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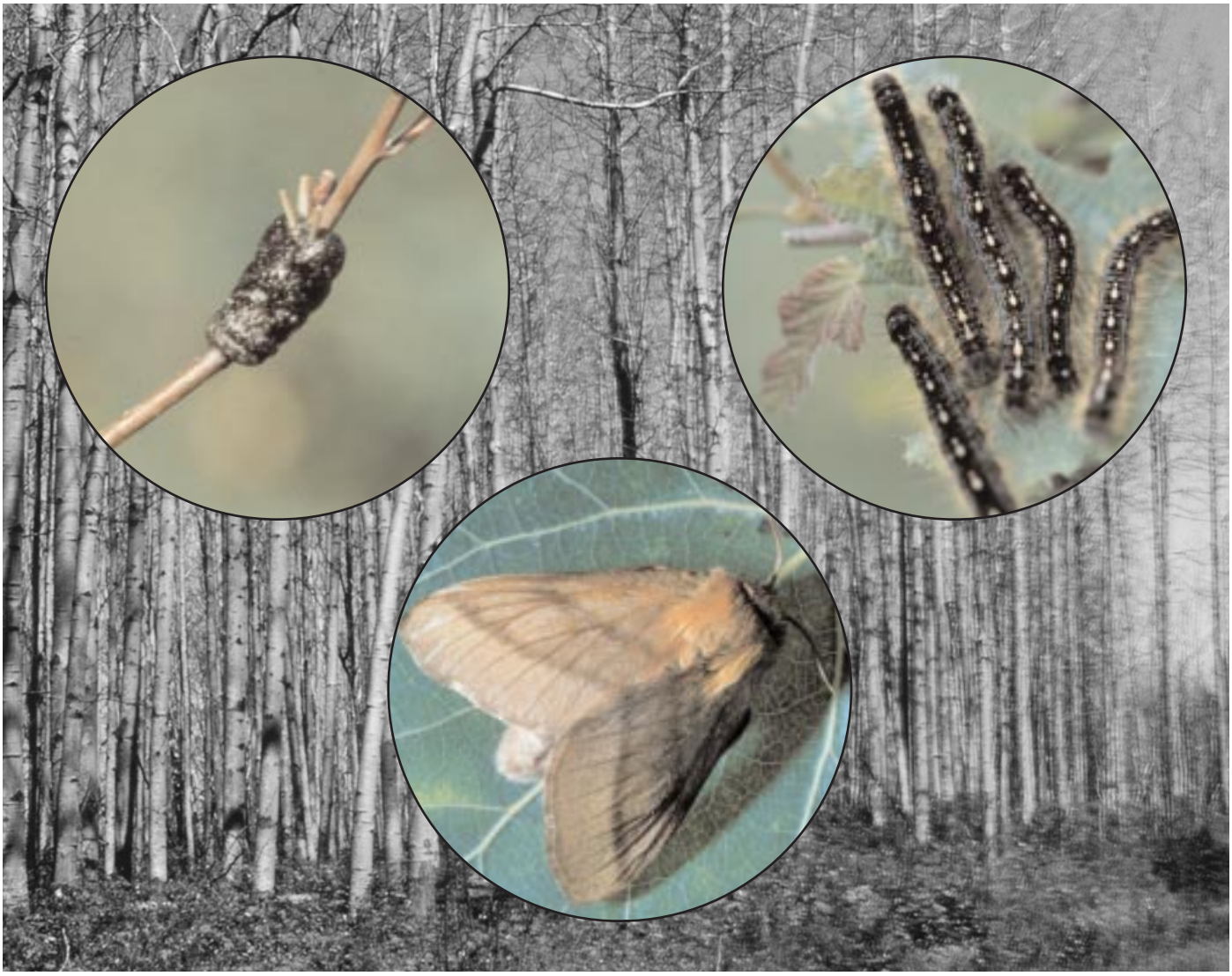
An annotated bibliography of the Forest tent caterpillar, *Malacosoma disstria*



I.S. Otvos, L. Payne, V. Kilvert and N. Conder

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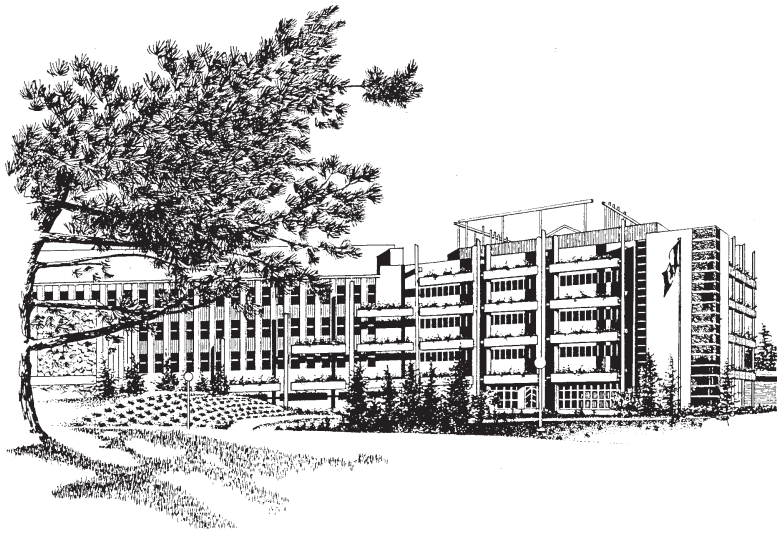

The Pacific Forestry Centre, Victoria, British Columbia

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PREFACE

The forest tent caterpillar, *Malacosoma disstria* Hübner, is native to North America and is widely distributed throughout Canada and the United States wherever deciduous trees grow. The preferred host of the forest tent caterpillar is aspen (*Populus tremuloides*). However, *M. disstria* can also be a serious, defoliating pest of various species of oak (*Quercus* spp.) and maple (*Acer* spp.) in the north and west, and tupelo gum (*Nyssa aquatica*), black gum (*Nyssa sylvatica*), and sweetgum (*Liquidambar styraciflua*) in the southern United States. During outbreaks, larvae will also defoliate underbrush after stripping preferred hosts and they have been known to eat herbs if no other food is available.

This annotated bibliography on the forest tent caterpillar contains 493 references and was compiled to provide a working tool for people interested in this insect. We thought it advantageous to bring together all the published and unpublished articles we could obtain, annotate them, and make the annotations available in a timely fashion. This annotated bibliography and its subject and author indices will be useful to all those interested in forest tent caterpillar outbreaks, including forest entomologists and managers. This document should considerably reduce the time needed to search for an article, and should help users locate and obtain articles of particular interest. This bibliography is the second in a series on the major forest insects of British Columbia.

The literature search was done mainly electronically using *TreeCD* (up to and including October 1996) and *Agricola* (up to and including September 1996). Hard copies of *Biological Abstracts* were searched from 1927 to 1989, and from January 1990 to December 1996 they were searched electronically. *Dissertation Abstracts* was used to obtain copies of abstracts of doctoral theses. When an abstract or summary of an article was not available, we prepared the annotation after reading the article. When the summary or abstract was part of a database, it was downloaded and paraphrased after reading the article to standardize style and format. We then expanded the bibliography by cross-referencing the articles with those cited in their lists of references. Wherever possible, abbreviations for journal and publication names are those listed in *Biosis Serial Sources, Volume 1996, Biosis, Philadelphia, Pennsylvania.*

The authors plan to publish a detailed literature review of these articles as an Information Report, and they plan to publish a critical review of the literature on this insect in a scientific journal.

Please send hard copies of any articles on this insect that are either cited from secondary sources (such as *Biological Abstracts*) or that were not included in the bibliography (either because they may have been overlooked or because they could not be obtained) to the senior author.

ACKNOWLEDGEMENTS

We thank Alice Solyma and Barbara Hendel of the Pacific Forestry Centre library for their invaluable assistance in obtaining the master's theses and several of the more obscure references. We also thank all those people at universities and various institutes for their help in obtaining copies of unpublished reports and theses. Finally, we thank Mario Biello for assisting in the translating the French annotations into English.

ABSTRACT

Annotations are provided for a total of 493 references on the forest tent caterpillar from as early as 1878 until 1996. Subject, author, and geographic indices are provided to guide the user to specific references. Unpublished reports are included if they were available on request.

RÉSUMÉ

Des annotations sont fournies pour 493 références sur la livrée des forêts et ce, pour la période allant de 1878 à 1996. Des répertoires par sujet, par auteur et par région géographique renvoient l'utilisateur à des références particulières. Les rapports inédits sont inclus s'ils sont disponibles sur demande.

ANNOTATED BIBLIOGRAPHY

1. Abrahamson, L.P.; Harper, J.D. 1973. **Microbial insecticides control forest tent caterpillar in southwestern Alabama.** U.S. Dep. Agric. For. Serv., South. For. Exp. Sta., Res. Note No. SO-157. 3 p.

   This note reports on the efficacy of a number of products tested in the field. Dipel (a wettable powder formulation of *Bacillus thuringiensis)* at 0.25 and 0.50 lb/acre, Thuricide HPC (a liquid formulation of *B. thuringiensis*) at 1 qt/acre, nuclear polyhedrosis virus at a rate of $2.5x10^{10}$ PIBs/acre, spores of the fungus *Entomophthora megasperma* at a rate of $4.2x10^{6}$ spores/acre, and trichlorfon at 0.5 and 0.75 lb/acre, applied as aerial sprays to 12 plots infested with *Malacosoma disstria* in *Nyssa aquatica* swamp forest in SW Alabama. Dipel (at 0.50 lb/acre) and trichlorfon (at both rates) gave excellent control, Thuricide and Dipel (at 0.25 lb/acre) was somewhat less effective, and the virus and fungal treatments had no significant effect.

   Control - 2,3,4,5

2. Abrahamson, L.P.; Morris, R.C. 1973. **Forest tent caterpillar: control with ULV trichlorfon in water tupelo ponds.** J. Econ. Entomol. 66(2): 574.

   Swamp stands of water tupelo, *Nyssa aquatica,* and black gum, *N. sylvatica* var. *biflora,* in Alabama infested with *Malacosoma disstria* were aerially sprayed during April with an ultra-low-volume [ULV] formulation at three rates. Aerial photos taken in May showed that defoliation was negligible within treated plots, while trees outside the treated areas were completely defoliated. A ground check one week after treatment confirmed that the spray at ca. 0.50 lb a.i. [active ingredient]/acre provided adequate protection against defoliation by *M. disstria.*

   Control - 2

3. Addy, N.D. 1969. **Rearing the forest tent caterpillar on an artificial diet.** J. Econ. Entomol. 62(1): 270-271.

   The ingredients are listed, the preparation of the diet is explained, and the rearing methods used are described. In tests of this technique, the number of *Malacosoma disstria* larvae reaching adulthood was ca. 80% of the initial egg population.

   Biology - 6

4. Addy, N.D.; Batzer, H.O.; Mattson, W.J.; Miller, W.E. 1971. **Impact of insects on multiple-use values of north-central [US] forests: an experimental rating scheme.** U.S. Dep. Agric. For. Serv., North Cent. For. Exp. Sta. Res. Pap. NC-57. 8 p.

This paper describes a points system for establishing research priorities, by assessing the total disturbance of timber, recreation, wildlife, and hydrology by a given species. *Malacosoma disstria* was considered to have the greatest impact of 15 species of forest insects compared on multiple-use values.

Outbreaks - 3

5. Allen, D. C. 1987. **Insects, decline and general health of northern hardwoods: issues relevant to good forest management.** Pages 252–285 *in* R.D. Nyland (ed.). Managing Northern Hardwoods. Proc. Silvicultural Symp., Syracuse, N.Y. June 23-25, 1986. State Univ. of New York, Coll. Environ. Sci. and For., Fac. For., Syracuse, N.Y., Misc. Publ. No. 13 (ESF)87-002. Soc. Am. For. Publ. No. 87-03.

Location, extent, and degree of defoliation of sugar maple by *Malacosoma disstria* is reviewed, as is information concerning secondary pests taking advantage of stressed or dying trees. Damage done to black cherry and white ash are briefly summarized.

Outbreaks - 1,3

6. Anderson, G.W.; Martin, M.P. 1981. **Factors related to the incidence of *Hypoxylon* cankers in aspen and survival of cankered trees.** For. Sci. 27(3): 461-476.

"Factors associated with the incidence of new bole cankers in *Populus tremuloides* caused by *Hypoxylon mammatum* were identified from 8 years observation on 74 plots distributed over the aspen range of northern Minnesota. These factors were: length and intensity of defoliation during an infestation by *Malacosoma disstria* immediately preceding this study, plot density, presence of *Saperda calcarata*, prevalence of Hypoxylon cankers in the upper bole initially, crown class, crown density and possibly site index. Prior defoliation remained an important factor over the entire 8-year period. Outcome following infection was analyzed by life tables. Trees with cankers below the crown suffered 96% mortality within 6 years. For trees with cankers higher in the bole, deaths occurred over a longer period and were due directly to infection only when infection subsequently spread to the lower bole. Trees with cankers in the upper bole which developed new leaders (28%) had subsequent survival similar to that of uninfected trees. We estimate that most of the trees with cankers in the upper bole which failed to develop new leaders would be dead within a period of 12 to 15 years after infection."

Outbreaks - 3

7. Anderson, J.F. 1978. **Hardwood defoliating caterpillars in northeastern United States.** J. Arboric. 4(12): 265-269.

Outbreaks of 13 species of Lepidoptera in broadleaved forests since 1970 are reviewed, noting their distribution and severity, possibilities of biological and chemical control, and the biology of the pests, *namely: Alsophila pometaria, Dasychira basiflava, Dryocampa rubicunda, Ennomos subsignarius, Erranis tilaria, Heterocampa guttivitta, Hydria prunivorata, Hyphantria cunea, Lymantria dispar, Malacosoma disstria, M. americanum, Paleacrita vernata, and Symmerista canicosta.*

General Background

8. Anderson, R.M.; May, R.M. 1980. **Infectious diseases and population cycles of forest insects.** Science 210(4470): 658-661.

"The regulation of natural populations of invertebrate hosts by viral, bacterial, protozoan, or helminth infections is discussed, using models that combine elements of conventional epidemiology (where the host population is assumed constant) with dynamic elements drawn from predator-prey studies; the apparent absence of acquired immunity in invertebrates simplifies the analysis. Highly pathogenic infections, with long-lived infective stages, tend to produce cyclic behavior in their host populations. The models give an explanation of the 9- to 10-year population cycles of the larch bud moth (*Zeiraphera diniana*) in the European Alps and suggest that microsporidian protozoan and baculovirus infections may be responsible for the 5- to 12-year population cycles observed in many temperate forest insects [including *Malacosoma disstria*]."

Outbreaks - 6; Control - 3,4,6

9. Angus, T.A. 1951. **Bacteria associated with forest tent caterpillar.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 7(2): 4.

Four unidentified species of bacteria were isolated from dead or moribund *Malacosoma disstria* larvae found in the field. Two of these bacteria were Gram-positive sporulating rods which appear to be related to the *Bacillus cereus* group. The other two, which may have been identical, were short, motile, Gram-negative rods. One of the latter, tentatively called Bacterium 'B', was considered the most promising isolate; it was pathogenic when introduced, even in small quantities, into the body cavity. A large number of larvae were reared under conditions of stress and fed on foliage sprayed with a suspension of Bacterium 'B'. An estimated 70% of these larvae died before pupating, and over 90% of the dead larvae yielded pure cultures of the test organism.

Biology - 3

10. Angus, T.A. 1965. **Mortality due to *Bacillus thuringiensis* in post-larval stages of some Lepidoptera.** Proc. Entomol. Soc. Ont. 95(0): 133-134.

This paper gives a short review of the mode of action of *Bacillus thuringiensis* and notes mortality caused by *B. thuringiensis* in larval, pre-pupal and pupal stages of *Malacosoma disstria* (Hubn*)*, *Sarrothripus cinereana* N.D., *Nymphalis antiopa* (L.), *Dendrolimus sibericus* Tschetverikov, and *Spilonota ocellana* (Dennis and Schiffermuller). Larval mortality of *M. disstria* amounted to 53% (all dead larvae contained vegetative cells of *B. thuringiensis*), 37% cocooned larvae failed to eclose (95% were positive for *B. thuringiensis*), some had died as prepupae, some as pupae.

Biology - 3

11. Angus, T.A.; Heimpel, A.M. 1958. **Further observations on the action of *Bacillus sotto* toxin.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 14(4): 1-2.

Fourteen species of lepidopteran larvae (including *Malacosoma disstria*, *M. pluviale* and *M. amercanum*) reared on foliage coated with *Bacillus sotto* died within 24 and 96 hours of feeding. No shift in blood

alkalinity was observed in infected larvae. It was observed that general paralysis does not precede death in species with moderately alkaline midgut contents, as it does in hornworm and silkworm which have highly alkaline midgut contents.

Biology - 3

12. Anon. 1974. **Forest tent caterpillar advisory.** Gt. Lakes For. Res. Cent., For. Bull. Misc. 2. 3 p.

This report gives some general information of the life history and habits of the forest tent caterpillar, as well as some control measures (i.e., removing egg masses, using insecticides to kill larvae). This bulletin also contains two maps showing areas where the infestations was expected to cause light or heavy damage during 1974.

General Background; Outbreaks - 1; Control - 2

13. Arnold, J.W.; Sohi, S.S. 1974. **Hemocytes of *Malacosoma disstria* Hübner (Lepidoptera: Lasiocampidae): morphology of the cells in fresh blood and after cultivation in vitro.** Can. J. Zool. 52(4): 481-485.

"Hemocytes of the forest tent caterpillar, *Malacosoma disstria,* were examined in blood films prepared from full-grown larvae, and in tissue cultures of blood cells maintained by serial passage in vitro up to 148 times. In fresh larval blood, five categories of hemocytes were identified as follows: prohemocytes, plasmatocytes, granular hemocytes, spherule cell, and oenocytoids. The granular hemocytes were the most numerous by far. In the tissue cultures, only three categories were found, prohemocytes, plasmatocytes, and granular hemocytes, and here the granular hemocytes were the least numerous. Each category in culture was autonomous and able to divide. Hemocytes in cultures were larger than the cells in fresh blood, and were mostly round."

Biology - 7

14. Arthur, A.P.; Coppel, H.C. 1953. **Studies on dipterous parasites of the spruce budworm, *Choristoneura fumiferana* (Clem.) (Lepidoptera: Tortricidae).** Can. J. Zool. 31(4): 374-391.

"*Sarcophaga aldrichi* Park. is a native parasite which has been reared continually, though in small numbers, from *Choristoneura fumiferana* (Clem.) in British Columbia. It is also an important parasite of *Malacosoma disstria* Hbn. and is apparently widely distributed throughout North America. The parasite can be reared in the laboratory on pork liver, or on a mixture of liver and fish, from larvae deposited on the rearing medium by ovoviviparous females. The total time required for development from deposition of the larvae to the beginning of puparial formation was five to eight days. The puparia were formed 7 to 44 days later. No adults emerged without a period of diapause, which normally lasted throughout the winter months. The distinguishing characters of the immature stages are described. The methods used in rearing spruce budworm pupae for obtaining parasites are outlined."

Biology - 2

15. Baird, A.B. 1917. **An historical account of the forest tent caterpillar and of the fall webworm in North America.** Annu. Rep. Entomol. Soc. Ont. [later Proc. Entomol. Soc. Ont.]. 47(0): 73-87.

This paper gives a historical account of the forest tent caterpillar and the fall webworm infestations in the United States and Canada from 1797 until 1915.

Outbreaks - 1

16. Baird, A.B. 1920. **Further notes on the tent-caterpillar and its natural control, 1919.** Proc. Entomol. Soc. B.C. 11(0):101-102.

Outbreaks of *Malacosoma pluvialis* and *M. disstria* in Victoria and Vancouver in 1919 were reviewed and chief control factors noted. At both sites, overcrowding and diseases together were responsible for the death of large numbers of larvae. Insect parasites were almost entirely absent in Vancouver outbreak. In Victoria, the effects of insect parasites were reduced as cold weather delayed hatching of parasite eggs.

Biology - 2,3,4

17. Baker, W.A. 1972. **Eastern forest insects**. U.S. Dep. Agric. For. Serv., Misc. Publ. No. 1175. pp. 330-333.

The major portion of this publication is devoted to the identification, distribution, host relationships, and life histories of insects occurring in eastern forests. Insects discussed are those which occur either entirely in portions of the U.S. lying east of the 100th meridian or which occur in both eastern and western halves of the country.

General Background

18. Barbehenn, R.V.; Martin, M.M. 1994. **Tannin sensitivity in larvae of *Malacosoma disstria* (Lepidoptera): roles of the peritrophic envelope and midgut oxidation.** J. Chem. Ecol. 20(8): 1985-2001.

"Final instar *Malacosoma disstria* fed artificial diets containing tannic acid develop lethal pupal deformities. We examined some of the factors potentially underlying tannin sensitivity in this species, including the permeability of the peritrophic envelope to tannic acid and the chemical fate of tannic acid in the gut. Tannic acid does not penetrate the peritrophic envelope of *M. disstria*, demonstrating that the containment of tannic acid within the endoperitrophic space is not sufficient to protect an insect herbivore from the adverse effects of tannins. Ingested tannic acid undergoes extensive chemical modification in the midgut. Only 19–21% of the high molecular weight components of the tannic acid ingested was recovered in the frass. Of two possible chemical fates of tannic acid, oxidation is the predominant chemical transformation, whereas little hydrolysis occurs. Measurements of gut redox parameters showed that conditions in the midgut favor the oxidation of phenols. However, similar conditions occur in the midguts of *Orgyia leucostigma*, in which no

oxidation occurs. Therefore, oxidizing gut redox conditions do not necessarily lead to polyphenol oxidation in lepidopteran larvae. We conclude that the sensitivity of *M. disstria* to ingested tannins is a consequence of their oxidation in the midgut."

Biology - 8

19. Barbehenn, R.V.; Martin, M.M. 1995. **Peritrophic envelope permeability in herbivorous insects.** J. Insect Physiol. 41(4): 303-311.

"A sensitive method was developed for measuring the size and flux of marker substances that permeate the peritrophic envelopes (PEs) of insects. Seven species of herbivorous insects were fed polydisperse fluorescein isothiocyanate-labeled dextrans (FITC-dextrans), and the average size and amount of FITC-dextrans that diffused through their PEs were measured using high-performance size-exclusion chromatography. The diameters of FITC-dextrans that diffused through the PEs of four species of larval Lepidoptera [*Orgyia leucostigma*, *O. pseudotsugata*, *Malacosoma disstria* and *Manduca sexta*] and three species of Orthoptera ranged from 21 to 29 and from 24 to 36 nm, respectively. The flux of FITC-dextrans that diffused through the PEs of Lepidoptera and Orthoptera ranged from 32 to 159 and from 91 to 2821 ng/h, respectively. We conclude that: (1) on average, the PEs of Orthoptera are more permeable than those of Lepidoptera; (2) that pores in the peritrophic membranes of Lepidoptera and Orthoptera are too large to allow the PE to function as an effective size-dependent ultrafilter for digestive enzymes and free plant allelochemicals; and (3) that the permeability of the PE to some digestive enzymes and ingested plant allelochemicals is determined by the chemical properties of the matrix."

Biology - 8

20. Barter, G.W.; Cameron, D.G. 1955. **Some effects of defoliation by the forest tent caterpillar.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 11(6): 1.

