table for market. Once in the heads the aphids are virtually impossible to contact with foliar sprays. Large populations would, of course, cause direct damage by their feeding and deposits of honey dew. This aphid is also a potential threat as a vector of lettuce-infecting viruses, especially cucumber mosaic and perhaps beet western yellows. *N. ribisnigri* is reported to be unable to transmit lettuce mosaic (Kennedy, Day and Eastop, 1962).

Other species of aphids, especially the green peach aphid, *Myzus persicae* (Sulzer), and the potato aphid, *Macrosiphum euphorbiae* (Thomas), occur commonly on lettuce in B.C. but they usually breed on the underside of the outer leaves, where they do not contaminate the saleable crop.

The lettuce aphid is now the most important insect pest of lettuce in British Columbia. The present outbreak demonstrates the ineffectiveness of currently recommended control strategies. Consequently, extensive monitoring of aphid populations and field tests to evaluate the efficacy of several aphicides including some promising systemics are in progress. Special attention is being given to optimum timing and placement of sprays.

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LEAFROLLERS (LEPIDOPTERA) ON BERRY CROPS IN THE LOWER FRASER VALLEY, BRITISH COLUMBIA

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A survey of tortricid leafrollers and other lepidopterous larvae with leafrolling habits on berry crops in the Lower Fraser Valley, B.C. revealed 16 species feeding on blueberry, four on cranberry, eight on raspberry and four on strawberry. The most abundant species were *Choristoneura rosaceana*, *Spilonota ocellana*, *Archips rosanus* and *Cheimophila salicella* on blueberry, *Operophtera bruceata*, *C. rosaceana* and *Acleris comariana* on rapsberry, *Rhopobota naevana* on cranberry, and *A. comariana* on strawberry. Some of the species have apparently not been reported previously as feeding on some of the berry crops. Four species previously reported as pests of berry crops in the Lower Fraser Valley were not found.

Fields teated with insecticides early in the season, whether or not for leafrollers, had lower leafroller populations than untreated fields. There is no objective evidence that leafroller populations were sufficient to cause economic injury to any of the crops. Subjective observations confirm the economic importance of leafroller damage to cranberry and suggest that economic injury may occur on blueberry.

INTRODUCTION

The objectives of this work were to determine the leafroller fauna of berry crops in the Lower Fraser Valley of British Columbia, and the abundance of the species involved relative to each other and to the crops they affect.

Species of leafrollers (Lepidoptera; Tortricidae) and other lepidopterous larvae with similar habits are considered to be pests of berry crops in the Fraser Valley. There are general control recommen-

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dations for "leafrollers" on blueberry and raspberry and specific ones for the omnivorous leaf-tier, *Cnephasia longana*, on strawberry and the black-headed fireworm, *Rhopobota naevana*, on cranberry (Anon 1981). Neilson (1969) reported the oblique-banded leafroller, *Choristoneura rosaceana*, and the orange tortrix, *Argyrotaenia citrana* as occasional pests of raspberry, *Exartema olivaceanum* and *Ancylis comptana fragariae* as pests of strawberry; and *Cheimophila salicella* as a pest of blueberry. The recently introduced *Acleris comariana* has been reported as damaging strawberry (Cram 1973) and *Badebecia urticana* as damaging blueberry (Creelman 1969). In view of recent discoveries of introduced Lepidoptera in British Columbia (e.g. Donganlar and Beirne 1978a, 1979a, 1979b, Cram 1973, Evans 1966, Gillespie *et al.* 1978, Raine 1966) it was important that a survey be made to detect the presence of new and potential pests.

"Leafroller" is used here as a descriptive term to include all Tortricidae and several non-tortricid species whose larvae habitually feed in rolled or webbed leaves.

MATERIALS AND METHODS

Collections of leafroller larvae were made from berry crops on different dates in 1980 and 1981 at several sites in the Lower Fraser Valley. With the exceptions of an abandoned commercial cranberry field and an experimental raspberry field maintained by Agriculture Canada, all the sites were on commercial berry farms.

