Insect and mite monitoring in commercial apple orchards in Nova Scotia (1979 - 1985)

by

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Short Title. INSECT AND MITE MONITORING IN APPLE ORCHARDS

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ABSTRACT

Between 133 and 196 apple orchard blocks were monitored by Insect and Mite Monitoring Services for at least 14 insect and mite pests during the period 1979-1985 for the purpose of determining the need for control action Some monitoring techniques were greatly improved through experience and simple investigations (sequential sampling for Operophtera brumata (L), tapping for mirids, and colony estimation and threshold establishment for Dysaphis plantaginea (Pass)), while some others await improvement through further research The monitoring service was well received by growers, and pest management decisions became more efficient and effective. The cost to operate the service was approximately 90-100 dollars/hectare During the monitoring period, some pests became less frequent (O brumata, Orthosia hibisci Guenee, Phyllonorycter blancardella (F)), some more frequent (Panonychus ulmi (Koch), D. plantaginea, mirids), and some fluctuated cyclically (Rhagoletis pomonella (Walsh)) or erratically (Typhlocyba pomaria McA) The monitoring program helped minimize pesticide use without sacrificing quality or yield However, further advances in Integrated Pest Management will require the development of even more sophisticated monitoring programs

M.Sc. Richard E. L. Rogers Département d'Entomologie

Dépistage des insectes et des acariens en vergers commerciaux de la Nouvelle-Ecosse (1979-1985)

RESUME

De 1979 à 1985, dans le cadre de Services de dépistage d'insectes et d'acariens visant à déterminer les besoins de traitements, on a dépisté entre 133 à 196 parcelles de pommiers. Certaines techniques de dépistage ont été grandement amélioré suite à l'expérience acquise et à des études simples, notamment au niveau de l'échantillonnage séquentiel d'Operophtera brumata (L.), de la technique de frappage pour les mirides, de l'estimation du nombre de colonies et du seuil d'action de Dysaphis plantaginea (Pass.). D'autres techniques pourraient être amélioré avec plus de recherche. Les services de dépistage ont été bien reçu par les producteurs, et les décisions de régie sont devenues efficaces. Le coût d'opération des services était approximativement 90-100 dollards/hectare. Au cours de cette étude, certains ravageurs devinrent moins fréquents (O. brumata, Orthosia hibisci Guenée, Phyllonorycter blancardella (F.)), et d'autres, plus fréquents (Panonychus ulmi (Koch), D. plantaginea, les mirides). On a également observé des ravageurs dont les populations ont montre des fluctuations cycliques (Ragoletis pomonella (Walsh)) ou irrégulières (Typhlocyba pomaria McA.). Le programme de dépistage a démontré que les efforts de dépistage sont essentiels pour maximiser les rendements et la qualité de la récolte. Toutefois, l'amélioration des programmes de lutte intégrée demandera le développement de programmes plus sophistiqués.

ACKNOWLEDGMENTS

First of all, I must thank C R MacLellan for the training, motivation and support he has given me Also, he was the driving force in the formation of Insect and Mite Monitoring Services (IMMS), without his contacts, experience, and leadership this unique service may never have become established Next, I wish to thank the apple growers of the Annapolis Valley for their participation and interest in the services of IMMS Without their progressive thinking, cooperation and continued support this program could not have existed for the past seven years Also, I express gratitude to government funding agencies such as the Department of Supply and Services, and the Technology Acceleration Program of the Canada/Nova Scotia Agri-Food Development Agreement for the financial support they provided The funds not only helped IMMS to remain viable, but also permitted some unique and valuable research in pest management, and practical application of same I would like to extend my appreciation to Dr R J Whitman, Dr J M Hardman, the entomology staff, and the federal and provincial departments of agriculture, all of Kentville, for their help and cooperation Finally, I thank Dr C. Vincent for the french translation of the abstract, and the following people who provided the much needed incentive to finish this manuscript - Dr S B Hill (my supervisor), W J Fairchild, and all friends and acquaintances who demonstrated, through their perseverance, that theses can be conquered

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INTRODUCTION

Farming in general is a very speculative way to make a living because of the huge labor and financial inputs involved, and the unpredictable nature of returns This is especially true of fruit growing The variables involved in producing a quality crop, and marketing for satisfactory returns are numerous and it is not surprising why fewer people endeavor to enter the fruit-growing business today Weather, disease, insects and mites are the major culprits that can reduce quality or produce crop failures Of these factors, diseases and arthropod pests can be combated with a variety of cultural, biological, and chemical controls Artificial controls are expensive to use, so it is wise to use them only when and where necessary.

In Nova Scotia, apples have been a prominent crop since they were first introduced to the province by Acadian settlers in 1633 It was here, in the 1940's, that the philosophy of pest control which aims to minimize the use of toxic chemicals and maximize the benefits derived from natural enemies, while maintaining pest damage at an acceptable level, was first conceptualized and experimented with by a group of entomologists (Pickett et al, 1946) This more environmentally and ecologically acceptable approach is generally known as Integrated Pest Management, or IPM Today, IPM is widely accepted, and practiced, to various degrees, by over 95 % of Nova Scotia fruit growers (MacLellan, 1979)

The term IPM is often used when describing pest control activities in agriculture and forestry In most cases, what is being practiced is reduced spraying, but this has been demonstrated, in Nova Scotia, to be the prerequisite to encouraging natural controls In other words, IPM is not possible without reduced spraying However, further innovations in IPM are frequently hampered by a) inadequate research funding, b) few, feasible nonchemical alternatives to combat pest problems that do arise, and c) low numbers of trained personnel to research and implement IPM

Biological control is the foundation upon which the IPM approach is built, and monitoring is an essential tool which allows for continuous assessment and reevaluation of all strategies for pest management (Figure 1). Monitoring is also important for predicting the need for and correct timing of control actions These features are necessary if production costs and resistance development (by pests, to pesticides) are to be minimized (Figure 2) In an unpublished seminar paper, K Sanford (1983), a research entomologist at Kentville, N S , wrote

> Since we must rely on broadly toxic chemicals to control numbers of pests that are above economic thresholds, we have to learn to use them judiciously so that by regulating the dosage, the timing and the number of applications we can achieve an integrated pest management approach Basic to this is the need to know for sure if the pest is numerous enough to make the treatment necessary This is where pest monitoring and economic threshold information is used

Provincial extension personnel and federal researchers provide as much information concerning arthropod populations as their work loads permit, and each year a new spray calendar is carefully prepared, but what is required is regular and extensive surveys using accurate monitoring techniques Only with an effective monitoring program in place can nonchemical alternatives be used with minimum economic risk and scientific evaluation of results

Government is unable to provide pest monitoring on a large scale and most growers do not have the time or the training to adequately assess their own insect and mite populations, yet this information is basic to an IPM approach In 1979 a privately operated monitoring service was set up to

Figure 1. Components of IPM and the position of monitoring in the scheme

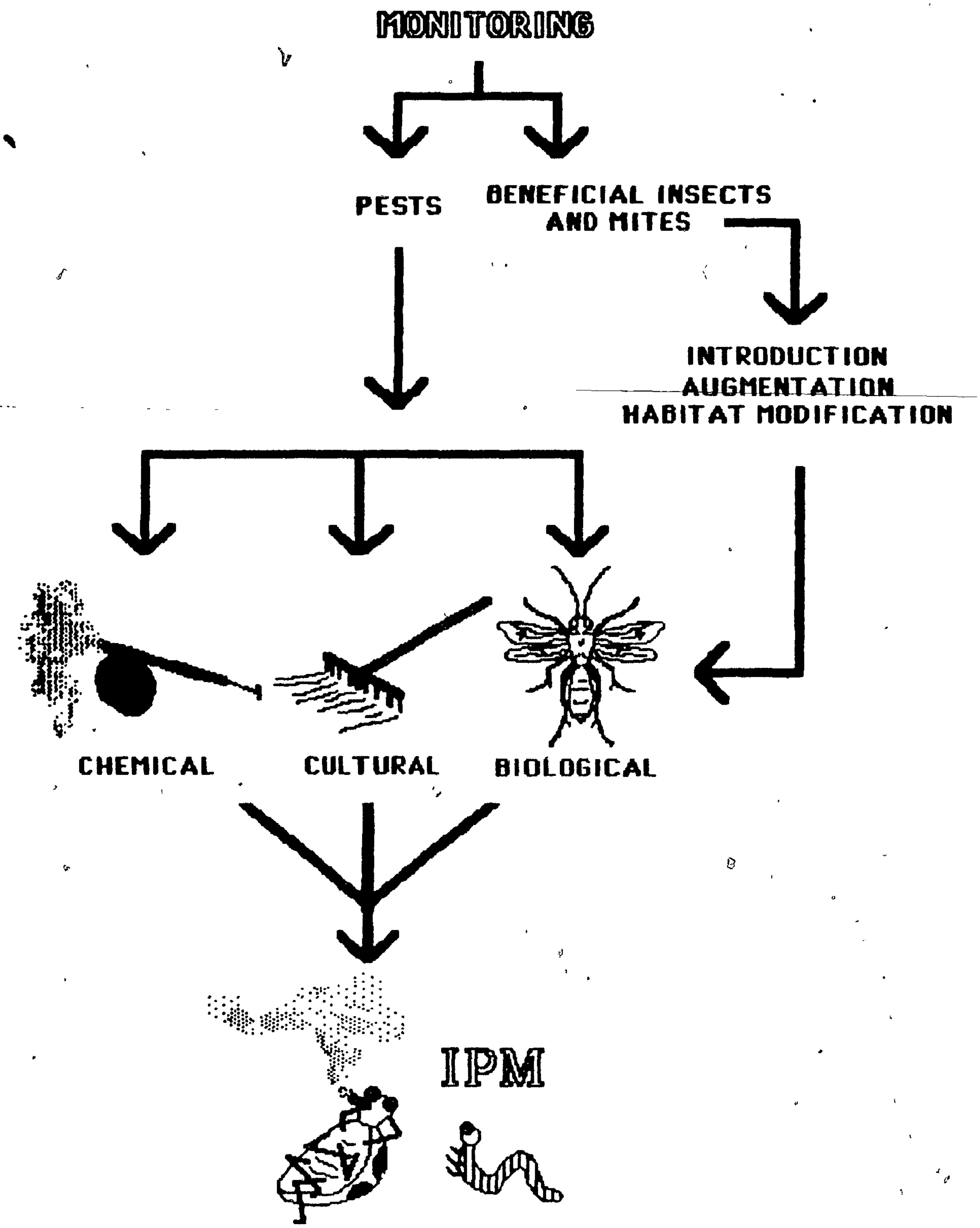
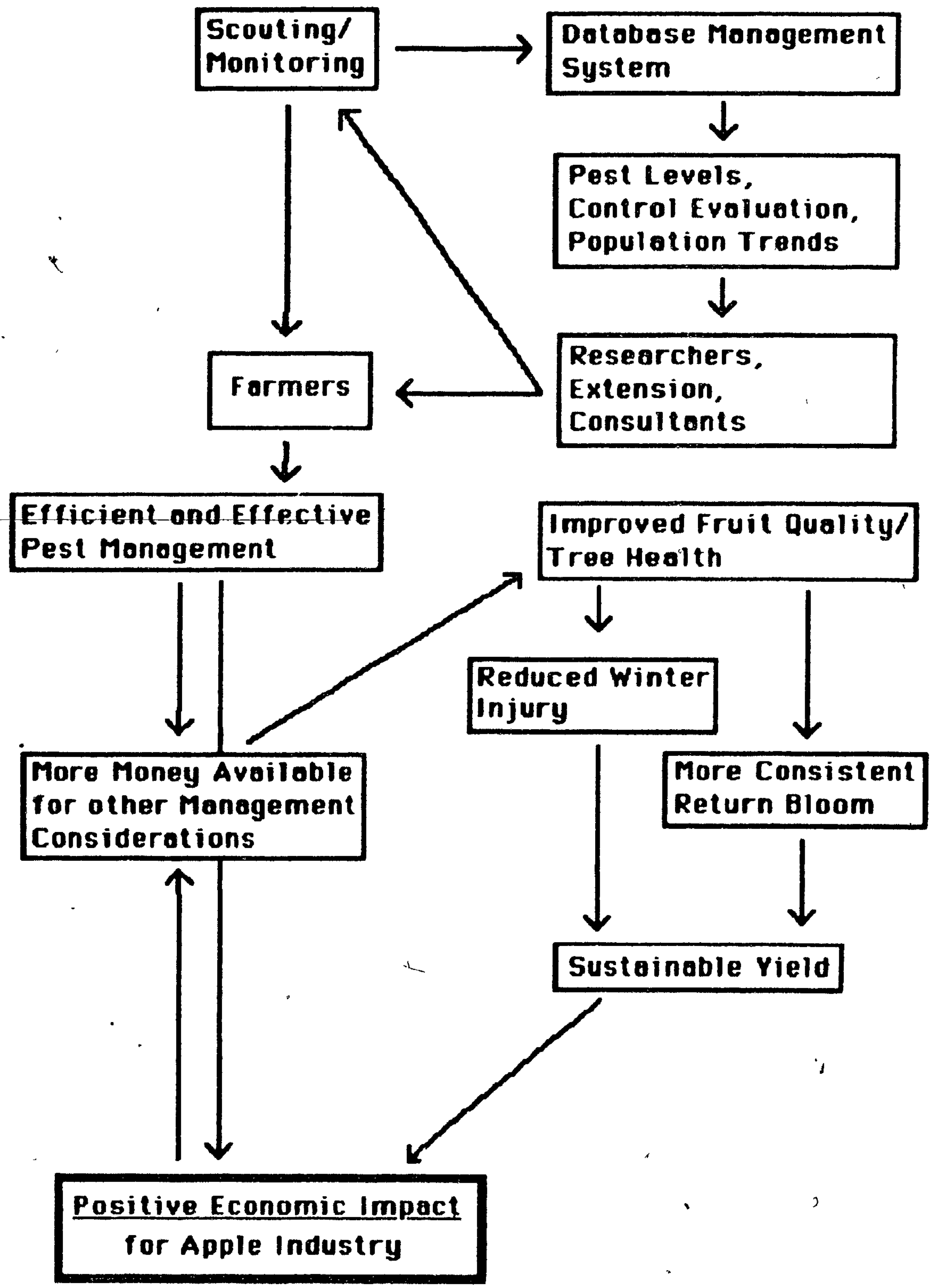

MONITORING
PESTS
BENEFICIAL INSECTS AND MITES
INTRODUCTION
AUGMENTATION
HABITAT MODIFICATION
CHEMICAL
CULTURAL
BIOLOGICAL
IPM

Figure 2. Monitoring can have a beneficial impact on orchard management and apple industry economics.


Scouting/
Monitoring
Database Management
System
Pest Levels,
Control Evaluation,
Population Trends
Researchers,
Extension,
Consultants
Farmers
Efficient and Effective
Pest Management
Improved Fruit Quality/
Tree Health
Reduced Winter
Injury
More Consistent
Return Bloom
More Money Available
for other Management
Considerations
Sustainable Yield
Positive Economic Impact
for Apple Industry

serve the needs of growers, who previously may not have been informed in time to alleviate pest problems This service was well received and the data proved useful to government In 1980 and 1983 contracts made it feasible to provide data for pest management cost/benefit studies, to continue intensive sampling, to improve sampling techniques, and to contribute to the weekly information newsletter "Orchard Outlook", published by Nova Scotia Department of Agriculture and Marketing in Kentville, N S (Appendix 1)

This thesis (i) describes the monitoring techniques used by Insect and Mite Monitoring Services (IMMS) for 14 individual arthropod pests or groups of pests as follows green pug moth (GPM), *Chloroclystis rectangulata* (L), speckled green fruitworm (SGFW), *Orthosia hibisci* Guenee, winter moth (WM), *Operophtera brumata* (L), paleapple leafroller (PALR), *Pseudexentera mali* Freeman, Rosy apple aphid (RAA), *Dysaphis plantaginea* (Pass), stinging mirids (SM), *Atractotomus mali* (Meyer), *Campyloma verbasci* (Meyer), and *Lygocoris communis novascotiensis* (Knight), white apple leafhopper (WALH), *Typhlocyba pomaria* McA , fruit-tree leafroller (FTLR), *Archips argyrospilus* Walker, apple maggot (AM), *Rhagoletis pomonella* (Walsh), codling moth (CM), *Cydia pomonella* (L), eye-spotted budmoth (ESBM), *Spilonota ocellana* (D & S), spotted tentiform leafminer (STLM), *Phyllonorycter blancardella* (F), apple rust mite (ARM), *Aculus schlectendali* (Nal), and European red mite (ERM), *Panonychus ulmi* (Koch), (ii) presents monitoring data from 1979 to 1985 with discussion of possible trends, (iii) explains methods of information transfer, and (iv) provides an estimate of costs to operate a private service profitably, based on IMMS expenses in 1985

LITERATURE REVIEW

Integrated Pest Management

Integrated Pest Management (IPM) is generally accepted to be a pest management approach that attempts to utilize all methods of pest suppression (e g biological, cultural, chemical) in an ecologically sound manner for the maintenance of pest populations within acceptable limits Many definitions have been proposed for IPM, but they all involve the same basic concept and philosophy (Intersociety Consortium for Plant Protection, 1979)

The IPM approach was first described and implemented in Nova Scotia, with great success (Pickett et al, 1958) Pickett et al (1946) reported that the IPM effort was initiated because insect species of previously minor importance were becoming major pest problems To combat these pests, and to produce fruit reasonably free of insect damage, they said that chemical applications had risen to 6-10 from 2 to 3 applications during the early 1900's Also, it was obvious that the newer chemicals (arsenicals and pyrethrum) and application technology (equipment and techniques) were not helping to reduce pest problems (Pickett, 1949)

When investigations first began, in the early 1940's, it was necessary to do a "certain amount of insectary work to gain a more intimate knowledge of the life histories and habits of many species (orchard insects and mites)" (Pickett et al, 1946) Also, the complexity of the orchard ecosystem required the initiation of long-term ecological studies of the major pests (MacLellan, 1979) Lord (1947, 1949) demonstrated the importance of predators and parasites in the natural control of oystershell scale, *Lepidosaphes ulmi* (L), and ERM MacLellan and Specht (1954) identified year round mortality factors of CM Further intensive investigation of the population dynamics of this species (MacPhee and MacLellan, 1971; MacLellan, 1972) resulted in greater understanding of the natural control factors, and reduced rates and more accurate timing for chemical controls Natural control of lecanium scale, *Lecanium* spp, was identified to be achieved mostly by two parasites and predaceous mirids (MacPhee and MacLellan, 1971)

Ecological data on major pests (Pickett and Patterson, 1953) provided evidence for the need to protect natural enemies in the orchard ecosystem One of the results of research in Nova Scotia, from 1950 to the present, was a spray calendar that recommended fewer applications of insecticides and miticides The chemicals chosen for inclusion in the calendar had stated low and high rates (to be used according to the severity of the pest problem), and were rated as to how harmful they were to natural enemies

MacPhee and Paradis (1981) discuss IPM experience in Eastern Canada apple orchards IPM is being practiced in other apple growing regions of Canada as well (MacPhee, 1975, Madsen et al, 1975, Downing and Arrand, 1978; Hagley et al, 1980, McKay et al, 1981, McMullen, 1981, Paradis, 1981, Hagley, 1982, Vincent et Bostanian, 1984) Onion and carrot crops are also being introduced to the IPM approach (Madder and McEwen, 1982)

In the United States, a great deal of interest in IPM is indicated by government policy statements (Kuhr. 1979), and the establishment of research projects and organizations to deal with research and implementation (Croft, 1983) Many published works dealing with the need, principles and implementation of IPM, for apples and other crops, have been written in the USA (Croft, 1975, Prostak, 1977, Intersociety Consortium for Plant Protection, 1979, Knipling, 1979, Prokopy et al, 1980, Tette, 1981, Burr and Lienk, 1981, Croft and Hoyt, 1983, Andaloro et al, 1983)

Whalon and Croft (1984) provide a useful review of the latest developments in the implementation of apple IPM in North America Hall (1978), Prokopy et al (1980), and Thompson and White (1982) assess tree fruit IPM from an economic standpoint

Other countries have also undertaken to implement the IPM approach (Niemczyk, 1975, Gonzales, 1975, Gruys, 1982, Collyer and Geldermalsen, 1975, Mathys, 1981, Kolbe, 1982)

Pesticide Use and Insect Damage

In recent years there is the view, by some not truly familiar with the situation here, that many Nova Scotian growers have returned to high pesticide use (Whalon and Croft, 1984) My observations indicate that this view is unjustified Most growers are concerned about reducing or maintaining low pesticide use and about encouraging natural controls However, in the few cases where widely toxic insecticides were indiscriminately introduced into the integrated control program, natural enemy numbers were lowered (MacLellan, 1979)

In a 4 year study (1980-1983) in commercial IPM orchards in Nova Scotia, the frequency of insecticide and miticide applications were 2 5 and 0 5 yr^{-1} respectively (Hardman et al, 1986) In 1980, insecticide and miticide frequencies were reported higher in commercial apple orchards in Quebec (4 0 and 1 0 respectively), Ontario (6 0 and 1 0), and British Columbia (5 4 and 0 5) (Stemeroff and George, 1983) Prokopy et al (1980) reported insecticide and miticide frequencies (1978-1979) to be 10 5 and 3 0 yr^{-1} respectively, in commercial apple orchards of Massachusetts In IPM orchards in Massachusetts (1978-1979), insecticide applications were 6 6 yr^{-1} and miticide applications were 1 6 yr^{-1} (Prokopy et al, 1980) In a 4 year study in an experimental IPM orchard in Quebec, Bostanian and

Coulombe (1986) reported 4.25 insecticide applications yr^{-1}. Mite control was left primarily to an organophosphate-resistant strain of the predatory mite, *Amblyseius fallacis* Garman.