An outbreak of *Malacosoma disstria* occurred in New Brunswick during 1941, 1950, and 1951. Radial growth of aspen [*Populus tremuloides*], which was almost totally defoliated, was reduced during each year of defoliation but did not cease immediately upon loss of foliage. Reduction of radial growth for the three years 1949–51 respectively amounted to 42, 52, and 77%. Some recovery of growth rate occurred in 1952, but the growth that year was still below normal and about the same as that of the first year of the outbreak. Radial growth reduction of white birch [*Betula papyrifera*?] amounted to 22, 68, and 86%, respectively, compared with figures on defoliation of 23, 87, and 52%, respectively. Growth in 1952 was similar to that of 1950. Since the beginning of the outbreak, 29% of the aspen and 31% of the birch have died. Mortality was closely related to attack by several species of borer, particularly *Agrilus* spp., and bark beetles, which appeared to be encouraged by the weakened condition of the trees.

Outbreaks - 1,3

21. Batzer, H.O. 1955a. **Some effects of defoliation of aspen, *Populus tremuloides* Michx., stands in northern Minnesota by the forest tent caterpillar, *Malacosoma disstria* Hbn., with notes on parasitism of cocoons by *Sarcophaga aldrichi* Park. and coccooning habits of the host.** M.Sc. thesis. Univ. Minn., St. Paul, Minn. 63 p.

"The investigation was approached from two aspects: (1) the effect of defoliation damage by the forest tent caterpillar on aspen stands, and (2) an evaluation of coccooning habits which might affect sampling methods for cocoon parasitism by *Sarcophaga aldrichi*." Some crown dieback, but no tree mortality could be attributed to defoliation by *Malacosoma disstria.* Defoliation did not appreciably affect tree height, but radial growth was reduced in areas that had been severely defoliated. Trees in areas that had been severely defoliated had not completely recover by the following year, and had reduced radial growth. The location of *M. disstria* cocoons, either on brush, on understory vegetation, or in tree crowns did not affect the rate of parasitism by *S. aldrichi.* Cocoons that were protected (i.e., in tightly rolled leaves or surrounded by other cocoons) were less likely to be parasitized than exposed cocoons. The reliability of a common cocoon collecting method was tested.

Biology - 2; Outbreaks - 3,4c

22. Batzer, H.O. 1955b. **Effects of defoliation by the forest tent caterpillar**. Pages 27–28 *in* R.T. Everley (ed.). Proc. 10th Ann. Meet., North Cent. Branch, Entomol. Soc. Am.

In 1953 a project was initiated to determine the effects of one or more years of defoliation by the forests tent caterpillar on aspen stands. A direct relationship between time since defoliation and percent of trees with die-back was observed. Radial growth of attacked trees was reduced after one or two years of severe defoliation. No appreciable tree mortality was observed in the defoliated stands. However, there was a substantial amount of die-back observed in severely defoliated stands, with up to 25% mortality of the twigs in the crown. Larval feeding preference among hosts was observed.

Outbreaks - 3

23. Batzer, H.O.; Hodson, A.C.; Schneider, A.E. 1954. **Preliminary results of an inquiry into effects of defoliation of aspen trees by the forest tent caterpillar [*Malacosoma disstria*].** Minn. For. Notes No. 31. 2 p.

No tree was found whose death could be attributed solely to defoliation. In general the extent of crown dieback was directly related to vigor class, but appeared to be unaffected by stand age, density or site.

Outbreaks - 3

24. Batzer, H.O.; Martin, M.P.; Mattson, W.J.; Miller, W.E. 1995. **The forest tent caterpillar in aspen stands: distribution and density estimation of four life stages in four vegetation strata.** For. Sci. 41(1): 99-121.

"The forest tent caterpillar (*Malacosoma disstria* Hbn.) exemplifies the mobile defoliator that expands in vertical distribution during development from tree canopy to ground. For such insects the problem of estimating absolute numbers of each life stage is complex and has seldom been addressed. We investigated the distribution of eggs, small larvae, large larvae, and cocoons (pupae) in overstory-tree, high-shrub, low-shrub, and ground strata in stands of quaking aspen (*Populus tremuloides* Michx.) in which defoliation ranged from virtually none to complete. The study took place in 11 stands in northern Minnesota during 5 years and in stands in Upper Michigan during 1 year. Trees were divided for insect counting into vertical crown-thirds, horizontal crown-halves,

branches, branch parts, and bole. Insects were also counted on entire high shrubs, and in several sizes of low-shrub and ground plots. Eggs and small larvae occurred in the tree stratum regardless of population density. Vertical and horizontal distribution in overstory trees shifted through successive life stages and with different population densities. Density and defoliation intensity affected proportions of large larval and cocoon populations occurring in the three lower strata. Cocoons were maximally dispersed, with up to 97% occurring in high-shrub, low-shrub, and ground strata. Egg-mass numbers were satisfactorily estimated in trees from a sample of branches and tree DBH. Abundance of all life stages on trees was related to a power of tree DBH which at moderate to high population densities averaged 2.72 for egg masses, 4.23 for small larvae, 2.99 for large larvae, and, when defoliation did not exceed 60%, 2.33 for cocoons. These relations form the core of models devised for indirectly estimating absolute density of insects in the tree stratum from DBH and stand tables. At moderate to high densities, absolute density estimation in the four combined strata produced overall standard errors whose mid-range percentages of estimates were 31 for eggs, 56 for small larvae, 40 for large larvae, and 38 for cocoons. Forest tent caterpillar distribution in aspen stands appears determined to a high degree by stand foliar area."

Outbreaks - 4abcd, 6

25. Batzer, H.O.; Morris, R.C. 1971. **Forest tent caterpillar [*Malacosoma disstria*].** U.S. Dept. Agric. For. Serv., For. Pest Leafl. No. 9. Revised 1978. 8 p.

An excellent review of many aspects of the forest tent caterpillar, *Malacosoma disstria*, including distribution, general background, host relationships, damage, life history and habits, weather, parasites, and natural and artificial control.

General Background

26. Bauce, E.; Allen, D.C. 1991. **Etiology of a sugar maple decline.** Can. J. For. Res. 21(5): 686-693.

The effect of climatic and insect defoliation on the growth of sugar maple (*Acer saccharum*) in different stages of decline in an 85-year-old stand was assessed in New York State in 1987–88. Dendrochronological studies indicated that from the early stages of stand development, sugar maples currently declining showed slower growth than healthy trees. Defoliation by insects had occurred in 1953–54 by forest tent caterpillar (*Malacosoma disstria*) and in 1967–68 by saddled prominent (*Heterocampa guttivitta*), but trees had apparently recovered from the earlier infestation before decline was noted. A steady growth decline of all dominant trees during the last 30 years was significantly correlated with adverse climatic conditions. High levels of stand density (competition) appeared to predispose sugar maples to adverse effects of climatic stresses (winters with periodic thaws and sparse snow cover, summer drought, low autumn soil water recharge). Data from soil and foliar analyses are also presented. Overall, it is concluded that, at least in some cases, sugar maple decline may be part of a natural stand density regulatory process and it may be prevented by silvicultural intervention.

Outbreaks - 3

27. Beams, H.W.; Anderson, E. 1957. **Light and electron microscopy studies on the striated border of the intestinal epithelial cells of insects.** J. Morph. 100(3): 601-619.

Light microscope preparations of the middle intestine of *Malacosoma* spp. reveal several structures in the striated border of the epithelial cells. Electron micrographs show that the gut epithelium is composed of a multitude of microvilli. It is believed that folding and twisting of the microvilli give the gut its striated appearance under the light microscope.

Biology - 8

28. Benoit, P. 1978. **Principaux insectes forestiers au Quebec en 1977.** [**Principal forest insect pests in Quebec in 1977.]** Phytoprotection 59(2): 108-116.

["Light and moderate defoliation of trembling aspen took place in 1977 at Temiscaming and around Ville-Marie in the west of the Province. Severe to extreme infestations near Notre-Dame-de-la-Doré and from Sainte-Jean d'Arc to Lac Saint Jean persisted in intensity, causing 90 and 100% defoliation and covering 36 km^2 and 10 km^2, respectively; meanwhile estimates from egg-mass counts from branches were 50% of those in 1976, which would normally indicate lower larval populations in 1978.

Forest tent caterpillar was present at low levels in all southern regions, except at Saint-Judes (Saint Hyacinthe) where 130 ha of trembling aspen was 60% defoliated, at Deauville (Sherbrooke) where 3 ha of this tree species were equally defoliated, and at Franklin Centre (Huntingdon), where an area of plantation and naturally regenerated maple forming two mixed woodlots of approximately 60 ha each, had individual trees that were defoliated from nearly 100 down to 30%, respectively. It appears, after egg-mass counts from branches, that attacks by forest tent caterpillar will intensify in the latter area in 1978, but it will be necessary to verify the identity of the defoliator because forest tent caterpillar and gypsy moth co-exist at the same time in the spring and the damage they cause is similar, However, control measures differ somewhat."]

(Entire reference pertaining to *M. disstria* included in annotation. Translated from original French.)

Outbreaks - 1,3

29. Benoit, P.; Martineau, R. 1975. **Principaux insectes forestiers au Québec en 1974. [Principal forest insects in Quebec in 1974].** Ann. Soc. Entomol. Que. 20(2): 55-60.

["The last outbreak of forest tent caterpillar, *M. disstria*, in Quebec, started at the beginning of the 1960s and populations of these insects have for some years been rising in Ontario. For these two reasons, we believe that it will not be long before we undergo the damage of a new invasion. In fact, this year we observed moderate to severe defoliation of many square miles in the counties of Abitibi, Temiscaming, and Pontiac. In other respects, it is interesting to learn that the moderate infestation observed near Mont-Laurier in 1973 has almost completely collapsed in 1974. We found only traces of these insects elsewhere in the province."]

(Entire reference pertaining to *M. disstria* included in annotation. Translated from original French.)

Outbreaks - 1

30. Benoit, P.; Martineau, R. 1976. **Principaux insectes forestiers au Québec en 1975. [Principal forest insects in Quebec in 1975].** Ann. Soc. Entomol. Que. 21(2): 81-86.

["Annual collections of forest tent caterpillar indicate more and more the imminence of a real outbreak. The most important focal point is the one which extends from Lake Abitibi to Val d'Or where the insect has caused severe damage since 1973. Two other small centres, near Lac Saint-Jean, one west and the other north, cover 26 km^2 and 5 km^2, respectively."]

(Entire reference pertaining to *M. disstria* included in annotation. Translated from original French.)

Outbreaks - 1

31. Bergeron, Y.; Charron, D. 1994. **Postfire stand dynamics in a southern boreal forest (Quebec): a dendroecological approach.** Ecoscience 1(2): 173-184.

Arboreal succession of a mid-successional southern boreal forest, which originated after a fire 75 years ago, was studied. The pre-fire forest of *Thuja occidentalis* L. and *Abies balsamea* (L.) Mill. was replaced by the current forest composed of *Populus tremuloides* Michx. and *Betula papyrifera* Marsh. Defoliation by *Malacosoma disstria* caused decreased hardwood growth during the 1950s, while softwood growth was retarded by outbreaks of *Choristoneura fumiferana* around 1940 and from 1972 to 1987. The differences in the size of the various tree species were related to their different growth rates, rather than successive species invasion. Episodic defoliation by insects (*M. disstria* and *C. fumiferana*) were found to influence stand development.

Host Relationships - 1

32. Bergold, G.H. 1951. **Notes on a polyhedral disease of forest tent caterpillar, *Malacosoma disstria*.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 7(4): 1-2.

A total of 104,900 forest tent caterpillar (*Malacosoma disstria*) larvae were collected from the field and reared in 2x4 foot wooden trays (about 3,600 larvae per tray). Of these, 97,021 larvae were artificially infected with polyhedrosis virus sprayed onto foliage that the larvae consumed. Approximately 93.5% of these died of virus infection (80% of these contained polyhedral bodies when examined under the microscope), most of these after 11 days. Of the 7,969 control larvae in the trays, 71% died of a bacterial disease induced by the crowded rearing conditions; generally they died at 15 days. One hundred control larvae were reared in more favorable rearing conditions; of these, 6% died of virus, 16% from bacterial disease, and 78% developed to adults. Infection experiments were also carried out using foliage sprayed with different concentrations of virus. The higher concentrations only increased mortality rates by a slight amount, indicating a high resistance of that particular forest tent caterpillar population to that polyhedrosis virus. Finally, the author developed a process for liberating virus particles from polyhedral bodies using 0.03 M Na_2CO_3 per 5 mg of polyhedral bodies per mL. Mature virus particles were described as rod-shaped and 310x50 microns. Injection of these particles resulted in an LD_{50} of $1x10^{-10}$ mg of virus particles per larva.

Biology - 3

33. Bergold, G.H.; McGugan, B.M. 1951. **Virus diseases of forest tent caterpillar** . Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 7(1): 2-3.

A polyhedral virus disease was found in caterpillars of *Malacosoma disstria* at a number of widely scattered points in Ontario.

Biology - 3

34. Bernier, R.L., Jr.; Gannon, D.J.; Moser, G.P.; Mazzarello, M.; Griffiths, M.M.; Guest, P.J. 1990. **Development of a novel Bt strain for the control of forestry pests.** Pages 245-251 *in* Brighton Crop Protection Conf., Pests and Diseases - 1990. Vol. 1. British Crop Protection Council. Thornton Heath, U.K.

BIODART is a new water-based *Bacillus thuringiensis*-related bioinsecticide developed for the control of *Choristoneura fumiferana* var. *clemens* [(unnamed) variety of *C. fumiferana* Clemens], *Lymantria dispar,* and *Malacosoma disstria* in forestry. The product contains a novel and indigenous Canadian *B. thuringiensis* strain (A20) selected for its higher intrinsic potency and broad spectrum of activity when compared with HD-1 and NRD-12. Trials conducted in three Canadian provinces in the summer of 1988 and 1989 demonstrated the effectiveness of the product in controlling larval populations of *C. fumiferana* and *L. dispar* and in significantly reducing defoliation. The A20 strain also shows good broad spectrum activity against a range of important agricultural pests and its potential for use in agricultural outlets is discussed.

Control - 3

35. Bess, H.A. 1936. **The biology of *Leschenaultia exul* Townsend, a tachinid parasite of *Malacosoma americana* Fabricus and *Malacosoma disstria* Hubner.** Ann. Entomol. Soc. Am. 29(4): 593-613.

Laboratory rearings of *Leschenaultia exul* from *Malacosoma americana* in 1933, 1934, and 1935 were conducted to observe the biology of this species.

Biology - 2

36. Bieman, D.N.; Witter, J.A. 1983. **Mating behavior of *Malacosoma disstria* at two levels of mate competition.** Fla. Entomol. 66(2): 272-279.

"During a 3 year field study two levels of mate competition were observed in *M. disstria* Hubner, the forest tent caterpillar. Levels were indicated by the mean number per year of male attempts to mate females which were already in copula (interference rate). Sex ratio at emergence and population density probably determined interference rates. In the low level of mate competition, matings started late in the day and were short in duration, with some males terminating matings. At the high level, matings began earlier and ended later, with some females rejecting males and some males prolonging matings. The greater mate competition reflected a higher operational sex ratio, which probably increased the likelihood of some males finding females earlier and enhanced opportunities for females to be selective. The chance of sperm competition would be greater and prolonged matings were likely responses to this. Male-terminated matings probably were responses to low chance of sperm competition."

Biology - 1

37. Biggs, W.D.; Jansons, V. 1984. **Results of forest insect and disease surveys in the North Central Region of Ontario, 1983.** For. Can., Gt. Lakes For. Cent., Misc. Rep. No. 2. pp. 5-6.

The major insect pests dealt with in this report on forest pests, diseases and abiotic damage in Ontario are *Bucculatrix canadensisella, Choristoneura fumiferana, C. pinus, Eucosma gloriola, Fenusa pusilla, Malacosoma disstria, Monochamus scutellatus, Neodiprion abietis, N. nanulus, Phyllonorycter ontario, Pikonema alaskensis, Pissodes strobi, Pristiphora erichsonii,* and *P. geniculata.* Damage to white spruce [*Picea glauca*] by a species of *Formica* near *Formica exsectoides* is described, and notes are provided on about 20 other insect pests. Special surveys on black spruce [*Picea mariana*] (including seed and cone pests) and jack pine [*Pinus banksiana*] are also described.

Outbreaks - 1,3

38. Bird, F.T. 1969. **Infection and mortality of spruce budworm, *Choristoneura fumiferana*, and forest tent caterpillar, *Malacosoma disstria*, caused by nuclear and cytoplasmic polyhedrosis viruses.** Can. Entomol. 101(12): 1269-85.

"Cytoplasmic polyhedrosis viruses are, in general, more infectious to *Choristoneura fumiferana* and *Malacosoma disstria* than the nuclear polyhedrosis viruses which affect these insects. The cytoplasmic polyhedrosis viruses interfere with and retard development of the nuclear polyhedrosis viruses. Larvae of both insects, as they grow older, develop resistance to both. Resistance develops more rapidly and to a greater degree against nuclear polyhedrosis than against cytoplasmic polyhedrosis viruses. The nuclear polyhedrosis viruses are more lethal than cytoplasmic polyhedrosis viruses, and all larvae infected with nuclear polyhedrosis viruses die except those infected so late in larval development that they are able to pupate. Most young larvae infected with the cytoplasmic polyhedrosis virus die or are seriously affected, but infection has progressively less effect as the larvae mature."

Biology - 3; Control - 4

39. Bird, F.T. 1971. ***Malacosoma disstria* Hübner, forest tent caterpillar (Lepidoptera: Lasiocampidae).** Pages 144-147 *in* R.M. Prentice, and P.S. Corbet (comp.) Biological control programmes in Canada, 1959-1968. Tech. Communi. No. 4, Commonwealth Inst. Biological Control. Trinidad.

This article identifies species of bacteria and fungi, a microsporidian disease, and cytoplasmic and nuclear polyhedrosis viruses as potentially useful biological control agents. Reviews of field trials using virus for control of *Malacosoma disstria* are given. Mortality caused at different life stages is reported.

Biology - 3

40. Blais, J.R.; Prentice, R.M.; Sippell, W.L.; Wallace, D.R. 1955**. Effects of weather on the forest tent caterpillar, *Malacosoma disstria* Hbn., in Central Canada in the spring of 1953.** Can. Entomol. 87(1): 1-8.

"Populations of the forest tent caterpillar that had reached epidemic proportions throughout an area of approximately 43,000 square miles in central Canada were drastically reduced over most of the area due to unusual weather conditions in the spring of 1953. Unseasonably high temperatures in early May caused the eggs to hatch and the trembling aspen foliage to open. The warm spell was followed by several days of freezing temperatures and snow, and by several weeks of cool, wet weather. In northern Ontario, many of the young larvae succumbed at the time of freezing temperatures, while many more died of starvation, since most of the trembling aspen foliage was destroyed by the frost. Farther west, in Manitoba, fewer larvae were killed directly by the freezing temperatures, and the aspen foliage was not destroyed to the same degree. In this area, high larval mortality resulted from the prolonged cold and wet weather that followed hatching; only between 5 and 10% of the larvae were still alive one month after hatching. The parasite, *Sarcophaga aldrichi* Parker, which had been increasing in numbers during the previous few years in this region, was not affected by the unusual weather, and large numbers of this parasite caused further reduction of the residual tent caterpillar population."

(Annotation contains summary of reference.)

Biology - 2,4; Outbreaks - 1,3

41. Blais, R. 1995. **Colorant et filtre excitateur pour l'amélioration de la lecture de cernes annuels de croissance de certains feuillus [Use of a dye and an exciter filter for improved identification of annual rings of some broadleaves.]** For. Chron. 71(2): 211-212.

The use of a dye (uranin) in conjunction with an exciter filter is compared with the use of only a low-power microscope. The results show that with the dye-based method, a larger number of rings can be detected in many cases, and, based on the larger number of rings, the observed reductions in growth can be linked with defoliation periods more effectively. The method was developed during a study of the effect of *Malacosoma disstria* infestations on radial growth of *Populus tremuloides* and *Betula populifolia* trees in Quebec.

Host Relationships - 1,2; Outbreaks - 3

42. Blomme, C.G. 1991. **Ring-billed gulls, *Larus delawarensis*, feeding in flight on forest tent caterpillar, *Malacosoma disstria*, cocoons.** Can. Field-Nat. 105(2): 280-281.

"Twelve ring-billed gulls were observed feeding in flight on pupae of forest tent caterpillar on a Carolina poplar [*Populus canadensis*]. This opportunistic behaviour allowed the gulls to take cocoons in areas where they could not normally perch for feeding."

Biology - 2

43. Bowers, R.C.; Begon, M.; Hodgkinson, D.E. 1993. **Host-pathogen population cycles in forest insects? Lessons from simple models reconsidered.** Oikos 67(3): 529-538.

"A host-pathogen model with free-living infective stages and host self-regulation has been investigated with a view to clarifying the possible role of pathogens in the cyclic dynamics of forest insect pests generally, and of a granulosis virus in the dynamics of the larch budmoth in particular. Contrary to previous related analyses, lacking self-regulation, no support is provided for the view

that host-pathogen interactions alone are capable of generating cyclic dynamics of the type observed in forest Lepidoptera. Overall, cycles are less likely here than in the absence of simple self-regulation, and parameters from field estimates usually fail to generate cycles. Even where cycles are generated, and the cycle period corresponds with field data, disease prevalence tends to peak at too high a value, and host density peaks at a very much lower value than field data suggest. Notwithstanding, the model emphasises that host-pathogen interactions may still be important in generating observed cycles, even though they are not solely responsible for them."

Biology - 3; Outbreaks - 5

44. Brandt, J.P.; Amirault, P. 1994. **Forest insect- and disease-caused depletions to forests of West-Central Canada: 1982-87.** Nat. Resour. Can., Can. For. Serv., North. For. Res. Cent., Inf. Rep. NOR-X-333. 28 p.

"Major forest insect- and disease-caused depletions to the forest resources of Alberta, Saskatchewan, Manitoba and the Northwest Territories were determined as 3 765 000 m^3/year between 1982 and 1987. A set of depletion rules were constructed for the major forest pests of the prairie provinces and were used to create depletion estimates. Significant depletions were caused by spruce budworm (*Choristoneura fumiferana* [Clem.]), jack pine budworm (*C. pinus pinus* Free.), forest tent caterpillar (*Malacosoma disstria* Hbn.), mountain pine beetle (*Dendroctonus ponderosae* Hopk.), spruce beetle *(D. rufipennis* [Kby.]), and wood decay. Depletion estimates were not determined for dwarf mistletoe, pests of young stands, and fungi such as needle casts of conifers, stem rusts of conifers, and cankers of conifers and hardwoods. The impact of Dutch Elm disease on commercial forests was negligible. Spruce budworm defoliation resulted in 1900 m^3/year of volume loss due to growth reduction and 9900 m^3/year due to mortality. Jack pine budworm caused volume losses of 80 600 m^3/year in growth reduction and 425 700 m^3/year in mortality. Forest tent caterpillar defoliation caused 1 801 400 m^3/year in growth reduction; with the depletion estimates used, there was no mortality associated with forest tent caterpillar. Volume depletions for mountain pine beetle and spruce beetle were 64 400m^3/year and 7900 m^3/year, respectively. Wood decay volume loss was 1 373 200 m^3/year."

Outbreaks - 1,3

45. Brinkman, K.A.; Roe, E.I. 1975. **Quaking aspen: silvics and management in the Lake States.** U.S. Dep. Agric. Handb. 486. pp. 16, 17, 36, 44.

