	42	58	40	65	54	75	60	85	51	80	68	66	44
3	40	12	21	12	39	24	82	36	68	32	76	61	72	61	79	66	74	66	57	44
4	13	8	28	8	42	20	78	60	77	36	74	63	75	61	89	66	68	63	62	30
5	25	9	28	10	34	31	66	48	72	42	82	56	71	61	90	68	78	63		
6	35	6	42	16	37	30	46	39	59	57	72	63	82	63	68	64	79	66		
7	34	12	40	16	36	25	60	24	61	34	78	57	89	67	82	60	79	60		
8	22	7	38	20	42	28	74	38	64	32	82	49	89	64	86	66	74	54		
9	28	5	36	17	45	32	77	44	68	30	82	62	92	69	86	59	74	48		
10	21	11	44	20	46	28	66	31	60	46	74	59	88	68	87	58	78	43		
11	20	6	54	17	45	30	71	54	70	56	75	58	88	59	90	70	83	52		
12	20	2	20	6	54	29	69	42	62	44	81	56	88	57	82	64	84	56		
13	20	2	32	6	62	38	46	39	70	36	82	62	88	63	83	59	84	56		
14	31	18	49	14	39	24	61	42	78	50	86	66	83	66	86	58	86	54		
15	31	21	50	18	63	26	54	30	66	52	90	65	84	54	85	61	72	64		
16	36	20	60	24	44	24	67	26	60	44	89	62	78	56	83	64	65	56		
17	25	16	54	42	40	22	64	53	72	38	78	59	86	57	76	45	68	53		
18	36	18	68	40	30	20	73	52	52	46	78	51	89	58	78	43	68	46		
19	49	31	57	40	36	20	59	35	46	43	82	56	92	61	68	47	63	44		
20	52	38	51	42	40	20	58	46	66	39	78	63	91	70	78	49	60	50		
21	38	30	56	40	44	25	54	25	74	32	91	60	89	66	79	50	76	52		
22	48	30	50	44	46	20	60	28	78	52	87	65	84	59	79	44	78	45		
23	38	32	52	32	49	39	72	47	81	48	79	59	82	55	78	50	63	44		
24	41	23	43	31	52	33	62	42	80	48	80	57	69	58	85	45	68	38		
25	50	18	43	34	51	28	48	36	84	50	84	63	75	63	86	52	68	38		
26	53	30	46	33	62	24	64	28	78	52	70	51	88	70	82	50	75	50		
27	51	35	54	31	60	41	73	47	74	56	73	46	86	65	88	55	80	54		
28	47	24	56	33	64	25	84	43	69	59	77	46	84	66	88	57	82	54		
29	35	22			75	39	74	54	74	55	82	50	74	62	81	54	70	36		
30	29	16			64	52	61	48	79	50	78	60	81	48	83	63	69	52		
31	38	10			76	46			74	60			82	50	82	60				

APPENDIX 3

Phermone Trap Catches, 1981

Appendix 3. Phermone trap catches of *P. flavedana* males, 1981.

Date	Site				
	Frederick Co. (Wiggington)	Frederick Co. (Laboratory)	Frederick Co. (Brumback)	Frederick Co. (Farm)	Madison Co. (Graves)
5/11	0	3	0	0	0
5/18	1	17	0	3	7
5/25	6	21	0	2	0
6/1	3	25	1	17	18
6/8	7	12	2	8	5
6/16	2	15	0	14	0
6/22	2	3	3	5	3
6/29	1	2	1	9	0
7/7	0	0	0	5	1
7/13	0	0	0	0	0
7/20	0	10	0		
7/29	0	2	0		
8/5	3	16	0		
8/11	0	2	0		
8/19	2	18	0		
8/26	0	23	2		
9/1	0	6	0		
9/9	7	5	19		
9/16	3	8	6		
9/23	0	0	4		
10/13	0	0	1		

Appendix 3. (continued)

Date	Site
	Nelson Co. (Flippin)
4/26	0
5/3	2
5/10	18
5/17	84
5/24	51
5/31	62
6/7	29
6/14	6
6/20	0
6/27	0
7/2	3
7/11	14
7/21	18
7/28	18
8/4	21
8/12	0
8/18	6
8/24	12
9/1	7
9/8	4
9/15	12
9/21	29
9/28	20
10/5	5
10/9	3
10/16	4
10/23	3

Appendix 3. Phermone trap catches of *P. idaeusalis* males, 1981.