On blueberry, leafroller populations were surveyed by collecting all larvae and pupae found on each of 10 plants from within a block of 10 x 10 plants inside the field. At each visit, one plant was selected from each row and was not re-sampled subsequently. Six sampling visits were made at each of the nine sites in Pitt Meadows and Richmond, at about three-week intervals from April 28 to August 19, 1980. On cranberry, larvae were collected by hand searching without regard for the unit searched. Six sampling visit were made at each of four sites in Pitt Meadows, Burnaby and Richmond at about three-week intervals from May 12 to August 18, 1980. On raspberry, leafroller populations were surveyed by collecting all larvae and pupae on each of 10 plants at each visit from sample plots laid out in the same fashion as for blueberry. Six sampling visits were made at each of three sites in Langley and Abbotsford at about three-week intervals from April 23 to August 25, 1980. Additionally, larvae were collected at about three-week intervals from June 3 to September 1, 1980 and from April 21 to September 1, 1981 at the Agriculture Canada raspberry field. On strawberry, leafroller populations were surveyed at about three-week intervals from April 15 to August 20, 1980 from four sites in Richmond and Langley. Ten samples were collected at each of six visits. A sample consisted of all leafroller larvae and pupae from one-metre sections of row chosen randomly from within 10-row x 30-metre sample plots. Each section was sampled only once. The species are discussed in order of apparent importance.

RESULTS AND DISCUSSION

Blueberry

Numbers of leafroller larvae per blueberry plant varied considerably between the sites surveyed. Populations peaked in May: variations could be correlated with histories of insecticide use. The lowest populations were at the two sites that were sprayed in 1980, where the number of larvae did not exceed one per plant. Somewhat higher populations were at four sites that were not sprayed in 1980 but had been sprayed one or two years before. At these sites, peak populations reached four larvae per plant. The highest populations were at three sites that had not been sprayed for at least five years, where peak populations were from 15 to 25 larvae per plant.

In all, 14 species of Tortricidae, one of Geometridae and one of Oecophoridae were collected from rolled leaves and webbed blossom and fruit clusters on blueberry (Table 1). Six of the tortricid species and *Cheimophila salicella* (Oecophoridae) are not native to North America. Seven of the remainder and *Operophtera bruceata* (Geometridae) are indigenous. A *Clepsis* sp., represented by a single specimen, is of unknown provenance.

Chroistoneura rosaceana, the oblique-banded leafroller, was the most abundant species from late April to mid-May, 1980. This is apparently the first record of its occurrence on cultivated blueberry in North America. Larvae fed in leafrollers and in blossom and developing fruit clusters. Pupation was in June, and adults flew in July and August. Larvae collected on August 19 from recently-laid egg masses fed for 2 to 3 weeks until they reached the second or third instar, and then entered diapause. First and second instar larvae were frequently found in August feeding in abandoned rolls of *C. salicella*. *Choristoneura rosaceana* is univoltine on blueberry in the Fraser Valley; it is bivoltine further south (Chapman and Leink 1971).

Spilonota ocellana, the eye-spotted budmoth, was more abundant than *C. rosaceana* at one site but less so at others. This is apparently the first record of its occurence on cultivated blueberry in North America. Larvae were collected from late April to late June. They fed almost exclusively in developing flower and fruit clusters, webbing the clusters together into loose nests of bracts, bud scales, petals and frass. Larvae pupated in late June and early July. Eggs were laid singly and hatched in July and August. The larvae overwintered as early instars. The biology of *S. ocellana* on blueberry in British Columbia is similar to that described on apple in New York (Chapman and Lienk 1971) except that flowers and fruit provide the major food source

on blueberry, whereas on apple, the larvae feed on leaves and fruit.