This Agricultural Handbook provides some general background information on forest tent caterpillar outbreak cycles, the damage they cause, and the impacts these outbreaks have on quaking aspen.

General Background

46. Broome, J.R.; Sikorowski, P.P.; Neel, W.W. 1974. **Effect of sunlight on the activity of nuclear polyhedrosis virus from *Malacosoma disstria.*** J. Econ. Entomol. 67(1): 135-136.

Outdoor tests in Mississippi in October 1971 indicated that exposure to sunlight for 10 hours caused total loss of activity of aqueous suspensions of the nuclear polyhedrosis virus of *Malacosoma disstria* Hbn. when applied to the upper surface of the leaves of sweet gum (*Liquidambar styraciflua*). The

lack of persistence of this virus in direct sunlight is of concern because *M. disstria* larvae are serious defoliators of sweet gum, water tupelo gum [*Nyssa uniflora*] and black gum [*N. multiflora*] in the south-eastern United States.

Control - 4

47. Brown, A.W.A. 1938a. **Forest tent caterpillar in Ontario in 1931-1938.** Annu. Rep. Entomol. Soc. Ont. [later Proc. Entomol. Soc. Ont.] 69(0): 37-42.

An account is given of an outbreak of *Malacosoma disstria* Hbn. that occurred in Ontario from 1931 to 1938. It was concluded that, in this region, new infestations develop more or less simultaneously in widely separated areas and that the outbreak moves steadily east-southeast in successive years, becoming less severe at the original centre. Peak infestations last for 3 years and are followed by sharp declines. During this time increasing control is exerted by *Sarcophaga aldrichi* Parker, a muscardine fungus and wilt disease, while food shortage and late spring frosts also contribute to the collapse of the outbreak. Outbreaks are most likely to occur in extensive continuous areas of second-growth poplar and birch about 30-40 years old.

Biology - 2,3,4; Outbreaks - 1

48. Brown, A.W.A. 1938b. **The forest insect survey for 1938.** Annu. Rep. Entomol. Soc. Ont. [later Proc. Entomol. Soc. Ont.] 69(0): 45-52.

This article summarizes information gathered from the 5117 collections made by Forest Insect and Disease Survey personnel during 1938, covering the entirety of Canada. Information gathered during the summer of 1938 indicated that infestations were on the wane in Ontario, as described in Brown 1938a (abstract 47). The beetle *Carabus taedatus* is reported to be a controlling factor in an infestation along the Saskatchewan River near Nipawin. Other infestations in Manitoba include one extending from the Duck Mountains to The Pas, near Portage la Prairie, along the Red River and in the Pembina Valley.

Biology - 2; Outbreaks - 1

49. Brown, C.E. 1965. **Mass transport of forest tent caterpillar moths, *Malacosoma disstria* Hübner, by a cold front.** Can. Entomol. 97(10): 1073-5.

"On 12-13 July, 1964, forest tent caterpillar, *Malacosoma disstria* Hübner, adults were carried southward from an outbreak in the forested area of central Alberta for at least 300 miles by the turbulent air associated with a cold front. Details of the area of dispersal and the weather system responsible are given."

Biology - 4

50. Brown, C.E. 1966. **Habits and control of the forest tent caterpillar, *Malacosoma disstria* Hbn.** Dep. For., Ottawa, Ont. For. Serv. Misc. Publ. 79. 6 p.

This publication describes the life cycle of the forest tent caterpillar, the appearance of each stage of development from egg to adult, and natural control factors. Information on the safe handling and use of DDT and malathion to control this insect is also given.

Biology - 1,2,4; Control - 1,2

51. Brownwright, A.J.; MacDonald, J.A.; Sohi, S.S. 1992. **Electron microscopy of *Malacosoma disstria* (Lepidoptera: Lasiocampidae) nuclear polyhedrosis virus in hemocyte cultures.** Pages 884–885 *in* G.W. Bailey, J. Bentley, and J.A. Small (eds.). Proc. 50th Annu. Meet. Electron Microscopy Soc. Am., Boston, Mass. Aug. 16-21, 1992. San Francisco Press, San Francisco, Calif.

This paper presents a light microscope (LM) and transmission electron microscope (TEM) study of NPV in *Malacosoma disstria* IPRI-MD-66 cells.

Biology - 3,7

52. Bucher, G.E. 1957. **Disease of the larvae of tent caterpillars caused by a sporeforming bacterium**. Can. J. Microbiol. 3(5): 695-709.

"A newly discovered bacterial disease of larvae of *Malacosoma pluviale* (Dyar) (Lep.) is caused by infection of the gut with a large, motile, sporeforming bacterium, *Bacillus* sp., that increases in size before sporulation and bears the spore without bulging. It has not been cultivated. The bacterium invades the host with the food and multiplies in the midgut and foregut, producing changes in the pH and causing dysentery in the host. Sporulation occurs in the gut and both rods and spores are passed in the faeces and spread the disease. The infected larva loses its appetite, regurgitates excessively, produces wet faeces, decreases markedly in length, and dies in a characteristic, short, dry, mummified condition after about a week. Small ingested doses of spores initiate infection in laboratory populations of *M. pluviale* in all instars. *M. americana* (F.) also is susceptible to the disease but *M. disstria* Hbn. is resistant, only a few individuals dying from it."

Biology - 3

53. Burand, J.P.; Summers, M.D.; Smith, G.E. 1980. **Transfection with baculovirus DNA.** Virology 101(1): 286-290.

"Purified DNA from the nuclear polyhedrosis viruses of *Autographa californica* (Ac*M*NPV) and *Rachiplusia ou* (Ro*M*NPV) were found to be infectious in TN-368 cells employing the calcium phosphate precipitation technique (F.L. Graham and A.J. van der Eb, *Virology*, **52**, 456-467, 1973). Transfection with Ac*M*NPV produced 3600 PFU/μg DNA compared to 2900 PFU/μg DNA with RoMNPV. Of eight baculovirus DNAs tested, only Ac*M*NPV DNA and Ro*M*NPV DNA could transfect TN-368 cells. The *in vitro* host range of Ac*M*NPV DNA was determined to be the same as Ac*M*NPV extracellular virus. Ac*M*NPV Form I DNA was fourfold more infectious in TN-368 cells than Form II DNA."

Biology - 3

54. Butcher, J.W.; Hodson, A.C. 1953. **Field comparisons of endrin, dieldrin, DDT and toxaphene for control of the forest tent caterpillar.** Univ. Minn., School of Forestry, St. Paul, Minn. Minn. For. Notes No. 16. p. 2.

Excellent control of *Malacosoma disstria* was given by spraying with all the chemicals tested, at rates varying from 0.15 to 1.50 lb./acre. Of the insecticides tested, toxaphene was the slowest-acting but considered to be the safest to use around populated areas.

Control - 1,2

55. Byers, J.R. 1975. **Tyndall blue and surface white of tent caterpillars, *Malacosoma* spp.** J. Insect Physiol. 21(2): 401-415.

"Blues and surface whites of tent caterpillars are structural colours resulting from the scattering of light by small, transparent, cuticular filaments. The filaments are small enough to be Tyndall-active, that is they scatter the short wavelengths of incident light more effectively than the long wavelengths. Immediately beneath the surface filaments of blue-coloured cuticle there is a layer of dark pigment which absorbs transmitted light. Therefore, only Tyndall-scattered light is reflected from the cuticle and since this light is diminished in long wavelengths it appears blue. Cuticle that is surface white lacks the layer of dark pigment. Light passing through the surface layer is therefore subject to scattering within the cuticle and by underlying tissues. Sufficient complementary long wavelengths are backscattered from below the surface mat of filaments that the reflected light appears white. Tyndall blue systems found in other insects are briefly discussed."

Biology - 8

56. Caesar, L. 1916**. Insects of the season in Ontario.** Annu. Rep. Entomol. Soc. Ontario. [later Proc. Entomol. Soc. Ont.] 36(0): 29-32.

Provides a review of outbreaks and damage caused by major forest insect pests in the province of Ontario during 1915.

Outbreaks - 1

57. Cameron, M.J.W. 1967. **Suitability of pathogens for biological control.** Pages 182-196 *in* P.A. van der Laan (ed.). Insect Pathology and Microbial Control. Proc. Internat. Colloq. on Insect Pathology and Microbial Control, Wageningen, the Netherlands, Sept. 5–10, 1966. North Holland Publishing Co., Amsterdam, Netherlands.

This paper discusses in general terms the suitability of using viruses, bacteria, fungi and other pathogens for biological control of insects. It also mentions that *Entomophthora megasperma* Cohn. was observed infecting *Malacosoma disstria* larvae near Sault Ste. Marie, Ontario.

Biology - 3

58. Campbell, I.M. 1966. **Genetic variation related to survival in lepidopteran species.** Pages 129-135 *in* H.D. Gerhold, E.J. Schreiner, R.E. McDermott, and J.A. Winieski (eds.). Breeding Pest Resistant Trees. Proc. N.A.T.O. and N.S.F. Advanced Study Inst. on Genetic Improvement for Disease and Insect Resistance of Forest Trees, Pennsylvania, 1964. Pergamon Press, Oxford, U.K.

Malacosoma disstria was selected to illustrate the genetic hypothesis that a large variation within several physiological characters (duration of pre-hatching diapause, fecundity, female pupal weight, egg weight, larval feeding period, and food demand) determined by the same two X- chromosomal variants and operating to cause non-random breeding is fundamental to the numerical fluctuations characterizing populations of many lepidopteran species. Developmental differences, weight of adults, and relative times of adult eclosion, observed in *M. disstria* populations near Sudbury, Ontario, were in complete accordance with the genetic hypothesis. Field observations also revealed different types of migratory activity in adults of different genotypes. *M. disstria* adults with the large body size phenotype were found to be the migratory type and small sized adults were found to be the sedentary type. This genetic variation within lepidopteran species allows host tree resistance to be a matter of temporally selecting genotypes by timing of foliation. The success of parasitic species is also dependent on developmental synchronization and as a result it is expected that no single parasite species can equally attack all physiological types of a host.

Biology - 1

59. Carruthers, R.I.; Soper, R.S. 1987. **Fungal diseases.** Pages 357-416 *in* J.R. Fuxa and Y. Tanada (eds.). Epizootiology of insect diseases. John Wiley and Sons, New York, N.Y.

This chapter summarizes the status of the field of fungal epizootiology and the techniques currently employed in this area of research. This is followed by summaries of several specific host/pathogen life systems which are chosen because of their relevance as models illustrating the current level of understanding of fungal disease epizootics and their place within their associated ecosystems. (*Erynia crostosa* mycosis of the forest tent caterpillar is discussed.) Last, by way of examples, the direction of research essential in furthering the understanding of host pathogen dynamics is presented.

Biology - 3

60. Cerezke, H.F.; Emond, F.J. 1989. **Forest insect and disease conditions in Alberta, Saskatchewan, Manitoba, and the Northwest Territories in 1987.** For. Can., North. For. Cent., Inf. Rep. NOR-X-300. pp. 7-10.

Forest pest conditions during 1987 are summarized and some predictions of infestation status are given for 1988. Major pests discussed, in order of importance, are *Choristoneura fumiferana, C. pinus pinus*, aspen defoliators (*Malacosoma disstria, C. conflictana*), dwarf mistletoes (*Arceuthobium americanum, A. pusillum*), *Ceratocystis ulmi, Armillaria ostoyae, Dendroctonus ponderosae* and *D. rufipennis*, and *Pristiphora erichsonii*. Other damaging agents are reported in a table. Results are given of surveys of acid rain symptoms, pests and damage in nurseries and plantations, and climatic injury.

Outbreaks - 1,3

61. Cerezke, H.F.; Moody, B.H. 1987. **Forest insect and disease conditions in Alberta, Saskatchewan, Manitoba and the Northwest Territories in 1986, and prediction for 1987.** Can. For. Serv., North. For. Res. Cent., Edmonton, Alta. Unpublished Rep. pp. 15-17.

The report summarizes forest insect and disease conditions in 1986 and provides predictions of infestation levels for 1987.

Outbreaks - 1,3

62. Chapman, J.W.; Glaser, R.W. 1915. **A preliminary list of insects which have wilt, with a comparative study of their polyhedra.** J. Econ. Entomol. 8(1): 140-149.

This article presents a list of species which have wilt and the distribution of wilt within the range of the host species. A striking similarity in shape between the polyhedra of different species was found, however the polyhedra in the different species varied greatly in size.

Biology - 3

63. Chisholm, M.D.; Palaniswamy, P.; Underhill, E.W. 1982. **Orientation disruption of male forest tent caterpillar, *Malacosoma disstria* (Hübner) (Lepidoptera: Lasiocampidae), by air permeation with sex pheromone components.** Environ. Entomol. 11(6): 1248-1250.

"Disruption of *Malacosoma disstria* (Hübner) male moth orientation to female-baited traps by chemical permeation of the air in small field plots has been demonstrated: (5Z,7E)-5,7-dodecadienal, (5Z,7Z)-5,7-dodecadienal and (Z)-7-dodecenal individually were effective. (5E,7E)-5,7-dodecadienal did not disrupt. An isomeric mixture of 5,7-dodecadienals, such as might be the crude product of Wittig-type synthesis, also disrupted [orientation] effectively."

Biology - 5

64. Chisholm, M.D.; Palaniswamy, P.; Underhill, E.W.; Steck, W.F. 1986. **Forest tent caterpillar control**. Can. Patent No. 1212697. 17 p.

The authors found and synthesized compounds that can be used both as confusants and as attractants of male *Malacosoma disstria* moths. A method has also been devised to permeate the air in the flight path of the male moths with vapors of at least one of the compounds (5Z,7E-dodecadienal, 5Z,7Z-dodecadienal, and 7Z-dodecenal) in amounts sufficient to disrupt and confuse the males in their efforts to locate female moths, thereby reducing mating frequency. The preferred confusant is 5Z,7E-dodecadienal alone or in combination with any or all of its isomers. 7Z-Dodecenal has some confusant activity and may be used alone or in conjunction with 5Z,7E-dodecadienal and 5Z,7Z-dodecadienal.

Biology - 5

65. Chisholm, M.D.; Steck, W.F.; Bailey, B.K.; Underhill, E.W. 1981. **Synthesis of sex pheromone components of the forest tent caterpillar, *Malacosoma disstria* (Hübner) and of the western tent caterpillar, *Malacosoma californicum* (Packard).** J. Chem. Ecol. 7(1): 159-164.

"All four geometrical isomers of 5,7-dodecadien-1-ol have been stereoselectively synthesised by using Wittig condensation reactions. (5Z,7E)-5,7-Dodecadien-1-ol and its corresponding aldehyde are components of the sex pheromone of *Malacosoma disstria* Hbn., and (5E,7Z)-5,7-dodecadienal is a component of the pheromone of the western tent caterpillar [*M. californicum* (Pack.)]. These compounds have been successfully tested in the field."

Biology - 5

66. Chisholm, M.D.; Underhill, E.W.; Steck, W.; Slessor, K.N.; Grant, G.G. 1980**. (Z)-5, (E)-7-dodecadienal and (Z)-5, (E)-7-dodecadien-1-ol, sex pheromone components of the forest tent caterpillar, *Malacosoma disstria*.** Environ. Entomol. 9(3): 278-282.

"By capillary gas chromatography, mass spectrometry, electroanntenogram measurements, and male behavioral response tests, (Z)-5, (E)-7-dodecadienal was identified as the principal component of the sex pheromone of the forest tent caterpillar, *Malacosoma disstria* (Hübner). (Z)-5, (E)-7-Dodecadien-1-ol was indicated as a secondary component. In field trapping males were attracted to lures containing each component separately but best trapping occurred with aldehyde: alcohol ratios between 1:10 and 1:3. n-Dodecanal was also found in female tip extracts."

Biology - 5

67. Churchill, G.B.; Duncan, D.P.; John, H.H.; Hodson, A.C. 1964a. **Long range effect on aspen of defoliation by the forest tent caterpillar.** Minn. For. Note No. 147. 2 p.

The objectives of this study were to determine the effects of defoliation by *Malacosoma disstria* on aspen (*Populus tremuloides*) in plots by a study conducted from 1953 to 1955. Recovery of growth after defoliation ceases was found to take one growing season at most of the locations where severe defoliation took place. No effects on basal area growth were observed two years after cessation of defoliation. Dominant trees in the stands experienced increased growth three years after defoliation, possibly as a result of higher mortality of other trees in those stands.

Outbreaks - 3

68. Churchill, G.B.; John, H.H.; Duncan, D.P.; Hodson, A.C. 1964b. **Long-term effects of defoliation of aspen by the forest tent caterpillar.** Ecology 45(3): 630-633.

"A second study of the effects on aspen of defoliation by the forest tent caterpillar in Minnesota was conducted six years after the conclusion of an initial comprehensive investigation. Results indicate increasing mortality in other than suppressed trees with increasing intensity. *Hypoxylon*, *Nectria* and insect incidence increased with defoliation intensity. Growth is significantly reduced one year

beyond the cessation of defoliation in stands where three successive heavy defoliations have occurred. Growth of the dominants increases significantly, however, the third year after defoliation in such stands."

Outbreaks - 3

69. Ciesla, W.M.; Drake, L.E.; Wilmore, D.H. 1971. **Color photos, aerial sprays and the forest tent caterpillar.** Photogrammetric Engineering 37(8): 867-873.

"Colour and false-colour aerial photos, taken at scales of 1:6000 and 1:15,000, were used to measure the amount of foliage saved by the aerial application of experimental chemicals to suppress infestations of the forest tent caterpillar, *Malacosoma disstria* Hbn., a hardwood defoliator, in SW Alabama. Plots protected by aerial sprays were readily discerned on both types of film but Ektachrome infra-red Aero film provided greater contrast between susceptible and unsusceptible host types and greater contrast between classes of defoliation. The 1:15,000 photo scale was somewhat superior because it permitted interpretation of a larger land area with a minimal loss of detail. This permitted measurement of the impact of spray drift upon adjacent plots. Microdensitometer scans of three adjacent plots on false-colour film receiving similar degrees of damage revealed significant differences in optical density of the cyan layer; however, these differences could not be directly attributed to the amount of foliage saved."

Outbreaks - 2a; Control - 2

70. Clark, E.C. 1958. **Ecology of the polyhedroses of the tent caterpillars.** Ecology 39(1): 132-139.

This article explores the transmission of tent caterpillar polyhedrosis in *Malacosoma* spp. It also provides a brief description of other components of the disease. Lepidopteran polyhedroses often occur after population levels have been at a high density for a number of years. There is little information available on polyhedroses when they occur during early years preceding high population levels or during endemic low population levels. The author reported tests "...which demonstrated the transmission of the virus by host plant contamination and in association with the egg in a natural epizootic of the disease… ." Egg masses were transferred from a virus-free area to a virus-infected area; some larvae showed polyhedrosis. The reverse transfer was performed and polyhedrosis was again found. No larvae in the control virus-free group showed evidence of polyhedrosis. The author also noted that the virus, which is occluded within the polyhedra, can persist in the environment for years before being ingested and becoming active. The insect ingests the virus while consuming contaminated host plant foliage. The virus may be distributed by agents such as wind and movements of host larvae and other arthropods. Density of host may also be an important factor.

Biology - 3

71. Collman, S.J. 1987. **Biology and control of tent caterpillars**. Wash. State Coop. Exten. Serv., The Service, June 1987. Pullman, Wash. Exten. Bull. 1106. 3 p.

This is a general report on the two tent caterpillars in Washington State: the forest tent caterpillar (*Malacosoma disstria* Hübner) and the western tent caterpillar (*Malacosoma pluviale* Dyar). Included are details regarding damage to hosts, life history, natural enemies, and methods of control.

General Background; Biology - 1

72. Condrashoff, S.F. 1957**. A history of recent forest tent caterpillar infestations in the interior of British Columbia.** Proc. Entomol. Soc. B.C. 54(0): 21-23.

This paper provides general background on the forest tent caterpillar (*Malacosoma disstria*) in British Columbia, noting that the forest tent caterpillar was of interest for studies "...on population dynamics, natural control, and as a possible indicator species for predicting outbreaks of other forest insect species." In 1957, although *M. disstria* had often caused severe damage, complete tree mortality had not been recorded anywhere in British Columbia The article summarizes the history of infestations from 1923 through to 1957 and provides a visual timeline of them. These outbreaks demonstrate the extreme fluctuations undergone by typical *M. disstria* populations, with years of intensely high population levels followed by years of unnoticeable background population levels. Finally, the author speculates on causes of population collapse, noting that although such factors are difficult to determine, parasitism was a definite factor and disease a likely factor.

Outbreaks - 1,3

73. Conner, W.H.; Day, J.W., Jr. 1992. **Diameter growth of *Taxodium distichum* (L.) Rich. and *Nyssa aquatica* L. from 1979-1985 in four Louisiana swamp stands.** Am. Midl. Nat. 127(2): 290-299.

A multi-year study was conducted on four mixed stands of baldcypress (*Taxodium distichum*) and water tupelo (*Nyssa aquatica*) to examine the effects of various flooding regimes on diameter growth. Water tupelo was found to grow at a slower rate at all four locations, a factor attributed to annual defoliation by *Malacosoma disstria*.

Host Relationships - 3

74. Connola, D.P.; Waters, W.E.; Smith, W.E. 1957. **The development and application of a sequential sampling plan for forest tent caterpillar in New York.** N.Y. State Mus. Sci. Serv. Bull. No. 366. 22 p.

To efficiently predict the extent and degree of defoliation in the following year, the advantages, disadvantages, and practical use of different methods of egg mass sampling were compared. It was found that the use of a sequential sampling method would have significantly reduced the number of worker hours spent at sampling sites. Instructions on the use of the sequential sampling plan for forest tent caterpillar egg mass surveys are appended.

Outbreaks - 4a

75. Cook, D.; Stoltz, D.B.; Pauley, C. 1984**. Purification and preliminary characterization of insect spherulocytes.** Insect Biochem. 15(3): 419-426.

"Spherulocytes were purified from the haemolymph of two lepidopteran species, *Heliothis virescens* and *Malacosoma disstria*. Analysis by polyacrylamide gel electrophoresis revealed the presence of two to four major polypeptides of relatively low molecular weight in purified *M. disstria* cells and one or two in *H. virescens* spherulocytes. A sulphated glycosaminoglycan-like substance was extracted from the purified cells."

Biology - 1

76. Cumming, M.E.P. 1954. **Forest tent caterpillar egg surveys.** Dep. Agric. Can., Sci. Serv., Div. For. Biol., Bi-mon. Prog. Rep. 10(3): 3.

Egg surveys conducted in the Prairie Provinces during the fall of 1953 indicated reduced populations in Red River Valley, Manitoba and a light infestation in the Saskatoon area. In west-central Alberta, where parasitoids had reduced the population, only three egg masses were found.

Biology - 2; Outbreaks - 1

77. Daniel, C.J. 1990. **Climate and outbreaks of the forest tent caterpillar in Ontario.** M.Sc. thesis. Univ. B.C., Vancouver. 147 p.