In Nova Scotia, insect injury to fruit (1980-1982) averaged from 1.8 to 3.6 % yr^{-1} (Hardman et al, 1984e). These levels of injury were lower than the mean (6.6 %) reported by MacLellan (1979) from his 25-year survey of insect damage in Nova Scotia, IPM orchards. They were also lower than means reported from IPM apple orchards in Massachusetts (Prokopy et al, 1980), Pennsylvania (Hull et al, 1983), and Quebec (Bostanian and Coulombe, 1986) (3.2, 4.2, and 6.8 % respectively).

Monitoring and Thresholds

Monitoring of pest populations is a necessary and valuable component of any IPM program (Leeper and Tette, 1980). However, there are three prerequisites to using specific monitoring and sampling techniques. "They must be economical, be relatively easy to use, and provide a reasonably precise estimate of density and/or distribution of the critical stages of the pest" (Hoyt et al, 1983).

Treatment threshold (synonymus with action or economic threshold) is the pest density at which control measures should be considered to avoid economic injury (Metcalf and Luckman, 1975), where economic injury is that density where the loss caused by the pest equals the cost of available control measures (National Academy of Sciences, 1969). To avoid the misconception that thresholds were precisely established, based on prevailing economic conditions, I adopted treatment threshold as the preferred term to use in Nova Scotia. Stern (1973), and Mumford and Norton (1984) review economic thresholds in detail.

Both sampling methods and treatment thresholds vary between regions (Hoyt et al, 1983) (Table 1), and even between individual orchards, because of personal preference with regard to sampling, different pest biology, economic considerations, and grower attitudes (van Emden, 1977). Therefore, sampling methods and thresholds are usually considered provisional (i.e. require further research and experimentation).

Pest Biology and Identification

There are many possible references that deal with the biology and identification of the insect and mite pests in this study. The most useful and specific to northeastern North America are government and university information publications (Agriculture Canada Pest Data Sheets, Brittain and Pickett, 1933, Chapman and Lienk, 1974, Paradis, 1981, Nova Scotia Tree Fruit Protection Guide, 1982). Insect information sheets from the United Kingdom (Agricultural Development and Advisory Service Leaflets) are also very good because of the number of pests that are common to both sides of the Atlantic Ocean. Metcalf et al (1962) and Alford (1984) are useful reference texts for pest and beneficial insects and mites. Life cycles of selected insect and mite pests found in Nova Scotia apple orchards are graphically represented in Appendix 2.

Table 1. Some monitoring techniques and thresholds used in North America and the United Kingdom for selected insect and mite pests of apple orchards.[1]

PEST[2]	SAMPLE TIMING	TECHNIQUE & SAMPLE UNIT	THRESHOLD	WHERE USED	REFERENCE
SGFW	pink to mid-June	examine 30 developing fruit/tree	1[3]	Ma	Prokopy et al (1980)
	ditto	examine 100 fruit clusters	2[4]	Mich.,N.C., N.Y.,W.Va	Whalon and Croft (1984)
	calyx	limb taps	5[5]	B.C.	ditto
WM	early pink	examine 2 clusters/tree	10[6]	U.K	Agricultural Development and Advisory Service (1979)
RAA	June	examine whole tree	1[7]	U.K.	ditto
	ditto	examine 100 clusters	2[8]	Mich.,N.C.	Whalon and Croft (1984)
	Oct-Nov	examine twigs and small branches	--[9]	N.Y	Matheson (1919)
WALH	June-Aug	examine 30 leaves/tree	0.25[10]	Ma.	Prokopy et al (1980)
	ditto	examine 100 leaves	0.5[10]	N.Y.	Whalon and Croft (1984)
AM	July-Aug	red sticky spheres	1[11]	Ma.	Prokopy et al (1980)
	ditto	red sticky spheres and yellow sticky boards	1[11]	Me., Mich., N.Y.	Whalon and Croft (1984)
CM	June-Aug	pheromone traps	60+[12]	Ma.	Prokopy et al (1980)
	ditto	ditto	2+[13]	B.C.	McMullen (1981)

Table I. (Cont'd)

PEST	SAMPLE TIMING	TECHNIQUE & SAMPLE UNIT	THRESHOLD	WHERE USED	REFERENCE
ERM	June-July	brush leaves	15,30[14]	B.C.	Downing and Arrand (1978) McMullen (1981)
	June-Aug	ditto	8[15]	Ma	Prokopy et al (1980)
	ditto	examine leaves	4[16]	U K	Agricultural Development and Advisory Service (1979)

1 - Compare techniques and thresholds with those of this study See text and Appendix 3, 2 - Pest abbreviations Appendix 3, 3 - Larvae/tree, 4 - Larvae/100 fruit clusters, 5 - Larvae/100 limb taps, 6 - Infested clusters/50 trees, 7 - 1 infested tree/50 trees; 8 - colonies/100 clusters, 9 - severe infestations reported even when few eggs observed, 10 - active forms/leaf, 11 - flies/block, 12 - cumulative male moths/trap, 13 - male moths/trap in 2 consecutive weeks, 14 - active and egg stages/leaf for June and July respectively No treatment if ratio of ERM to predator mites 10:1 or less; 15 - combined total of ERM and Tetranychus urticae (Koch) active stages/leaf, 16 - active and egg stages/leaf

MATERIALS AND METHODS

Project Region

A detailed presentation of topography and climate are given in a report by Bircham (1983) Bircham (1983), Embree et al (1984), and Nova Scotia Department of Agriculture and Marketing (1983) provide details of tree censuses and summarize annual yields and crop values

Topography

Orchards participating in the monitoring program are located in the Annapolis Valley region of Nova Scotia The valley floor extends for a length of approximately 125 kms from Windsor to Falmouth, in the east, to Annapolis Royal, in the west Its average width is approximately 5 kms, "tapers from a width of approximately 13 kilometres at Kentville-Wolfville to 3 kilometres at Annapolis Royal" (Bircham, 1983) The "North Mountain", 235 m ASL, and the "South Mountain", an extensive highland area approximately 215 m ASL, border the valley along its length

Soil survey maps show that most soils in the valley are of Canada Land Inventory classes 2-3, although soils along the Annapolis and Cornwallis rivers are, for the most part, classes 3-5 (Cann et al, 1954, 1965, MacDougall et al, 1969)

Climate

The Annapolis Valley experiences a temperate climate that is cool and humid, and moderated by its proximity to the Bay of Fundy (Bircham, 1983) Rising land to the north and south provides wind protection and air drainage, which reduces risk of frost In general, the Annapolis Valley is characteristically cool in spring (delaying bloom till risk of frost is low), not excessively hot in summer, slow to cool in autumn, and not extremely ld in winter (Table 2)

Table 2. Summary of monthly and yearly mean temperatures (°C) at Kentville, Nova Scotia, 1979-1985*

Month	1979	1980	1981	1982	1983	1984	1985	30 yr
Jan	-3.5	-5.2	-8.0	-8.0	-3.2	-5.6	-8.0	-5.0
Feb	-7.9	-6.2	-0.6	-5.4	-3.8	-0.7	-4.4	-5.2
Mar	1.5	-1.9	0.8	-0.7	0.5	-1.9	-1.5	-1.0
Apr	4.9	6.1	6.1	5.1	6.4	4.5	4.1	4.4
May	12.6	10.1	12.1	9.9	11.3	11.6	10.4	10.4
Jun	16.3	14.6	15.9	14.6	16.5	16.2	15.1	15.8
Jul	19.4	18.2	18.8	19.4	19.7	21.1	20.0	19.1
Aug	17.4	21.5	18.0	17.0	18.8	21.0	18.0	18.4
Sep	14.2	13.7	14.2	15.1	16.3	13.9	15.4	14.2
Oct	9.0	8.8	8.5	8.6	9.9	9.2	9.3	9.0
Nov	5.6	2.9	4.2	5.9	4.6	4.6	---	4.0
Dec	-2.3	-5.3	1.2	0.1	-2.0	-0.4	---	-2.4
Year	7.3	6.5	7.6	6.8	7.9	7.8	---	6.8

* Taken from Kentville Research Station Annual Reports 1979 - 1983, and Read (1984, 1985)

Precipitation, in combination with melting snow, typically provides more than adequate moisture from late March to early May. Adequate precipitation is normal for the remainder of the growing season (Table 3), although a continuous 2-3 week hot, dry period is not uncommon between late June and early August.

Weather information was broadcast hourly by local radio stations, and they provided a weather telephone line as well. Continuous weather information was transmitted from Geizer's Hill, Halifax, Nova Scotia by the weather service of Environment Canada, and rebroadcast over a network of repeater stations. In the Annapolis Valley, the information could be picked up by a good quality crystal-controlled radio on VHF/FM 162.55 MHz (call letters XLK 473).

Table 3. Summary of monthly and yearly mean precipitation (mm) at Kentville, Nova Scotia, 1979-1985*

Month	1979	1980	1981	1982	1983	1984	1985	30 yr
Jan	238.3	53.6	168.5	181.2	102.8	93.4	79.8	134.4
Feb	140.4	30.8	52.3	76.1	105.6	117.7	104.7	105.2
Mar	117.1	114.2	101.2	61.5	123.2	140.1	102.6	98.5
Apr	98.4	81.3	64.0	136.7	114.7	98.0	62.0	81.4
May	152.8	26.6	121.2	44.8	143.2	86.2	147.3	77.3
Jun	87.4	129.1	103.6	89.8	39.1	83.8	234.7	71.2
Jul	93.3	121.3	83.5	96.2	77.2	43.2	47.9	70.2
Aug	128.8	52.7	51.0	47.4	106.3	143.8	121.0	98.2
Sep	69.7	61.6	158.2	79.4	36.8	100.4	20.1	85.6
Oct	135.0	89.3	156.2	23.8	42.2	48.0	55.8	102.0
Nov	166.4	115.6	145.3	92.7	102.6	28.6	---	120.0
Dec	151.8	167.0	157.1	93.6	115.6	94.5	---	130.4
Year	1579.4	1043.3	1362.1	1115.3	1109.3	1077.7	---	1174.4

* Taken from Kentville Research Station Annual Reports 1979 - 1983, and Read (1984, 1985)

Characterization of Orchards and Marketing Strategies

During the period 1949-1964 "orchard care was classified by the annual number of sprayings" (Bircham, 1983). An orchard was considered first class if it received more than six sprays, and for this period "first class" orchards increased from 50% to 80% (Nova Scotia Department of Agriculture and Marketing, 1950, Redmond and Embree, 1965). Other factors of orchard care were not extensively documented until 1980-1982 (Hardman et al, 1984a). Using general tree health, quality of pruning, sanitation, and care of terrain to evaluate the level of care, it was found that, on a point scale (poor, fair, good, very good, and excellent), 67-75 % of Annapolis Valley orchards surveyed were in the good to very good categories. By 1982, surveyed orchards represented 18 % of the 3643 ha of commercial apple orchards in the Annapolis Valley of Nova Scotia (Embree et al, 1984). Thus, up to three fourths 1) had healthy trees that were pruned with some regularity and frequency, 2) prunings, fall vegetation and other debris were kept to a minimum and, 3) efforts were made to prevent the terrain from becoming excessively trenched or uneven (to prevent erosion and allow easier movement of vehicles and equipment) Only 6-20 % were considered to be poor or fair, and 13-16 % were in the excellent category This most recent thinking demonstrates the desire, by growers and researchers, to take into account factors other than just pesticides in the total management scheme

Mean orchard tree age was 35 yr, with a range from 5 to 66 (Hardman et al, 1984a) New plantings were common, but were not included in the survey Progressive growers usually remove (i e phase out of production) trees over 50 yr because they tend to be less productive and harder to manage

The varieties McIntosh, Gravenstein, Cortland, Red Delicious, Spy and Spartan represent 76 % of the total tree population (Embree et al, 1984) In 91 4 % of surveyed orchards, one or the other of these six was the main variety (McIntosh, 40 7 %, Gravenstein, 16 3 %, Cortland, 15 5 %, Red Delicious, 7 6 %, Spy, 7 1 %, Spartan, 4 2 %) (Hardman et al, 1986)

The majority of orchards serviced by IMMS were intended for fresh-fruit production (83 %) and the remainder were for processing and U-pick (12 % and 5 % respectively) (Hardman et al, 1986)

Pesticides Used

The pesticides and spray techniques used in Nova Scotia during the period 1906-1938 were discussed by Kelsall (1939) MacLellan (1979) reviewed annual pesticide recommendations for the period 1953-1977

Pesticides used in commercial apple orchards of the Annapolis Valley (1980-1983) were documented by IMMS (Hardman et al, 1986)

The most commonly used insecticides (1980 - 1983) were fenvalerate for WM, azinphos-methyl for CM, dimethoate for AM, malathion for SM, and pirimicarb for RAA (Table 4) Other insect pests received treatments less frequently and irregularly Most miticide applications were for ERM Cyhexatin was used for 80 % of the treatments (Table 5)

Orchards Monitored

For the years 1979 to 1985 respectively 133, 146, 159. 168, 180. 196, and 187 monitoring stations were surveyed In 1985, the mean number of stations per grower client was 2 9 with a range from 1 to 12 Extent of grower participation was dictated by hectares of orchard owned, economic situation, grower's own ability and available time, degree of progressiveness, and attitude toward the practice of IPM

Insect and mite surveys were conducted in relatively small areas of each station to minimize cost and increase efficiency Sites were selected according to subjective evaluation of the indicativeness of the site to the block as a whole Assessments usually involved 3-10 trees, depending on the pest or pests under investigation The data collected from these survey sites was used to describe insect and mite abundance in larger areas of orchard, to a maximum size as determined by the following criteria

1 Shape
2 Boundary vegetation
3 Age classes of trees
4 Varietal composition
5 Management practices

Any deviation from uniformity, within blocks, in any number of the above criteria was considered to result in the monitoring data being reliable over

Table 4. Mean dosages of insecticide applied in Nova Scotia apple orchards (1980 - 1983) compared with dosages recommended in the pest control program [1]

Target of application	Insecticide	Dosage applied (g AI/ha)	Range	Number of applications	Recommended dosage[2] (g AI/ha)
WM	Fenvalerate 30 EC	80	42-653	188	68
	Permethrin 25 WP	106	69-207	137	106
	Azinphos-methyl 50 WP	496	69-828	131	425
	B thuringiensis	741	552-6621	32	
	Phosmet 50 WP	997	138-1655	13	1625
	Methidathion 25 EC	1005	790-1053	11	1062
	Phosalone 30 WP	993	993	7	975
	Lead arsenate 32 WP	1086	132-2119	5	2160
CM	Azinphos-methyl 50 WP	311	138-828	206	212-875
	Phosmet 50 WP	504	138-1655	109	425-1625
	Phosalone 30 WP	465	207-993	26	255-975
	Dimethoate 48 EC	505	505	1	
AM	Dimethoate 48 EC	507	168-2055	240	480
	Azinphos-methyl 50 WP	625	207-2069	42	875
	Phosmet 50 WP	1458	207-1655	24	1625
	Lead arsenate 32 WP	1907	1589-2119	5	
	Phosalone 30 WP	993	993	2	975
	Fenvalerate 30 EC	105	105	1	
SM	Malathion 25 WP	202	17-1655	126	106-212
	Dimethoate 48 EC	1023	135-1516	25	
	Fenvalerate 30 EC	63	63	3	
RAA	Pirimicarb 50 WP	456	414-828	71	425-875
	Dimethoate 48 EC	1020	505-1516	13	960
	Methidathion 25 EC	526	526	3	
	Nicotine sulphate 40 EC	562	562	2	1700
STLM	Fenvalerate 30 EC	122	63-316	40	135
	Nicotine sulphate 40 EC	1606	337-1685	17	1700
	Phosmet 50 WP	448	448	1	
WALH	Dimethoate 48 EC	1219	674-1516	28	960
ESBM	Nicotine sulphate 40 EC	1293	393-1685	20	1700
	Malathion 25 WP	931	207-1655	4	1688
	Fenvalerate 30 EC	126	126	1	

1 Modified from Hardman et al (1986).

2 Pest control program for Nova Scotia apple orchards (Advisory Committee on Tree Fruits, 1982)

Table 5. (Cont'd)

Target of application	Insecticide	Dosage applied (g AI/ha)	Range	Number of applications	Recommended dosage (g AI/ha)
SGFW	Dimethoate 48 EC	1011	1011	4	
	Methidathion 25 EC	856	790-1053	4	1062
	Permethrin 25 WP	103	103	1	
	Fenvalerate 30 EC	63	63	1	
	Azinphos-methyl 50 WP	207	207	1	212-425
	Phosmet 50 WP	414	414	1	1625
	Phosalone 30 WP	993	993	1	975
PALR	Dimethoate 48 EC	1011	1011	1	960
FT[1]	Carbaryl 50 WP	408	34-689	18	

[1] FT - fruit-thinning

Table 5. Mean dosages of miticides applied in Nova Scotia apple orchards (1980-1983) compared with dosages recommended in the pest control program [1]

Target of application	Insecticide	Dosage applied (g AI/ha)	Range	Number of applications	Recommended dosage[2] (g AI/ha)
ERM	Cyhexatin 50 WP	461	310-724	228	425-625
	Fenbutatin oxide 55 SC	695	579-772	26	688
	Superior oil concentrate	14868[3]	6950-16848	10	17000
	Dicofol 35 WP	1082	772-1159	10	1138
	Tetrasul 18 WP	635	149-1192	9	585
	Propargite 30 WP	938	662-1490	3	2025

[1] Modified from Hardman et al (1986)

[2] Pest control program for Nova Scotia apple orchards (Advisory Committee on Tree Fruits, 1982)

[3] ml AI/ha

a smaller area of orchard Furthermore, monitoring techniques used were not considered to be indicative of orchard areas larger than a maximum of 4 ha

Personnel

Two entomologists, C.R MacLellan and I, conducted the field work quite satisfactorily in 1979 Increased work load from 1980 to 1983 warranted the addition of two field scouts In 1984, three field scouts and I carried on after Mr MacLellan retired The number of field scouts was reduced to two in 1985 to trim expenses

Treatment Thresholds

Initial 1979 thresholds were those gleaned from the literature or from discussions with various researchers Treatment thresholds were adjusted (based on observed preharvest fruit and foliage injury, current year levels of pest abundance, and treatments applied) on an annual basis from 1980 to 1985, in an attempt to improve their accuracy (Table 6) Even after annual modifications, further refinements were often necessary on an individual orchard basis taking into account unique environmental, biological, and economic factors (Prokopy et al 1980), particularly grower expectations and marketing strategy Thus, all thresholds were considered provisional The guidelines of 1 % preharvest fruit injury per pest, with a maximum of 5 % for all pests combined, were generally considered acceptable (MacLellan, 1979)

Both quantitative and qualitative provisional treatment thresholds were used Qualitative categories were very light (VL), light (L), light-moderate (L-M), moderate (M), moderate-heavy (M-H), and heavy (H) The VL category was used to indicate that a pest was not detected, and H was used for pest populations that approached a level of abundance that was expected

Table 6. Modifications to provisional treatment thresholds for apple pests of Nova Scotia (1979-1985).