Archips rosanus, the European leafroller, was generally less common on blueberry than *C. rosaceana*. This is apparently the first record of this species on cultivated blueberry in North America. Larvae were collected from May 10 to late June, mostly from leafrollers but also from fruit clusters. Pupae were found in late June and July and adults in July. Egg masses were laid on old wood of blueberry bushes and hatched in early May of the following year. This description parallels the biology of *A. rosanus* on apple in New York state (Chapman and Lienk 1971).

Cheimophila salicella was the most abundant species in July and August, and at some sites was as common as or more common than *C. rosaceana* has been earlier in the year. Raine (1966) and Neilson (1969) reported *C. salicella* to be a pest of blueberry in the Lower Fraser Valley. Larvae were first collected on June 10, although they were observed earlier. They fed predominantly in leafrolls; early-instar larvae also fed on the blossom end of developing berries. The larvae were not seen to feed on ripe fruit. Pupation occurred in late August and early September; the adults emerged in March and laid eggs which hatched in mid-May. These observations agree with Raine's (1966) description of the biology of *C. salicella* on blueberry.

Operophtera bruceata, the Bruce spanworm, was common at two sites in April and May 1980 and 1981. This is apparently the first record of the species feeding on cultivated blueberry in North America. Larvae fed predominantly in flower buds and expanding flower clusters from mid-March to early May. Pupation was in early May; adults emerged in late November and laid overwintering eggs which hatched in mid-March. This life history is similar to that on aspen in Alberta as described by Brown (1962).

Croesia curvalana was common at two sites in May 1980 and 1981. It has damaged lowbush blueberry in Nova Scotia and New Brunswick (Kelleher 1975, 1976). Larvae fed both in leafrolls and flower clusters. Larvae pupated in June and adults were observed in late June and July. Captured females laid eggs singly on the lids of containers in which they were held but none of these hatched. It is presumed that the species overwinters in the egg stage, as does *C. albicommana* in California (Powell 1964).

Pandemis cerasana larvae were collected from blueberry at most sites in May and June 1980. Feeding was in leafrolls and blossom clusters. Adults were seen in June and early July. Egg masses laid on the upper surface of blueberry leaves hatched in 5 to 10 days and these larvae commonly fed in abandoned leafrolls of *Cheimophila salicella* before seeking overwintering sites. This is apparently the first report of *P. cerasana* on cultivated blueberry in North America. The life cycle on blueberry parallels that on oak in Victoria, B.C. as described by Evans (1970).

Badebecia urticana larvae were collected from blueberry in late April and May 1980. They fed most frequently in leafrolls and less so in flower and fruit clusters. Pupation was in June and adults occurred from late June to early August. In the laboratory, eggs were laid singly on the upper surface of blueberry leaves and hatched in 5 to 10 days. Larvae that were fed mature blueberry leaves developed to the second or third instar and then rolled a section of the edge of a leaf into a tube about 5 mm long and 1 mm in diameter, lined the tube with silk, and sealed it at both ends. Larvae remained dormant in these tubes for up to 4 months in the laboratory but eventually died from desiccation. This species is apparently univoltine and the tubes may be hibernaculae. *Badebecia nurticana* has been reported previously as damaging blueberry in British Columbia (Creelman 1969).

The remaining eight species found on blueberry, *Pandemis heparana*, *P. limitata*, *Aphelia alleniana*, *Archips argyrospilus*, *A. podana*, *Acleris variegana*, *Clepsis forbesi* and an unnamed *Clepsis* sp. were not found in sufficient numbers to carry out biological studies. Apparently none of these has been recorded previously from cultivated blueberry in North America.