“A review of the current understanding of forest tent caterpillar, (*Malacosoma disstria* Hbn.), population dynamics in Ontario suggests that two climatic factors, the temperature at the time of larval feeding and the minimum temperature through the winter, play important roles in determining outbreaks. Comparing the pattern of defoliation to similarly scaled temperature records over 41 years in Ontario shows no relationship between the year to year dynamics of outbreaks and either the temperature through the larval feeding period or the minimum overwintering temperature. A long-term analysis suggests that outbreaks are less severe in those regions with low overwintering temperatures and a patchy distribution of host. This latter finding, combined with an analysis of the synchrony and spread of defoliation, suggests that adult dispersal may play an important role in shaping the dynamics of outbreaks.”

Biology - 1,4; Outbreaks - 3,5

78. Daniel, C.J.; Myers, J.D.H. 1995. **Climate and outbreaks of the forest tent caterpillar.** Ecography 18(4): 353-362.

“Some have suggested that the periodic outbreaks of the forest tent caterpillar, *Malacosoma disstria*, are triggered by weather: the temperature at the time of early larval feeding, and overwintering temperatures. To assess the role of these factors, defoliation maps, compiled annually from flight surveys for the province of Ontario, were compared to similarily scaled temperature records. An analysis of the year to year variation shows no relationship between the pattern of increases or declines in defoliation and either temperatures during early larval development, or overwintering temperatures. Four periods of defoliation by forest tent caterpillars were observed in Ontario over 41 yr, but at individual sites extensive defoliation did not occur for each of the outbreak periods. Defoliation was less severe in regions with low overwintering temperatures, but was not related to the average number of degree days in the early spring. Outbreaks were most common in areas

where deciduous forests were extensive, and the mean overwintering temperatures were above -40 degrees C. While these weather variables do not apparently explain the details of population dynamics of forest tent caterpillars, extreme weather conditions might synchronize populations."

Outbreaks - 5

79. Davidson, A.G.; Prentice, R.M. 1967. **Insects and diseases.** Pages 116-144 *in* J.S. Maini and J.H. Cayford (eds.). Growth and utilization of poplars in Canada. Can. Dep. For. Rural Dev., Ottawa, Ont.

This paper reviews what was known in 1967 about some of the more important insect and disease problems from the standpoint of hosts, distribution, present or potential impact, life history, and control.

Biology - 1; Outbreaks - 3

80. de Barjac, H.; Bonnefoi, A. 1962. **A tentative classification on the basis of biochemistry and serology of 24 strains of *Bacillus thuringiensis* type.** Entomophaga 7(1): 5-31.

Twenty-four strains of *Bacillus thuringiensis* type, isolated from various insects, including *Malacosoma disstria* (*B. finitimus*), *Thaumetopoea pityocampa* (B. IP-BT 06.58), and *Dendrolimus sibiricus* (*B. dendrolimus*), were classified into six major biochemical groups which correspond to a classification by the flagellate agglutination reaction.

Biology - 3

81. deGryse, J.J. 1924. **The control of forest tent caterpillars in the Prairie Provinces.** Dep. Agric. Can., Entomol. Br., Circ. No. 19. 4 p.

This article describes life stages (illustrated), nature and extent of damage, and control measures.

Biology - 1; Outbreaks - 3; Control - 2,6

82. Dils, R.E.; Day, M.W. 1950. **Effect of defoliation [by *Malacosoma disstria*] upon the growth of aspen.** Mich. Agric. Exp. Sta., Q. Bull. 33(2): 111-113.

Measurements with the dial-gauge dendrometer on 4 defoliated, and 3 uninjured trees of *Populus tremuloides* of 5–7 inches dbh, indicated that 25% defoliation resulted in 38%, and total defoliation in 67% reduction in radial growth during the current vegetative period.

Outbreaks - 3

83. Ding, C.; Ma, M. 1992. **Identification of occluded insect viruses with immunogold-EM technique.** Sinozoologia 0(9): 43-47.

"Different types of occluded insect viruses were identified with polyclone antibody of *Lymantria dispar* NPV (LdNPV-AB) by using immunogold-EM technique. The experiments showed that the LdNPV-AB could react with several antigens including *Spodoptera exempta* NPV, *Operophtera brumata* NPC, *Malacosoma disstria* NPC, and *Choristoneura occidentalis* GV. No serological relation was revealed among LdNPV, *Euproctis chrysorrhoea* NPV, and *Choristoneura conflicatana* EPV. The reactions of antibody of *L. dispar* CPV with antigens of NPV, GV, EPV have not been detected. We concluded that the immunogold-EM technique is a convenient and reliable method for identification of insect virus."

(Article in Chinese with English abstract.)

Biology - 3

84. Donaghue, T.P.; Hayashi, Y. 1972. **Cytoplasmic polyhedrosis virus (CPV) of *Malacosoma disstria*: RNA polymerase activity in purified free virion.** Can. J. Microbiol. 18(2): 207-210.

"RNA polymerase activity is confirmed in virions of cytoplasmic polyhedrosis virus (CPV) of *M. disstria* obtained by the alkaline digestion of polyhedra as well as in virions isolated in a free form from the insect tissue."

Biology - 3

85. Drew, W.A.; Arnold, D.C. 1983. **The Lasiocampidae of Oklahoma, [USA] (Lepidoptera).** Proc. Okla. Acad. Sci. 63(0): 68-69.

"Keys and distribution data are presented for the 6 spp. [*Heteropacha rileyana, Malacosoma americanum, M. californicum lutescens, M. disstria, Phyllodesma americana,* and *Tolype velleda*] of Lasiocampidae (Lepidoptera) that occur in Oklahoma. "

General Background

86. Drouin, J.A.; Kusch, D.S. 1974. **Insecticide field trials on shade and shelterbelt trees in Alberta and Saskatchewan**. Can. For. Serv., North. For. Res. Cent., Info. Rep. NOR-X-81. 40 p.

"Efficacy trials were carried out on 20 insect species [including the defoliators *Malacosoma disstria* and *Pikonema* [*Pachynematus*] *alaskensis*, the borers *Saperda calcarata* and *Proteoteras willingana*, the leaf-miner *Lithocolletis* sp., and the Spruce needle-miner *Tanica albolineana*] with 30 different insecticides. Field trials were also conducted with a new ultra low volume sprayer unit and two specialized formulations on five insect species to obtain information on proper timing, type of equipment best suited, and the effects of the chemicals on target species and on birds, small mammals or other beneficial insects."

Control - 2

87. Duncan, D.P.; Hodson, A.C. 1958. **Influence of the forest tent caterpillar upon the aspen forests of Minnesota.** For. Sci. 4 (1): 71-83.

The objectives of this study were to determine the effect of defoliation by the forest tent caterpillar upon the management of aspen stands in northern Minnesota. In 1953, a research project was initiated to answer questions regarding several effects of forest tent caterpillar damage. The following subjects are discussed: the amount of aspen mortality and growth losses which may be attributable to the forest tent caterpillar, the recovery of growth following the cessation of defoliation, indirect losses due to secondary attacks by other insects and diseases, and the influence of defoliation upon the growth of conifers and brush species in the understory.

Outbreaks - 1,3

88. Duncan, D.P.; Hodson, A.C.; Schneider, A.E.; Batzer, H.; Froelich, R., Meyer, D.; Shiue, C.-J. 1956. **Influence of the forest tent caterpillar (*Malacosoma disstria* Hbn.) upon the aspen forests of Minnesota.** Office of Iron Range Resour. and Rehabilitation, St. Paul, Minn. 45 p.

A study was conducted from 1953 to 1955 to determine what impact outbreaks of *M. disstria* have on timber values. No increased mortality of aspen was observed. However, the understory balsam fir, *Abies balsamea,* did show increased radial growth during periods of defoliation. This increased volume in balsam fir was only one-third that of the volume of aspen growth lost due to defoliation.

Parts of this paper were later published in a scientific journal (see abstract 87).

Outbreaks - 1,3

89. Dyer, E.D.A. 1952. **Forest insect survey notes, British Columbia.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 8(5): 4.

"The forest tent caterpillar, *Malacosoma disstria* Hbn., was very abundant in several parts of the central and southeastern interior, completely defoliating large areas of aspen."

(Entire reference pertaining to *M. disstria* included in annotation.)

Outbreaks - 1,3

90. Ebling, P.M.; Kaupp, W.J. 1995. **Differentiation and comparative activity of six isolates of a nuclear polyhedrosis virus from the forest tent caterpillar, *Malacosoma disstria,* Hübner.** J. Invertebr. Pathol. 66(2): 198-200.

Six different isolates of NPV were collected from different forest tent caterpillar (*Malacosoma disstria*) populations in Ontario to test and compare their activities. This investigation was prompted by poor performance of a particular NPV spray made to control *M. disstria.* Each of the isolates was concentrated, amplified, and characterized with restriction enzymes. Each was then passed through laboratory-reared larvae three times to produce enough virus for testing purposes. The DNA was isolated from occlusion bodies and digested in order to obtain fragmentation profiles for each isolate. Next, a bioassay was performed using occlusion bodies from each isolate. The occlusion bodies were placed on the surface of artificial diet and five newly-molted third instar larvae placed

onto the diet. Dead larvae were examined for NPV infection under a microscope using oil immersion. Activity of the isolates was compared using t-tests. Isolate 7-21 was the most active, killing 40.1 ± 12.4% of all third instar larvae feeding on it. Isolate 6-8 was the least active, killing 11.1 ± 3.4%. There was a significant difference between the two. However, no one isolate was significantly more active than all the others. The authors speculated that the poor performance of the spray may have been due to the inadvertent use of a low-activity isolate and that in the future isolates for potential spray use should be tested for efficacy so that an isolate of high activity is selected.

Biology - 3; Control - 4

91. Ebling, P.M.; Kaupp, W.J. 1997. **Pathogenicity of a nuclear polyhedrosis virus to forest tent caterpillar, *Malacosoma disstria* (Hübner) (Lepidoptera: Lasiocampidae).** Can. Entomol. 129(1): 195-196.

The results of feeding bioassays to determine dose response of fourth instar *Malacosoma disstria* larvae to NPV isolate 7-21 (Ebling and Kaupp 1995, see abstract 90) are given. The number of occlusion bodies required to obtain LD_{10}, LD_{50}, and LD_{90} were calculated to be $5.1x10^2$, $2.0x10^4$, and $7.6x10^5$ occlusion bodies per larva, respectively.

Biology - 3; Control - 4

92. Eggen, D.A. 1978. **The relationship between flushing time of trembling aspen and the survival of the forest tent caterpillar.** M.Sc. thesis. Univ. Mich., Ann Arbor, Mich. 49 p.

Thesis could not be obtained.

Host Relationships - 1

93. Eggen, D.A. 1987. **A comparative study of the parasite complexes of gypsy moth and forest tent caterpillar in New York.** Ph.D. thesis. Univ. N.Y., Syracuse, N.Y. 225 p.

The thesis examines the parasite complexes of larval and pupal gypsy moth and forest tent caterpillar, and what, if any, interactions take place between the two parasitoid complexes when the hosts occur in the same area. The results of this investigation indicate that no interaction takes place. Rearings of parasitoids showed that the parasitoids complexes did differ somewhat in composition to what had been reported previously in the literature.

Biology - 2

94. Elgee, D.E. 1971. **Disease in forest tent caterpillar larvae hatching from egg bands contaminated with virus.** Can. For. Serv., Bi-mon. Res. Notes 27(6): 41.

This note describes experiments in which egg bands of *Malacosoma disstria* were painted with nucleopolyhedrosis virus suspensions of various strengths, and incubated. Mortality of the larvae occurred, thus proving that transmission of the virus from one generation to the next could take place via the accessory gland secretions that cover the egg masses.

Biology - 3

95. Elliott, K.R. 1961. **Status of the forest tent caterpillar in Manitoba and Saskatchewan.** Proc. Entomol. Soc. Manit. 16(0): 28-31.

"In 1961, the isolated outbreak in the Cypress Hills Provincial Forest declined... . The new general outbreak in the northern forested areas expanded rapidly in 1961, but remained within the Northern Coniferous, Manitoba Lowlands and Mixedwood sections of the Boreal Forest Region that occur north of the Aspen-Oak and Aspen Grove sections." The largest infestation in Manitoba occurred in a 2,500 square mile area bounded by The Pas, Snow Lake and the west shores of Amisk and Namew lakes. In Saskatchewan the largest infestation occurred within an area of 1,400 square miles near Cold Lake on the Alberta-Saskatchewan border. Numerous new infestations occurred varying in size. Egg-band surveys indicate that the main outbreak will enlarge in 1962 with the possible coalescing of some of the separate infestations.

Biology - 1; Outbreaks - 1,2b,3

96. Emond, F.J.; Cerezke, H.F. 1989. **Forest insect and disease conditions in Alberta, Saskatchewan, Manitoba, and the Northwest Territories in 1988 and predictions for 1989.** For. Can., North. For. Cent., Inf. Rep. NOR-X-303. 29 p.

The occurrence and economic importance of the tortricids *Choristoneura fumiferana, Choristoneura conflictana,* and *Choristoneura pinus,* the lasiocampid *Malacosoma disstria,* the scolytid *Dendroctonus ponderosae,* the tenthredinids *Pikonema alaskensis* and *Pristiphora erichsonii,* Dutch elm disease (caused by *Ceratocystis ulmi*) and dwarf mistletoe (*Arceuthobium americanum*) during 1988 are summarized and some predictions of infestation status are given for 1989. Additional noteworthy insects, diseases, and tree damage agents are reported in a table. Results of surveys for acid rain symptoms and pests and damage incidence in nurseries and plantations are also given.

Outbreaks - 1,3

97. Ennis, T.J.; Sohi, S.S. 1976. **Chromosomal characterization of five Lepidopteran cell lines of *Malacosoma disstria* (Lasiocampidae) and *Choristoneura fumiferana* (Tortricidae).** Can. J. Genet. Cytol. 18(3): 471-477.

"Chromosome number and morphology have been examined in four established cell lines (Md63, Md66, Md108, and Md109) of the forest tent caterpillar, *Malacosoma disstria* Hübner, and one (Cf124) of the spruce budworm, *Choristoneura fumiferana* (Clemens). Chromosome number distributions of Md63 (mode=112), Md108 (mode=103), Md109 (mode=103) and Cf124 (mode=110) overlap sufficiently to prevent identification of individual lines by number alone. However, Md66 is exceptional in possessing a modal number of 157. Once large chromosome occurs in cells of all lines. The presence of this chromosome, the lack of any distinct polyploid series among chromosome numbers encountered, and the general inverse relationship between number and size of

chromosomes, suggest that the high level of heteroploidy characteristic of these and other lepidopteran cell lines reflects not only a possible polyploid origin but also extensive chromosomal rearrangement and fragmentation. Tolerance for such change is attribute to the holokinetic organisation of lepidopteran chromosomes. A distinct heteropycnotic body is present in about 10% of Cf124 cell nuclei, and can be used as a marker for this line. This body may represent the sex chromatin normally encountered in somatic cells of female *C. fumiferana*."

Biology - 7

98. Entwistle, P.F.; Adams, P.H.W.; Evans, H.F.; Rivers, C.F.; Bird, F.T.; Burk, J.M. 1983. **Epizootiology of a nuclear polyhedrosis virus (Baculoviridae) in European spruce sawfly (*Gilpinia hercyniae*): spread of disease from small epicentres in comparison with spread of baculovirus diseases in other hosts.** J. Appl. Ecol. 20(2): 473-487.

"The patterns of spatial growth of small epicentres of nuclear polyhedrosis virus disease of *Gilpinia hercyniae* (Htg.) (GHNPV) were studied in Welsh spruce forests. Very little spread of virus occurred in the first sawfly generation infected, but thereafter it was considerable. Three phases were recognized. The pattern of primary spread followed an indented curve of rapidly diminishing disease incidence with distance from the epicentre. Logarithmic conversion of the units of distance and disease incidence transformed the curves to straight lines. The gradient of primary dispersal (b = -1.98 ± 0.16) was similar for spread in different forests and in different years. Epicentral flattening of the primary dispersal curve preceded the development of a wave-like pattern which characterized the secondary dispersal phase. Following this, the wave form was lost and the pattern of disease became less coherent. This was called the interference phase. The tripartite developmental sequence agreed well, both in form and scale, with figures published by Bird and Burk (1961) on the spread of a GHNPV disease in *G. hercyniae* in Canada, A very similar sequence is detected in data published by Young (1974) on the spread of a non-occluded baculovirus of *Oryctes rhinoceros* (ORBV) in one of the Tonga Islands. A short-term study on the spread of *Malacosoma disstria* nuclear polyhedrosis virus (MDNPV) in Canada (Stairs, 1965) [see abstract 415] indicated the same pattern of primary dispersal. Disease spread further in *O. rhinoceros* and *M. disstria* than in *G. hercyniae*, the estimated gradients of primary dispersal being -0.25 and -0.37 for ORBV and MDNPV diseases, respectively."

Biology - 3

99. Evlakhova, A.A.; Shvetsova, O.I. 1966. **Zadachi issledovanii po mikrobiologischeskomu metodu bor'by s vrednymi nasekomymi. [Undertakings of studies on the microbial control of harmful insects].** Zh. Obshch. Biol. 27(4): 448-456.

This review contains 60 references, and includes information on *Malacosoma disstria.*

General Background

100. Fashingbauer, B.A. 1951. **The effects of defoliation by the forest tent caterpillar, *Malacosoma disstria* Hbn., and spraying for the control of the forest tent caterpillar upon bird life and the effects of spraying for the control of the forest tent caterpillar upon amphibians.** M.Sc. thesis. Univ. Minn., St. Paul, Minn. 221 p.

This study was conducted during the summer of 1951 in north-central Minnesota. Three 14-acre plots were used for this experiment, two of which were located in the middle of an area heavily infested with *Malacosoma disstria.* One of these two plots was treated with DDT at a rate of one pound in one gal./acre to prevent defoliation, the other plot was left untreated to permit complete defoliation. Censuses of bird populations were conducted on the assumption that singing males representing breeding pairs. The application of DDT completely controlled *M. disstria* in the treated plot. Neither defoliation nor spray appeared to have any deleterious effects on bird populations, even though several birds that were caught were found to have eaten *M. disstria* larvae (presumably from the treated plot). However, the DDT spray did completely eliminate the wood frogs, *Rana sylvatica,* that were in the temporary ponds in the treated plot. The author indicates this mortality was caused by the frogs eating the DDT-contaminated *M. disstria* larvae.

Biology - 2; Control - 1

101. Fashingbauer, B.A.; Hodson, A.C.; Marshall, W.H. 1957. **The inter-relations of a forest tent caterpillar outbreak, song birds and DDT application.** Flicker 29(4): 132-143, 146.

The effects of complete defoliation by the forest tent caterpillar and the use of DDT as a chemical control on bird behaviour and survival were studied in Minnesota. The number and location of singing males plotted during the season was used as an indicator of the breeding bird population inhabiting the area. There was no observed death of birds or movement of birds into or out of the sprayed plot. The life habits, such as choice of perching sites, nest location, nesting success, and feeding habits, appeared to be similar in sprayed, completely defoliated, and control plots. Observations indicated that the birds exert little effect in reducing insect numbers.

Biology - 2; Control - 1

102. Fast, P.G.; Videnova, E. 1974. **The δ-endotoxin of *Bacillus thuringiensis.* V. On the occurrence of endotoxin fragments in hemolymph.** J. Invertebr. Pathol. 23(3): 280-284.

"Leucine-^{3}H labelled crystals of *Bacillus thuringiensis* δ-endotoxin were fed to last-instar larvae of spruce budworm, *Choristoneura fumiferana,* the eastern forest tent caterpillar, *Malacosoma disstria* and silkworm, *Bombyx mori.* Radioactivity was detected in haemolymph 1 minute after feeding in the first two species, but not until 3-5 minutes in larvae of *B. mori.* Most of the radioactivity from the haemolymph of all three species eluted from gel filtration columns at the same elution volume, indicating similar molecular weights (<1800 daltons)."

Biology - 3

103. Felt, E.P. 1929. **Protection of trees from insects.** Annu. Rep. Que. Soc. Prot. Plants 21(0): 43-48.

"Brief bibliographic data are given for four early New York entomologists, namely Fitch, Lintner, Comstock and Slingerland, and these are followed by short accounts, with indication of their economic status, of a long series of insects occurring in shade trees. Some of the more important of these are: forest tent caterpillar, *Malacosoma disstria,* white-marked tussock moth, *Hemerocampa leucostigma,* bagworm, *Thyridopteryx ephemeraeformis,* elm leaf beetle, *Galerucella leuteola,* willow leaf beetle, *Plagiodera versicolora,* Japanese beetle, *Popillia japonica,* satin moth, *Stilpnotia salicis,* sugar

maple borer, *Glycobius speciosus*, leopard moth, *Zeuzera pyrina*, hickory bark beetle, *Scolytus quadrispinosus*, Norway maple aphid, *Chaitophorus lyropicta*, San Jose scale, *Aspidiotus perniciosus*, elm scale, *Gossyparia spuria*, golden oak scale, *Asterolecanium variolosum*, and the cottony maple scale, *Pulvinaria vitis*."

Outbreaks - 1

104. Felt, E.P. 1935. **The important shade tree insects in 1934.** J. Econ. Entomol. 28(2): 390-393.

This article gives the location of infestations of several insects, including a brief note on small infestations of *Malacosoma disstria* in Massachusetts, Connecticut, and New Hampshire in 1934. The author indicated that the size of these infestations might increase during 1935.

Outbreaks - 1

105. Felt, E.P.; Bromley, S.W. 1941. **Major shade tree insects of 1940.** J. Econ. Entomol. 34(2): 180-181.

Malacosoma disstria was found to be "extremely abundant and destructive to sugar maple trees in portions of New York, especially the Catskills and Adirondacks, and in parts of New Hampshire and Vermont… ." Trees that had been defoliated for two successive years had a lot of dead wood on them. Areas with a lot of forest tent caterpillar also had elevated populations of *Sarcophaga aldrichi*.

Outbreaks - 3

106. Felt, E.P.; Bromley, S.W. 1943. **Shade tree insects and protective concealment in military areas.** J. Econ. Entomol. 36(2): 326-7.

The following insects were among those responsible for defoliation or other extensive damage to trees used for camouflage:- the elm leaf beetle (*Galerucella xanthomelaena* Schrank), the Japanese beetle (*Popillia japonica* Newmn.), the gypsy moth caterpillar (*Porthetria* [*Lymantria*] *dispar* L.), the spring cankerworm (*Paleacrita vernata* Peck), the fall cankerworm (*Alsophila pometaria* Harr.), the forest tent caterpillar (*Malacosoma disstria* Hbn.), the two-lined chestnut borer (*Agrilus bilineatus* Web.), the bronze birch borer (*Agrilus anxius* Gory), the dark elm bark beetle (*Hylurgopinus rufipes* Eich.), the European elm bark beetle (*Scolytus multistriatus* Marsh), the pine bark beetles (especially *Ips pini* Say, and *Ips calligraphus* Germ.), the spruce bark beetle (*Dendroctonus piceaperda* Hopk.), the balsam bark beetle (*Pityokteines spasus* Lec.), the cedar bark beetle (*Phloeosinus dentatus* Say), and the pine bark beetle (*Dendroctonus frontalis* Zumm.). Storm damage and defoliation by leaf-eating insects were factors which facilitated borer attack.

Outbreaks - 3

107. Felt, E.P.; Bromley, S.W. 1944. **The insect menace to shade trees in the northeast.** J. Econ. Entomol. 37(2): 212-3.