Pest[1]	Developmental stage	1979	1980	1981	1982	1983	1984	1985
GPM	Larva	--[2]	--	--	--	--	--	M-H[3]
SGFW	Adult	13[4]	30	30	30	30	30	--
	Larva	--	--	--	--	--	--	1[5]
WM	Larva	L[6]	L	L	L&L-M[7]	L-M	L-M	L-M
PALR	Adult	95[4]	95	--	--	--	--	--
	Larva	M[8]	M-H	H	H	M-H	M-H	M-H
RAA	Colonies	10[9]	8	8	8	6-8	0.5[10]	0.5
ABB[11]	Nymph	16[12]	10	10	8	8[13]	8	8
WALH	Nymph-1	--	M[14]	M-H	M-H	M-H	0.5[15]	M-H[16]
	Nymph-2	--	M[14]	M-H	M-H	M-H	2.0[15]	--
FTLR	Adult	10[4]	10	--	--	--	--	--
	Larva	--	--	L-M[3]	L-M	M	M	M
AM	Adult	1[17]	1	1	1	1	1	1
CM	Adult-1	60[4]	60	50	50	50	50	50
	Adult-2	10[4]	10	10	10	20	10	10
ESBM	Adult	20[4]	20	20	40	40	40	--
STLM	Adult	--	500[4]	2000	4600	--	--	--
	Larva-1	--	--	1[18]	1	1	1[19]	1
	Larva-2	--	--	1[18]	1	1	2[19]	--
ARM	June	M-H[20]	M-H	M-H	M-H	M-H	M-H	M-H
	July	M-H[20]	M-H	M-H	M-H	M-H	M-H	M-H
	August	M-H[20]	M-H	M-H	M-H	M-H	M-H	M-H
ERM	June	40[21]	40	40	40	40	35	30
	July	10[21]	10	10	10	10	10	10
	August	10[21]	10	10	10	10	10	15

1 Pest not monitored or no threshold established.
2 See text and Appendix 3 for pest abbreviations and qualitative assessment categories.
3 Qualitative assessment of larvae during WM survey.
4 Number of adult males per trap
5 Number of larvae found during WM survey.
6 Qualitative assessment category arrived at through experienced observation.
7 Qualitative assessment category arrived at through sequential sampling
8 Qualitative assessment category - related to infested terminals.
9 Mean number of colonies/tree - size of tree not quantitatively considered
10 Mean number of colonies/foot of tree height
11 Apple brown bug - but includes other mirid (stinging bug) pests.
12 Number of nymphs/three whole tree taps.
13 Number of nymphs/ 20 limb taps
14 Qualitative assessment of nymphs in situ on leaves.
15 Quantitative count of nymphs/leaf, in situ
16 Qualitative assessment of nymphs on mite plates.
17 Number of adults, regardless of sex, per orchard, regardless of number of traps
18 Number of mines/leaf.
19 Number of living leafminers/leaf
20 Qualitative assessment of mites on plates.
21 Quantitative count of all developmental stages of mites/leaf; calculated from plate count.

to produce foliage or crop failure Foliage failure would be severe chewing or total removal of leaves, or severe or total depletion of leaf chloroplast Crop failure would be severe size and yield reduction, or direct damage to the majority of the fruit Other assessment categories were intermediate to VL and H Thus, assessments were relative to pest abundance and threshold levels were dependant on how much economic damage or stress was expected from a given population Experience and intuitive estimation were very important to the assignment of qualitative assessment categories

It is difficult, if not impossible, to quantify qualitative assessments in a way that others could use directly because of the variablity of injury caused by different pests In some cases it is even doubtful if economic damage is inflicted at all (e g GPM)

The assessment of M-H was established for larvae of GPM and PALR, for nymphs of WALH, and for active stages of ARM These pests can be very numerous and visible (as is the case with lepidopterous larvae), but damage to fruit, reduction of yield, and tree stress are minimal Fewer FTLR larvae could be tolerated because they cause direct fruit damage as a result of feeding on developing fruit Therefore, M was considered appropriate for the threshold Qualitative assessment thresholds for other pests were chosen in a similar fashion, after consultation with other entomologists and growers, and based on field observations

Pest Monitoring Methods

INSECTS PREBLOOM

<u>Green pug moth</u>

Larvae were first noticed in 1981, but their identity was unknown I collected several larvae in 1982 and reared them to the adult stage They were identified by Barry Wright, of the Nova Scotia Museum, Halifax, and verified by lepidopterists at the Biosystematics Research Institute (BRI), Ottawa The first record of this species in North America was from Nova Scotia in 1970 (Ferguson, 1972) Neil (1980) found the species in New Brunswick in 1978 (its first occurrence in North America outside of N S) Rogers (1984) and Whitman (1985) reviewed its distribution and life history

Attempts were made in 1983 and 1984 to assess larval abundance and to relate this to fruit injury In 1985, larvae were monitored as for winter moth, except that a treatment threshold of M-H was used

Speckled green fruitworm

Adults emerge in April Pherocon®[1] 1CP traps, each containing a polyethylene cap (now available as a hollow fibre[2]) impregnated with a pheromone lure (Hill and Roelofs, 1979), were placed one/orchard block approximately mid-April They were hung at eye level (some small trees did not allow this), near the periphery Cardinal point positioning in trees, and trap orientation were not standardized Except for an adjustment of the treatment threshold after the first season, this monitoring technique was employed consistantly from 1979 to 1984 (Table 6) Adults were not monitored in 1985 because lures were not available in time

Optimum control timing was recommended in the pink stage of bud development, but early calyx treatments were considered to be fairly successful as well

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[1] Zoecon Industries Limited, P O Box 30, Highway 7A, Port Perry, Ontario L0B 1N0

[2] Pest-Select International, Inc (formerly Albany International - Controlled Release Division), P O Box 11646, Phoenix, AZ 85061 Order from United Agri Products, P O Box 2357, Fresno, CA 93745

Larvae were crudely monitored (1979-1985) by counting those that dropped onto tapping trays during the mirid bug survey (see stinging mirids) at early calyx. If 3 or more larvae were found in an orchard by this method then an organophosphate (OP) treatment was discussed with the grower(s) concerned. In 1985, larvae were monitored prebloom by carefully identifying larvae encountered during WM surveys. As few as one SGFW larva encountered during a survey was considered to warrant treatment. An OP was recommended if no other pests were threatening, or a synthetic pyrethroid (SP) was considered if WM required treatment as well.

Winter moth

An unrefined qualitative assessment technique was used from 1979 to 1982. From 1983 to 1985 a sequential sampling plan was used (Table 7) after being developed and field tested in 1982 (Rogers, 1982). No fewer than 3 trees were examined on each sample occasion, until after bloom (see below), and treatable populations were arbitrarily divided into several categories (L-M, M, M-H, H) to be consistent with the qualitative categories used for other pests.

The original qualitative method of assessing WM larvae consisted of a 10-15 minute search of both fruit and foliage buds at random locations within, at least, several trees of each orchard block. Searches were conducted once weekly from green tip to early bloom. After bloom, larvae were assessed less systematically because of their habit of moving from bud to bud at this time. By observing numbers in tapping trays during the stinging mirid survey, and by scanning for chewing damage to fruit and foliage after bloom, it was possible to get an index of larval abundance in the postbloom period, thus providing a check for control effectiveness and accuracy of prebloom assessment.

Table 7. Sequential sampling chart for winter moth larvae on apple trees in Nova Scotia - tabular form *

Total number trees examined (20 clusters per tree)	Total number of larvae found					
	H	M-H	M	L-M	L	VL
	Spray				Continue sampling	No spray
3	>4	4	3	2	0-1	--
4	>5	5	3-4	2	0-1	--
5	>6	6	4-5	3	0-2	--
6	>7	6-7	4-5	3	1-2	0
7	>8	7-8	5-6	3-4	1-2	0
8	>9	7-9	5-6	3-4	1-2	0
9	>10	8-10	6-7	4-5	1-3	0
10	>11	9-11	6-8	4-5	2-3	1
11	>12	10-12	7-9	4-6	2-3	1
12	>13	10-13	7-9	4-6	2-3	1

* Modified from Rogers (1982)

Optimum control timing was considered to be during bud separation because the larvae are exposed at this time However, treatments could be applied with reasonable confidence from green tip to pink, and again in early calyx, depending on the severity of infestation and larval development (MacPhee, 1981).

INSEETS CALYX

<u>Paleapple leafroller</u>

Adults emerge in April and were monitored in 1979 and 1980 with Pherocon®[1] 1CP traps and experimental sex attractant chemicals[2] These chemicals (pheromones) appeared to attract at least two closely related

[1] Zoecon Industries Limited

[2] Supplied by W L Roelofs, Geneva, New York

species making trap captures difficult to interpret with any accuracy Therefore, trapping was discontinued after 1980

Larvae were monitored qualitatively by examining the very tip of terminal growth for rolled leaves and larvae This technique was used by provincial extention entomologists and adopted by IMMS No formal counts of infested and non-infested terminals were conducted because the threshold for this pest was high enough that quick visual impressions were considered sufficient Therefore, there was no reason to incorporate a more time consuming and costly technique Treatment was considered necessary in calyx only if ≥75% of terminals were estimated to be infested (M-H or greater) or a significant number of larvae were found on or near fruit clusters

Rosy apple aphid

This pest was monitored by counting colonies on several whole trees, preferably on more susceptible cultivars (Gravenstein, Cortland, Idared), if present Provincial and federal entomologists suggested this method

Tree size had only a minor bearing on the need to treat in 1979-80 because of lack of experience and research with regard to this factor In 1981-82 tree size was taken into account more regularly, but still no definite threshold to tree height correlations had been established A reseach project to investigate this problem was undertaken in 1982 (Rogers, 1983) The results helped to establish, for 1983, a variable threshold of greater accuracy, but nevertheless still crude in nature (i e the threshold changed with tree height, and the experience of the observer dictated what that might be) By 1984, I had established a more acceptable and accurate threshold of 0 5 colonies ft^{-1} (1 5 colonies m^{-1}) of tree height (Appendix 4) This threshold was used exclusively in 1984 and 1985

Stinging mirids

Several species of mirid pests were surveyed at the same time with the same monitoring technique The initial threshold was as determined by MacPhee (1976) From 1979 to 1983 inclusive, this involved tapping the terminal portion of most limbs, between 1-2 m above ground, all around a single tree and counting the nymphs of pest mirids that fell onto a 0 28 m^2 drop cloth At least 2-3 trees per orchard block (of the most susceptible cultivars present, Delicious, Spy) were tapped in this manner The highest single count was used to compare with the current threshold for the purpose of devising control recommendations

As with RAA, tree size was not taken into consideration to any great extent To rectify this shortcoming, I conducted a simple investigation in 1983 to compare mirid counts from 20 limb beats to those of whole, standard tree (4-5 m in height) limb beats This suggested that tapping could be standardized so that comparable results could be obtained, regardless of tree size In 1984 the modified tapping method was used This involved tapping an eqivalent number of branches per orchard (i e 20) Preferably, four limbs (from cardinal points N, E, S, W) from each of five trees were tapped However, dwarf and very young trees may have had as few as one limb tapped per tree, on as many as 20 trees If the amount of plant debris that fell onto the cloth made counting mirids difficult then the tapping set was subdivided into 2 sets of 10 limbs, 4 sets of 5, etc The count recorded was the total number of stinging bugs per 20 limbs tapped per orchard

Optimal treatment period was early calyx, with only a 3-5 day window between earliest possible pest detection and the occurrence of injury to fruit Accurate timing of assessments and sprays was critical

White apple leafhopper

Sufficient numbers of nymphs hatch at early calyx to permit assessment Nymphs were counted on the undersides of up to 100 leaves per block (this survey technique adopted from provincial extension entomologists) and the average number of nymphs leaf^{-1} was compared to the current threshold to determine if control action should be considered within one week of petal fall This technique for first generation WALH assessment was used from 1979 to 1984 (Table 6) Second generation nymphs were similarly assessed in early August of the same period In 1985, first and second generation nymphs were qualitatively assessed on plates while doing mite counts (refer to mite counting procedure)

Fruit-tree leafroller

Adults emerge in August and, from 1979 to 1980, were monitored using Pherocon®[1] ICP traps and rubber septa caps[1] containing sex attractant chemical (Carde et al, 1977) Adult monitoring was discontinued in 1981 because of the infrequent occurrence of treatable populations Larvae occur at early calyx, and were only noted, subsequent to 1981, when encountered during other surveys

INSECTS POST CALYX

Apple maggot

Adults emerge early July Pherocon®[1] AM traps (yellow colored), baited with a feeding stimulant (ammonium acetate), were used to monitor this pest Three traps/monitoring station were deployed 2-4 days after the onset of emergence was detected by researchers at the Kentville Research Station Traps were hung according to the following placement criteria (as

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[1] Zoecon Industries Limited

used by research entomologists in Kentville) 1) eye-level, 2) outside of canopy in plain sight, 3) near fruit, 4) on the southeast-southwest side of tree, 5) on an early variety (Bow Sweet, Cox's Orange, Gravenstein, Close, Quinte, Tydeman Red, Yellow Transparent), 6) on the periphery of the block where, through past experience or damage history, the greatest likelihood of intercepting apple maggot flies exists Treatments were recommended when as few as one fly was trapped $block^{-1}$, further treatments were based on the same threshold, but applied no sooner than 10 days apart

Preharvest surveys of fruit by provincial apple maggot inspectors determined levels of infestation (eggs and larvae in fruit) in individual orchards These data were made available to IMMS and the results for clients' orchards were summarized (see results)

<u>Codling moth</u>

Adult codling moths were monitored with Pherocon®[1] ICP traps (MacLellan,1976) baited with an effective sex attractant[1] (Roelofs et al, 1971) Traps were placed, one $orchard^{-1}$, 1-3 days before expected moth activity and left in place for 5-6 weeks The need for a first treatment was based on cumulative male codling moth capture (Table 6) If captures did not exceed the threshold for first treatment until the end of the flight and egg-laying period, then it was unlikely that a treatment would be recommended because the majority of eggs would have been laid, and hatch well progressed, so the potential for further damage avoidance would be small Cumulative moth capture was considered to be zero immediately after first treatment A second treatment was recommended only if cumulative captures after the first treatment exceeded the second threshold

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[1] Zoecon Industries Limited

Eye-spotted budmoth

The ESBM overwinters as a second instar larva in a hibernaculum located on an apple tree twig Larvae emerge and begin feeding on foliage at about the half inch green stage of bud development (MacLellan, 1978) From this time till pink they are difficult to control, and cause no fruit damage Therefore, monitoring was delayed until adult emergence in mid-July At this time, adult males were monitored with Pherocon®[1] 1CP traps, baited with a sex attractant[2] (MacLellan, 1978) Controls were recommended when cumulative male captures exceeded the threshold value (Table 6)

This pest was not monitored in 1985 because lures were not available for the adults and post 2nd instar larval assessments were not considered reliable for determining the need for control

Spotted tentiform leafminer

Adults emerge from overwintering pupae from late April through early May An attempt to monitor the adults with Scentry™[2] Delta traps (triangular in shape) and a hollow fiber sex attractant lure[2] (Roelofs et al, 1977), from 1979 to 1981, proved futile because there was no correlation between adult male captures and the extent of foliage injury (i.e larval mines/leaf) MacLellan and I found that counts of first generation mines in July proved useful for determining the need for control and this technique was used from 1982 to 1985 I introduced further refinements in 1984 to quantify the levels of parasitism and to consider this information in control recommendations Second generation mines were counted from 1982 to 1984 In 1985, sampling second generation mines was considered unnecessary with regard to control recommendations because 1) treatment

[1] Zoecon Industries Limited
[2] Pest-Select

of this generation was determined to be too harsh on natural enemies, and 2) when left untreated at this stage it was unlikely that a problem would exist the following year

MITES

Apple rust mite

All post-egg stages of ARM were surveyed three times a season, mid-June, mid-July, mid-August Four leaf clusters from each of five trees, of the cultivars Delicious or Spy, if present, were collected from about "eye-level" and "arms reach in" (Herbert and Butler, 1973) The clusters were put into 5 lb plastic bags, sealed with a loose knot, and returned to the lab within four hours If the samples could not be processed the same day they were stored in a cool place (i e cold room or refrigerator)

At the lab, all leaves (of every cluster sample^{-1}) were counted and brushed with a commercially available mite brushing machine[1] (Henderson and MacBurnie, 1943, Morgan et al, 1955) This procedure was varied after 1981 so that no more than 100 leaves sample^{-1} were brushed, in an effort to speed up the brushing process In 1985, samples of 50 leaves were used with satisfactory results Brushings collected on rotating, circular plates which were lightly coated with a hand cleaner paste[2] The cleaner proved to be a very inexpensive, easy to use, and effective immobilizing agent Each plate was then placed on a tray gridded with black and white concentric circles and the relative abundance of apple rust mites was qualitatively assessed with the aid of a binocular microscope

[1] Manufactured by J G N Edwards, Llanfair Orchards, RR 1 Okanagan Falls, B C, Canada V0H 1R0 Tel (604) 497-5218

[2] Luster Sheen, Kiwi Polish Company (Canada) Limited, Hamilton, Ontario

Rust mites can be tolerated in quite high numbers so treatment recommendations were not often advised because of the expense and harmful effects on beneficial mites. However, if the problem was definitely serious or other pest mites appeared threatening, a miticide treatment was recommended.

European red mite

All stages of ERM were surveyed three times a season, mid-June, mid-July, mid-August. Collection and sample processing were the same as for ARM. Each plate was placed on a tray gridded with black and white concentric circles and all stages of ERM were counted in an area eqivalent to one sixteenth of the plate. Plate counts were later converted to counts of mites leaf^{-1} by the following general formula.

$$\textbf{Mites leaf}^{-1} = \textbf{(Plate count) (20)} \div \textbf{(No. leaves brushed)}$$

Brushing was determined to be only 80% efficient (H.J. Herbert, personal communication, 1979), therefore the plate count had to be multiplied by 20 instead of 16 to get total numbers of mites plate^{-1}. From 1979 to 1981 it was assumed that the average number of leaves cluster^{-1} was 8 (H.J. Herbert & K.H. Sanford, personal communication, 1979), so during this period the number of leaves brushed was considered to be 160 (i.e. 20x8=160). Greater speed and accuracy of mite counts was achieved by counting and brushing no more than 100 leaves sample^{-1} from 1982 to 1984, and 50 leaves sample^{-1} in 1985. Thus, number of leaves brushed became an actual number, not an assumed number.

RESULTS AND DISCUSSION

Pest Monitoring Results

Annual mean abundances were calculated for the AM and ERM, and the results are presented below Annual mean abundances were calculated for some other pests, but the data were not fully treated statistically because of time and cost limitations These means are summarized in Appendix 5, interpreted to some extent by Hardman et al (1984b), and mentioned in the following text Fruit and foliage injury surveys were undertaken from 1980 to 1984 and some of the results are presented in Appendix 6 and Hardman et al (1984d) Percent of orchards recommended for treatments are summarized in Appendix 7 and detailed below

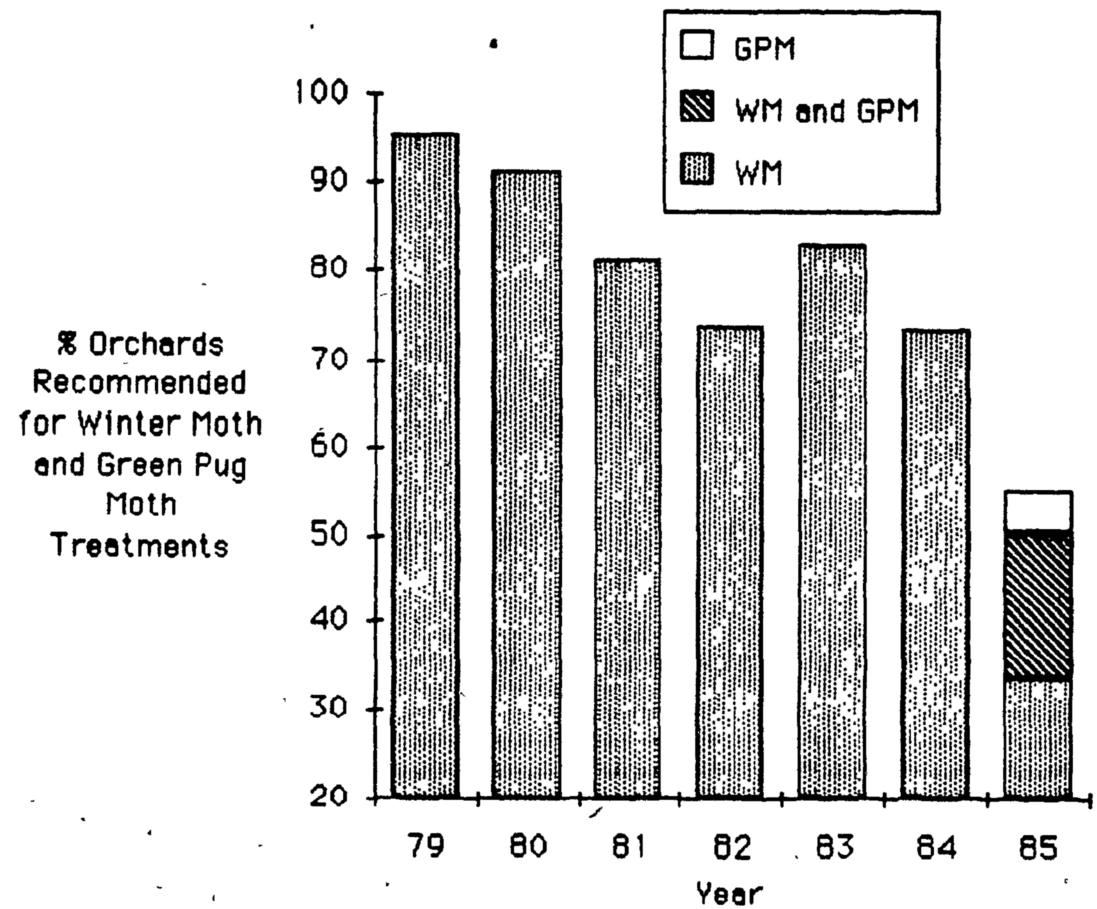
INSECTS PREBLOOM

<u>Green pug moth</u>

I observed and evaluated GPM infestations for two years before I became confident that little or no direct fruit damage would result, even when larvae are very numerous However, this pest may be a problem with regard to yield, and studies to determine this are needed Larvae appeared to feed only on the sexual parts of apple blossoms (only minor foliage feeding before blossom buds were well developed was observed) and dropped to the ground just before the completion of petal fall Therefore, it is possible, that excessive thinning may result when larvae are numerous

Quantitative results were first acquired in 1985 Only 5 % of orchards were recommended for treatment for GPM alone, although suspected economic populations were found in conjunction with treatable WM populations in an additional 17 % of orchard blocks (Figure 3)

Figure 3. Percent of orchards recommended for winter moth and green pug moth treatments from 1979 to 1985. GPM = green pug moth, WM = winter moth.