Date	Site				
	Frederick Co. (Wiggington)	Frederick Co. (Laboratory)	Frederick Co. (Brumback)	Frederick Co. (Farm)	Madison Co. (Graves)
5/4	0	0	0	0	9
5/11	11	0	4	0	58
5/18	63	49	13	4	81
5/25	33	42	31	35	25
6/1	28	51	12	39	20
6/8	18	24	8	9	30
6/16	52	89	31	77	15
6/22	42	38	22	34	11
6/29	30	14	6	14	9
7/7	2	0	0	5	2
7/13	0	2	0	0	0
7/20	4	4	0		
7/29	7	4	2		
8/5	4	13	7		
8/11	1	1	1		
8/19	19	30	4		
8/26	12	35	4		
9/1	9	9	9		
9/9	34	2	4		
9/16	13	8	2		
9/23	5	5	0		
10/13	0	0	0		

Appendix 3. (continued)

Date	Site Nelson Co. (Flippin)
5/3	1
5/10	10
5/17	25
5/24	18
5/31	17
6/7	11
6/14	6
6/20	7
6/27	0
7/2	0
7/11	0
7/21	0
7/28	0
8/4	0
8/12	0
8/18	1
8/24	2
9/1	1
9/8	0
9/15	4
9/21	2
9/28	0
10/5	0
10/9	0
10/13	0

Appendix 4. Egg mass deposition and hatch data for *Platynota* spp., 1981.

Nelson Co. (Flippin)			Frederick Co. (Wiggington)		
Date	Total No. Deposited	Total No. Hatched	Date	Total No. Deposited	Total No. Hatched
6/13	1				
6/20	2	1			
6/27	3	2			
7/2	6	3			
7/9		6			
8/11	11				
8/18	13		8/19	1	
8/24	13	1	8/26	2	
9/1	21	6	9/1	4	2
9/8		20	9/9		4

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OVICIDAL ACTIVITY OF METHOMYL ON EGGS OF PEST AND BENEFICIAL INSECTS AND MITES ASSOCIATED WITH APPLES IN VIRGINIA

by

Paul Joseph David

(ABSTRACT)

Methomyl at seven concentrations, 0.051 to 0.204 kg ai/378.5 ℓ water, was evaluated against eggs of pest and beneficial insects and mites associated with apples. The pest eggs studied were: *Laspeyresia pomonella*, *Panonychus ulmi*, *Platynota* spp., aphids, and *Argyrotaenia velutinana*. For *A. velutinana*, five rates of methomyl ranging from 0.013 to 0.204 kg ai/378.5 ℓ water were used. *Platynota* spp., aphid, and *A. velutinana* eggs were highly susceptible to the material. *P. ulmi* eggs were not susceptible.

Eggs of beneficial syrphid flies, *Aphidoletes aphidimyza*, *Leptothrips mali*, and *Stethorus punctum* were highly susceptible to methomyl. Eggs of *Orius insidiosus* were moderately susceptible. *Chrysopa* spp. eggs appeared to be unaffected by the material.

LC_{50} values for methomyl on eggs of *Platynota* spp. *L. pomonella*, *O. insidiosus*, *Chrysopa* spp., and *S. punctum* were generated. LC_{50} values for *P. ulmi* eggs were unobtainable.

Three rates of methomyl, used as an ovicide, were evaluated in the field for control of the *Platynota* spp. complex on apples compared

to two formulations of FMC 45806, permethrin, and *Bacillus thuringiensis*. Methomyl provided the best control.

Seasonal activity of *P. flavedana* and *P. idaeusalis* were monitored in reference to degree-day accumulations. Regression equations for male moth flights and egg deposition of the species are presented. Seasonal activity and prospects for development of a phenology model to predict seasonal activity of the species is discussed.