The authors discussed the insect pests of elm, oak, and other shade trees in the northeastern United States, including: elm leaf beetle (*Galerucella xanthomelaena* Schrank), cankerworms (*Paleacrita vernata*

Peck and *Alsophila pometaria* Harris), and the European elm bark beetle (*Scolytus multistriatus* Marsh.) which is an important vector of the Dutch elm disease fungus. Oak suffered repeated defoliation by the two cankerworms, as well as damage by the forest tent caterpillar (*Malacosoma disstria* Hbn.), gypsy moth (*Porthetria* [*Lymantria*] *dispar* L.) and the two-lined chestnut borer (*Agrilus bilineatus* Web.). Low temperatures and drought produced conditions favourable for the invasion of borers such as *Agrilus bilineatus* in oak, *Agrilus anxius* Gory in ornamental European birch, and *Melanophila fulvoguttata* Harris in hemlock. The extensive constructional work of recent years resulted in the severe-injury or death of many trees owing to injudicious drainage, flooding or filling. In one district pitch pine suffered injury through attack by the turpentine beetles, *Dendroctorius terebrans* Oliv. and *D. valens* Lec, which were attracted to the site by the paint on nearby structures.

Outbreaks - 3

108. Fitzgerald, T.D.; Costa, J.C. III. 1986. **Trail-based communication and foraging behaviour of young colonies of forest tent caterpillars (Lepidoptera: Lasiocampidae).** Ann. Entomol. Soc. Am. 79(6): 999-1007.

"Field and laboratory studies showed that young colonies of the forest tent caterpillar, *Malacosoma disstria* Hübner, wandered extensively in search of food but maintained physical cohesiveness by marking trails with a pheromone secreted from the posterior end of the abdomen. Trails established by hungry caterpillars during the colony's forays are lightly marked and serve to guide dispersed siblings to a common feeding site. Trails established directly after feeding by sated caterpillars are more heavily marked and more stimulating than exploratory trails and have the immediate effect of recruiting successive waves of fed caterpillars from the current feeding site to a distant bivouac. Although caterpillars occasionally follow trails of sated siblings to food, recruitment to food is clearly not an integral component of the nomadic foraging behaviour and concomitant trail marking system of this species. Comparisons are drawn between the trail system of this species and that of *M. americanum* (F.), a sympatric congener that recruits to food and utilizes a distinctly different fixed-base mode of foraging."

Biology -1,5

109. Fitzgerald, T.D.; Edgerly, J.S. 1979. **Specificity of trail markers of forest and eastern tent caterpillars.** J. Chem. Ecol. 5(4): 565-574.

"Exploratory trails deposited on paper strips by the forest tent caterpillar (FTC), *Malacosoma disstria* Hubner, and the eastern tent caterpillar (ETC), *M. americanum* (Fabricius), as well as extracts of these trails, readily elicited interspecific trail-following behaviour. In 2-choice tests involving simple Y mazes constructed from these paper strips, the caterpillars of both species preferred by approximately 3:1 the trails of the FTC. Studies involving whole colonies of the ETC maintained under near-natural conditions in the laboratory, however, indicated that the trails deposited by successful foragers of FTC as they returned to their tent from feeding sites were more attractive than the exploratory trails of either ETC or FTC. The pronounced interspecific response of these congeners to each other's trails suggests that they utilise either qualitatively similar or identical trail-marking chemicals. Both species preferred their own trails to those of *Archips cerasivoranus* (Fitch) (Tortricidae), providing the first evidence that more distantly related lepidopterous larvae utilize distinct trails."

Biology - 1,5

110. Fitzgerald, T.D.; Webster, F.X. 1993. **Identification and behavioral assays of the trail pheromone of the forest tent caterpillar, *Malacosoma disstria* Hübner (Lepidoptera: Lasiocampidae).** Can. J. Zool. 71(8): 1511-1515.

"Behavioural assays showed that the steroid 5β-cholestan-3-one, isolated from the abdomen of larvae of the forest tent caterpillar (*Malacosoma disstria*) constitutes the chemical basis of trail-following in this insect. Caterpillars follow artificial trails prepared from solvent dilutions of the compound at rates as low as 10^{-11} g / mm of trail, though the true threshold sensitivity is likely to be 1 or 2 orders of magnitude lower than this. Fourth-instar larvae store an average of 58 ng of the pheromone. Field and laboratory studies indicate that the compound is fully competitive with their authentic trails. The caterpillars are highly sensitive to differences in the concentration of the pheromone, preferring stronger trails to weaker trails. The caterpillars also respond to 5β-cholestane-3,24-dione, a chemical not found in *M. disstria* but known to be a component of the trail pheromone of the eastern tent caterpillar, *Malacosoma americanum*."

Biology - 1,5

111. Forest Insect and Disease Survey. **Annual report.** 1937-1993. Can. For. Serv., Ottawa, Ont.

By various authors, these reports give information on major forest insects and diseases of Canada by year and region (also published in French as: **Enquête sur les Insectes et Maladies des Forêts, Rapport Annuel**). Generally, the reports provide infestation and damage levels, localities and extent of infestations and forecasts for the following year.

References to the forest tent caterpillar occur in the following pages. Page numbers in the table refer to the English version.

	Regions					
Year	Nfld	Maritimes	Quebec	Ontario	Prairie Provinces	BC
1937			16,18,19	16,18,20	20	
1938		51	43,44	43,44	43,44,47	
1939			15,16	15,16	15,16	
1940			16	16	16	
1941			10	10	11	11
1942			9	9	9	
1943		9	21	9,21,36	51,58,64	64
1944	8	8	8,17	30	44,45,54	
1945	10	9,10	9,23	30,37	46,55	
1946		9	24	37	57,69	81
1947		14		45	73	96
1948		13		49,60,61	83,106	
1949		8,9	23	41,42,47,48,51,52,53	78,79	109,111
1950		8	24	43-47	74	116
1951			22	41-45	66,67,69,88,97	108,111
1952		7,20	22,24	43-46	81,101,115	134,140,141
1953		14,22	33-34	55	93,113,123	
1954		18	31	50	84,104	120
1955		14		39	75,85	96
1956				41	66,75	83

Regions						
Year	Nfld	Maritimes	Quebec	Ontario	Prairie Provinces	BC
1957				36	60,68	76
1958				51	62,66,76	90
1959				56	73,83	99
1960				48,50	70,77,82,86	100
1961		29	48	58,69	81,86,89,94,101	114
1962		28	45	52,64	72,80,84,85,90,94,105	113
1963		28	44	51,63	79,85,97	116
1964		26	45	51,66	83,89,98	119
1965			35	45-48	69	
1966			46			
1967		22	37,40,46	55	99	115
1968		23	38	58	85,100	118
1969		24	42	58	78,87	103
1970		23	39	51,52,62	68,69	81
1971		24	43	57	74	85
1972		23	42	56	75	88
1973		18,22	31,36	50,52	70	78,81
1974				**missing**		
1975		5,19,22	5,33,37	5,53,55,67	5,69,70,74	5,81
1976		5,19,22	5,40	5,55,57,58,69	5,71,75	5,83
1977		5,19,22	5,35,39,51	5,54-56,65,69	5,71,72,79	5,86
1978		5,17,19	5,29,31	5,39,42	5,56	5,63,68
1979		5,17,19	5,29,31,32	5,43,45	5,59,60,61	
1980		9,10,22	11	11	11,12	12
1981		16	16	17	18	18
1982	22	22,23	17,23	23	23	
1983	20	20	20	20	20	21
1984	19	19,20	20	20,21	21	21
1985	25	25	25	25,26	26	26
1986	24	24,26	25,26	25-27	25,27	25,27
1987				**missing**		
1988	20,21	20,21	21,22	21,22	21-23	21,23
1989	22,23	22,23	22-24	22,24	22,24,25	22,25,26
1990	24,25	24,25	24,25	24,25,26	24,26,27	24,27
1991	21	21,22	21,22	21-23	21,23	21,23,24
1992	16,17	17,18	17,18	17-19	17-20	17,19,20
1993	19	19,20	20,21	21,22		22,23

Outbreaks - 1,3

112. Foster, H.R. 1951. **Pre-hatch spray test against the forest tent caterpillar.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 7(3): 1-2.

A pre-hatch aerial spray of DDT (12 1/2% DDT in fuel oil at ca. 6 qt./acre) was applied on 27 April to a stand of small aspen bearing egg bands. Only 26% of larvae emerging from egg masses in treated plots survived until May 9, compared with 57.5 and 61.5% for control plots. When the trees at the edges of the spray plot (which did not receive adequate coverage) were removed from the

study, the data for the spray plot "were as follows: percentage hatch, 89%; survival of emerged larvae, 7.8%; effectiveness of spray application, 87%." The advantage of pre-hatch spraying was that it increased the period available for control measures during the outbreak.

Control - 1

113. Froelich, R.; Hodson, A.C.; Schneider, A.E.; Duncan, D.P. 1955. **Influence of aspen defoliation by tent caterpillar in Minnesota on the radial growth of associated balsam fir.** Minn. For. Notes No. 45. 2 p.

A study was made in mixed aspen/balsam fir stands to determine the effect of defoliation of aspen by *Malacosoma disstria* on radial growth of both species. It was found that during years of heavy defoliation, average radial growth of aspen decreased by nearly 70%, while that of balsam fir increased by 20%.

Outbreaks - 3

114. Froelich, R.; Shiue, C.-J.; Duncan, D.P.; Hodson, A.C. 1956. **The effect of rainfall on the basal area growth of aspen as related to defoliation by the forest tent caterpillar [*Malacosoma disstria*]**. Minn. For. Notes No. 48. 2 p.

Previous studies [see abstracts 23 and 113] showed that growth rates decreased as the degree of defoliation of aspen stands increased. This study examined the effects of rainfall on the growth of aspen, both in the years preceding defoliation and in the year of defoliation. It was concluded that rainfall was not the major factor contributing to growth reduction. "It was estimated that 72% of reduction in basal area increment in the first year of heavy defoliation, and 87% in the second year, was the direct result of the forest tent caterpillar."

Biology - 4

115. Frye, R.D.; Ramse, D.A. 1975a. **Natural control agents in forest tent caterpillar populations.** N. Dak. Farm Res. 32(6): 14-19.

An outbreak of *Malacosoma disstria* Hbn. occurred in 1969-71 in a national game preserve in North Dakota, the major food-plants attacked being basswood, *Tilia americana*, and chokecherry, *Prunus virginiana*. Severe defoliation destroyed most of the foliage used as food by deer and elk in the area. Since chemical control is not permitted because the area is a wildlife sanctuary, a survey of natural enemies that might be of value in biological control was made. Lists are given of 15 insect parasites, four hyperparasites, two predators, seven predacious birds, about six other insects and four spiders that were found in association with the lymantriid, and eight pathogens (viruses, fungi, a bacterium and a protozoan). Parasites appeared to exercise considerable control, parasitism in the egg, larval and pupal stages averaging 2.46-4.13, 33.4, and 66.3%, respectively.

Biology - 2

116. Frye, R.D.; Ramse, D. 1975b. **Control of the forest tent caterpillar with microbial agents.** N. Dak. Farm Res. 33(1): 19-22.

Outbreaks of *Malacosoma disstria* Hbn. caused widespread defoliation of trees (basswood (*Tilia americana*) being the major overstory species attacked and chokecherry (*Prunus virginiana*) the major understory species) in the Sully's Hill National Game Preserve, North Dakota, and adjacent areas during the summers of 1970 and 1971. When the effectiveness of biological and chemical insecticides against larvae was evaluated in laboratory and field tests during the two years, carbaryl at a rate of 1 lb toxicant/acre and a mixture of Biotrol XK (a preparation containing *Bacillus thuringiensis*) and Savol (a crop oil) at 0.5 lb and 10 US gal/acre, respectively, gave the most consistent control. Weather appeared to be an important factor affecting the development of the pest.

Control - 2, 3

117. Furniss, R.L.; Carolin, V.M. 1977. **Western forest insects.** U.S. Dep. Agric. For. Serv., Misc. Publ. No. 1339. pp. 186-191.

This manual covers the insects and related organisms in forests and woodlands of North America, west of the 100th Meridian and north of Mexico. It provides common and scientific names of insects and host species as well as details of life cycles, distribution, and destructiveness.

General Background

118. Futuyma, D.J.; Saks, M. 1981. **The effect of variation in host plant on the growth of an oligophagous insect, *Malacosoma americanum* and its polyphagous relative, *Malacosoma disstria*.** Entomol. Exp. Appl. 30(2): 163-168.

"Larvae of *Malacosoma americanum* (F.) (Lepidoptera: Lasiocampidae) an oligophagous species that feeds primarily on *Prunus* and other rosaceous trees, were compared to larvae of the more highly polyphagous congener *M. disstria* Hbn. with respect to their sensitivity to variation in the foliage of a common host plant, *Prunus serotina* Ehrh. Pupal weight and time to pupation were measured on larvae reared on foliage from open-grown and from shaded saplings. The difference in foliage had a pronounced effect, but no difference was evident between the species in their response to the variation in foliage. This comparison implies that sensitivity to intraspecific variation in host quality does not differ between host-specific and generalized species. However, results from other species suggest that some species of insects do differ in this respect."

Host Relationships - 6

119. Futuyma, D.J.; Wasserman, S.S. 1981. **Food plant specialization and feeding efficiency in the tent caterpillars *Malacosoma disstria and M. americanum*.** Entomol. Exp. Appl. 30(2): 106-110.

"Larvae of *Malacosoma americanum* (F.), an oligophagous species that feeds primarily on *Prunus* and other rosaceous trees, were compared to larvae of the more highly polyphagous congener *M. disstria* Hbn., with respect to the efficiency of utilization of the foliage of a common host plant, *Prunus serotina* Ehrh. We obtained values similar to those reported for other Lepidoptera for the commonly used measures of the fraction of ingested food that was assimilated, and for the growth in dry

weight per unit of food ingested or assimilated. Moreover, the two species did not differ in any measure of efficiency. Our results are compatible with the conclusion that specialized phytophagous insects do not use their host plants with greater physiological efficiency than do generalized insects."

Host Relationships - 6

120. Gahan, A.B. 1937. **Two new Chalcidoid egg parasites (Eulophidae and Mymaridae).** Proc. Entomol. Soc. Wash. 39(9): 266-269.

"*Tetrastichus silvaticus* parasitizing *Malacosoma disstria* and *Erythmelus psallidis* parasitizing the cotton flea hopper, *Psallus seriatus*."

Biology - 2

121. Gardette, M.; Jabri, N.; Alexakis, A.; Normant, J.F. 1984. **General methodology for the synthesis of conjugated dienic insect sex pheromones.** Tetrahedron 40(14): 2741-2750.

"A general methodology for the synthesis of various types of dienic insect sex pheromones (Z-E, E-Z, Z-Z) is based on the carbocupration of acetylene by functionalized or non-functionalized lithium dialkyl cuprates, followed by the coupling of the resulting Z dialkenyl cuprates with functionalized or non-functionalized E or Z alkenyl iodides under Pd° catalysis. The following compounds were efficiently synthesized with a high degree of stereoisomeric purity: (E-Z)7,9-dodecadien-1-yl acetate (*Lobesia botrana*), (E-Z)10,12-hexadecadien-1-ol (*Bombyx mori*), (Z-E)9,11-tetradecadien-1-yl acetate (*Spodoptera littoralis*), (Z-E)5,7-dodecadien-1-ol (*Malacosoma disstria*), (Z-Z)11,13-hexadecadien-1-al (*Amyelois transitella*), (Z)9,11-dodceadien-1-yl acetate (*Diparopsis castanea*) and (Z-Z)9,11-tridecadien-1-yl (a known 'pseudo-pheromone')."

Control - 5

122. Gautreau, E.J. 1964. **Unhatched forest tent caterpillar egg bands in northern Alberta associated with late spring frost.** For. Can., For. Entomol. Path. Br., Bi-mon. Progr. Rep. 20(3): 3.

Dissections of *Malacosoma disstria* eggs shows that this insect overwinters as fully developed embryos which have marked resistance to cold as long as they are dormant. High temperatures in late April, 1963, initiated embryo activity, making them susceptible to freezing temperatures in May in Alberta. This resulted in high embryo mortality.

Biology - 4

123. Ghent, A.W. 1958. **Mortality of overstory trembling aspen in relation to outbreaks of the forest tent caterpillar [*Malacosoma disstria*] and the spruce budworm [*Choristoneura fumiferana*].** Ecology 39(2): 222-32.

A study was undertaken to determine the relation of aspen mortality in the Lake Nipigon forest area of Ontario, to the outbreak of *M. disstria* in the late 1930's and to determine what influence aspen mortality might have had on the exposure, flowering and consequent susceptibility of understory

balsam fir and spruce to budworm attack. The influence of aspen mortality on flowering of balsam fir was confirmed, but it was shown that the elimination of the aspen overstory began long before the outbreak of *M. disstria* and was largely due to stem breakage during midsummer gales where the crowns were in full leaf (40% of the overstory had disintegrated in this way before heavy defoliation began). In this region, where aspen regularly attains a DBH greater than or equal to 25 inches, it may be the normal fate of this species to outgrow its structural limitations. Death of overstory aspen was accompanied by establishment of *Acer spicatum* shrub growth which was probably responsible for the absence of aspen sucker reproduction. This study does not support the suggestion that the progress of overstory elimination was accelerated by *M. disstria* defoliation and that the succession of the coniferous component of these stands was hastened in this way.

Outbreaks - 1,3

124. Ginzburg, L.R.; Taneyhill, D.E. 1994. **Population cycles of forest Lepidoptera: a maternal effect hypothesis.** J. Anim. Ecol. 63(1): 79-92.

"Many species of forest Lepidoptera have cyclic population dynamics. Although there are numerous potential causes, including interactions with predators, parasitoids, pathogens, and food quality, strongly density-dependent interactions are often difficult to demonstrate. Both autocorrelation analysis and attractor-reconstruction methods have recently been applied to a number of species' time series. Results suggest that complex dynamics, i.e. cycles or deterministic chaos, may be more prevalent than once thought, and that higher-dimensional models are necessary. We develop a two-dimensional difference equation model that relates the average quality of individuals to patterns of abundance. The delayed density dependence is caused by transmission of quality through generations via maternal effects. We show that the maternal effect model can produce patterns of population fluctuations similar to those displayed by one class of host-parasitoid models. We review empirical evidence for maternal and quality effects in dynamics of forest Lepidoptera. We fit the maternal effect and delayed logistic models to six species of forest moths for which delayed density dependence and maternal or quality effects have been found. The maternal effect model was a good predictor of the period of the oscillations for the species that we examined. We discuss why models of this type give better fits to moth cycles than do first order models with added delays."

Outbreaks - 5,6

125. Godwin, P.A.; Odell, T.M. 1977. **Alternate hosts of *Blepharipa pratensis* (Meigen).** U.S. Dep. Agric. For. Serv., Northeast. For. Exp. Sta., Res. Note No. NE-245. 3 p.

"A current tactic for biological control of the gypsy moth, *Lymantria dispar* Linnaeus, is to release its parasites in forests susceptible to gypsy moth damage before the gypsy moth arrives. The basic assumption in these anticipatory releases is that the parasites can find and utilize native insects as hosts in the interim. *Blepharipa pratensis* is being used in this way. The efficacy of such releases has not been demonstrated. The present state of our knowledge about the niche requirements of gypsy moth parasites in general, and *B. pratensis* in particular, does not permit an evaluation now. However, we do have sufficient information to determine the crucial point of whether *B. pratensis* can live and develop in particular native lepidopteran species that are potential hosts. We report here on the survival of *B. pratensi*s in eight potential North American hosts [*Lymantria dispar*

Linnaeus, *Malacosoma disstria* Hubner, *Malacosoma americanum*(Fabricius), *Hemiluca maia* Drury, *Anisota senatoria* (J.E. Smith), *Nymphalis antiopa* Linnaeus, *Dasychira basiflava* (Packard)], *Heterocampa guttivitta* (Walker)]."

Biology - 2

126. Gole, J.W.D.; Downer, R.G.H.; Sohi, S.S. 1982. **Octopamine-sensitive adenylate cyclase in haemocytes of the forest tent caterpillar, *Malacosoma disstria* Hubner (Lepidoptera: Lasiocampidae).** Can. J. Zool. 60(5): 825-829.

"Injection of octopamine into the haemocoel of third instar larvae and pupae of the forest tent caterpillar, *Malacosoma disstria*, results in a rapid elevation of haemolymph cyclic AMP levels. The elevated cyclic AMP levels are due, at least in part, to the action of octopamine on haemocytes, as evidenced by the octopamine-induced stimulation of adenylate cyclase in an established haemocyte cell line (Md66). The effect is simulated by the adrenergic agonist, synephrine, and inhibited by the α-adrenergic blocking agent, phentolamine. The insect haemocyte receptor-enzyme system resembles equivalent vertebrate systems in being activated by sodium fluoride and requiring GTP for expression of effector-induced activation of the enzyme."

Biology - 7

127. Gorham, R.P. 1922. **Insect pests of the year 1922, in New Brunswick.** Proc. Acadian Entomol. Soc. 1922(0): 18-22.

This paper reviews major insect pest outbreaks in New Brunswick. Extreme low temperatures along the Salmon River were responsible for forest tent caterpillar egg masses failing to hatch.

Biology - 4; Outbreaks - 1,3

128. Goyer, R.A. 1991. **Integrated pest management of forest defoliators in the southeastern United States.** Pages 131-142 *in* A.G. Raske and B.E. Wickman (eds.). Towards Integrated Pest Management of Forest Defoliators. Proc. 18th Internat. Congr. Entomol., Vancouver, B.C., Canada. July 3-9, 1988. Special Issue For. Ecol. Manage. Vol. 39.

A summary is presented of defoliator pests in southeastern USA (particularly Louisiana), a report on current integrated pest management (IPM) strategies, and several new pest problems in which IPM efforts may be concentrated in the future. Of defoliating insect species that occur in the temperate and sub-tropical forests of this region, two groups stand out as persistent, annual problems that demand the attention of forest pest managers. These are the tent caterpillars (Lepidoptera: Lasiocampidae), particularly *Malacosoma disstria*, which has infested water tupelo [*Nyssa aquatica*] and poplar [*Populus* spp.] trees since the 1940s, and the pine sawflies (Hymenoptera: Diprionidae), particularly the red-headed pine sawfly (*Neodiprion lecontei*). Pest-management tactics developed to date have involved population dynamics and modeling as well as biological and cultural controls.

Sampling schemes using pheromone-baited traps provide an indication of relative population density for several important defoliator species. The use of traditional chemical controls has been inhibited by the diversity of forest fauna, economics, and environmental sensitivity.

Biology - 2,3,5; Outbreaks - 5,6

129. Goyer, R.A.; Lenhard, G.J.; Smith, J.D. 1990. **Insect herbivores of a bald-cypress/tupelo ecosystem.** Pages 517-521 *in* B.D. Jackson. (ed.). Proc. International Forested Wetlands Resource: Identification and Inventory. Baton Rouge, La, Sept. 19-22, 1988. Special Issue For. Ecol. Manage. Vol. 33-34.

"The forest tent caterpillar, *Malacosoma disstria* Hubner, and the fruit-tree leafroller, *Archips argyrospilus* (Walker), are the two dominant insect herbivores affecting Louisiana's forested wetlands. The lack of tree species diversity and the paucity of natural enemies has resulted in continuous epidemics of these two herbivores. The resultant effects have been severe radial-growth losses of tupelo, *Nyssa aquatica* L., caused by the forest tent caterpillar, and growth reduction, dieback, and scattered mortality of bald cypress, *Taxodium distichum* L. by a relatively new insect pest of this tree species, the fruit-tree leafroller."