GPM
WM and GPM
WM
100
90
80
70
60
50
40
30
20
% Orchards Recommended for Winter Moth and Green Pug Moth Treatments
79
80
81
82
83
84
85
Year

Speckled green fruitworm

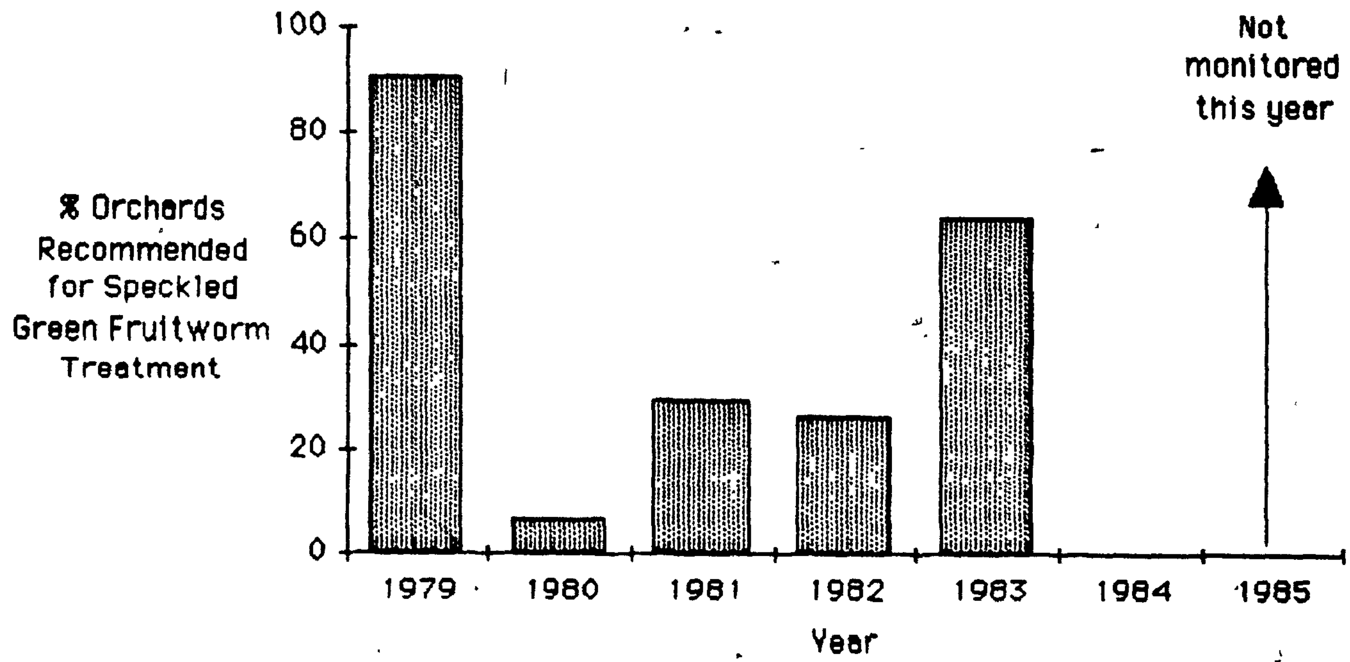
Treatments were recommended in 90 % of monitored orchard blocks in 1979 (Figure 4) when the threshold was 13 adult males trap^{-1} (mean trap capture was 49.5). Most blocks were treated as recommended, although most insecticides were selected and timed for WM as well, thus eliminating a double treatment. The low occurrance of above threshold counts in 1980 (20.4 trap^{-1}) was probably a reflection of 1) controls being applied efficiently and effectively in 1979, and 2) the treatment threshold being raised to 30 adult males trap^{-1} in 1980, more than twice that of the previous year. The latter was deemed a necessary adjustment based on intuitive conclusions about the relative abundance that could be tolerated. In this case, the new threshold worked extremely well.

Higher mean trap captures in 1981 and 1983 (24.9 and 34.6 trap^{-1} respectively), excluding 1979, (Appendix 5) and more numerous treatment recommendations in those years, demonstrated the species ability to reinfest. Captures in 1982 and 1984 were 20.6 and 5.6 trap^{-1} respectively. In 1984, there were 0 % control recommendations. The adults were not monitored in 1985 because lures were not readily available, and no quantitative records of assessments for larvae were made because of inadequate technique. I am concerned that this pest, if not accurately monitored every year, could reinfest without warning and cause significant damage and influence a return to routine spraying on an annual basis.

Winter moth

Most orchards had detectable levels of WM every year (mean qualitative abundances L-M, L-M, L-M, L-M, M, M for 1979-1984 respectively). However, even with low tolerence for WM fruit injury, it was not necessary to apply routine, annual chemical controls.

Figure 4. Percent of orchards recommended for speckled green fruitworm treatments from 1979 to 1985.



% Orchards Recommended for Speckled Green Fruitworm Treatment
100
80
60
40
20
0
Not monitored this year
1979
1980
1981
1982
1983
1984
1985
Year

Orchards recommended for treatment decreased from a high of 96 % in 1979, to a low of 51 % in 1985 (Figure 3) The intermediate years support a downward trend However, endemic populations in shade trees and wooded areas can easily reinfest orchards sufficiently to cause economic concerns (Holliday, 1977) Therefore, it appears that the best one could hope for would be no treatment every other year

INSECTS CALYX

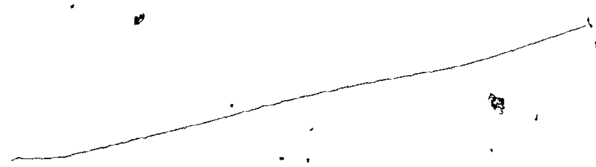
Paleapple leafroller

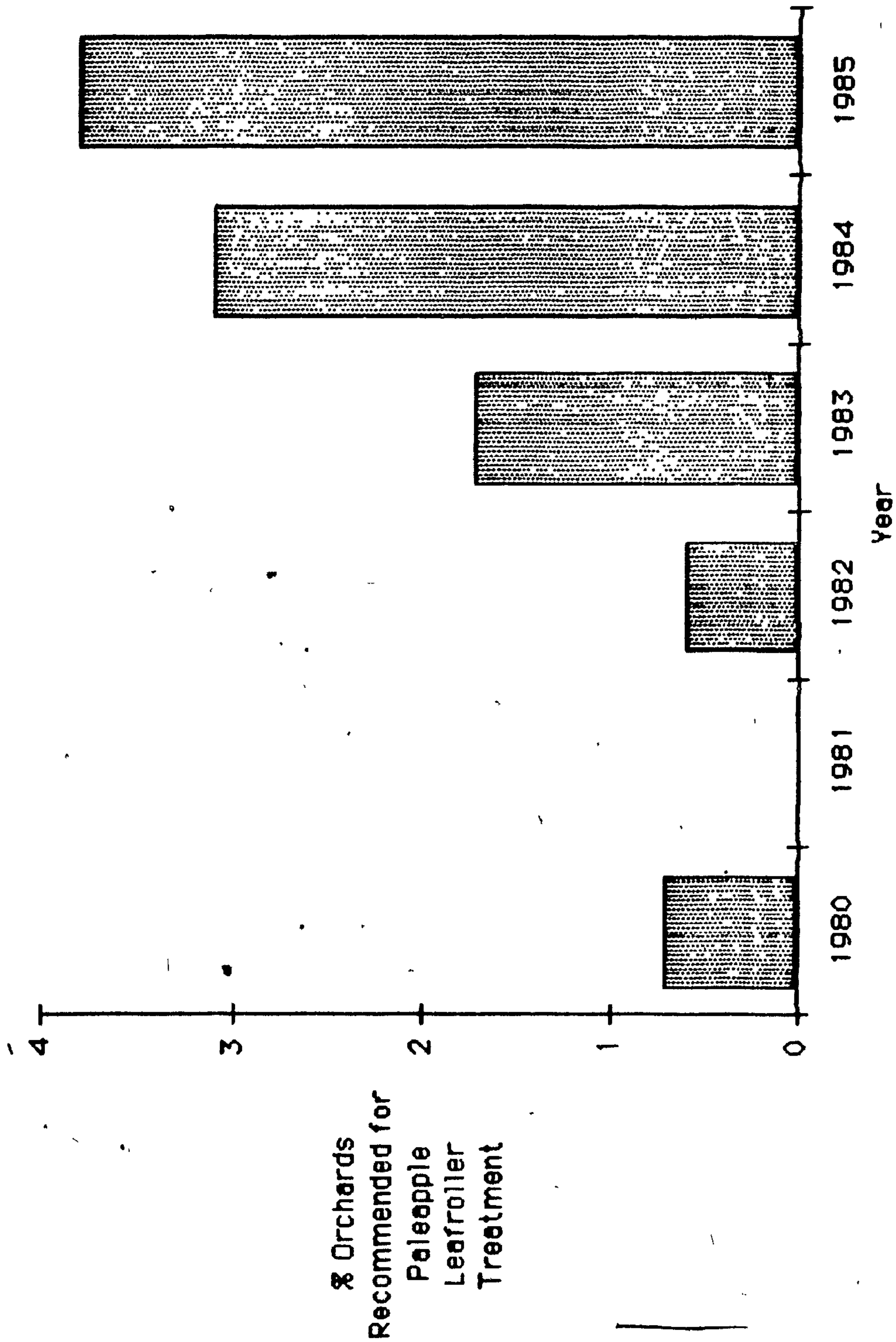
This insect, apparently, was rarely a concern before the late 1970's (C R MacLellan, personal communication) It gained the status of minor pest, after this time, because of its increased prevalence and potential for fruit damage When larvae are abundant, their habit of feeding on terminal growth can significantly alter development of dwarf trees and young plantings (Chapman and Lienk, 1971). Also, heavy populations were observed to cause substantial fruit injury when the larvae were in fruit clusters

Attempts were made in 1979 and 1980 to monitor PALR by pheromone trapping of adult males This was not successful because the lures attracted at least two species of moth that were very similar in appearance Positive identification, and distinguishing characters (other than a slight size difference) could not be established, even with the help of BRI, Ottawa

Larval abundance assessments were not done in 1979 From 1980 to 1985 the percent of orchards recommended for treatment based on larval assessments (i e at or above M-H) ranged from 0 to 4 % (Figure 5) Mean larval abundances, on a qualitative point scale, were L for the years 1980-1984 (Appendix 5)

Figure 5. Percent of orchards recommended for paleapple leafroller treatments from 1980 to 1985.




% Orchards
Recommended for
Paleapple
Leafroller
Treatment
0
1
2
3
4
1980
1981
1982
1983
1984
1985
Year

Sometimes, PALR larvae in orchards caused considerable concern to growers because of their numbers In most cases, the concern was unjustified because of misidentification of larvae (i e mistaken for WM or just considered a "green worm") and a lack of understanding with regard to their damage potential

Rosy apple aphid

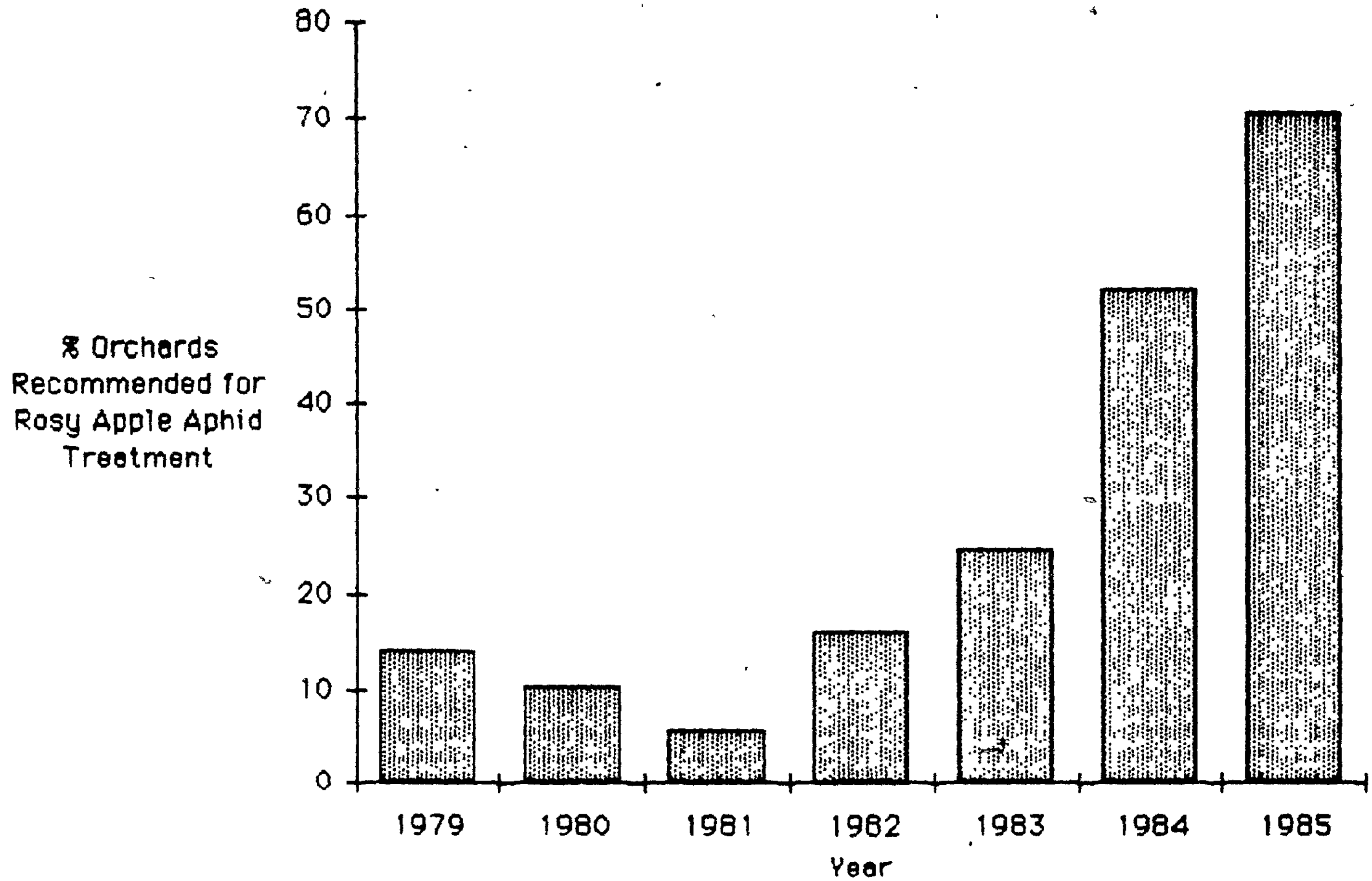
Rosy aphids caused great concern to apple growers for several reasons 1) they were not easily detected and assessable at an early stage (i e prebloom) unless colony size made damage obvious, 2) damaged fruit were obvious and unsightly, were difficult to pick around at harvest time, and there was the possibility of large "aphid apples" getting included with uninjured fruit - this was a problem because the reduced storage quality of these fruit could lead to premature storage rot in otherwise good bins of fruit Therefore, over the seven years of this program, grower tolerence to aphid injury was noted to be very low

In 1979, RAA was assessed and recommended for treatment using assessment techniques and thresholds that lacked precision and sensitivity Experience with this pest improved assessments, and in 1982 a study on the within-tree distribution of colonies (Rogers, 1983) improved monitoring and allowed greater confidence and reliability in determining the need for control action

Estimates of mean colony abundance per 15 foot tree ranged from 0 1 to 7 1 during the period 1979-1984 (Appendix 5) Colony abundance in 1985 was 6 9 tree^{-1}

In 1979, 14 % of monitored blocks exceeded acceptable levels A low of 6 % was reached in 1981, followed by a steady increase to the very high level of 71 % in 1985 (Figure 6)

Figure 6. Percent of orchards recommended for rosy apple aphid treatments from 1979 to 1985.


% Orchards
Recommended for
Rosy Apple Aphid
Treatment
0
10
20
30
40
50
60
70
80
1979
1980
1981
1982
1983
1984
1985
Year

It was necessary for quite a few growers to apply a second treatment in 1985 because initial treatments did not prevent a second increase Also, where populations exceeded treatable levels, and were not effectively controlled, all varieties suffered excessive damage An extended period of cool, wet weather (May through June), and the scarcity of natural enemies were the major factors influencing this situation

The 1985 RAA season raised the following questions with regard to monitoring this pest 1) Over what period of time and how frequently is it feasible and necessary to check RAA development? 2) Should the treatment threshold be variable over time? 3) How effective are natural enemies and how can their abundance be related to RAA populations? These questions must be answered if this pest is to be effectively and economically managed

Based on my experience, I feel that RAA should be checked once at the tight cluster stage of bud development, twice weekly for two weeks immediately following bloom, and once weekly for at least two more weeks If a developing problem is detected prebloom, appropriate action could be taken to minimize the effect on natural enemies that normally appear at calyx or later The above frequency of inspections would be feasible only if growers participated in the monitoring effort, e g the first 2-3 inspections done professionally, and follow up inspections done by growers This ties in well with question 2) because, initially, RAA is not obvious, but colony abundance can be very indicative of a spray or no spray situation, and professional observation is most reliable Colony abundance during follow up inspections is often difficult to interpret for a professional because the damage is done by the third or fourth inspection, and there is questionable merit to treatment This is when a grower can make a subjective decision

Aphids have many natural enemies, both in the form of parasites and predators (Bouchard et al, 1982, Dixon, 1973, Kuenen, 1962, Quaintance and Baker, 1920) Bouchard et al (1982) suspected some of the entomophagous insect fauna in Quebec apple orchards of providing significant control of the apple aphid, *Aphis pomi* Geer However, when I tried to incorporate natural enemy presence and abundance into treatment recommendations for RAA, I met with little success Syrphid eggs and larvae typically appeared early, but they failed to be numerous enough to regulate the numbers of RAA Cecidomyid larvae did not become numerous until it was too late to prevent further aphid damage to fruit

These observations contradict Kuenen's (1962) impression of aphid control in Nova Scotia and agree with his view of the situation elsewhere according to his statement " in Nova Scotia it seems that natural enemies are the main factor controlling the pest (RAA) populations to sufficiently low levels But we cannot hope for similar success elsewhere " With regard to RAA, I agree with Dixon (1973) when he says " although they kill many aphids there is no evidence to indicate that natural enemies can regulate the numbers of aphids they do not curb the increase of dense populations and they hinder the increase of sparse ones It took me seven years of trial and error to come to a similar realization However, I feel that natural enemies could be important to RAA control through introduction and augmentation programs, where parasites and predators are reared for mass release

Stinging mirids

Apple brown bug (A mali) was found to be the most common and abundant mirid pest in Nova Scotia orchards However, thresholds and counts included other pest mirids Mean abundances of pest mirids ranged from 5.4 to 14.2 sample^{-1} during the period 1979-1984 (Appendix 5)

Treatment recommendations increased from < 20 % in 1979 and 1980, to a high of 45 % in 1984 (Figure 7) The greater sensitivity of sampling and thresholds, over the years, may partly explain the increased treatment recommendations However, just as for RAA, SM are not responding well to present pest management practices I will hazard a guess that, the trend to replacing organophosphates with synthetic pyrethroids in the prebloom period, beginning in the early 1980's, is producing some negative repercussions

<u>White apple leafhopper</u>

WALH was not monitored in 1979 Both first and second generation nymphs were monitored from 1980 to 1984 During this period, treatment recommendations for both generations of nymphs fluctuated independently and with no apparent trends (Figure 8) The first generation experienced a low of 1 % in 1980 and a high of 33 % in 1984 Second generation nymphs were lowest in 1980 at 3 % and highest in 1982 at 20 %

This pest was difficult to assess accurately because of the lengthy hatching period of each generation Also, controls were not consistently effective, as a result of suspected resistance in some populations Resistance is confirmed in some regions of North America (Trammel, 1974). Control recommendations were often left up to provincial extension staff and the growers

There was no consistent correlation between population densities for each generation, so it was not possible to predict the extent or severity of the second generation from first generation data In 1985, the second

Figure 7. Percent of orchards recommended for mirid pest treatments from 1979 to 1985.