Cranberry

Five leafroller species were collected from cranberry (Table 1). *Rhopobota naevana* (Tortricidae), the black-headed fireworm, was predominant at all sites. It was much more abundant at sites which were unsprayed and untended than at sites which were sprayed and well tended. Larvae were collected everywhere on unsprayed sites, whereas at sprayed sites they occurred only in areas that were not reached by the insecticide. This was the only leafroller species collected at sprayed sites; small numbers of *Cheimophila salicella*, *Choristoneura rosaceana* and an unidentified species of tortricid were collected at unsprayed sites in 1980 and small numbers of *Archips rosanus* and *Aphelia alleniana* in 1981.

There were two full generations of *R. naevana*. Egg hatch started about May 18 and was over by June 1. Larvae matured and dropped to the duff to pupate about June 13, and the first adults were seen on July 6. Females laid eggs singly on the undersides of cranberry leaves and the second generation larvae first appeared on July 27. These larvae began to pupate on August 10, and second generation adults appeared on August 24. Most eggs from these adults overwintered; a very few hatched but these larvae did not complete development and were found dead inside cranberry tips in late September.

The life history of R. naevana on cranberry in British Columbia is essentially the same as it is on cranberry in Massachusetts (Franklin 1948) and in Washington (Plank 1922).

TABLE 1. Hosts and relative abundance of leafrollers on berry crops in the Lower Fraser Valley, British Columbia. Relative abundance rated as follows: – = not found; + = 1-2 individuals collected; + + = 1-5 individuals collected at most sites; + + + = occurred at most sites but not comprising more than 10% of individuals collected and never abundant; + + + + = occurred at all sites, comprising 20% or more of individuals collected and abundant at most sites.

	Species	Hosts			
		Blueberry	Cranberry	Raspberry	Strawberry
*	Acleris comariana (Zell.)	-	-	++	++++
*	Acleris variegana (D.&S.)	++	-	-	-
	Ancylis comptana fragariae (W.&R.)	-	-	-	-
	Aphelia alleniana (Fern.)	++	+	+	+++
	Archips argyrospilus (Wlk.)	++	-	+	-
*	Archips podana (Scop.)	+	-	-	-
*	Archips rosanus (L.)	++++	+	++	-
	Argyrotaenia citrana (Fern.)	-	-	-	-
	Badebecia urticana (Hbn.)	+++	-	++	++
*	Cheimophila salicella (Hbn.)	++++	+	-	-
	Choristoneura rosaceana (Harr.)	++++	+	++++	++
	Clepsis forbesi (Obr.)	+	-	-	-
	Clepsis sp.	+	-	-	-
*	Cnephasia longana (Haw.)	-	-	-	-
	Croesia curvalana (Kft.)	+++	-	-	-
	Exartema olivaceanum (Fern.)	-	-	-	-
	Herpetogramma pertextalis(Led.)	-	-	++	-
	Operophtera bruceata (Hulst.)	+++	-	+++	-
*	Pandemis cerasana (Hbn.)	+++	-	-	-
*	Pandemis heparana (D. & S.)	++	-	-	-
	Pandemis limitata (Rob.)	++	-	-	-
	Rhopobota naevana (Hbn.)	-	++++	-	-
*	Spilonota ocellana (D.& S.)	++++	-	-	-
	Tortricid sp. 1	-	+	-	-

* Introduced species (Gillespie and Gillespie 1982)

Raspberry

Leafrollers were rare at three sites where various insecticides were applied against western raspberry fruitworm, *Byturus bakeri* (Coleoptera: Byturidae), and other pests in late April and again in mid-June, 1980. Second generation larvae of some tortricids were common at one unsprayed site.

Eight leafroller species were collected from raspberry (Table 1). Of these, 6 were Tortricidae, 2 of which, *Acleris comariana* and *Archips rosanus*, are introduced.

The predominant species in early April was *Operophtera bruceata*. Also collected at this time were *A. comariana*, *Badebecia urticana*, *Choristoneura rosaceana* and *Herpetogramma pertextalis* (Lepidoptera: Pryalidae). *Herpetogramma pertextalis* was the most abudant species at sprayed sites in May and June whereas *C. rosaceana* and *A. comariana* were most abundant at the unsprayed sites. At sprayed sites the larvae did not exceed three per plant; at the unsprayed site there were about 10 per plant in April, 1981, and populations decreased thereafter.