Outbreaks - 3

130. Goyer, R.A.; Lenhard, G.J.; Smith, J.D.; May, R.A. 1987. **Estimating the number of eggs per egg mass of the forest tent caterpillar, *Malacosoma disstria,* on three tree species in the southern U.S.** J. Entomol. Sci. 22(2): 188-191.

"Several parameters of forest tent caterpillars (FTC), *Malacosoma disstria* Hübner, were evaluated for estimating the number of eggs per mass on three tree species in the southern U.S. Egg mass length without its spumaline (protective) coating was the most highly correlated measurement with actual number of eggs per mass on water tupelo, *Nyssa aquatica* L., water oak, *Quercus nigra* L. and flowering dogwood, *Cornus florida* L. Fecundity was significantly higher on water tupelo in Louisiana than on water oak and flowering dogwood in South Carolina."

Host Relationships - 3,4,6; Outbreaks - 4a

131. Grant, G.G. 1975. **Electrophysiological evidence for a humidity (water) receptor on the antennae of several Lepidoptera.** Can. For. Serv., Bi-mon. Res. Notes 31(3): 19.

Electroantennogram data suggest that adults of *Trichoplusia ni* (Hbn.), *Mythimna* (*Pseudaletia*) *unipuncta* (Haw.), *Mamestra configurata* Wlk., *Plodia interpunctella* (Hbn.) and *Ephestia* (*Cadra*) *cautella* (Wlk.) possess humidity receptors on their antennae. No evidence for such receptors was found in *Malacosoma disstria* Hbn. and *Hemerocampa* (*Orgyia*) *leucostigma* (J.E. Smith), which do not feed as adults.

Biology - 1

132. Grant, J. 1959. **Pine siskins killing forest tent caterpillars.** Proc. Entomol. Soc. B.C. 56(0): 20.

"In June 1954 the trembling aspen woodlands along the Fraser River Valley south of Quesnel, British Columbia, were denuded by an outbreak of forest tent caterpillar, *Malacosoma disstria* Hbn. On June 22 in the semi-open country around Castle Rock, flocks of pine siskins, *Spinus pinus* (Wilson) were numerous and two instances of predation upon the fully-grown larvae were observed. The bird carried a larva to a suitable branch, then standing on the insect's body, grasping the head in its bill and pulled until the viscera were removed. These were laid along the branch and a small portion of the body contents were selected and eaten. One siskin killed three larvae in this manner in a few minutes."

(Entire reference included in annotation.)

Biology - 2

133. Great Lakes Forest Research Centre 1967-1996. **Survey bulletin: Forest insect and disease conditions in Ontario.** Can. For. Serv., Gt. Lakes For. Res. Cent., Sault Ste. Marie, Ont.

These are a series of published and unpublished reports (also called Forest Research Laboratory Bulletins from 1967-1970). They include information on occurrence, populations, locality and extent of infestations of major insect pests and diseases in Ontario. References to the forest tent caterpillar occur in the following years and pages.

	Page Numbers		
Year	May-June	July-Aug.	Sept.-Oct.
1967	3	5	missing
1968	4-5	missing	missing
1969	missing	-	missing
1970	missing	-	-
1971	-	missing	missing

	Page Numbers		
Year	May	June-July	Aug.-Sept.
1972	2	5	2-3
1973	4	5-6	2,4
1974	-	missing	4
1975	missing	missing	3-4
1976	missing	4-6	missing

Quarterly Reports

	Page Numbers		
Year	Spring	Summer	Fall
1977	1-2	missing	missing
1978	missing	3-4	missing
1979	7	missing	-
1980	missing	missing	missing
1981	9	missing	missing
1982	-	5	10
1983	-	11	6
1984	-	10-12	10
1985	-	11-13	13-14

Page Numbers			
Year	Spring	Summer	Fall
1986	10	11-13	13-15
1987	10	12-14	11-13
1988	10	7-11	5-7
1989	-	4-8	9-13
1990	-	4-9	9-12
1991	6	11-15	missing
1992	3-4	4-6	4-6
1993	4	4-5	4
1994	2	5-7	5
1995	2	4,6	6-7

Outbreaks - 1,3

134. Green, G.W.; Sullivan, C.R. 1950. **Ants attacking larvae of the forest tent caterpillar, *Malacosoma disstria* Hbn. (Lepidoptera: Lasiocampidae).** Can. Entomol. 82(9): 194-195.

During field studies of the larvae on small *Populus tremuloides* trees, 2 species of ant (*Camponotus Herculeanus ligniperdus* and *Formica fusca*) were found frequently attacking first to fourth instar *M. disstria* larvae. There were 2 types of attack: (1) by foraging ants, mainly *Camponotus* workers, which persistently carried off larvae in any stage of development from the first to the fourth instar. These attacks decreased in the spring of 1950, which was a much wetter season than the previous one; (2) by defenders of aphid colonies, where the young larvae were moving about the trees to feed or moult. This type of attack was observed both in 1949 and in 1950. Larger larvae were driven off but not killed.

Biology - 2

135. Greenblatt, J.A. 1974. **Behavioral studies on tent caterpillars.** M.Sc. thesis. Univ. Mich., Ann Arbor, Mich. 55 p.

The objective of this thesis was to "...review the literature on individual differences in tent caterpillars and to confirm the presence of behavior types in *Malacosoma americanum* (Fabricius) and *Malacosoma disstria*. In addition we wanted to verify that the behavior types are stable - that is, an individual that responds to a light source on one day will continue to be an active individual throughout its life."

Portions of this thesis were published in Greenblatt and Witter, 1976 (see abstract 136).

Biology - 1

136. Greenblatt, J.A.; Witter, J.A. 1976**. Behavioral studies on *Malacosoma disstria* (Lepidoptera: Lasiocampidae).** Can. Entomol. 108(11): 1225-1228.

"First-stage forest tent caterpillar larvae were tested for the presence of active and sluggish behaviour types such as Wellington found in *Malacosoma californicum pluviale* (Dyar). Larvae capable of directed movement towards a 30 W light source were classified as active. Larvae were tested on 3 consecutive days, and only a small percentage responded on all 3 days. A much larger percentage remained sluggish throughout the period. Chi-square test confirmed that the differences in response were not random. There was a tendency for some larvae to respond to light during the test and for others not to respond. The reduced consistency in the response of "active" larvae in *M. disstria* Hübner compared with that reported for *M.c. pluviale* may be partly due to real behavioral differences, but it also may be partly due to some procedural differences between our tests and Wellington's."

Biology - 1

137. Grisdale, D.G. 1968. **A method for reducing incidence of virus infection in insect rearings.** J. Invertebr. Pathol. 10(13): 425.

Mortality due to contamination by polyhedrosis virus can be practically eliminated by treating egg bands with a concentrated sodium hypochlorite solution (i.e., "Javex") for one minute and then flushing with cold water.

Biology - 3,6

138. Grisdale, D.G. 1975. **A simple method for removing pupae from cocoons**: ***Malacosoma disstria* (Hbn.) and *Orgyia* spp.** Can. For. Serv. Bi-mon. Res. Notes 31 (2): 9.

When *Malacosoma disstria* Hbn. and *Orgyia* spp. are reared in the laboratory on a large scale for the investigation of sex pheromones, most workers who handle the cocoons suffer from allergies caused by the yellow powder and urticating larval hairs in the cocoons. When the cocoons were washed in household bleach (containing 6% available sodium hypochlorite) mixed with an equal quantity of tap water, and then rinsed in a screened box under running water, 2000 pupae could be separated from the cocoons by one person in 0.5 h without the danger of an allergic reaction.

Biology - 6

139. Grisdale, D.G. 1976. **Laboratory methods for rearing the forest tent caterpillar.** Can. For. Serv., Bi-mon. Res. Notes 32(1): 1.

Further information is provided on methods that have been used successfully in Canada since 1966 for rearing *Malacosoma disstria* Hbn. in the laboratory on an artificial diet. Raw linseed oil at 15 ml/100 ml diet was an essential ingredient of the larval diet, and without it many adults emerged with malformed wings. Most of the eggs used were collected in the field in mid-September and stored at temperatures of 0-2°C. In one test, all the eggs in a sample of 14 egg-masses hatched after storage for 7 months.

Biology - 6

140. Grisdale, D.G. 1985. ***Malacosoma disstria.*** Pages 369-379 *in* P. Singh and R.F. Moore (eds.). Handbook of insect rearing Vol. 2. Elsevier, N.Y.

This chapter lists the facilities and equipment needed for rearing the forest tent caterpillar as well as provides a recipe for artificial diet and lists names and sources of ingredients. Methods for rearing and colony maintenance are described in detail and include instructions for egg sterilization.

Biology - 6

141. Gross, H.L. 1985. **The impact of insects and disease on the forests of Ontario.** Environ. Can., Can. For. Serv., Gt. Lakes For. Res. Cent. Inf. Rep. O-X-366. 96 p.

"Annual losses experienced by Ontario forests for the period 1977-1981 are presented for Ontario as a provincial summary, as regional reports for five of the administrative regions, and as a combined report for the three administrative regions in southern Ontario... . The data are presented by pest agent for the various host tree species." Information concerning outbreaks of *Malacosoma disstria* are provided on a region-by-region basis.

Outbreaks - 3

142. Gross, H.L. 1991. **Dieback and growth loss of sugar maple associated with defoliation by the forest tent caterpillar.** For. Chron. 67: (1) 33-42.

"Sugar maple (*Acer saccharum* Marsh.) stands in southwestern Ontario experienced a forest tent caterpillar (*Malacosoma disstria* Hbn.) infestation in the mid 1970s. The defoliation was considered a key factor that accounted for an upsurge in the amount of dieback damage that occurred in 1977 and 1978 in the area affected by the caterpillar. Growth loss, dieback and food reserve relationships were examined. In the years 1977-1979 defoliated maples grew at a reduced rate that averaged 39.5% less than that for maples in stands adjacent to the infestation. Trees that recovered from the influence of defoliation were compared with those that died or continued to experience dieback. Those that recovered had greater food reserves in 1978 and 1979, on the basis of sapwood starch content, that did maples that declined. Stands showed good recovery from dieback. Dominant and codominant maples that had less than 40% branch mortality in 1978 generally recovered to good vigor and crown shape by 1980."

Outbreaks - 1,3

143. Haanstad, J.O.; Norris, D.M. 1992. **Altered elm resistance to smaller European elm bark beetle (Coleoptera: Scolytidae) and forest tent caterpillar (Lepidoptera: Lasiocampidae).** J. Econ. Entomol. 85(1): 172-181.

"N-ethylmaleimide in paraffin oil as a stem band and an inoculated heat-killed microbial suspension [of the fungus *Ceratocystis ulmi*] each altered Siberian [*Ulmus pumila*] and American elm [*U. americana*] regarding preference for herbivory by the forest tent caterpillar, *Malacosoma disstria*

Hübner, and for cortical feeding by the smaller European elm bark beetle, *Scolytus multistriatus* Marsham. Such alteration was affected by the time after treatment, sample height in the plant, and the N-ethylmaleimide concentration."

Host Relationships - 6; Control - 2,6

144. Hajek, A.E.; Butler, L.; Walsh, S.R.A.; Silver, J.C.; Hain, F.P.; Hastings, F.L.; Odell, T.M.; Smitely, D.R. 1996. **Host range of the gypsy moth (Lepidoptera: Lymantriidae) pathogen *Entomophaga maimaiga* (Zygomycetes: Entomphthorales) in the field versus laboratory.** Environ. Entomol. 25(4): 709-721.

A total of 1 790 lepidopteran larvae were collected from seven plots in Virginia to determine levels of infection by *Entomophaga maimaiga*. Of these, only 1 of 318 *Malacosoma disstria* larvae and 1 of 96 *Catocala ilia* larvae collected were found to be infected with the pathogen. Both infected larvae were collected from plots in the George Washington National Forest. Laboratory studies of the pathogen suggest that *E. maimaiga* should have had a greater host range in the field. Some suggestions are made concerning the lower field infection rates.

Biology - 3

145. Hall, R.J.; Crown, P.H.; Titus, S.J. 1984. **Change detection methodology for aspen defoliation with Landsat MSS digital data.** Can. J. Remote Sens. 10(2): 135-142.

"A method was developed to detect aspen defoliation [caused by *Malacosoma disstria*], without detailed field data, based on an understanding of the expected spectral changes and an application of digital analysis and statistical techniques. The analysis procedure included the creation of a three-band multidate color composite image on which color renditions were analysed to identify defoliation areas. A simple three-band parallelepiped classification was performed using LANDSAT band 7 data from images before (1977) and after (1980) defoliation plus the 1980 band 5 data. Areas identified as defoliated on the color composite were classified as a single theme. Discriminant analyses were employed to relate spectral band combinations to band differences and ratios, to determine their relative effectiveness in classifying defoliated areas. A simple three-spectral-band combination was more effective than the band difference or ratio combinations analysed for classification of defoliated areas."

Outbreaks - 2a

146. Hall, R.J.; Still, G.N.; Crown, P.H. 1983. **Mapping the distribution of aspen defoliation using Landsat color composites.** Can. J. Remote Sens. 9(2): 86-91.

"The Northern Forest Research Centre of the Canadian Forestry Service monitors forest pest conditions in conjunction with other agencies. The forest tent caterpillar (*Malacosoma disstria* Hübner) is considered to be the most important defoliator of aspen timber in central-western Canada. Annual monitoring of defoliation is accomplished primarily by aerial observation and sketch-mapping surveys, which are quick and timely but commonly result in overestimates of affected areas and are impractical for remote areas. To acquire more complete information, a study was conducted to assess the applicability of visual image analysis of multidate LANDSAT color composites in mapping the distribution of defoliated aspen. The map produced from the

interpretation of the LANDSAT imagery more accurately delineated the affected areas than did the aerial survey map. Satellite imagery also provides a potential means to study extensive and remote areas, if the methodology used is modified, and can be useful in planning future aerial surveys. Further work and an operational trial are outlined."

Outbreaks - 2a

147. Hanec, W. 1966. **Cold-hardiness in the forest tent caterpillar, *Malacosoma disstria* Hübner.** J. Insect Physiol. 12(11): 1443-1449.

"The seasonal variations in glycerol content and supercooling temperatures in the eggs of the forest tent caterpillar, *Malacosoma disstria* Hübn., were investigated. Glycerol accumulated in the autumn and early winter and reached a peak in January when 35.2 per cent (dry weight basis) was recovered from eggs and decreased to <1.0 per cent during the post-diapause stage in spring just before hatching. Temperatures between 10 and 32.2°C caused a rapid decrease in glycerol during post-diapause. At 5°C the glycerol concentration decreased more slowly and the eggs did not hatch. Supercooling temperatures of -29.5°C were recorded for summer eggs, the lowest supercooling temperatures occurred from November to April, when they ranged from -32.6 to -40.8°C, and did not increase until a few days before hatching after exposure to warm spring temperatures. The concentration of glycerol is not completely correlated with cold-hardiness; accordingly other factors additional to glycerol are presumably involved. Approximately 80 per cent of newly hatched unfed larvae survived for 10 days at -1.0 to 15°C, but below and above this range survival was low."

Biology - 4

148. Hanec, W.; Prentice, R.M. 1962. **The effect of low temperatures on the hatching and survival of the forest tent caterpillar, *Malacosoma disstria* Hbn.** Proc. Entomol. Soc. Manit. 18(0): 43.

“The forest tent caterpillar is resistant to 5°F until about three days prior to commencement of hatching. At this stage 12 days of cold treatment are required to reduce survival to 50 per cent. Newly-hatched larvae are quite susceptible to low temperatures. Survival is greatest at 20°F to 25°F. Lower temperatures are lethal probably due to the cold factor and at higher temperatures, mortality may be due to starvation. Hatching occurs when the temperature rises to 50°F or higher.”

(Entire reference included in annotation.)

Biology - 6

149. Hardy, G.A. 1943. **Field observations on the forest tent caterpillar, *Malacosoma disstria* var. *erosa* Stretch.** Proc. Entomol. Soc. B.C. 40(0): 28-29.

General observations were made on *Malacosoma disstria* in the vicinity of Lac la Hache in the Cariboo District of British Columbia in 1942. Most aspens (*Populus tremuloides*) in the area were completely defoliated, while adjacent willow, alder, birch, dogwood and rose also suffered. Buffalo berry (*Shepherdia canadensis*) and silverberry (*Elaeagnus argentea*) were completely ignored by the feeding

caterpillars, but were freely employed to support their cocoons. Examination of 100 cocoons gathered at random showed 44 to contain parasitized larvae. Twenty-six of the pupae were also parasitized, while the remaining 30 pupae appeared to be free from parasites.

Biology - 1,2; Outbreaks - 3,4c

150. Hargitt, C.W. 1926. **Studies in behaviorism.** Proc. Indiana Acad. Sci. 35(0): 269-273.

"The article comprises a brief resume of the writer's experimental studies, citing the caterpillar *Euproctis* (*Porthesia*) *chrysorrhoea*, claimed as a classic type of organism exhibiting tropic reactions. Following this are described observations upon 2 species of caterpillars, *Malacosoma americana* and *M. disstria*. Their habits have much in common with the former, but their behavior shows marked differences. Living often in the same region, indeed on adjacent trees, one feeding by day, the other by night, conviction was forced that no one tropic agent, nor any combinations of tropisms, sufficed to afford a key to the behavior."

Biology - 1

151. Harmsen, R; Rose, M.R. 1984. **Habitat effects on larval mortality in the forest tent caterpillar, *Malacosoma disstria* (Lepidoptera: Lasiocampidae).** Proc. Entomol. Soc. Ont. 114(0): 87-89.

Larvae of *Malacosoma disstria* are difficult to find in the periods between outbreaks. The authors were unable to collect them between outbreaks from dry upland areas in Canada but could collect them from wet lowland areas during this stage of the cycle. A differential-mortality hypothesis was used in a general model for insect outbreaks published by the authors. Experiments with artificial infestations on aspen (*Populus)* in Ontario in 1978 indicated that survival was higher in a lowland habitat than in upland ones, possibly as a result of habitat selection on the part of parasites and predators.

Host Relationships - 1; Outbreaks - 5

152. Harmsen, R.; Rose, M.R.; Woodhouse, B. 1976. **A general mathematical model for insect outbreak.** Proc. Entomol. Soc. Ont. 107(0): 11-18.

“Elementary catastrophe models are well suited to represent insect outbreak dynamics. The model takes various control parameters into account and stresses the importance of stochastic inputs. Forest tent caterpillar outbreaks may occur when populations escape from ecologically confining refugia and disperse over the entire habitat. Outbreak and refugia-contained populations may be represented by different parts of the attractor sheets of the elementary catastrophe cusp manifold, determined by $\varepsilon X = -(x^3 + ax + b)$. Slow equations for outbreak dynamics on the cusp are $A = -c_1(x + 3)^2 + c_2(b + 3)^2$ and $B = -c_3a(x + 3) + c_4(x + 3) - c_5(b + 3)$.”

Outbreaks - 5,6

153. Harper, J.D. 1974. **Forest insect control with *Bacillus thuringiensis* - survey of current knowledge.** University Printing Service, Auburn Univ., Auburn, Ala. pp. 35-37.

"Based on the relatively limited number of tests, *B.t.* [*Bacillus thuringiensis*] appears to be extremely effective against tent caterpillars. All of the species treated have shown good responses. Most reports indicate that larvae respond very rapidly to infection following ingestion of *B.t.* Larvae are seen to drop from the foliage in a moribund condition. Apparently, the tent caterpillar is extremely sensitive to the *B.t.* endotoxin, with gut disruption occurring very quickly, resulting in near total paralysis. Excellent control should thus be obtainable providing adequate coverage is achieved. Relatively low dosages of 2.0 to 4.0 BIU / acre can provide control if the above condition is met."

Control - 3

154. Harper, J.D.; Abrahamson, L.P. 1979. **Forest tent caterpillar control with aerially applied formulations of *Bacillus thuringiensis* and Dimilin.** J. Econ. Entomol. 72(1): 74-77.

"Field tests were conducted annually from 1973 through 1976 to determine effectiveness of aerially applied formulations of *Bacillus thuringiensis* Berliner (Dipel® and Thuricide®) and Dimilin® (1-(4 chlorophenyl)-3-(2,6 difluorobenzoyl)-urea) for control of *Malacosoma disstria* Hübner that infests water tupelo, *Nyssa aquatica* L., forests in southwestern Alabama. Heavy larval mortality and prevention of >20% net foliage loss were obtained on 4.0- and 8.1- ha plots with Dipel WP at 8.6 BIU / ha, Dipel LC at 4.8 and 9.6 BIU / ha, Thuricide 16B at 9.6 BIU / ha, Dimilin W-25 at 34-215 g / ha, and Dimilin 2-F at 34-134 g / ha."

Control - 3,6

155. Harper, J.D.; Hyland, J.R. 1981. **Patterns of forest tent caterpillar defoliation in southwest Alabama - 1973-1979.** J. Ala. Acad. Sci. 52(1): 25-31.

"An aerial survey of about 100 000 ha of bottomland hardwood forest in the Mobile-Tensaw River basin and the lower Alabama and Tombigwee River basin of south-western Alabama was conducted in 1973-79 to determine the extent of defoliation of water tupelo (*Nyssa aquatica*), sweetgum (*Liquidambar styraciflua*) and blackgum (*N. sylvatica* var. *biflora*) by *Malacosoma disstria* Hbn. The area of defoliation in different years varied from 11 240 to 36 891 ha. The areas of heaviest defoliation alternated biennially within the ecosystem."

Outbreaks - 1,3

156. Harris, J.D.F. 1979. **Intermitochondrial bridge junctions in fat body cells of the pre-hatch larvae of the forest tent caterpillar *Malacosoma disstria* Hbn.** Eur. J. Cell Biol. 19 (2): 131-133.

"An electron microscopic feature of fat body cells of diapausing *Malacosoma disstria* pre-hatch caterpillars, experimentally held at certain controlled time-and-temperature conditions, is an elaborate bridge junction between mitochondria, strikingly similar in appearance to the septate

junction which has frequently been described as occurring between cells of many invertebrate species. It is suggested that the internitochondrial junctions may well represent elaborate forms of interaction between organelles in order to enhance metabolic efficiency in times of stress."

Biology - 1,4

157. Harvey, G.T.; Sohi, S.S. 1985**. Isozyme characterization of 28 cell lines from five insect species**. Can. J. Zool. 63(10): 2270-2276.

"Correct identity of cell lines is essential for their use in any investigation; isozyme patterns of cell cultures can give reliable identification. Starch gel electrophoresis was used to develop isozyme profiles of 8 hymenopteran and 20 lepidopteran cell lines and of the insect species from which they were developed. Species identity of 26 of the cell lines [including IPRI-MD-66 from *Malacosoma disstria*] was confirmed. For nine of the cell lines these results support the identity established by serological and chromosomal analyses. For the remaining cell lines they provide the first confirmation of species identity. Isozyme profiles of several cell lines from the same species showed unique characteristics that will be useful in monitoring their identity. Two cell lines (IPRI-OL-7 and IPRI-OL-11) considered to be from *Orgyia leucostigma* appear to contain isozymes of *Choristoneura fumiferana*. Other supporting evidence and possible causes of this contamination are discussed. These results demonstrate the usefulness of isozyme profiles for the identification and monitoring of cell cultures."