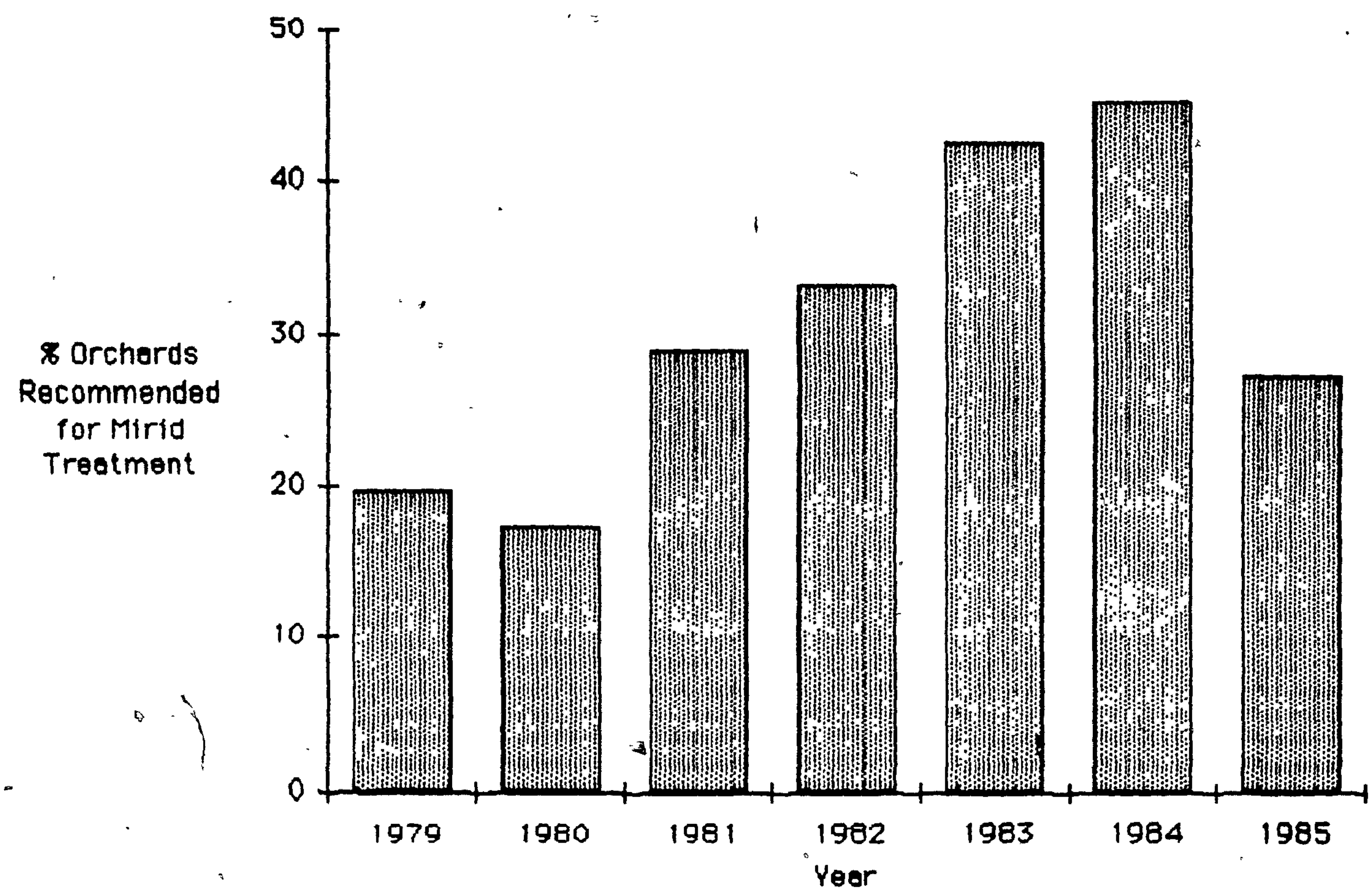
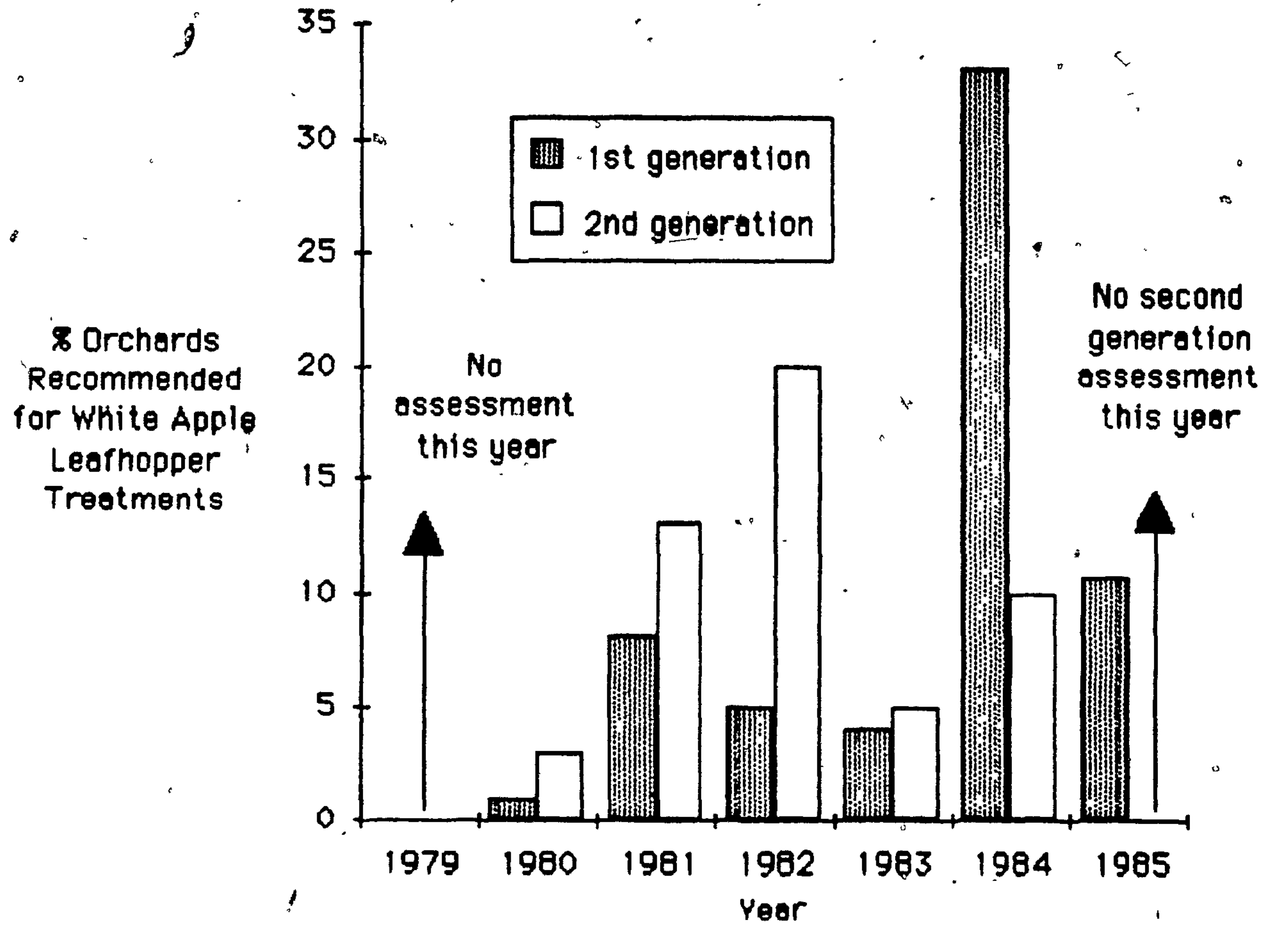

% Orchards Recommended for Mirid Treatment
50
40
30
20
10
0
1979
1980
1981
1982
1983
1984
1985
Year

Figure 8. Percent of orchards recommended for white apple leafhopper treatments from 1979 to 1985.


% Orchards Recommended for White Apple Leafhopper Treatments
35
30
25
20
15
10
5
0
1st generation
2nd generation
No assessment this year
No second generation assessment this year
1979
1980
1981
1982
1983
1984
1985
Year

generation did not appear until the latter half of August At that time, it did not seem to be developing into a problem, based on limited observations

Experience indicated that the second generation was not worth evaluating because 1) it was not numerous in a high percentage of orchards, 2) it was extremely difficult to control in August and the insecticides or miticide (formetanate hydrochloride) for control were considered hazardous to natural enemies, 3) injury to foliage was seldom significantly detrimental to the crop and, 4) any excrement on the fruit, as a result of leafhopper defecation, could be removed by washing, a procedure that some packing warehouses practiced as needed

Fruit-tree leafroller

Pheromone traps were used to monitor the adult of this insect in 1979 and 1980 It was realized at the end of the 1980 season that economic populations seldom existed under current spray regimes, so trapping was discontinued Larval surveys from 1981 to 1985 did not detect any treatable populations (Appendix 7)

INSECTS POST CALYX

Apple maggot

This pest's persistence, ability to reinfest an orchard, and its potential for causing crop losses were dramatically witnessed during seven years of monitoring

In 1979, 49 % of orchard blocks were recommended for treatment A three year decline in treatment recommendations and infested orchards followed (Figures 9 & 10) The trend seemed so strong that it was felt that AM was being effectively detected, and controlled In 1983, however, 49 % of monitored orchards were recommended for treatment, as in 1979, and 19 % of all blocks had infested fruit

Figure 9. Percent of orchards recommended for at least one apple maggot treatment from 1979 to 1985.

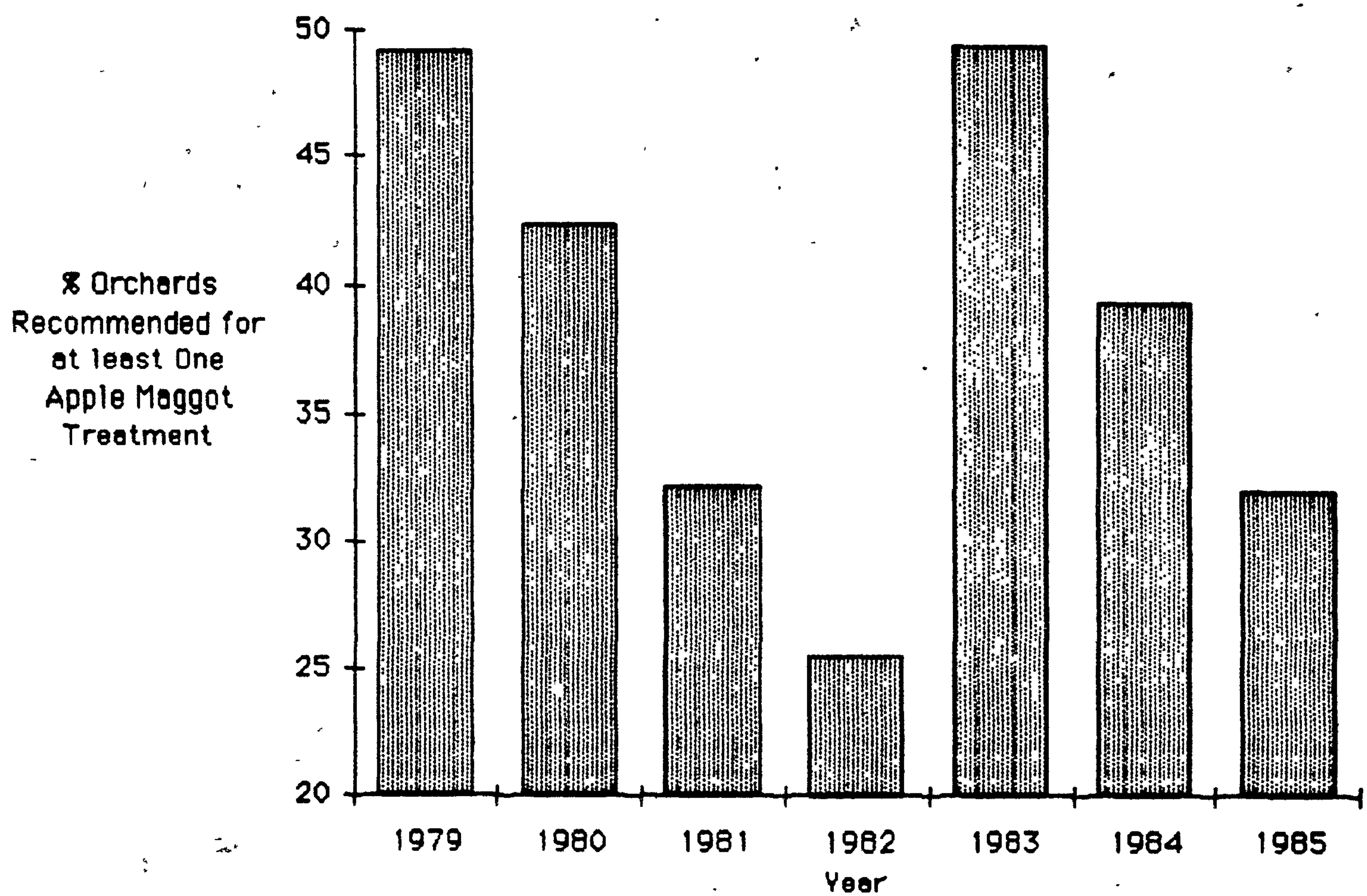
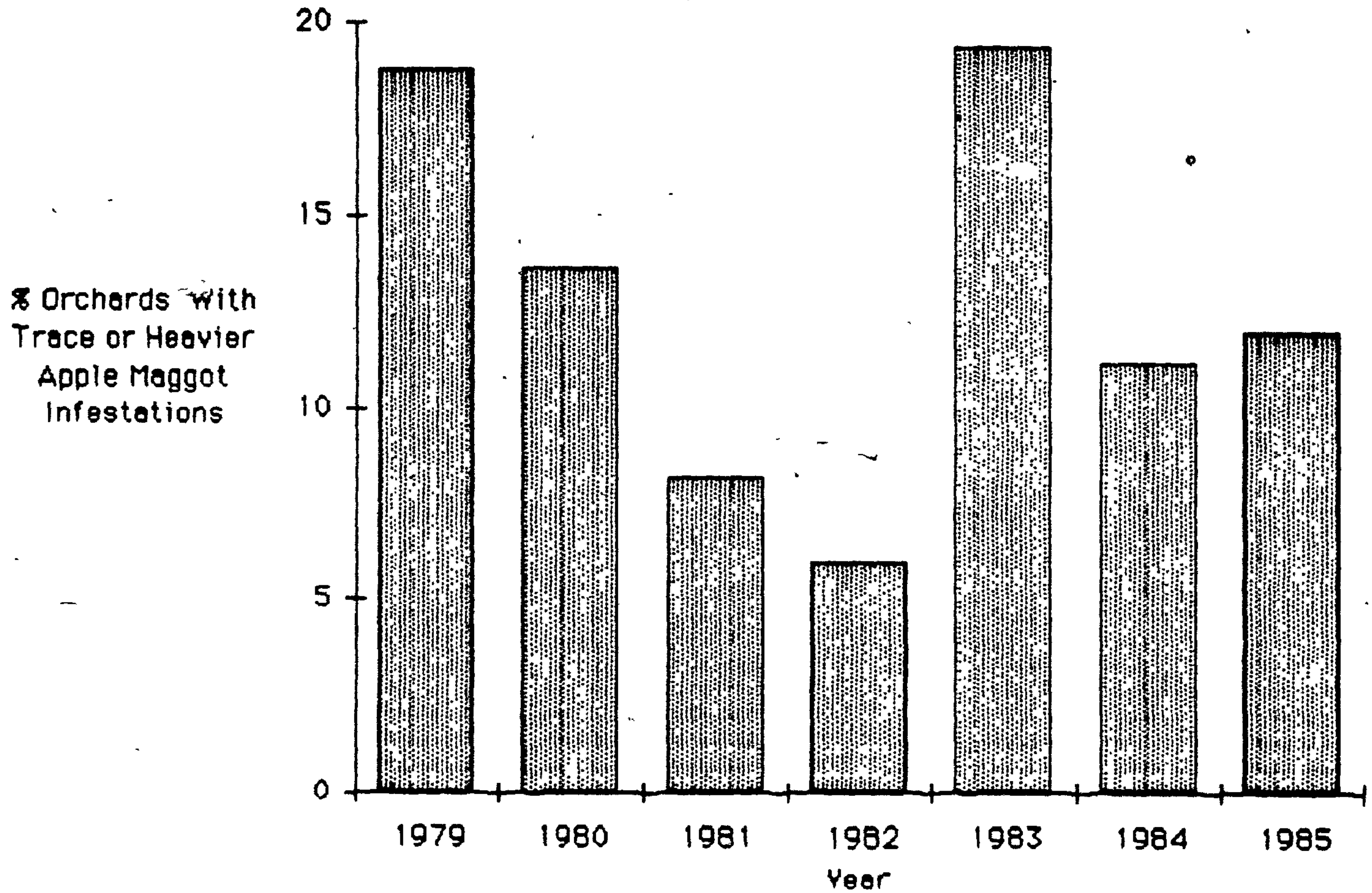

% Orchards Recommended for at least One Apple Maggot Treatment
50
45
40
35
30
25
20
1979
1980
1981
1982
1983
1984
1985
Year

Figure 10. Percent of orchards with trace or heavier apple maggot infestations from 1979 to 1985 Provincial maggot inspectors determined the levels of infestations (i.e trace - heavy with regard to egg laying punctures and larval activity) by in orchard surveys of fruit


% Orchards with
Trace or Heavier
Apple Maggot
Infestations
20
15
10
5
0
1979
1980
1981
1982
1983
1984
1985
Year

A strong correlation was detected between percent orchards recommended for treatment (Figure 9), percent with infested fruit (Figure 10), and mean annual trap capture (Figure 11) Therefore, I feel that monitoring with yellow sticky traps can detect population fluctuations, but cannot prevent infestation levels from following increasing population trends Monitoring did, however, keep surprise infestations to a minimum, and helped prevent high population densities from becoming established

Codling moth

In 1979, 52 % of monitored blocks were recommended for treatment An unexplained low was experienced in 1980 (high late captures and injury), and the remaining seasons from 1981 to 1985 varied in the range 35-46 % (Figure 12) Mean captures per season ranged from 44 9 to 73 9 adult males $trap^{-1}$ (1979-1984) (Appendix 5)

In most cases, CM was effectively controlled with minimum dosages of pesticides A one fourth rate of pesticide was recommended most often Timing (of control applications) was accurately forecasted through cooperation of provincial extension, and C R MacLellan

Very few orchards escaped having a CM problem at one time or another, but seldom did a problem persist so as to require annual pesticide treatments Effective detection and control of CM prevented this serious and recurring pest from causing excessive injury to fruit (Appendix 6)

Figure 11. Mean number of apple maggot flies per trap, 1979-1985. Vertical lines are standard errors

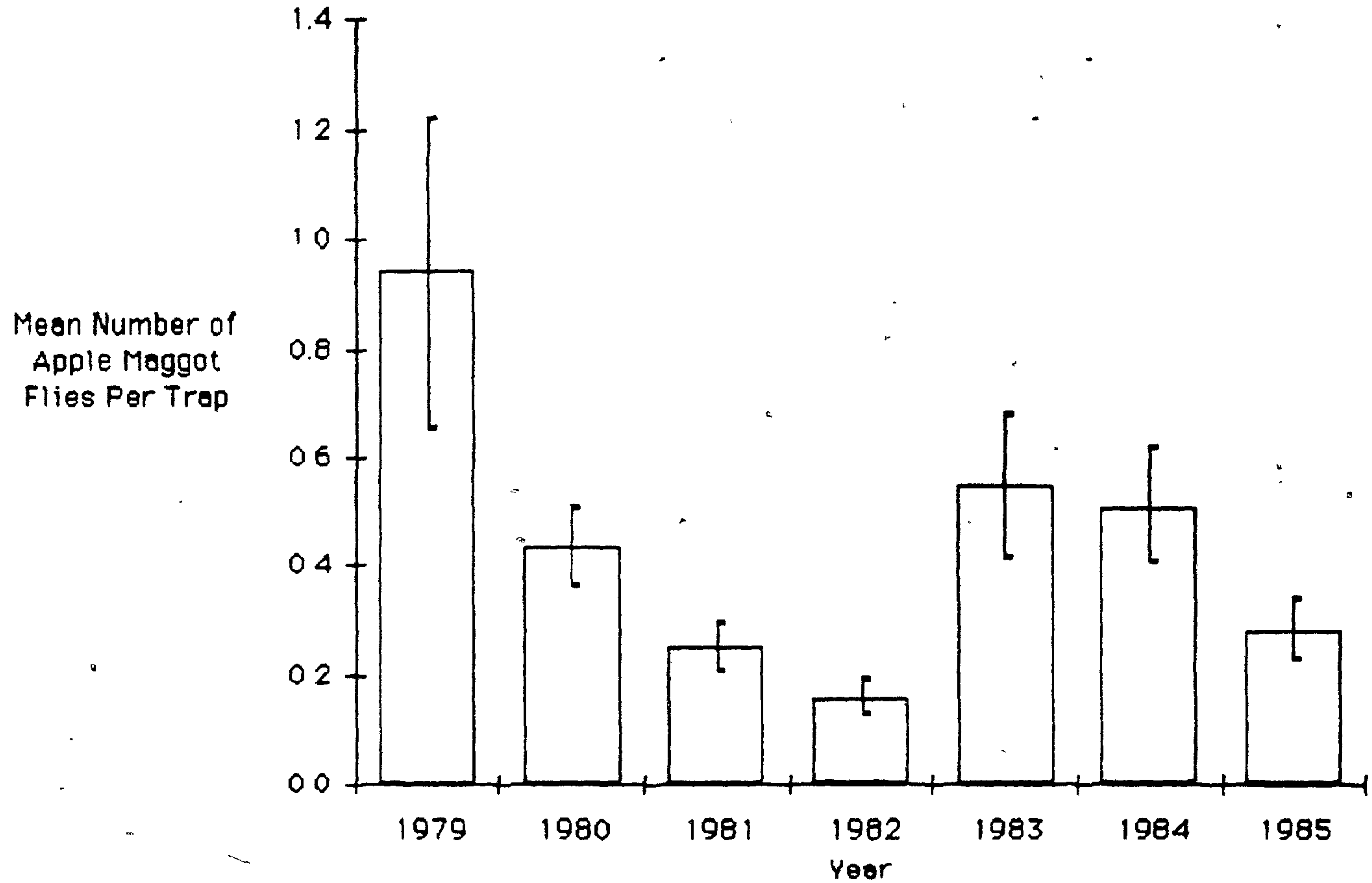
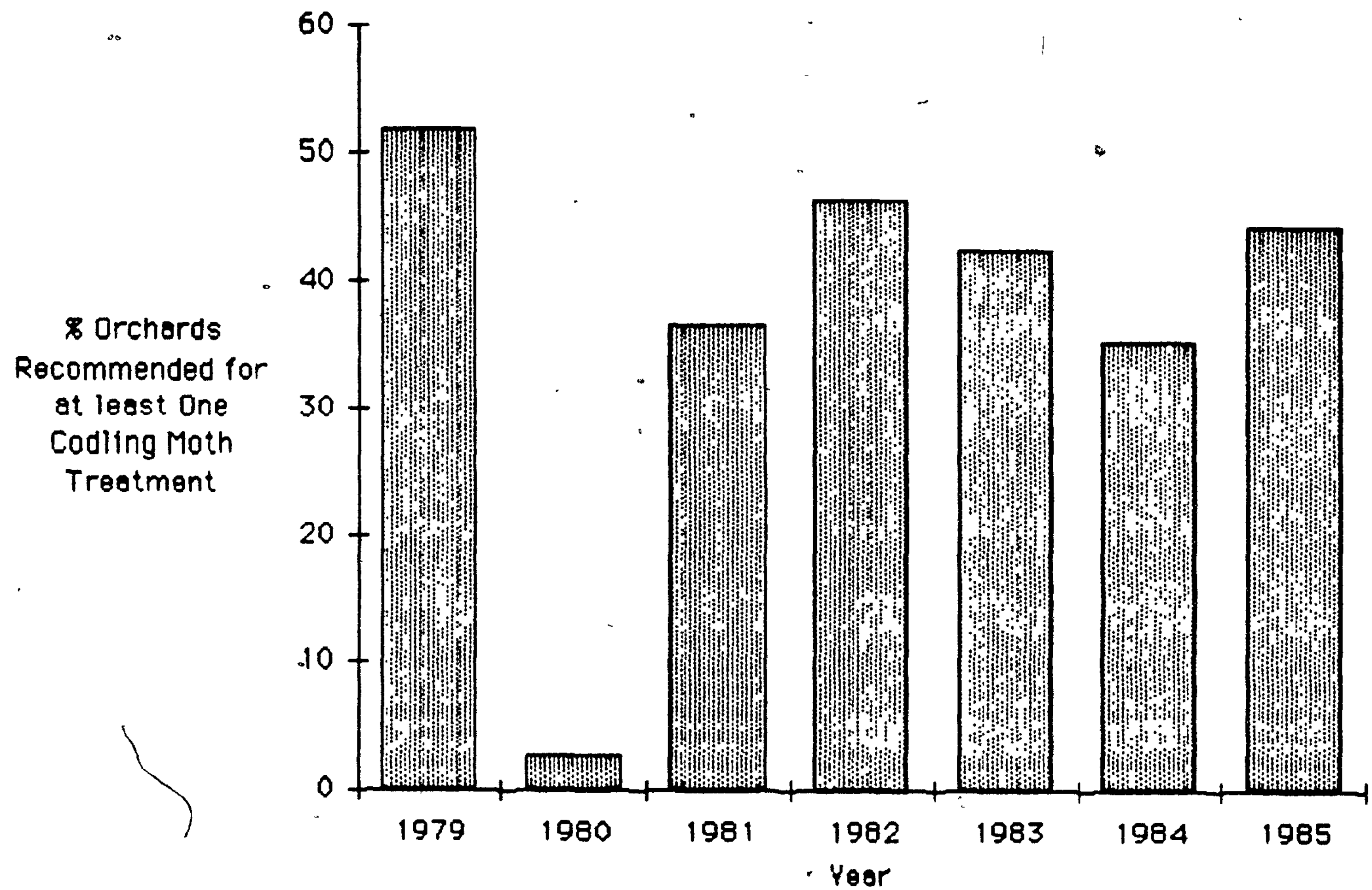

Mean Number of
Apple Maggot
Flies Per Trap
1.4
1 2
1 0
0.8
0 6
0 4
0 2
0 0
1979
1980
1981
1982
1983
1984
1985
Year

Figure 12. Percent of orchards recommended for at least one codling moth treatment from 1979 to 1985.