Larvae of *O. bruceata* fed extensively on flower buds of raspberry in April and early May. Flower buds had grown beyond the shelter of the leaves by mid-May, after which no larvae were seen to feed on them.

Choristoneura rosaceana was bivoltine on raspberry and univoltine on all other host plants surveyed in this study. Larvae hatching from egg masses on blueberry in July entered diapause and overwintered, whereas on raspberry at least some of the hatched larvae developed to adults in late August and their larvae overwintered.

Larvae of *H. pertextalis* found in May and early June pupated in early to late June. Adults emerged in the laboratory in late June and early July, but were not observed in raspberry fields. The mode of overwintering is unknown.

The biology of the other species on raspberry is as described for the other crops in this paper.

Strawberry

Very few leafrollers were found in most commercial strawberry fields. In Richmond and Langley no larvae were collected either in sample plots or by searching large areas. Two sites were sprayed early in the season for aphids. At a third site in Langley a few larvae of *Acleris comariana* and *Choristoneura rosaceana* were found, but never more than one larva/m of row. By June 26 adults of both species were seen, and the field was plowed under shortly thereafter. This field was treated with a miticide early in the season.

The fourth site in Richmond was not sprayed in 1979 or in 1980. There, larval populations were quite high, reached a peak of 28 larvae/m of row. Even the high population levels produced no visible effect on the crop: at no time did the plants appear defoliated, and no berries were seen that appeared to have been damaged by larval feeding. Alford (1976) observed no effect on yield at densities of 6.5 *A. comariana* larvae/m of row on strawberry in Britain.

Only four tortricid species were collected on strawberry (Table 1). In decreasing order of abundance these were *A. comariana*, *Aphelia alleniana*, *Badebecia urticana* and *C. rosaceana*. Of these only *A. comariana* is an introduced species.

The life histories of *C. rosaceana* and *B. urticana* were similar to those on blueberry. *Acleris comariana* was the most abundant species. In May, it comprised more than 90% or larvae collected. Eggs hatched about mid-April. Peak larval populations were seen on May 13 and most larvae had pupated by June 4. Adults were seen first on June 26. Larvae of the second generation were present on July 4 and began to pupate by August 20. This species was a serious pest in Richmond, B.C. when it was first discovered on strawberry plantings (Cram 1973). It has been reported as an occasional, and at times serious pest of strawberry in Britain (Alford 1975). Larvae have been found to prefer leaves to flowers or developing fruitlets (Alford 1975), which tends to lessen the species' impact on strawberry yields.

The second most abundant species on strawberry was *Aphelia alleniana*. Larvae had emerged from overwintering sites and were quite large by April 15. Mature larvae and pupae were found on June 4, and adults were seen in June. The egg masses were laid on the upper surface of strawberry leaves. From July through August, first instar larvae fed between the basal veins of strawberry leaves and in deserted leafrolls of *A. comariana*. In September, larvae were found in the same sites but were concealed by silk. These structures probably serve as overwintering sites.

CONCLUSIONS

Although characteristic levels of abundance were determined for leafrollers on blueberry, raspberry and strawberry crops, there is as yet no evidence that they cause economic injury to those crops at the levels encountered. Fields sprayed with insecticides tended to have lower leafroller populations than unsprayed fields, but this does not mean that insecticide sprays were needed to prevent the development of damaging populations at these sites. However, high larval populations of *Rhopobota naevana* in unsprayed cranberry fields did cause obvious damage, and various leafrollers in unsprayed blueberry fields damaged the blossom and fruit clusters.