Biology - 7

158. Hawtin, R.E.; King, L.A.; Possee, R.D. 1992. **Prospects for the development of a genetically engineered baculovirus insecticide.** Pestic. Sci. 34 (1): 9-15.

"Baculoviruses are insect-specific pathogens which have been employed for the natural control of insect pests for many years. They present an alternative to the use of chemical agents for crop protection. Their restricted host range enables particular pest species to be targeted, and this prevents any loss of beneficial insects from a treated area. However, their large-scale development as insect control agents has been limited because they take longer to kill the host following infection than rapidly-acting chemical insecticides. The aim of genetic modification of baculoviruses is to increase their speed of action, while preserving their beneficial characteristics, so creating a fast-acting, environmentally friendly insecticide. The prospects for achieving this are discussed in this paper, with consideration of scientific progress and the influence of economic and legislative factors."

Control - 3

159. Hayashi, Y. 1968. **Constitution of the ribosomal fraction from the forest-tent-caterpillar (*Malacosoma disstria*) midgut infected with a cytoplasmic-polyhedrosis virus.** J. Invertebr. Pathol. 12(3): 468-70.

Sedimentation profiles of *M. disstria* midgut cells infected with cytoplasmic polyhedrosis virus (CPV) were compared with profiles from uninfected cells and virus particles suspended in a sucrose gradient. Newly synthesized virus could be identified from the profiles, and the author suggests that this technique could be used to determine where viral protein synthesis takes place in the cells.

Biology - 3

160. Hayashi, Y. 1970. **Occluded and free virions in midgut cells of *Malacosoma disstria* infected with cytoplasmic-polyhedrosis virus (CPV).** J. Invertebr. Pathol. 16(3): 442-450.

"The proportion of occluded virions and free virions in infected midgut cells of *Malacosoma disstria* was determined at advanced stages (10 days) of cytoplasmic-polyhedrosis virus infection. In infected cells, less than 30% of the virions were occluded within polyhedral bodies, and more than 70% were found as free forms. In virus with uridine-^{3}H, it was found that free virions were labeled more quickly than those occluded in the polyhedra. Occlusion of virions within the protein matrix of the polyhedral inclusion body did not occur until 5-10 hr after the appearance of free virions."

Biology - 3

161. Hayashi, Y.; Bird, F.T. 1968. **The use of sucrose gradients in the isolation of cytoplasmic-polyhedrosis virus particles.** J. Invertebr. Pathol. 11(1): 40-44.

"Sucrose density gradients were used to isolate both free virus from midgut cells of the forest tent caterpillar, *Malacosoma disstria*, infected with a cytoplasmic-polyhedrosis virus, and virus released when polyhedra were dissolved in weak alkali. Electron micrographs showed a high degree of purity of the virus preparations, and ultraviolet absorption spectra demonstrated typical nucleoproteins."

Biology - 3

162. Hayashi, Y.; Cunningham, J.C. 1971. **The release of viral genome RNA from virions of the cytoplasmic-polyhedrosis virus of *Malacosoma disstria* by acetone treatment.** J. Invertebr. Pathol. 17(3): 433-439.

"Acetone treatment of the CPV of *Malacosoma disstria* released the viral genome RNA from nonoccluded virions, virions liberated from polyhedra by alkali treatment, and virions still occluded in polyhedra; in the third case the RNA was retained within the polyhedra until they had been dissolved by alkali treatment. The components were separated by sucrose gradient centrifugation; typical 15 and 12S viral RNA samples were obtained by this method. Acetone treatment may prove useful for the extraction of double-stranded RNA from virus-infected tissues."

Biology - 3

163. Hayashi, Y.; Donaghue, T.P. 1971. **Cytoplasmic polyhedrosis virus: RNA synthesized *in vivo* and *in vitro* in infected midgut.** Biochem. Biophys. Res. Commun. 42(2): 214-221.

"RNA synthesized *in vivo* and *in vitro* in [*Malacosoma disstria*] midgut infected with CPV is analyzed. Both single- and double-stranded RNA can be synthesized *in vivo*, but only single-stranded RNA *in vitro*. The genome of cytoplasmic polyhedrosis virus (CPV) in insects is accepted as double-stranded RNA. However, irrespective of the extraction procedure employed, no intact genome molecules have been obtained. It was found that the extracted genome RNA fragments fell into a size distribution with two maxima, which was highly reproducible. These RNA fragments proved by a number of criteria to be double-stranded and not produced by random breaks in the molecule. During virus development it would be expected that virus-specific, single-stranded messenger RNA must result from the transcription of the parental genome in infected cells. It is the purpose of this communication to report on the detection of virus-specific single- and double-stranded RNA in infected cells. Further, the products which are synthesized *in vitro* by virus-induced RNA polymerase are characterized to identify the possible significance of RNAs produced *in vivo*."

Biology - 3

164. Hayashi, Y.; Durzan, D.J. 1971. **Amino acid composition of proteins extracted from virions of cytoplasmic-polyhedrosis virus.** J. Invertebr. Pathol. 18(1): 121-126.

"The ratio of basic to acidic amino acids in protein from free virions of CPV of *Malacosoma disstria* was 0.26, while that of occluded virions liberated from the polyhedra was 0.43. The ratio in free virions of CPV of *Orgyia leucostigma* was 0.39. This suggests that the virions of *O. leucostigma* reach a more advanced stage of maturity before occlusion than do those of *M. disstria*. By comparison, the composition of the free virions of *O. leucostigma* CPV was remarkably similar to that of the midgut protein of host cells. On the other hand, the composition of ribosomes of *M. disstria* was significantly different from either free or occluded virions of *M. disstria* CPV. Protein amino acids from virions of *Bombyx mori* differed from those of virions of other hosts in content of basic amino acids yielding a ratio of 0.68. These characteristics help to identify the viral strains and support previous serological studies reported with these proteins."

Biology - 3

165. Hayashi, Y.; Krywienczyk, J. 1972**. Electrophoretic fractionation of cytoplasmic polyhedrosis genome.** J. Invertebr. Pathol. 19(1): 160-162.

The article compares the cytoplasmic polyhedrosis virus (CPV) isolated from the forest tent caterpillar, *Malacosoma disstria*, and the CPV isolated from the silkworm, *Bombyx mori*. The fragments of the double-stranded RNA (dsRNA) from each of the two CPVs were resolved using polyacrylamide gel electrophoresis. The dsRNA of each CPV split into two groups: a slowly migrating group, and a quickly migrating group. However, *M. disstria* CPV had 16 bands while the *B. mori* CPV had only nine. This indicates that the two CPVs are different viruses. Indeed, the molecular weights of the two CPVs were very different, also indicating that they were two distinct viruses.

Biology - 3

166**.** Hayashi, Y.; Retnakaran, A. 1970. **The site of RNA synthesis of a cytoplasmic-polyhedrosis virus (CPV) in *Malacosoma disstria*.** J. Invertebr. Pathol. 16(1): 150-151.

The intracellular site of CPV-RNA synthesis in the midgut cells of *Malacosoma disstria* was studied by infecting fourth instar larvae with CPV and later treating infected fifth instar larvae with actinomycin D and ^{3}H-uridine. RNA was precipitated out of the nuclei and cytoplasm of the midgut cells and the radioactivity was measured. RNA extracted from healthy insects had very low radioactivity indicating that host RNA synthesis was blocked to a great extent. High incorporation was observed in the nuclei of infected midgut cells, however, significantly less incorporation was observed in the cytoplasm. Results of autoradiographs of midgut cells of infected and healthy larvae confirmed the original finding that RNA synthesis occurs mainly in the nucleus. It was concluded that CPV-RNA synthesis occurs primarily in the nucleus, but a minimal amount of synthesis also occurs in the cytoplasm. It was not determined if the former synthesis represented the initial phase of viral RNA formation and the latter the final phase of viral RNA synthesis.

Biology - 3

167. Hebert, P.D.N. 1983. **Egg dispersal patterns and adult feeding behaviour in the Lepidoptera.** Can. Entomol. 115(11): 1477-1481.

"The adults of many Lepidoptera augment carbohydrate and protein reserves accumulated during larval life by feeding on nectar or sap flows. However, the adults of other species have non-functional mouthparts. The feeding behaviour of the species in a particular family or subfamily tends to be stereotyped. Thus in some taxa nearly all of the species have functional mouthparts in the adult stage, while in other taxa the mouthparts are aborted. In those taxa whose adults feed, eggs are nearly always laid singly or in pairs. By contrast a significant proportion of the species whose adults fail to feed lay their eggs in clusters. This shift in egg laying behaviour can be explained by recognizing that an increased proportion of the energy reserves stored during larval life can be directed towards egg production if females engage in limited flight."

Biology - 1

168. Heimpel, A.M. 1955. **The pH in the gut and blood of the larch sawfly, *Pristophora erichsonii* (Htg.), and other insects with reference to the pathogenicity of *Bacillus cereus* Fr. and Fr.** Can. J. Zool. 33(2): 99-106.

"Regional pH measurements in the gut and the blood of 11 species of Hymenoptera and two of Lepidoptera [including *Malacosoma disstria*] were made. The larvae were examined in their later instars, after ecdysis, after starvation, or as mature larvae. The gut pH was found to change regionally during development and under these different conditions, but the blood pH tended to remain relatively unchanged. The pH in the gut and of the blood of the larch sawfly was found to be close to the optimum for good growth of *B. cereus* and was within the optimum activity range of the enzyme lecthinase in the anterior two-thirds of the mid-gut and in the blood. This apparently holds for most of the sawfly species examined and for *Carpocapsa pomonella*, but not for those Lepidoptera examined." [The *B. cereus* examined in this paper may have been a subspecies of *B. thuringiensis*, as there is still some confusion over the nomenclature and identification of the two bacteria. The bacteria examined here were not deleterious when fed to *M. disstria* larvae, but did cause mortality when injected into the larvae.]

Biology - 3; Control - 3

169. Heimpel, A.M. 1958. **Notes on methods for rearing two Canadian forest insects [*Pristiphora erichsonii* and *Malacosoma disstria*].** Annu. Rep. Entomol. Soc. Ont. [later Proc. Entomol. Soc. Ont.]. 88(0): 42-43.

In an attempt to rear larvae in the laboratory, the author collected egg masses which were kept at 32°F until December. The egg masses were then brought to room temperature and moistened twice daily. Hatching occurred in two to six days and a head of lettuce was then placed into each dish. Colonies of larvae hatching from each egg mass were reared separately from colonies obtained from other egg masses. Any diseased colonies were destroyed to ensure healthy rearings. Once larvae reached the third instar on the leaf lettuce, they were transferred to pin cherry foliage that was two to five weeks old. There they established readily and continued development. Since the object of the study was to rear larvae, no observations were made on the rearing of pupae or adults. The foliage the larvae fed on was obtained by keeping saplings outdoors until November, then holding them in a 65-70°F greenhouse from November through to December, at which time leaves had grown to an appropriate size for the larvae to feed on.

Biology - 6

170. Heimpel, A.M.; Angus, T.A. 1959. **The susceptibility of certain geometrids to crystalliferous bacteria.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 15(6): 20.

Some field and laboratory experiments were conducted to determine the effectiveness of *Bacillus entomocidus* var. *entomocidus*, *B. thuringiensis* var. *thuringiensis* and *B. thuringiensis* var. *sotto* against the western hemlock looper (*Lambdina fiscellaria lugubrosa*) and the oak looper (*L. f. somniaria*). In addition, a limited field trial was conducted using *B. thuringiensis* var. *thuringiensis* against *L. fiscellaria fiscellaria*. All three species were susceptible to the bacteria used, but the larvae took significantly longer (100-200 hr.) to die than other Lepidoptera (e.g., *Malacosoma disstria* 48-96 hr.). For the field trial against *L. f. fiscellaria*, a suspension of 2 1/2 lb./100 gal. of commercial microbial insecticide caused a reduction of 80-90% in the population in 10 days.

Biology - 3; Control - 3

171. Heinrich, B. 1979. **Foraging strategies of caterpillars - leaf damage and possible predator avoidance strategies.** Oecologia 42(3): 325-337.

"An analysis of the foraging behaviors of several species of palatable and unpalatable lepidopterous larvae indicates that palatable caterpillars partition their time between feeding and behaviors that could be related to escape visually oriented predators. Depending on the species, palatable caterpillars do all or several of the following: 1) restrict themselves to the underside of leaves at all times, 2) restrict foraging to night-time, 3) commute to and from their feeding area on leaves, 4) move from the unfinished leaf to a distant leaf after a feeding bout, thus removing themselves from the evidence of their eating, 5) snip off partially-eaten leaves after feeding on them. The less palatable, or unpalatable, caterpillars [including *Malacosoma disstria*] do not snip off partially-eaten leaves, feed from leaves leaving tattered edges, and are often exposed resting and feeding on the leaf surfaces in direct sunshine. I conclude that some caterpillar foraging behaviors may have evolved under the selective pressure of visually-oriented predators that use leaf-damage as a cue in their searching behavior."

Biology - 1

172. Hemming, J.D.C.; Lindroth, R.L. 1995. **Intraspecific variation in aspen phytochemistry: effects on performance of gypsy moths and forest tent caterpillars.** Oecologia 103(1): 79-88.

"Individual quaking aspen [*Populus tremuloides*] trees vary greatly in foliar chemistry and susceptibility to defoliation by gypsy moths and forest tent caterpillars. To relate performance of these insects to differences in foliar chemistry, we reared larvae from egg hatch to pupation on leaves from different aspen trees and analyzed leaf samples for water, nitrogen, total nonstructural carbohydrates, phenolic glycosides, and condensed tannins. Larval performance varied markedly among trees. Pupal weights of both species were strongly and inversely related to phenolic glycoside concentration. In addition, gypsy moth performance was positively related to condensed tannin concentrations, whereas forest tent caterpillar pupal weights were positively associated with leaf nitrogen concentrations. A subsequent study with larvae fed aspen leaves supplemented with the phenolic glycoside tremulacin confirmed that the compound reduced larval performance. Larvae exhibited increased stadium durations and decreased relative growth rates and food conversion efficiencies as dietary levels of tremulacin increased. Differences in performance were more pronounced for gypsy moths than for forest tent caterpillars. These results suggest that intraspecific variation in defensive chemistry may strongly mediate interactions between aspen, gypsy moths and forest tent caterpillars in the Great Lakes region, and may account for differential defoliation of aspen by these two insect species."

Host Relationships - 1

173. Hildahl, V. 1951. **Forest tent caterpillars, *Malacosoma disstria* Hbn.** Dep. Agric. Can., Sci. Serv., Div. Biol., Bi-mon. Prog. Rep. 7(6): 2-3.

Egg mass surveys conducted in the fall of 1951 indicated that the forest tent caterpillar infestations would increase in size as populations increased in the forested areas of Saskatchewan and Manitoba. In Manitoba, results of egg surveys completed in November 1951, show that light to severe defoliation is likely to occur in southeastern Manitoba. Complete defoliation is again expected in Saskatchewan.

Outbreaks - 1, 2b

174. Hildahl, V.; Campbell, A.E. 1975. **Forest tent caterpillar in the prairie provinces.** Can. For. Serv., North. For. Res. Cent., Inf. Rep. NOR-X-135. 12 p.

This is an excellent comprehensive study of the forest tent caterpillar, *Malacosoma disstria*, as it occurs in the provinces of Alberta, Saskatchewan and Manitoba (most often as a pest of *Populus tremuloides*). The article includes general background, observations on population cycling, outbreak history, host relationships, life stages and life history, feeding habits, damage, and natural and artificial control.

Biology - 1,2,3; Outbreaks - 1,3; Control - 2,3

175. Hildahl, V.; Reeks, W.A. 1960. **Outbreaks of the forest tent caterpillar, *Malacosoma disstria* Hbn., and their effects on stands of trembling aspen in Manitoba and Saskatchewan.** Can. Entomol. 92(3): 199-209.

A review is made of the pattern of attacks in Manitoba and Saskatchewan between 1923-53, and the effects are discussed of the latest outbreak on the stands. The outbreaks of the early 1950s ended abruptly and did not cause appreciable mortality. Increment loss, however, in stands covering ca. 1.5 million acres in the two provinces is estimated at 8.4% of the total basal area.

Outbreaks - 1,3

176. Hiratsuka, Y.; Cerezke, H.F.; Moody, B.H.; Petty, J.; Still, G.N. 1982. **Forest insect and disease conditions in Alberta, Saskatchewan, Manitoba, and the Northwest Territories in 1981 and predictions for 1982.** Environ. Can., Can. For. Serv., North. For. Res. Cent., Inf. Rep. NOR-X-239. pp. 2-4.

No new major forest insect or disease problems developed in 1981 in the three prairie provinces and the Northwest Territories. Large areas of moderate to severe defoliation caused mostly by the forest tent caterpillar were again prominent in the region. Estimated defoliated areas totaled 121 000 km^2 in Alberta, 82 000 km^2 in Saskatchewan, 1000 km^2 in the Northwest Territories, and less than 1000 km^2 in western Manitoba.

Outbreaks - 1,3

177. Hiratsuka, Y.; Cerezke, H.F.; Petty, J. 1980. **Forest insect and disease conditions in Alberta, Saskatchewan, Manitoba and the Northwest Territories in 1979 and predictions for 1980.** Environ. Can., Can. For. Serv., North. For. Res. Cent., Inf. Rep. NOR-X-225 5 p.

"No major forest insect or disease problems developed in 1979 in the three Prairie Provinces and the Northwest Territories...The area of aspen defoliation in Alberta by the forest tent caterpillar and some other aspen defoliators was similar or that reported in 1978, and no population decline is predicted for 1980. In Saskatchewan the area of severe outbreak of forest tent caterpillar increased markedly and encompasses 6,800,000 ha. The main areas of infestation were in central and southern Saskatchewan, and this is expected to continue in 1980."

Outbreaks - 1

178. Hiratsuka, Y.; Cerezke, H.F.; Petty, J.; Still, G.N. 1981. **Forest insect and disease conditions in Alberta, Saskatchewan, Manitoba, and the Northwest Territories in 1980 and predictions for 1981.** Environ. Can., Can. For. Serv., North. For. Res. Cent., Inf. Rep. NOR-X-231. pp. 4-6.

No major or significant forest insect or disease problems developed in the prairie provinces and Northwest Territories in 1980. In Alberta, aspen defoliation by the forest tent caterpillar and associated aspen defoliators increased to cover 75 000 km^2, and a similar level of infestation was expected for 1981. In Saskatchewan, trembling aspen stands covering 128 000 km^2 were affected by moderate to severe forest tent caterpillar defoliation. A general population decline was indicated for 1981 in west-central Saskatchewan, but continued high populations were expected in the eastern and extreme western parts of the province. Forest tent caterpillar defoliation in Manitoba occurred in limited areas in Turtle Mountain Provincial Park.

Outbreaks - 1,3

179. Hodges, R.W.; Dominick, T.; Davis, D.R.; Ferguson, D.C.; Franclemont, J.G.; Munroe, E.G. 1983. **Check list of the Lepidoptera of America North of Mexico (including Greenland).** Univ. Press, Cambridge, U.K. 294 p.

This book provides a list of lepidopteran species and synonymies.

Taxonomy

180. Hodson, A.C. 1939a. **Biological notes on the egg parasites of *Malacosoma disstria* Hbn.** Ann. Entomol. Soc. Am. 32(1): 131-136.

Egg parasites of the forest tent caterpillar were reviewed as part of an ecological study on *Malacosoma disstria.* Egg masses were collected from various localities in Northern Minnesota and the following parasites were isolated: *Ablerus clisiocampae* Ashm., *Trichogramma evanescens* Westw., *Oöencyrtus clisiocampae* Ashm., *Tetrastichus sylvaticus* Gahan, and *Telenomus clisiocampae* Ashm. The latter three species were present in nearly all of the collections. Rearing records showed that none of these parasites were very important natural enemies of *M. disstria.* Although nearly every egg mass had been attacked by parasites, average percent egg parasitism was low. The author presented various explanations for this phenomenon, but felt that it was the factors associated with oviposition and egg mass construction that contributed to the wide distribution but low attack rate per egg mass.

Biology - 2

181. Hodson, A.C. 1939b. ***Sarcophaga aldrichi* Parker as a parasite of *Malacosoma disstria* Hbn**. J. Econ. Entomol. 32(3): 396-401.

"Field observations and cocoon examinations have demonstrated that *Sarcophaga aldrichi* attacks *Malacosoma disstria* at the time when the caterpillars are constructing their cocoons and pupating. The life cycle of the parasite is adjusted in such a manner that the flies are ready to larviposit when the first cocoons appear in the field. They produce only one generation a year because of a long period of dormancy after leaving the host. They attack perfectly normal larvae and pupae in their cocoons and are not limited to parasitized or diseased hosts. *S. aldrichi* enters into direct competition with the other parasites and destroys them when they chance to occur in the same host. This species will breed in carrion, mashed caterpillars and other organic material. From the above evidence it may be classed as a facultative parasite which is bridging the ground between a specialized parasite and an exclusive scavenger."

Biology - 2

182. Hodson, A.C. 1941. **An ecological study of the forest tent caterpillar *Malacosoma disstria* Hbn., in northern Minnesota.** Minn. Agric. Exp. Sta., Tech. Bull. No. 148. 55 p.

The forest tent caterpillar (*Malacosoma disstria* Hbn.) is periodically a pest of deciduous trees in many parts of the United States and Canada. An outline of the life history of the moth is given, with particular reference to its seasonal activities in Minnesota. The principal host appears to be *Populus tremuloides*, but *Acer saccharum*, *Tilia americana, Quercus borealis*, *Q. macrocarpa Betula papyrifera* and

Ulmus americana are also readily attacked. Red maple (*Acer rubrum*) seems, however, to be consistently avoided by feeding caterpillars, although its leaves are sometimes used by the larvae when constructing their cocoons. Various methods of making population surveys are described (the results of the 1936-38 surveys being given), and a method is indicated whereby the amount of defoliation probable in the following year may be predicted by an egg survey and a knowledge of tree characteristics. Control may be brought about by a variety of natural forces such as unfavourable temperature conditions or the action of parasites.

Biology - 1,2,3,4; Host Relationships - 1; Outbreaks - 1,2b,3,4abcd,5

183. Hodson, A.C. 1942. **Biological notes on the basswood leaf-miner, *Baliosus ruber* (Weber).** J. Econ. Entomol. 35(4): 570-3.

Leaves of basswood (*Tilia americana*) are attacked throughout its range in North America by *Baliosus ruber* in both the larval and adult stages. An outbreak of the insect has been almost continuous in part of Minnesota since 1935, and while many trees have been considerably weakened, few have died, even where feeding has been heaviest. This insect has also been recorded as a pest of apple and oak in the United States, but oaks in a mixed stand containing infested basswood were only very slightly damaged. An account is given of the feeding habits and life history of the insect, and the author discusses the relation between population density and degree of damage, and also the control given by undetermined Hymenoptera that parasitized 100, 98.8, 66.6 and 47.5 per cent of the eggs in four localities in 1940. Basswood trees in a stand that had been treated with a spray of 2.5 lb. lead arsenate and 1 U.S. pint raw linseed oil per 100 U.S. gal. for the control of *Malacosoma disstria* were free from larval mines and showed only very light adult feeding, whereas damage was heavy in a neighbouring unsprayed stand.

Control - 6

184. Hodson, A.C. 1943. **Birds feeding on forest insects.** Flicker 15(4): 50-51.

During the summer of 1937 a large flock of crows were observed feeding on cocoons of the forest tent caterpillar on the boundary of Itasca State Park. It was estimated that they destroyed 20% of the cocoons in the stand. For three weeks there were no further observations of more than two crows at one time feeding on cocoons.