60
50
40
30
20
10
0
% Orchards
Recommended for
at least One
Codling Moth
Treatment
1979
1980
1981
1982
1983
1984
1985
Year

Eye-spotted budmoth

After monitoring this pest with pheromone traps from 1979 to 1981, it became apparent that the threshold being used was lower than necessary Adult trap captures did not correlate well with observed larval abundance in the spring, or with injury to fruit in the fall Recommendations for treatment were quite high during this period, ranging from 26 to 39 % (Figure 13) Doubling the threshold resulted in 3-12 % treatment recommendations from 1982 to 1984 with no detected increase in injury to fruit Mean seasonal captures ranged from 18 6 to 36 9 trap^{-1} (1979-1984) (Appendix5)

Lures were not available for the 1985 season, and no viable and reliable alternatives existed, so this pest was not formally monitored

Spotted tentiform leafminer

This pest was apparently becoming a problem in the late 1970's By 1980, grower concern warranted adding this pest to the monitoring roster As a pheromone had been developed in the USA and suitable traps were available, these monitoring tools were employed Little research into thresholds and economic injury levels had been done, however, so IMMS had to conduct its own research and rely heavily on experience and intuition As a result, 19-30 % of orchards were recommended for control action for one or the other of first and second generation leafminers in the years 1980 and 1981 (Figure 14) Pheromone traps were tried one more year but proved unsuitable for monitoring this pest in Nova Scotia, at least until the completion of further research

Larval mines were counted from 1982 to 1985 and found quite reliable as treatment indicators The percentage of orchards recommended

Figure 13. Percent of orchards recommended for eye-spotted budmoth treatments from 1979 to 1985

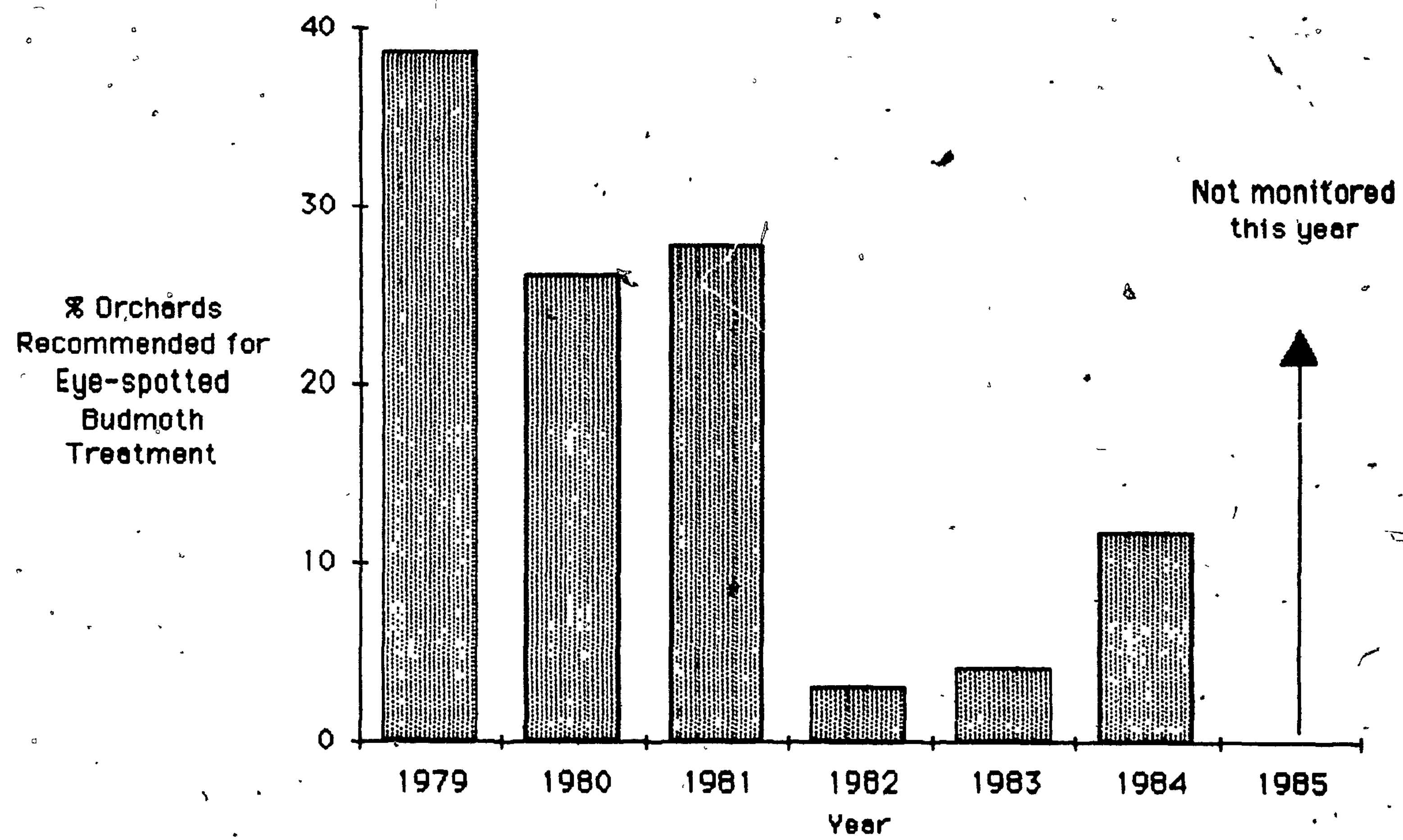
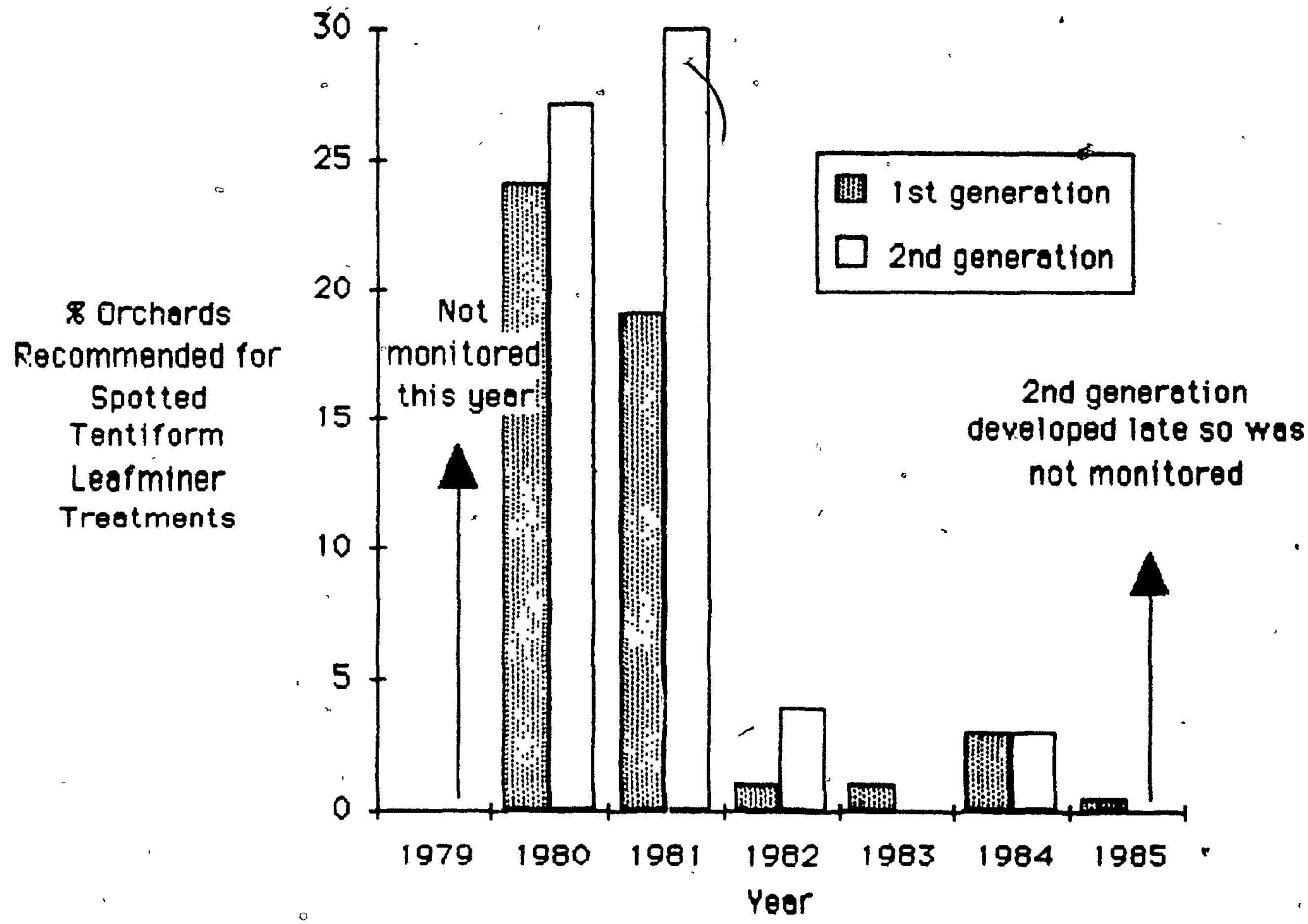

% Orchards
Recommended for
Eye-spotted
Budmoth
Treatment
40
30
20
10
0
Not monitored
this year
1979
1980
1981
1982
1983
1984
1985
Year

Figure 14. Percent of orchards recommended for spotted tentiform leafminer treatments from 1979 to 1985. Based on mines per leaf


% Orchards
Recommended for
Spotted
Tentiform
Leafminer
Treatments
30
25
20
15
10
5
0
Not
monitored
this year
1st generation
2nd generation
2nd generation
developed late so was
not monitored
1979
1980
1981
1982
1983
1984
1985
Year

for treatment for any one generation, from 1982 to 1985, ranged from 0 to 3 %

It should be noted that the leafminer was observed to be highly parasitised and rarely, if ever, was it prevalent in any given orchard for two consecutive years (except in one block that was treated late in the season, thus eliminating parasites) IMMS took great measures to prevent growers from becoming too concerned and possibly too anxious to apply insecticides (especially synthetic pyrethroids) Growers were receptive to this message, for the most part

MITES

Apple rust mite

The same technique was used to monitor and assess this pest from 1980 to 1985 Percent of orchards recommended for treatment for any given assessment period ranged from 0 to 14 % (Figure 15) Mean abundances, on a qualitative point scale, for any single sample period, for any given year, ranged from L to L-M (1981-1984) (Appendix 5)

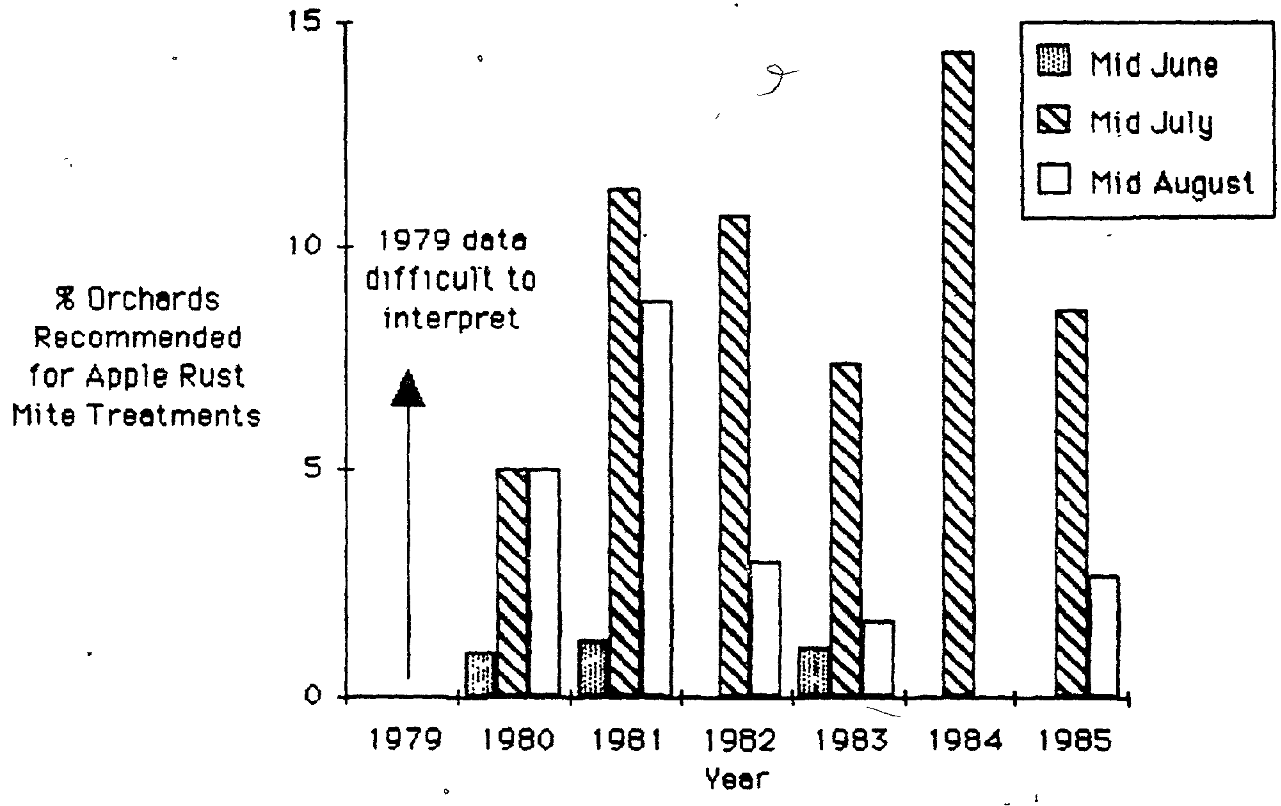
This mite (ARM) is a valuable food source for predator mites such as *Typhlodromus pyri* Scheuten, and *Zetzellia mali* (Ewing) (Herbert and Sanford, 1969, Downing and Arrand, 1978), and high numbers (300-600 per leaf) can be tolerated before damage is a concern (Downing and Arrand, 1978) It was easily controlled when necessary by single applications of Dikar®[1] (72 % mancozeb, 4 4 % dinocap) or low doses of miticides

European red mite

This mite causes great concern to growers because of its suspected influence on fruit quality and future yields (Chapman et al, 1952, Lienk et al, 1956, Herbert and Butler, 1973, Hardman et al, 1985) It has the

[1] Rohm and Haas Canada Inc , Calgary, Canada

Figure 15. Percent of orchards recommended for apple rust mite treatments from 1979 to 1985 Percentages for three assessment periods per season are shown


% Orchards Recommended for Apple Rust Mite Treatments
15
10
5
0
1979 data difficult to interpret
Mid June
Mid July
Mid August
1979
1980
1981
1982
1983
1984
1985
Year

potential, given the right weather conditions and lack of predators, to increase in numbers exponentially, in fact, it can double in numbers in less than one week (Herbert, 1981)

Basically, the same monitoring technique (except for minor modifications in sample size and thresholds) was used from 1979 to 1985 (Table 6) Percent of orchards recommended for treatment for any single sample period ranged from 4 to 49 % (Figure 16) Figure 17 a-c shows mite densities, per sample period, plotted against time Since mites are a useful indicator of excessive use of pesticides, or other mismanagement (MacLellan, 1979), I have to conclude from these data that, even with reductions in average pesticide use, Nova Scotia orchards do not demonstrate trends that would indicate improvements in the natural control of mites The broad spectrum chemicals (mostly synthetic pyrethroids) that are being used more frequently, in the prebloom period, in place of previously used chemicals (mostly organophosphates), may be contributing to this situation The newer pesticides are very valuable and useful additions to pest management arsenals, but they should be used with great caution and discretion in IPM programs

Figure 16. Percent of orchards recommended for European red mite treatments from 1979 to 1985 Percentages for three assessment periods per season are shown

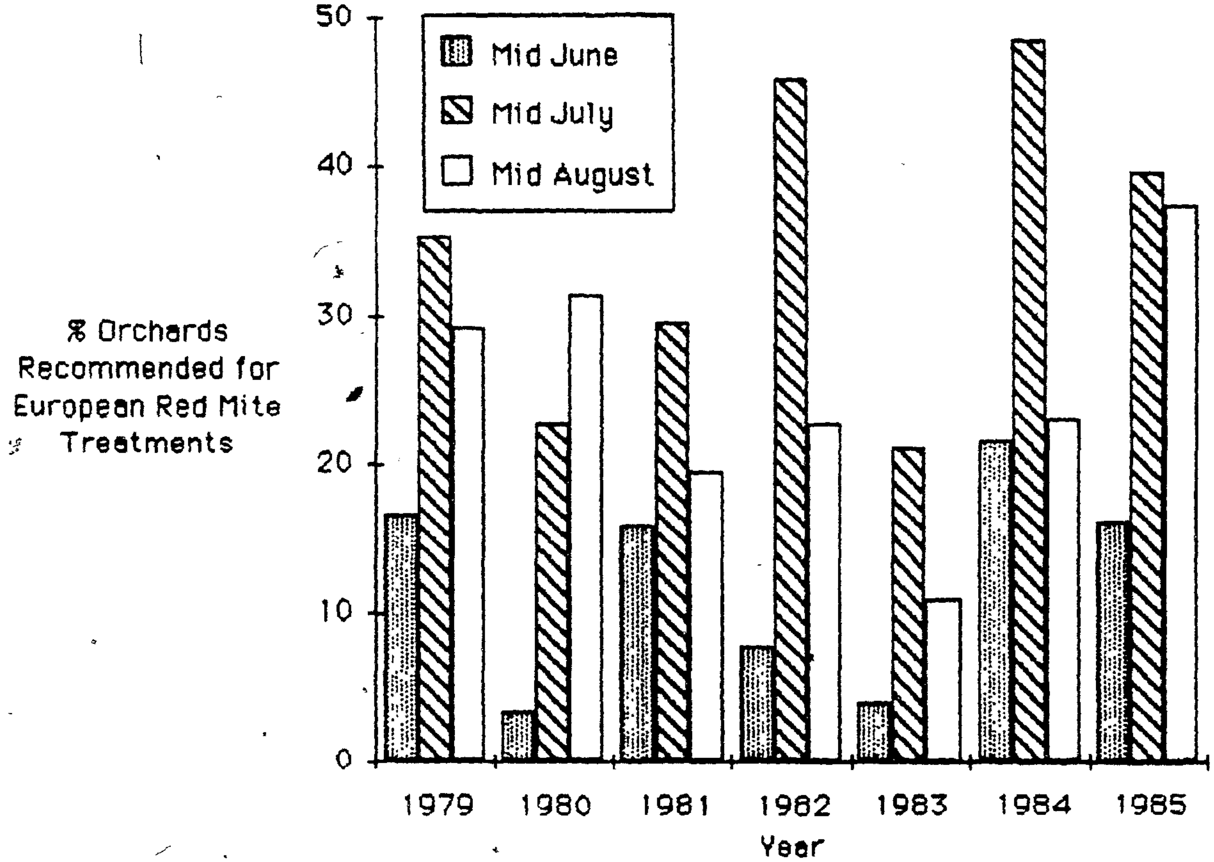
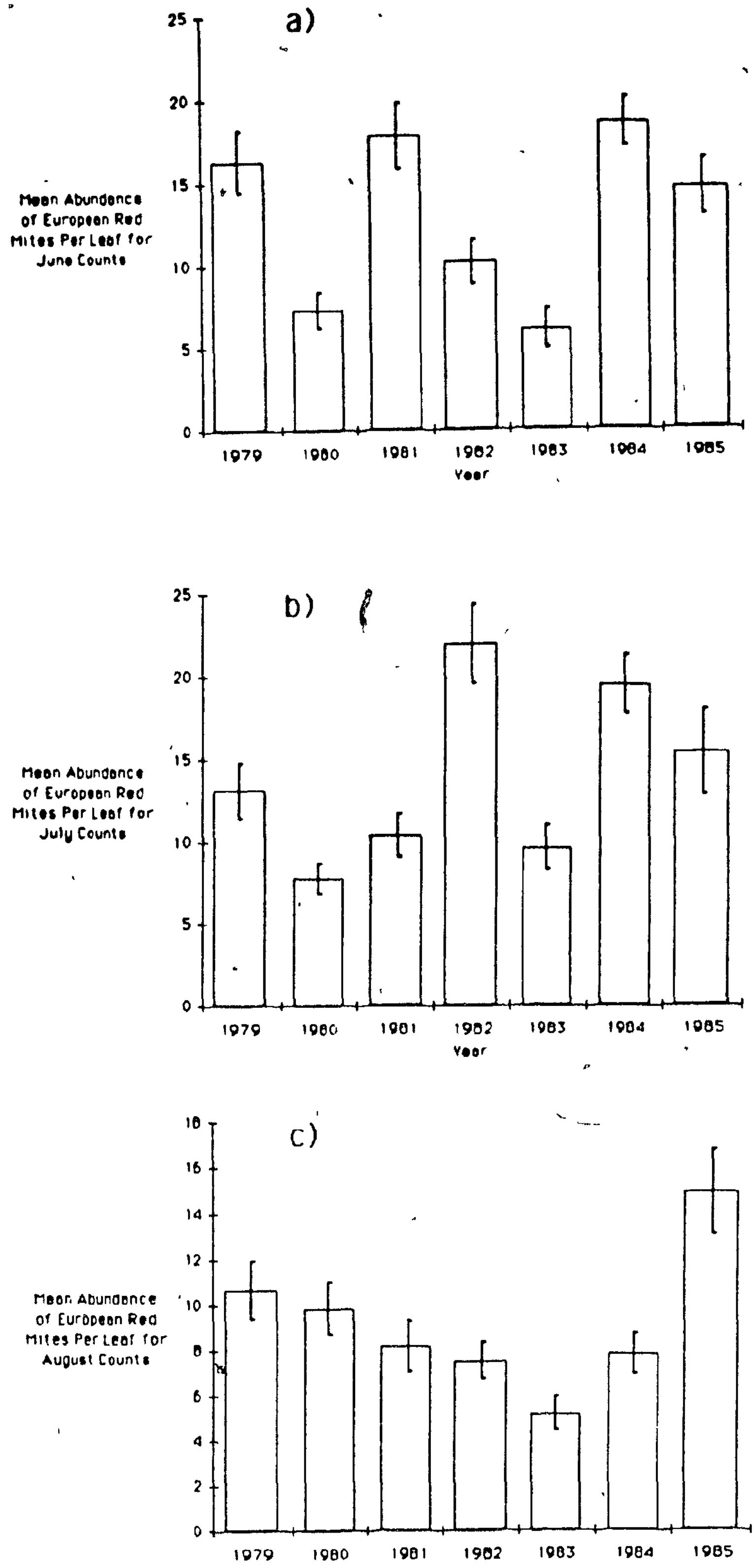