The leafroller fauna on berry crops in the Lower Fraser Valley consists of a complex of species, some of which are crop-specific whereas others are polyphagous. Furthermore, some of the species have not been reported previously on berry crops. On blueberry, six of the eight most common species are apparently new reports from that crop.

Generally, the importance of introduced species in the pest complex on berry crops is illustrated by

the fact that the most common species on each crop were introduced. On blueberry, five of the eight most common species were introduced. On raspberry, one common species, *A. comariana*, was introduced, and the most common species on each of cranberry and strawberry were also introduced. No new introduced species were found in this survey.

Cnephasia longana, *Exartema olivaceanum* and *Ancylis comptana fragariae*, which are reported pests of strawberry in the Lower Fraser Valley (Neilson 1969, Anon. 1981), were not found on strawberry in this survey, nor was *Argyrotaenia citrana*, reported as a pest of raspberry (Neilson 1969), found on raspberry. The absence of these species may simply be apparent, *i.e.*, they might be at low ebbs in cycles of population abundance, or it might reflect actual changes in the pest complex on those crops caused by outside pressures such as competition from other species or changes in insecticide treatments.

That several species were found for the first time in this survey, whereas 4 species previously recorded from berry crops in the Lower Fraser Valley were not found, indicates that the leafroller fauna there is changing.

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A LIST OF PLANT-FEEDING LEIDOPTERA INTRODUCED INTO BRITISH COLUMBIA

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ABSTRACT

Each of 48 species of plant-feeding Lepidoptera known to be foreign to North America and to occur in British Columbia is briefly summarized with its history and importance. Those feeding on stored products are not indicated.

INTRODUCTION

The following are species-based summaries of the history and importance of exotic Lepidoptera in British Columbia. We hope that this paper will stimulate further investigation of some of these species; particularly useful would be information on the adaptation of native parasites and predators to the exotic species as hosts.

The species are treated alphabetically in order of their generic names. Approved North American English common names (Benoit 1975, Sutherland 1978) are included where available. Where no such common names are available, we have used British common names, as in the reference material.

Species of Lepidoptera feeding on stored products are exluded from the list because they are virtually cosmopolitan, often independent of climate and can be regarded as being native to man's stored products, wherever such products occur.

Limitations of time and resources imposed some restrictions on the scope of these summaries. They are not complete bibliographes of each species, but rather brief notes on the history, distribution, host plants and pest status or potential in North America and elsewhere. Standard abbreviations of Canadian provinces and postal abbreviations of the United States (Table 1) are used throughout.

It is noteworthy that in the two successful eradications of introduced Lepidoptera in B.C., entomologists were aware of the presence of the insects before the pests had had a chance to spread from their original entry points. In both cases prompt and perhaps radical action prevented the establishment of breeding populations. It is also noteworthy that 19 of the 48 introduced Lepidoptera are of the family Tortricidae. This disproportionate representation might indicate an, as yet unknown, biological feature predisposing the Tortricidae to being imported, or to establishing once imported.

The criteria used here to include species in the list were rather strict. Only those species are included for which definite records were located, giving exotic origin and date of entry or first capture. There are probably many introduced species of Lepidoptera not included here for which no such records exist.

TABLE 1. Abbreviations of Provinces and States used in text.

CANADA	
Place	**Abbreviation**
Alberta	Alta.
British Columbia	B.C.
Manitoba	Man.
New Brunswick	N.B.
Newfoundland	Nfld.
NorthWest Territories	N.W.T.
Nova Scotia	N.S.
Ontario	Ont.
Prince Edward Island	P.E.I.
Quebec	Que.
Saskatchewan	Sask.
Yukon	Yuk.
UNITED STATES	
Arizona	AZ
California	CA
Connecticut	CT
District of Columbia	DC
Idaho	ID
Maine	ME
Maryland	MD
Massachussetts	MA
Michigan	MI
Montana	MT
New Jersey	NJ
New York	NY
Ohio	OH
Oregon	OR
Pennsylvania	PA