% Orchards Recommended for European Red Mite Treatments
Mid June
Mid July
Mid August
0
10
20
30
40
50
1979
1980
1981
1982
1983
1984
1985
Year

Figure 17. Mean abundance of European red mites per leaf for a) June, b) July, and c) August counts, 1979-1985 Vertical lines are standard errors


a)
Mean Abundance of European Red Mites Per Leaf for June Counts
0
5
10
15
20
25
1979
1980
1981
1982
1983
1984
1985
Year
b)
Mean Abundance of European Red Mites Per Leaf for July Counts
0
5
10
15
20
25
1979
1980
1981
1982
1983
1984
1985
Year
c)
Mean Abundance of European Red Mites Per Leaf for August Counts
0
2
4
6
8
10
12
14
16
18
1979
1980
1981
1982
1983
1984
1985
Year

Communication of monitoring results to growers

Monitoring data were initially noted on "Field Record" sheets (Appendix 8) by IMMS personnel Results were communicated to apple growers by one, or more, of the following means

1) Notified in person if the situation warranted immediate action
2) Written, on "Grower Report" (Appendix 9)
3) Telephone call to report results of samples brought back to the lab for processing, or to discuss problems and strategy
4) "Orchard Outlook" (Appendix 1) Observations were discussed and evaluated at weekly meetings and incorporated into the newsletter
5) Information sheets (Appendix 3) to provide up-to-date information to help growers interpret reported results for themselves

The above routes for flow of information worked very well More rapid collation and summary of data would have increased the value of the information, however, by allowing earlier predictions of current trends, as well as comparisons with preceding year trends This would have required full-time data processing staff and extensive use of computers for analysis and graphic presentations A computer was incorporated and a technician (summer student) was assigned to data entry on a part-time basis in 1985, but more time and training would be necessary to achieve the desired results

Cost of monitoring

From 1979 to 1983 monitoring was conducted very inexpensively on a part-time seasonal basis, even though in the latter half of these years considerable time was invested in improving and expanding service to growers In 1984, the program took on a more businesslike approach with goals to increase efficiency, effectiveness, extensiveness, and profits Advertising was initiated (Appendix 10) and a detailed price list of services was made available to growers (Appendix 11)

Cost data for 1985 are contained in Table 9 Monitoring costs in 1985 were up nearly 17 % from 1984 to just under $100 ha^{-1} Grower contributions amounted to 55 % of the costs, essentially the same as for 1984 The balance was made up with other work, mostly contracts

Published accounts of expenses associated with pest monitoring are not common because such programs are few and relatively new Stemeroff and George (1983) investigated government extension and research costs associated with IPM efforts and provided estimates of $50,000-110,000 per professional man-year In a government funded farm advisor program, Thompson and White (1982) discovered that costs were over $50 ha^{-1}, and this greatly exceeded income from acreage fees A pest management coordinator of this program made the comment that to make up the difference, taking on acreage without increasing costs would be a plausible possibility I feel this approach would lead to deterioration of the quality of service McKay et al (1981) estimated a budget for a consultant, that I calculated, to be $40 ha^{-1} excluding his/her salary A salary of $30,000 yr^{-1} would make the cost to growers to be $73 ha^{-1} McMullen (1981) reported the cost of consulting/monitoring by Environental and Pest Management Services (no longer operating (J Vakenti, personal communication)), of Penticton, B.C., to be $137.50 ha^{-1} The estimated saving to growers who used this service was $325 ha^{-1}, as a result of reduced pesticide applications

It is clear, to me, that apple growers cannot, would not, and probably should not provide funds, through fees to cover the whole cost of monitoring Reasons being that a) financial returns to growers have not been satisfactory in recent years, b) government provided similar service in

Table 8. Estimated costs to monitor 200 orchard blocks (2000 acres or 808 ha) for at least 14 arthropod pests of apple in Nova Scotia. Number of orchard visits assumed to be 1-2 per week for 20 weeks Cost figures based on IMMS salaries and expenses for 1985 and are to the nearest dollar. Cost per hectare can be calculated from TOTAL ÷ 808

Fixed annual costs		
Microcomputer lease	3,000	
Vehicle leases (2)	6,600	
Microscope lease	550	
Office/lab rental	5,500	
		15,650
Estimated operating expenses:		
Office supplies & postage	800	
Advertising	700	
Traps & supplies	4,000	
Vehicle gas, maintenance & repairs	4,000	
Bank charges & interest	700	
Employee salaries (2)	18,000	
Pest manager salary	29,000	
Remittances, workers comp, benefits	2,000	
Meals	200	
Telephone	900	
Secretarial services (incl answering service)	800	
Misc exp (e g rebates)	800	
Misc capital expenditures	500	
Depreciation	200	
Insurance	1,000	
		63,600
TOTAL		79,250

the past, albeit less intense, and c) all of society benefits from reduced pesticide use

It is difficult to operate a monitoring service with the annual uncertainties experienced, the intensity of service demanded, and the life style required by income (J Vakenti, personal communication) One way to operate, that might provide adequate returns for effort expended, would be to reduce service where possible and charge growers on a per visit basis, as opposed to charging a standard fee per season as has been typical in the past. This approach might reduce the cost to growers by allowing them to use this type of service to the extent they feel they can afford and need

Further use and development of IMMS, or any monitoring program, would require a) low cost to growers, b) some assurances to growers of program continuance, and c) economic stability and incentives to the monitoring service for risk taking, and initiative - with regard to research, development and implementation Because many groups benefit, and farm incomes are inadequate, I feel that both the federal and provincial governments should subsidize monitoring, at least until farm incomes show some improvement

Personnel

Although assistants, beyond a minimum of one, were not essential to the successful operation of the program, I found them highly desirable for the following reasons

1) Provided a valuable second opinion, once trained
2) Companionship and conversation appreciated on extended drives
3) Greater sampling speed and efficiency
4) Backup manpower in case of illness or accident

I feel some important attributes of a good IPM scout are as follows

1 Thrive on field work, but not "turned-off" by lab and desk work
2 Conscientious, motivated, and quick to learn
3 Able to work with minimum supervision.
4 Have respect for other people's property.
5 Safety conscious
6 Have inherent driving skills (e g. alert, quick, clear thinker)
7 Good communicator with a likable personality.

Few scouts, or potential scouts, possess all of these attributes, but their presence in any one individual should be maximized if difficulties are to be minimized

Treatment Recommendation Considerations

Many factors should be considered before a grower is advised to take control action against a pest or leave his sprayer in the barn Complex interactions can and do exist between pest abundance, natural enemy abundance, weather, and expected crop yield (Croft et al, 1983) These are only some of the relations that should be considered before a decision to treat is reached. If treatment is considered necessary to avoid excessive injury to fruit and foliage, the next step is to decide what chemical or alternative to chemicals will provide the most effective, economical, and ecologically sound management approach - Decisions must often be made quickly and on the spot, so truly objective consideration of all factors is not possible

In 1985, the concept of "pest pressure" was considered, in some cases, mainly on a trial basis The concept involved the consideration and subjective evaluation of all pests at any given time to determine if their combined abundances were of economic concern and therefore warranting of broad spectrum suppression This concept was brought to mind by the larval units (or larval equivalents) used by Andaloro et al (1983) in a cabbage pest management program Initial experience indicated that this concept should be routinely practiced on a conscious level (it could be that consultants and extension have been practicing this subconsciously for some time).

Quality and cost demands in the market place have put apple growers, and farmers in general, in a difficult situation. They are being forced to produce fruit of higher quality while trying to reduce production costs. As these are not compatible objectives, the determination of thresholds, that will reduce spraying while maintaining or improving fruit quality, for use in modern orchard management, is not easy

CONCLUSIONS

It became obvious that not all apple growers benefited to the same degree from the services provided by IMMS. Therefore, to achieve maximum benefit, I suggest that growers should fit the following criteria as closely as possible

1) Have 4 hectares or more
2) High quality fruit required to meet market demands
3) Consistent quality desired
4) Want to reduce pesticide costs by using only when necessary.
5) Want to avoid unforseen and excessive insect/mite/disease damage
6) Little time for pest surveillence
7) Lack ability and/or confidence to make reliable observations.
8) Desire to achieve a higher level of sophistication in pest management

I recognized the great responsibilities IMMS had with respect to providing reliable advice On the other hand, it was also apparent that growers had to do their share to complete the task of pest management To briefly state these responsibilities, I evaluated and modified some "Golden rules for success", as published by Agricultural Development and Advisory Service (1979), based on experiences here in Nova Scotia

<u>Consultant/scout responsibilities</u>

1) Sample conscientiously and on time
2) Record all observations and counts, study and keep these records.
3) Plan, prepare, and be alert (good observers make good common sense decisions)
4) Trust the thresholds, carefully consider recommendations, and use common sense in borderline situations

Grower responsibilities.

1) If control action is required, do it well Know the spray materials, rates, sprayer calibration, etc
2) Have faith in monitoring and the technology available for pest management Do not modify recommendations without consultation with one or more qualified individuals If questions or worries exist, obtain further discussion and advice
3) Accurate records of sprays and other management practices are essential (e g a lesson learned one year will scon be forgotten if no records exist to refer back to)

When IMMS first started, I felt that regular and frequent surveillence of arthropod pest populations would ultimately reduce the frequency of problems through efficient and effective spray decisions and operations The data presented here demonstrate that this was achieved to some extent with some insects, but others (e g ERM, RAA, WALH) were less responsive Factors other than just pest abundance must be considered, and the measurement, prediction and control of these require extensive research

One pest insect was essentially removed (FTLR), and one added (GPM) to the current pest roster of the Annapolis Valley Several insects could be considered worse pests, or at least potentially worse, (STLM, WALH, ABB) All other pest insects and mites, basically, did not change in status No pest caused as much concern as it would have without a monitoring program because the potential for pest population increases to go undetected, with the result of serious economic injury, was greatly reduced

The monitoring program achieved a major step toward the implementation of "true" IPM For many growers, using pesticides only when and where needed, with proper consideration given to selecting the right material and dosage, became the norm Thus, growers who participated in the monitoring program used as much as 50 % fewer insecticides and miticides, on average, than those who sprayed on a routine calendar schedule (Hardman et al, 1984c, Advisory Committee on Tree Fruits, 1985).

Growers would be anxious to use nonchemical alternatives, new orchard designs, and improved management procedures (that would discourage or prevent pest problems) if the technology could be developed and demonstrated to be as effective and cost competitive with present systems The use of alternative controls warrants constant monitoring and limitless trust in techniques and advisory staff Therefore, for IPM to progress further, by taking advantage of new developments, it is essential that monitoring tools and trained personnel be well established In Nova Scotia, orchard pest management is approaching the limits of currently available and commercially feasible technology

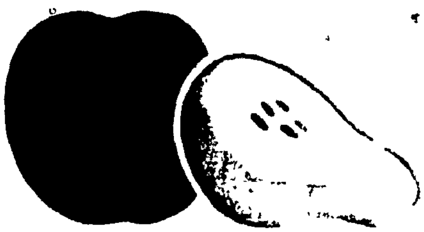
Monitoring techniques for WM, RAA, and ABB were improved, but all techniques need further refinements, including the development of feasible and accurate natural enemy assessment methods All thresholds should be reevaluated on an annual basis, taking into account detailed economic factors and natural enemy influences These kinds of improvements must be achieved by government and university researchers because of the high costs involved and because incentives to private investigators are usually nonexistant or inadequate However, the application of new monitoring technology and thresholds would best be accomplished by the private sector because of inherent efficiencies (minimum implementation costs) and concerns over reputation (quality service)

In conclusion, I feel that growers, government, and private consultants must cooperate totally, and have limitless trust in each other, if apple orchard pest management is to progress from limiting the use of pesticides to the implementation of IPM according to its full implications

Appendix 1. An example of the weekly newsletter Orchard Outlook. In 1985, IMMS contributed data and observations to issues 4 through 15.

Orchard Outlook

Newsletter



NO. 11 ISSN 0705-4823 JUNE 27, 1985

APPLE SCAB: The wet weather continues and so do the infection periods. The wetting period which began the evening of Tuesday the 18th, lasted until 4:30 PM on Wednesday the 19th. This was a 19½ hr wetting period with an average temperature of 17^{O}C resulting in a heavy infection period. Heavy rain during Monday night, June 24th, resulted in 33 mm of rain being recorded at Kentville. This infection period began at 10:30 PM in Kentville and lasted until noon of Tuesday the 25th, for a 13½ hr wetting period with an average temperature of 12.5^{O}C. This was classed as a moderate to heavy infection. Rain and shower activity began at 11:00 PM Tuesday the 25th, and continued through Wednesday and into Thursday. At the time of writing the Orchard Outlook this infection was still on-going and will be another heavy infection period.

As one would expect from the severity of the weather, apple scab is being found in the orchards. In most cases the scab is only being found on the foliage and not the fruit. When scab is found growers do not have too many options with regards to its control. In the past Cyprex, Easout and Benlate have been used to burn out or weaken the scab lesions. The use of these materials will depend upon your past spray programs and whether there has been resistance to Cyprex and Equal OR Easout and Benlate in the orchard. If the orchard does not have a resistance problem with Cyprex/Equal OR Benlate/Easout then one of these materials applied as two back-to-back sprays, at approximately 7 day intervals, may help to reduce the amount of scab in the orchard. The Easout and Benlate should be mixed with a half-rate of one of the following fungicides: captan, Manzate 200 or Polyram. If you have already used these materials twice this year then you would be advised to use either captan, Dithane M45, Manzate 200, Dikar or Polyram for the remainder of the season. The other option to growers is to try and stay ahead of the infection periods, keeping the fruit covered with fungicide to prevent its spread from the foliage to fruit. With the type of weather that has been occurring this will mean having to spray every 7 days. If the weather should happen to dry then the intervals can be lengthened to 10-14 days.

EUROPEAN RED MITE: As you well know, the weather has continued to be cloudy, cool and wet. Hatch of the new generation eggs is almost at a standstill. I hope that you have not rushed out during the past two days to apply your miticide. Miticides should always be applied when several days of good weather are forecast to occur. They have a good residual life and you need that several days of good control to obtain satisfactory results. At this time we are going to extend our treatment period for red mite all the way through next week, to JULY 6. Wait for good weather before you apply a miticide. After checking all blocks, the private monitoring service found that 15% of monitored blocks require a miticide now. APPLE RUST MITE was not at economic levels in a single block.

CODLING MOTH: Development of this species has also been slow due to the weather. At this time it appears that treatments will not be recommended before Saturday, July 6 and the period July 6-12 will be the recommended treatment period. This is certainly on the late side. There are a few areas in the Valley, particularly Grafton, where codling moth seems to be a few days earlier. If it has seemed that your treatments have missed the earliest hatching larvae, you should try to treat right around July 6. ANY growers who, because of their apple scab spray schedule, feel that the codling moth treatment has to be applied July 3-5 should use a HIGHER rate of insecticide than is indicated by trap captures. This is because the residue will have to last longer to kill the hatching larvae. If regular rainfall continues this will also have to be considered.

The normal interpretation of pheromone trap captures is as follows:

TOTAL MALE CAPTURE/TRAP	TREATMENT
0-49	no treatment
50-99	organophosphate ¼ rate
100-199	organophosphate ½ rate
200-more	organophosphate full rate

ROSY APPLE APHID: is now dispersing out over the trees. Most orchards that required insecticide have been treated now. In a few blocks two treatments were necessary. Possible reasons for this could only be explored on an individual basis. The beneficial orange maggots have finally appeared but are too late to have any real impact this year.

SPOTTED TENTIFORM LEAFMINER: The mines are showing up quite well now. We would not try to assess the first generation until next week, the first week of July.

FRUIT THINNING: The cool and wet weather has resulted in slow fruit growth this year. In most orchards visited this week Red Delicious were at or near the ½ inch stage of fruit development. In situations where Red Delicious are overset an application of Sevin will help to thin the fruit. The wet weather makes it difficult to predict what the June or July drop will be like and how effective the thinners will be. The wet and cool conditions should make a thinner more effective and good results should be obtained with the lower rates of Sevin. The rates for Sevin 50WP are 3.25-5.0 kg /ha (3-4½ lb/ac and Sevin 85WP 2.2-3.25 kg/ha (2-3 lb/ac). The Sevin can also be used to thin Spy where overset has occurred.

UREA: The last couple of days I have observed orchards with light green foliage. With drier and warmer weather the foliage colour should improve, however, where light green foliage is observed growers would be advised to apply urea with their next spray application.

NSFGA ORCHARD TOUR: The NSFGA annual orchard tour will be held on Tuesday, August 6. The tour will visit orchards in eastern Kings County. Further information on the tour will be provided at a later date.

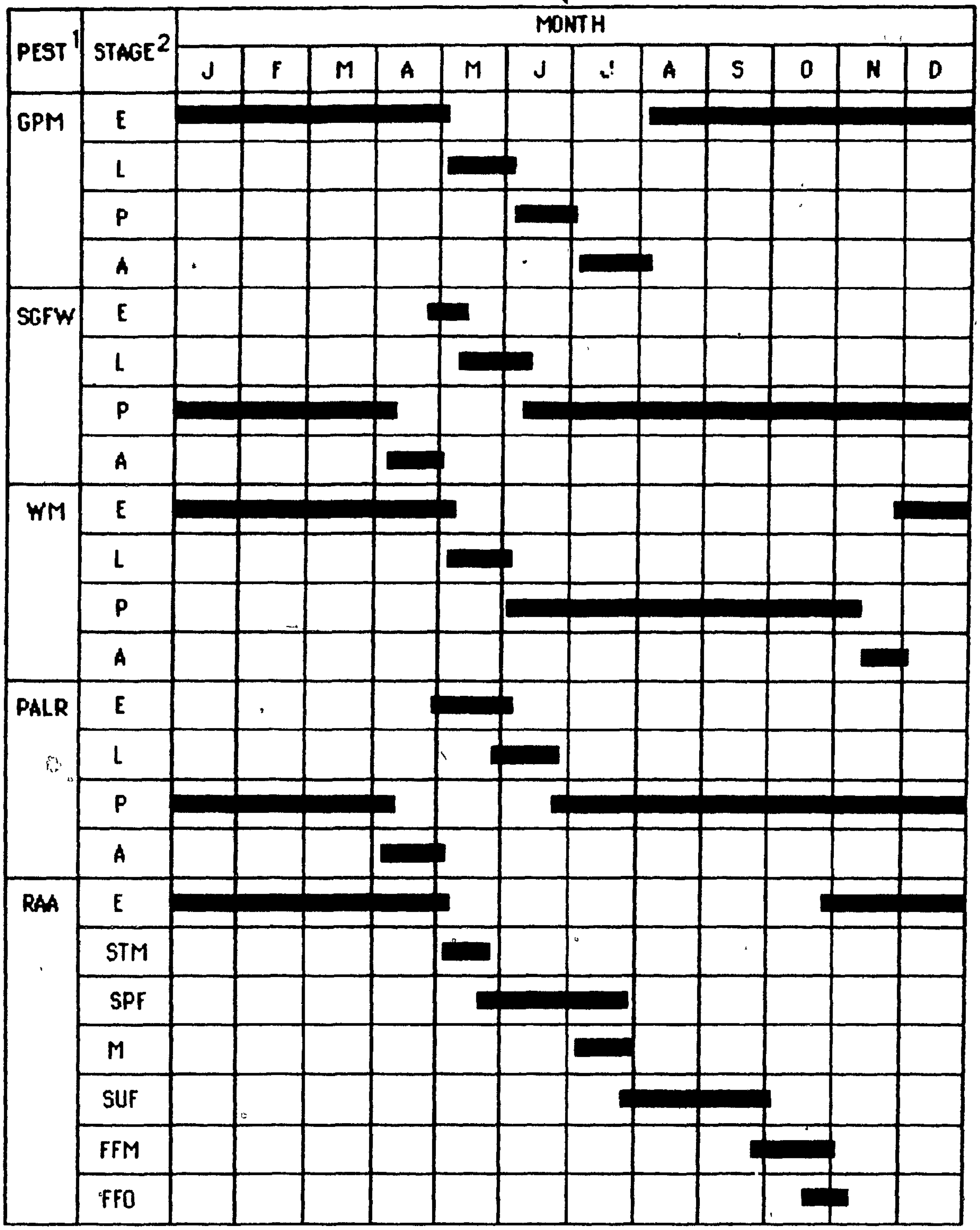
YOUR LOCAL CANADA EMPLOYMENT CENTRE FOR STUDENTS IS NOW OPEN. If your farm or organization needs a student this summer, PLEASE contact the Centre at:

Kentville, 59 Webster St., 2nd Floor 678-8800
Middleton, Canada Post Bldg., 2nd Floor 825-4446.

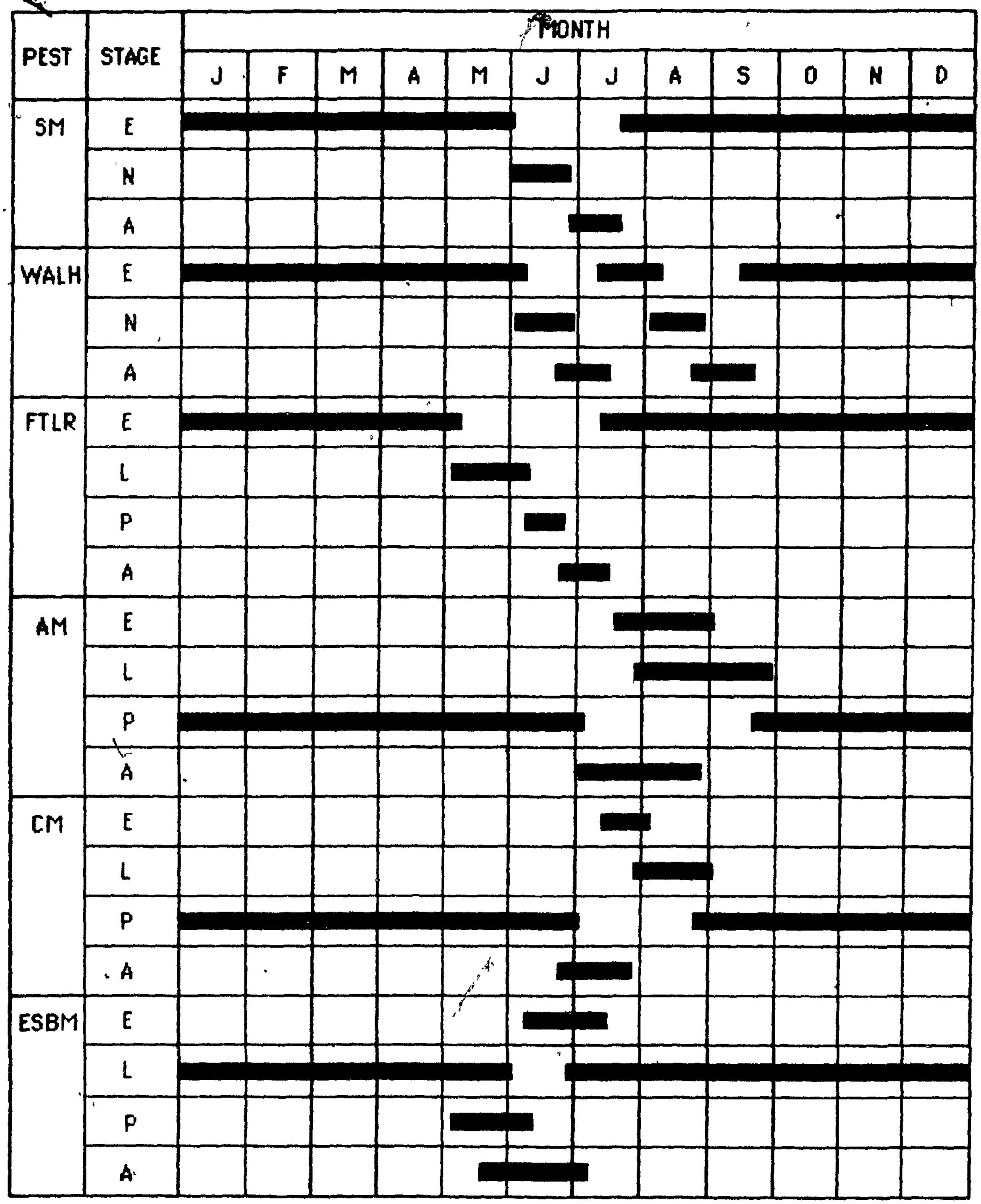
Written by Bill Craig and Rick Whitman, Horticulture & Biology Branch, NSDA&M in cooperation with Agriculture Canada and IMMS.

Appendix 2

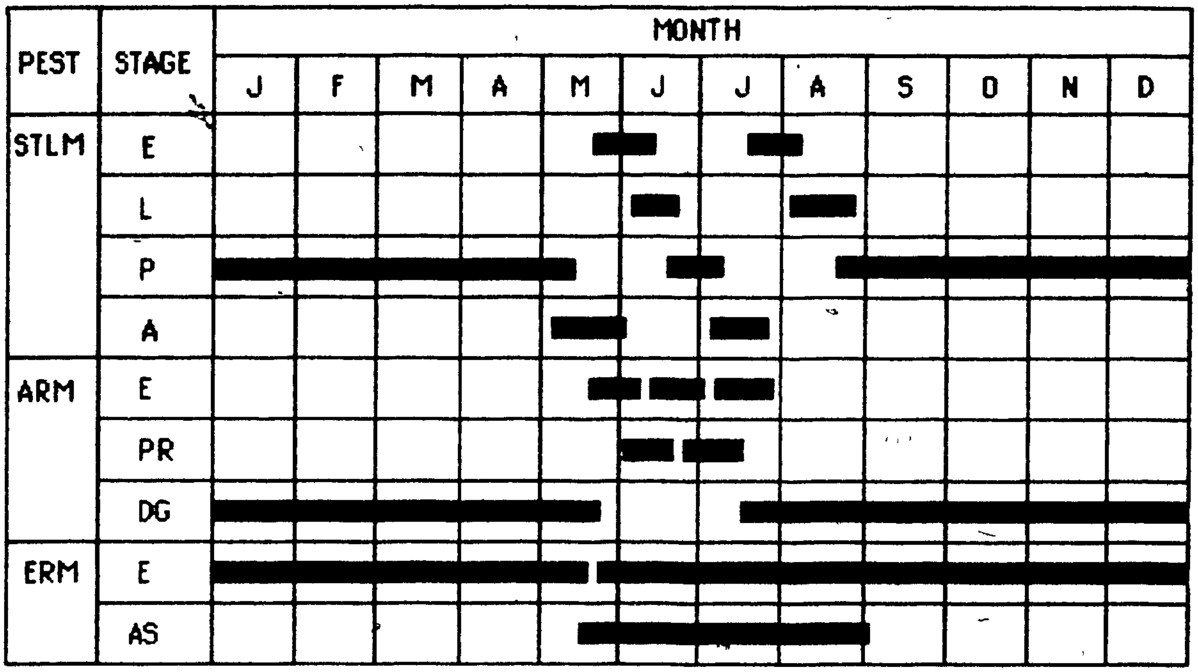
Life cycles of selected insect and mite pests of apple in Nova Scotia



Appendix 2 (cont'd)



Appendix 2 (cont'd)



1 See Appendix 3 for pest abbreviations

2 A = adult, AS = active stages, DG = deutogyne, E = egg, FFM = fall form (migratory), FFO = fall form (oviporous female), L = larva, M = migratory form, N = nymph, P = pupa, PR = protogyne, SPF = spring form, STM = stem mother, SUF = summer form

Appendix 3

An information sheet that was circulated to apple growers annually

Insect and Mite Monitoring Services

Pest abbreviations, optimal treatment periods, and thresholds for 1985.

Pest	Abbrev	Expected optimal treatment period	Threshold
1) Green pug moth	GPM	Bud separation	M-H*
2) Speckled green fruitworm	SGFW	Pink	1 larva/15 limbs
3) Winter moth	WM	Bud separation	L-M*
4) Paleapple leafroller	PALR	Early calyx	M-H*
5) Rosy apple aphid	RAA	Eary calyx-end June	0.5 col/ft of tree height
6) Stinging mirids	SM	Early calyx	8/20 limbs beats
7) White apple leafhopper	WALH	Early calyx	0.5/leaf(1st gen) 2.0/leaf(2nd gen)
8) Fruit-tree leafroller	FTLR	Early calyx	M*
9) Apple maggot	AM	Mid July-mid Aug.	1 adult/orchard
10) Codling moth	CM	Early-mid July	50,10 males/trap
11) Eye-spotted budmoth	ESBM	Mid July	--
12) Spotted tentiform leafminer	STLM	Mid-late July	1 live miner/leaf (1st generation)
13) Apple rust mite	ARM	Mid June-early Aug	M-H*
14) European red mite	ERM	Mid June, mid July, mid August	30, 10, 15 mites/leaf

* Qualitative assessment classifications

- YL .... very light
- L .... light
- L-M .... light-moderate
- M .... moderate
- M-H .... moderate-heavy
- H .... heavy

Appendix 4

Distribution of *Dysaphis plantaginea* (Pass.) colonies on a susceptible cultivar of apple in Nova Scotia, and a new economic threshold.

Richard E. L. Rogers

Insect and Mite Monitoring Services

RR#5 Berwick, Nova Scotia

Canada B0P 1E0.

Abstract

Colonies of rosy apple aphid (RAA), *Dysaphis plantaginea* (Pass.), were counted on three Cortland trees in each of three orchards in mid June and early July, 1982. Cardinal point positions and locations of colonies in upper or lower half of trees were recorded. Mean tree heights were 1.6, 3.2, and 4.4 m in orchards 1, 2, and 3 respectively. More colonies were found on the lower half of each tree regardless of height, and no cardinal point position was favored over any other. Maximum colony abundance averaged 13.7, 2.1, and 1.3 (orchards 1, 2, and 3 respectively). Injury data were collected, but not necessarily from the study trees. Orchard 1 (low yield) had 90.0 % injury by RAA, and orchards 2 and 3 had 1.4 % and 0.5 % respectively. Plotting the data on a log/log scale resulted in a straight line. Maximum acceptable injury by a single pest is normally considered to be 1.0 %. According to this assumption, 5.8 colonies m^{-1} of tree height could be tolerated. Consideration of other factors (yield, excessive honeydew, subtle fruit injury, unsightliness of numerous colonies, rapid expansion of colony size and numbers) influenced reducing the threshold to 1.5 colonies m^{-1} of tree height. This threshold worked well, and it appeared that when this level of abundance was reached, natural enemy pressure was not enough to prevent further colony development.

Appendix 5

Summary of annual mean abundances of some pest insects and mites of Nova Scotia apple orchards, 1979-1984.

Pest[1]	1979	1980	1981	1982	1983	1984
SGFW[2]	49.5	20.4	24.9	20.6	34.6	5.6
WM[3]	L-M	L-M	L-M	L-M	M	M
PALR[3]	--[4]	L	L	L	L	L
RAA	2.6[5]	2.6	0.1	3.7	3.2	7.1[6]
SM[7]	5.4	7.6	14.0	10.5	8.8	14.2
AM[2]	0.9	0.4	0.3	0.2	0.6	0.5
CM-1[8]	57.6	25.5	43.2	51.5	47.3	41.0
CM-2[9]	66.2	56.4	65.3	73.9	62.5	44.9
ESBM-1[8]	21.0	16.2	17.3	7.9	12.3	16.1
ESBM-2[9]	31.8	36.9	25.9	20.3	18.6	23.4
ARM-1[10]	--	--	VL	L	L	L
ARM-2	--	--	L	L	L	L-M
ARM-3	--	--	L	L	L	L
ERM-1[11]	16.5	7.4	17.7	10.3	6.1	18.7
ERM-2	13.2	7.9	10.5	22.1	10.0	19.6
ERM-3	10.8	10.0	8.1	7.6	5.4	7.9

1 See Appendix 3 for pest abbreviations and qualitative assessment categories.
2 Adults.
3 Qualitative assessment of larvae.
4 Not monitored or no definable results
5 Estimate of colonies per 15 ft (4.6 m) tree
6 Colonies per 15 ft (4.6 m) tree; calculated from mean per foot.
7 Nymphs
8 Adult trap capture to first treatment.
9 Adult trap capture to first treatment + residual (i.e. balance of catch for season).
10 Qualitative assessment of all active stages
11 Quantitative count of all developmental stages combined

Appendix 6

Some results of fruit and foliage injury surveys, 1980-1984. Fruit injury is expressed as mean percentage of crop, and foliage injury is a mean qualitative assessment category[1].

Pest[1]	1980	1981	1982	1983	1984
WM[2]	0.70	0.48	0.44	0.41	0.59
PALR	0.26	0.08	0.13	0.05	0.02
RAA	0.88	0.19	0.62	0.50	0.42
SM	0.33	0.17	0.37	0.18	0.17
CM	1.08	0.35	0.26	0.73	1.04
ARM	VL	L	L	L	L
ERM	L	L-M	L	L	L-M

1 See Appendix 3 for pest abbreviations and qualitative assessment categories.
2 Fruit injury from SGFW, WM, and FTLR combined

Appendix 7

Summary of monitoring results, 1979-1985. Percent of orchards having pests at treatable levels of abundance, but not necessarily treated. Data from 1979 to 1984 were reworked. Therefore, figures may differ somewhat from those reported elsewhere.

Pest[1]	1979	1980	1981	1982	1983	1984	1985
GPM	--[2]	--	--	--	--	--	21.5
SGFW	90.1	6.2	28.9	26.2	64.0	0	--
WM	95.5	91.1	81.1	74.0	82.9	73.7	50.5
PALR[3]	--	0.7	0	0.6	1.7	3.1	3.8
RAA	14.0	10.3	5.7	16.1	24.6	52.0	70.6
SM	19.7	17.1	28.9	33.3	42.3	45.0	27.4
WALH-1	--	1.0	8.0	5.0	4.0	33.0	10.7
WALH-2	--	3.0	13.0	20.0	5.0	10.0	--
FTLR	14.0	0	0	0	0	0	0
AM	49.2	42.5	32.1	25.6	49.4	39.3	31.9
CM	52.0	2.7	36.5	46.4	42.3	35.2	44.1
ESBM	38.6	26.0	27.7	3.0	4.0	11.7	--
STLM-1	--	24.0	19.0	1.0	1.0	3.0	0.5
STLM-2	--	27.0	30.0	4.0	0	3.0	--
ARM-1	--	1.0	1.3	<0.1	1.1	<0.1	0
ARM-2	--	5.0	11.3	10.7	7.4	14.3	8.6
ARM-3	--	5.0	8.8	3.0	1.7	<0.1	2.7
ERM-1	16.5	3.4	15.7	7.7	4.0	21.6	16.0
ERM-2	35.3	22.6	29.6	45.8	21.1	48.5	39.6
ERM-3	29.3	31.5	19.5	22.6	10.9	23.0	37.4

1 See Appendix 3 for pest abbreviations and qualitative assessment categories.

2 Not monitored or no definable results.

3 Based on larval survey

Appendix 8. IMMS field record sheet.

INSECT & MITE MONITORING SERVICES

RR#5 Berwick, Nova Scotia B0P 1E0
(902)538-3521

Page ____ of ____

FIELD RECORD- 198

Set # ______

Notes.

Appendix 9

IMMS grower report form.

IMMS

R.R. 5 BERWICK, NOVA SCOTIA
B0P 1E0 PH. 538-3521

--- GROWER REPORT ---

DATE

GROWER PAGE OF

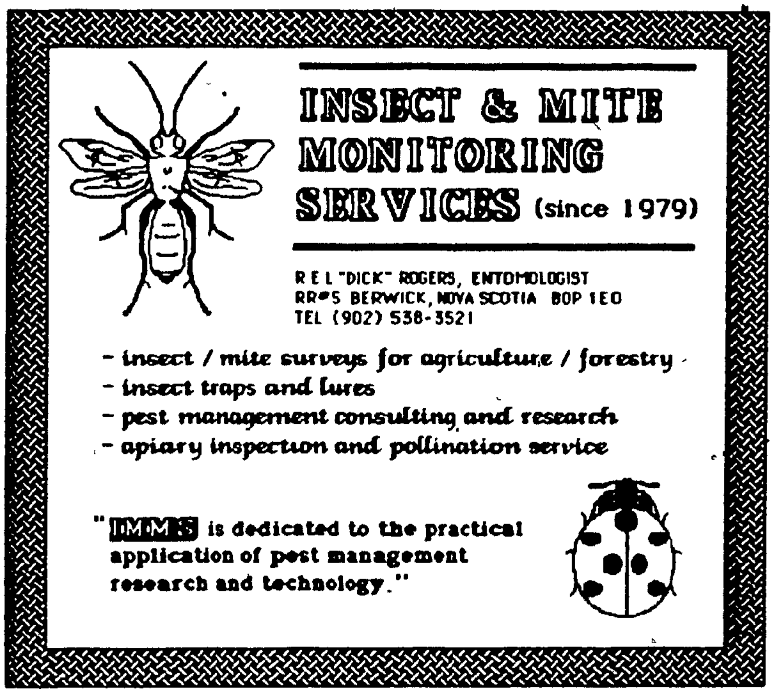
BLOCK(S)										
PESTS	Pest Status	Recommendations*	Pest Status	Recommendations*	Pest Status	Recommendations*	Pest Status	Recommendations*	Pest Status	Recommendations*
Speckled Green Fruit Worm										
Winter Moth										
Rosy Apple Aphid										
White Apple Leaf Hopper										
Apple Brown Bug (Stinging Bugs)										
Pale Apple Leaf Roller										
Fruit-Tree Leaf Roller										
Apple Rust Mite										
European Red Mite										
Spotted Tentiform Leaf Miner										
Codling Moth										
Apple Maggot										
Eye-Spotted Bud Moth										
Others										

Notes and Specific Recommendations

* ✓ - Control Recommended X - Control Not Recommended

Appendix 10

Example of IMMS advertising.



Appendix 11. IMMS price list for 1985.

INSECT AND MITE MONITORING SERVICES

RR#5 BERWICK, KINGS CO., NOVA SCOTIA BOP 1E0 TEL.(902)538-3521

PRICE LIST - 1985

REGULAR SERVICE :

Insect and mite monitoring station (covers a maximum of 4 hectares; includes traps and supplies necessary to monitor all major, and some minor arthropod pests of apple) 199.00

Apple scab survey (monitored blocks only, includes inspection of fruit and foliage for new scab lesions from primary infection periods - approx. early May to late June, survey useful for detecting errors in timing fungicide applications or spray ineffectiveness - also the last inspections can determine if it is safe to lengthen spray intervals). 75.00
per single visit 20.00

CUSTOM INSPECTION SERVICE : (further information and quotations available upon request)

Winter moth, stinging bugs, paleapple leafroller, white apple leafhopper, rosy aphid
per pest/visit 20.00
each additional pest on same visit 15.00

Codling moth, eye-spotted budmoth, speckled green fruitworm
each trap + placement 20.00
each visit thereafter outside of fully monitored blocks 15.00
each visit thereafter in fully monitored block 10.00

Apple maggot
Outside of fully monitored block
per trap (placed, and inspected 5-6 times). 50.00
2 or more traps per block, each 35.00
In fully monitored block.
per trap (placed, and inspected 5-6 times) 25.00
2 or more traps per block, each 20.00

Blueberry maggot
per trap (placed, and inspected 4-5 times) 50.00
2 or more traps per field, each 30.00

Mites (will accept samples from all apple districts of the maritimes; call or write for details)
per sample (includes assessment of 3 pest and 3 beneficial mites) 30.00
2 or more samples per block, each 25.00

OTHER SERVICES :

Bee hives for pollination (limited number available), each 30.00
Custom honey extraction, and extractor rental .... please call for prices
Other arthropod, and some vertebrate pest monitoring and trapping in both forest and agricultural situations (e g mouse population estimation) .... please call for quotations

PEST MANAGEMENT SUPPLIES :

Yellow sticky traps (blueberry / apple maggot), pkg of 3. .... 12.00
Pheromone trap plus lure (codling moth, eye-spotted budmoth, SG fruitworm) 10.00

Terms: Rebate of $5 per station if payment for stations received before June 1 (back dated checks or checks delayed by mail not considered as payment before such date); otherwise, 4 equal and interest free monthly installments (e.g. 199 X No. of stations/ 4 = installment payment, first payment due on or before May 31). Installments and other billings over thirty days subject to interest of 2.0% per month (24.0% per annum).

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