Biology - 2

185. Hodson, A.C. 1977. **Some aspects of forest tent caterpillar population dynamics.** Pages 5-16 *in* H.M. Kulman and H.C. Chiang (eds.). Insect ecology: Papers presented in the A.C. Hodson Ecology Lectures. Agric. Exp. Sta. Univ. Minn., Tech. Bull. No. 310.

The course of a forest tent caterpillar outbreak from its beginning in 1948 to its termination in 1959 is followed, with special attention given to a number of geographical and temporal changes. The important aspects covered are shifts in population numbers, changes in fecundity as represented by egg band size, defoliation history, pupal parasitism, and weather-induced mortality. Light trap records were taken at 19 sites in the infested area to follow adult population trends.

Biology - 2,4; Outbreaks - 1,4d,5

186. Hodson, A.C.; Weinman, C.J. 1945. **Factors affecting recovery from diapause and hatching of eggs of the forest tent caterpillar, *Malacosoma disstria* Hbn.** Minn. Agric. Exp. Sta., Tech. Bull. No. 170. 31 p.

"A study of the effect of temperature on the termination of an embryonic diapause of *Malacosoma disstria* has shown that the diapause lasts for about three months after embryonic development is complete...When the histological changes associated with yolk absorption were compared with hatching data it became evident that temperature had little effect on the diapause, and, instead, temperature influenced the course of developments after the diapause was broken...A further study of post-diapause development showed that temperatures covering a range of 10° to 25°C were nearly equally favourable for hatching, the optimum conditions being found in a saturated atmosphere at 15°C...Over the range of favourable temperatures the best moisture conditions were found to lie between relative humidities of 70 and 100 per cent...The eggs of *M. disstria* are not very resistant to desiccation, for hatch was reduced considerably after eight days of drying over calcium chloride at 23° to 26°C, and no hatch took place after 32 days of desiccation. The egg parasites were considerably more resistant to dessication. This experiment offered further evidence that the degree of hardness of the chorion is a determining factor in the escape of the larva from the egg." From authors' summary.

Biology - 4

187. Houseweart, M.W.; Jennings, D.T.; Pease, S.H.; Lawrence, R.K. 1984. **Alternate insect hosts and characteristics of forest stands supporting native populations of *Trichogramma minutum* Riley.** Maine Agric. Exp. Sta. Misc. Rep. No. 300. 32 p.

Alternate hosts are thought to be necessary before *Trichogramma minutum* parasitizes eggs of *Choristoneura fumiferana.* A survey in Maine's forests showed the presence of numerous possible alternate hosts for *T. minutum*, but only 4 major hosts were identified, viz. *Anisota rubicunda, Coleophora serratella, Heterocampa guttivitta,* and *Malacosoma disstria.* Parasitism varied with tree species and position in the crown. Regression analysis of stand data indicated that stands characterized by wet areas with large proportions of tamarack and alder basal area and small proportions of oak, positively influenced *T. minutum* parasitism.

Biology - 2

188. Howse, G.M.; Gross, H.L.; Syme, P.D.; Myren, D.T.; Meating, J.H.; Applejohn, M.J. 1982. **Forest insect and disease conditions in Ontario, 1981.** For. Can., Gt. Lakes For. Res. Cent., Inf. Rep. O-X-339. pp. 9 - 11.

This review of forest insects and diseases in Ontario in 1981 provides detailed information on three important pests of conifers and three of hardwood trees, together with forecasts of conditions for 1982 and notes on many other species. Special surveys and provincial forest insect control programmes are described.

Outbreaks - 1,3

189. Howse, G.M.; Syme, P.D.; Gross, H.L.; Myren, D.T.; Meating, J.H.; Applejohn, M.J.; Smith, K.L. 1983. **Forest insect and disease conditions in Ontario, 1982.** For. Can., Gt. Lakes For. Res. Cent. Inf. Rep. O-X-350. p. 12.

This review of the status of forest insects and diseases in Ontario in 1982 includes detailed reports on the major pests *Choristoneura fumiferana* (Clem.), *Choristoneura pinus pinus* Freeman, and *Neodiprion swainei* (Middleton) on conifers and *Bucculatrix canadensisella* Chamb., *Croesia semipurpurana* (Kearfott), *Lymantria dispar* (L.), and *Malacosoma disstria* Hbn. on deciduous trees. Special surveys on red pine (*Pinus resinosa*) and jack pine (*P. banksiana*) are also reported, as are control programs (with chemical and microbial insecticides) against *Choristoneura fumiferana* and *L. dispar*. Notes are provided on the host-plants, damage to host-plants, and incidence of numerous other pests and diseases.

Outbreaks - 1,3

190. Hulme, M.A.; Green, G.W. 1984. **Ch. 45. Biological Control of Forest Insect Pests in Canada 1969-1980: Retrospect and Prospect.** Pages 215-227 *in* J.S. Kelleher and M.A. Hulme (eds.). Biological control programmes against insects and weeds in Canada 1969-1980. Commonwealth Agric. Bureaux. Page Brothers, Norwich, U.K.

This chapter provides a brief summary of biological control methods that have been attempted against introduced and native forest defoliating insects (including *Malacosoma disstria*), including the use of *Bacillus thuringiensis*, viruses, fungi, parasitoids, and predators.

Control - 3,4

191. Hurley, J.E.; Titus, F.A. 1987. **Summaries of light trap catches for the Maritimes 1976-1986.** Environ. Can., Can. For. Serv., Maritimes For. Res. Cent., Inf. Rep. M-X-163. 34 p.

"This report lists light trap catches for 51 lepidopterous forest insects from 16 locations in the Maritimes form 1976 to 1986, inclusive."

Outbreaks - 4 d

192. Hurpin, B. 1967. **Influence des facteurs du milieu.** Pages 135-161 *in* P.A. van der Laan (ed.). Insect Pathology and Microbial Control. Proc. Internat. Colloq. on Insect Pathology and Microbial Control, Wageningen, the Netherlands, Sept. 5-10, 1966. North Holland Publishing Co., Amsterdam, Netherlands.

This paper discusses the effects of various factors (temperature, humidity, lighting, condition of the host) on the culturing of insect pathogens. There is a brief mention that the developmental stage of an insect can affect the susceptibility of insects to different pathogens. The example given for this is that susceptibility of larval instars of *Malacosoma disstria* to nuclear polyhedrosis diminishes with age.

(In French with English summary.)

Biology - 3

193. Hwang, S.-Y.; Lindroth, R.L. 1997. **Clonal variation in foliar chemistry of aspen: effects on gypsy moths and forest tent caterpillars.** Oecologia 111(1): 99-108.

"Quaking aspen (*Populus tremuloides*) exhibits striking intraspecific variation in concentrations of phenolic glycosides, compounds that play important roles in mediating interactions with herbivorous insects. This research was conducted to assess the contribution of genetic variation to overall phenotypic variation in aspen chemistry and interactions with gypsy moths (*Lymantria dispar*) and forest tent caterpillar (*Malacosoma disstria*). Thirteen aspen clones were propagated from field-collected root material. Insect performance assays, measuring survival, development, growth, and food utilization indices, were conducted with second and/or fourth instars. Leaf samples were assayed for water, nitrogen, total nonstructural carbohydrates, condensed tannins, and phenolic glycosides. Results showed substantial among-clone variation in the performance of both insect species. Chemical analysis revealed significant among-clone variation in all foliar constituents and that variation in allelochemical contents differed more than variation in primary metabolites. Regression analysis indicated that phenolic glycosides were the dominant factor responsible for among-clone variation in insect performance. We also found significant genetic trade-offs between growth and defense among aspen clones. Our results suggest that genetic factors are likely responsible for much of the tremendous phenotypic variation in secondary chemistry by aspen, and that the genetic structure of aspen populations may play important roles in the evolution of interactions with phytophagous insects."

Host Relationships - 1

194. Ives, W.G.H. 1971**. The forest tent caterpillar in Alberta.** Can. For. Serv., North. For. Res. Cent., Inf. Rep. Intern. Rep., NOR-4. 32 p.

"The outbreak history of the forest tent caterpillar is reviewed. The most recent outbreak started in 1957 and lasted until 1970. This outbreak progressed in area and intensity until 1962, peaked in 1963, and collapsed over wide areas in 1964 and has been relatively unimportant since then. Radial growth studies indicated 80 to 90% loss in radial increment after three years severe defoliation. The trees recovered within two years following severe defoliation. Evidence suggests that higher than average overwintering temperatures cause a decrease in populations the following summer. The day degrees above 40°F were higher for the winters (October 27 - April 26) preceding a decrease than they were for the winters preceding an increase. Egg parasitism was not a major mortality factor, although larval and pupal parasitism reached high levels in the older infestations. The role of disease was difficult to determine. Some second instar larvae were found to be infected with a nuclear polyhedrosis virus in 1964, and this may have caused widespread mortality. Disease was also believed responsible for population declines in 1966 in the Lake Wabamum area.

Biology - 2,3,4; Outbreaks - 1,3

195. Ives, W.G.H. 1973. **Heat units and outbreaks of the forest tent caterpillar, *Malacosoma disstria* (Lepidoptera: Lasiocampidae).** Can. Entomol. 105(4): 529-543.

"The numbers of heat units during a fixed overwintering period and a shifting early larval feeding period for the forest tent caterpillar, *Malacosoma disstria* Hübner, were calculated from daily temperature data and related to known infestations of this insect in the Prairie Provinces and Ontario. Paired comparisons showed that years with increasing populations had cooler

overwintering periods and warmer early feeding periods than did those with decreasing populations. Continuous records for each of 10 climatological stations showed that all known infestations in these areas were preceded by a single year (2 to 4 years earlier) with a relatively cold winter and an unusually warm spring, and that most population collapses were accompanied by cool springs and some by warm winters. The same general patterns prevailed for infestations in southern Ontario, when compared with the numbers of heat units at Toronto for the period 1860 to 1969. Some of the assumptions made during the analyses and the possible use of the results in predicting when and where outbreaks are likely to occur are discussed."

Biology - 4

196. Ives, W.G.H. 1981. **Environmental factors affecting 21 forest insect defoliators in Manitoba and Saskatchewan, 1945-69.** Environ. Can., Can. For. Serv., North. For. Res. Cent., Inf. Rep. NOR-X-233. 142 p.

Outbreak histories are presented for 21 forest defoliating insects, including *Malacosoma disstria*. The influences of such environmental factors as weather, small mammals, birds, parasites, invertebrate predators, diseases, and competition from other defoliators are described for various species.

Biology - 2,3,4; Outbreaks - 1

197. Ives, W.G.H. 1984. **Ch. 55. *Malacosoma disstria* Hübner, forest tent caterpillar (Lepidoptera: Lasiocampidae).** Pages 311-319 *in* J.S. Kelleher and M.A. Hulme (eds.). Biological control programmes against insects and weeds in Canada 1969-1980. Commonwealth Agric. Bureaux. Page Brothers, Norwich, U.K.

This chapter gives a detailed summary of research using *Bacillus thuringiensis* (Bt), *Pleistophora schubergi*, *Nosema distriae*, and nuclear polyhedrosis virus to control *Malacosoma disstria*.

Control - 3,4,6

198. Ives, W.G.H.; Muldrew, J.A. 1978. **Preliminary evaluations of the effectiveness of nucleopolyhedrosis virus sprays to control the forest tent caterpillar in Alberta.** Can. For. Serv., North. For. Res. Cent., Inf. Rep. NOR-X-204. 10 p.

"Nucleopolyhedrosis virus sprays were tested in Alberta during 1976 and 1977 to control the forest tent caterpillar, *Malacosoma disstria* Hübner. In 1976, dipping or hand-spraying egg bands in a suspension containing $1x10^8$ polyhedra/mL before the larvae hatched resulted in almost complete larval mortality, while spraying second-instar larvae with a suspension containing $1x10^7$ polyhedra/mL produced 100% mortality in one plot and 97% in the other. Total mortality in the check area amounted to 32%. In 1977, spraying egg bands before the larvae hatched at concentrations of $1x10^8$, $1x10^7$, $1x10^6$, and $5x10^5$ polyhedra/mL caused 100, 94, 81, and 68% mortality, respectively. Virus was also present in the two check areas, where total mortality amounted to 56 and 47%. In 1977 there was evidence of a carry-over of virus in the 1976 experimental area,

particularly in the larval spray plot that had had 100% mortality in 1976. In this plot the mortality reached 75%, while in the 1976 check area it was only 11%. There was evidence that the virus infection had spread as far as 4.6 km."

Control - 4

199. Ives, W.G.H.; Muldrew, J.A.; Smith, R.M. 1982. **Experimental aerial application of forest tent caterpillar baculovirus.** Can. For. Serv., North. For. Res. Cent., Inf. Rep. NOR-X-240. v + 9 p.

Small-scale experimental trials using nuclear polyhedrosis virus for control of *Malacosoma disstria* on *Populus tremuloides* were conducted in Alberta during 1978, 1979, and 1980. Concentrations of virus used ranged from $1x10^5$ to $1X10^9$ polyhedra / mL. Mortality varied with virus concentration, time of application, and larval instar. Some treatments increased total larval mortality by up to 30%, but none provided any foliage protection.

Control - 4

200. Ives, W.G.H.; Wong, H.R. 1988. **Tree and shrub insects of the Prairie provinces**. Environ. Can., Can. For. Serv., North. For. Res. Cent., Inf. Rep. NOR-X-292. p. 136-137.

This brief note covers the distribution, host, importance, life cycle, and appearance of the forest tent caterpillar and includes one page of colour photographs of the various life stages.

General Background

201. Johnson, W.T.; Morris, O.N. 1981. **Cold fog applications of pesticides for control of *Malacosoma disstria.*** J. Arboric. 7(9): 246-251.

"Tests were conducted to determine the effectiveness of a ULV [ultra-low volume] fog generator in dispersing *Bacillus thuringiensis* and Bt-combinations of synthetic organic insecticides in liquid formulations against the forest tent caterpillar, *Malacosoma disstria.* Those formulations containing superior horticultural oil as the carrier gave better control over those in which water was the sole carrier. The water portion of the mist particle was subject to rapid evaporation and appeared to be a major cause for poor control in the system described. The ULV fogger with some mechanical modifications, can be used effectively for application of microbial insecticides to trees. Thuricide 16B combined with acephate in an oil emulsion carrier was highly effective in reducing tent caterpillar populations."

Control - 2,3

202. Jones, J.R.; DeByle, N.V.; Bowers, D.M. 1985. **Insects and other invertebrates.** Pages 107-114 *in* N.V. DeByle, and R.P. Winokur (eds.). Aspen: ecology and management in the western United States 1985. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. RM-119.

This section of the report reviews insect and other invertebrate pests of quaking aspen. Outbreak histories, range, nature of damage caused, alternate hosts, and life cycles of each pest species are discussed.

Biology - 1; Outbreaks - 1,3

203. Jones, J.R.I.L. 1943. **Some food plants of Lepidopterous larvae: List No. 9.** Proc. Entomol. Soc. B.C. 40(0): 27.

The list includes *Acronicta* (*Apatela*) *funeralis* on willow (*Salix scouleriana* and some ornamental species) and Carolina poplar; *A. illita* on *Quercus robur* and *Alnus rubra*; *A. distans dolorosa* on *Alnus rubra*; *Halisidota maculata angulifera* on *Salix hookeriana* and *S. scouleriana* and *Hyphantria textor* on *Salix lasiandra*; *Malacosom[a] disstria erosa* on *Alnus rubra*; *M. pluvialis* on *Prunus emarginata; Nadata gibbosa oregonensis* on *Castanea* sp.; *Phoesia portlandia* on *Salix lasiandra, S. hookeriana, S. scouleriana, Populus trichocarpa,* and *P. tremuloides; Pseudothyatira cymatophoroides* on *Crataegus oxyacantha; Scoliopteryx libatrix* on *Salix lasiandra, S. scouleriana, Populus trichocarpa,* and Lombardy poplar; and *Schizura unicornis* on *Crataegus oxyacantha.*

Biology - 1

204. Karowe, D.N. 1989. **Differential effect of tannic acid on two tree-feeding Lepidoptera: implications for theories of plant anti-herbivore chemistry.** Oecologia 80(4): 507-512.

"Feeding efficiencies of ultimate instar larvae of two polyphagous tree-feeding Lepidoptera, *Malacosoma disstria* (Lasiocampidae) and the *Orgyia leucostigma* (Liparidae [Lymantriidae]), were measured on artificial diets containing from 0 to 8% tannic acid. Relative growth rate (RGR) of *O. leucostigma* was not affected by up to 8% tannic acid, suggesting that *O. leucostigma* has evolved an effective counteradaptation to hydrolyzable tannins. In contrast, as little as 0.5% tannic acid caused a significant reduction in RGR of *M. disstria*, due both to reduced efficiency of conversion of digested food (ECD) and reduced relative consumption rate (RCR), and caused a significant increase in mortality during the pupal stage. Moreover, when reared from hatching on tannin-containing diets, no *M. disstria* larvae survived past the fourth instar. Although tannins are commonly referred to as 'digestibility-reducing substances', tannic acid did not reduce the ability of *M. disstria* or *O. leucostigma* larvae to digest either the whole diet or nitrogen contained in the diet. For *M. disstria*, tannic acid acts as a toxin and a feeding deterrent, but not as a digestibility-reducing substance. Growing evidence that tannins commonly act as toxins warrants a reassessment of their role in anti-herbivore chemistry."

Host Relationships - 6

205. Kawarabata, T.; Hayashi, Y. 1972. **Development of a cytoplasmic polyhedrosis virus in an insect cell line.** J. Invertebr. Pathol. 19(3): 414-415.

Malacosoma disstria cytoplasmic polyhedrosis virus was used to infect Grace's mosquito line (derived from *Aedes aegypti*) so that the formation of viral polyhedra could be observed. The cell culture was

inoculated with virus and uridine-6-H^3, the latter for labeling the virus particles produced. Evidence from the experiment indicated that replication of *M. disstria* cytoplasmic polyhedrosis virus took place in the mosquito cell culture.

Biology - 3,7

206. Keddie, A.; Erlandson, M. 1995. **Characterization of a nuclear polyhedrosis virus from the forest tent caterpillar, *Malacosoma disstria*.** J. Invertebr. Pathol. 65(1): 43-47.

"A nuclear polyhedrosis virus (NPV) isolated from *Malacosoma disstria* larvae was characterized biochemically and immunologically. Restriction enzyme patterns were compared with those of NPV from *M. alpicola* (MaNPV) and *Autographa californica* (AcMNPV). Polyclonal antibodies were made to *M. disstria* NPV and used for immunoblots. This virus isolate, designated MdMNPV, contained virions with multiple nucleocapsids, an estimated genome of 130.4 ± 3.3 kb, and a restriction pattern distinct from that of MaNPV. Immunoblotting detected cross-reactivity among numerous structural proteins of MdMNPV and AcMNPV."

Biology - 3

207. Keddie, B.A.; Erlandson, M.A.; Hilchie, G.J. 1995. **Establishment and characterization of three *Malacosoma disstria* cell lines.** J. Invertebr. Path. 66(2): 136-142.

"Three cell lines were established from *Malacosoma disstria* hematocytes. Although the morphology, growth rates, isozyme patterns, and adherence characteristics of these cell lines (UA-Md203, UA-Md210, and UA-Md221) were different, all supported virus replication (AcMNPV and MdMNPV-A92). One cell line, UA-Md221 was extremely adherent and could not be removed by enzymatic treatment. Few cells were loosened or damaged by 2-hr incubation in trypsin, collagenase or enzyme mixture. We hypothesize that these cells inactivate these enzymes."

Biology - 7

208. Kennedy, H.E., Jr. 1983. **Water tupelo in the Atchafalaya Basin does not benefit from thinning.** U.S. Dep. Agric. For. Serv., South. For. Exp. Sta., Res. Note SO-298. 3 p.

Plots in a 55-yr-old stand of *Nyssa aquatica* [in Louisiana] were thinned to 109, 48, or 27 trees / acre in 1967, or left untreated. Total and merchantable height, diameter above butt swell, crown width, and live crown ratio were recorded at treatment and after 5 and 12 seasons. Residual trees showed no significant growth response to thinning. It was suggested that this could be because of the age of the stand, the small live crown ratio (18-24%) or yearly defoliation by the forest tent caterpillar (*Malacosoma disstria*). The greatest benefit from thinning is probably salvage of trees that would otherwise be lost through mortality.

Outbreaks - 3

209. Kettela, E.G.; Moran, G.V. 1972. **Forest insect and tree diseases in National Parks in the Maritime Provinces, 1971.** Environ. Can., Can. For. Serv., Marit. For. Res. Cent., Inf. Rep. M-X-30. 13 p.

This report includes the results and observations, sampling and special surveys in 1971 in Cape Breton Highlands National Park, Fundy National Park, Kejimkujik National Park , and Prince Edward Island National Park. Within each park, the pests are treated in alphabetical order. In 1971, the spruce budworm continued to be the most important pest in national parks in the Maritimes and for Fundy Park a detailed account is given of its current status, control program, and future prospects. Black-light moth traps were operated by Parks' staff in Fundy and Kejimkujik National Parks during June, July, and August and the numbers of the more common forest insects taken [including *Malacosoma disstria*] are listed in an appendix to this report.

Outbreaks - 1

210. Kim, M.K.; Sisson, G.; Stoltz, D. 1996. **Ichnovirus infection of an established gypsy moth cell line.** J. Gen. Virol. 77(9): 2321-2328.

"In the present study, a lepidopteran cell line (Ld652Y, from the gypsy moth, *Lymantria dispar*) exposed to *Hyposoter fugitvus* polydnavirus (HfPV) was found to display a variety of cytopathic effects. These included a transient inhibition of cell proliferation, rounding up, aggregation and apoptosis. In addition, unusual paracrystalline structures appeared within the lumen of the rough endoplasmic reticulum; similar structures were observed in the spherulocytes of parasitized *Malacosoma disstria.* Following Coomassie Blue staining, two new cell-associated polypeptides were detected; one of these, an 8 kDa polypeptide, could also be observed following exposure of Ld-652Y cells to media taken from infected cultures of to cell-free haemolymph from parasitized *M. disstria.* After a period of 2-4 weeks, the *L. dispar* cell cultures were observed to largely recover from the effects of exposure to virus, and resumed proliferation; 'transformed' cell populations tended to form aggregates, and adhered less tightly to the substrate. Viral DNA was stably maintained in all recovered cell lines, possibly in chromosomally integrated form."

Biology - 3

211. Kleiner, K.W.; Ellis, D.D.; McCown, B.H.; Raffa, K.F. 1995. **Field evaluation of transgenic poplar expressing a *Bacillus thuringiensis cryIA*(*a*) *d*-endotoxin gene against forest tent caterpillar (Lepidoptera: Lasiocampidae) and gypsy moth (Lepidoptera: Lasiocampidae) following winter dormancy.** Environ. Entomol. 24(5): 1358-1364.

"Hybrid *Populus* plants (clone NC 5339) genetically engineered with a *Bacillus thuringiensis cryIA*(*a*) *d*-endotoxin [δ-endotoxin] gene were planted in the field in the summer of 1993 and evaluated for insect resistance 3 times during the 1994 growing season. Foliage of plants containing the gene encoding the *d*-endotoxin elicited reduced feeding in bioassays conducted during June, July, and August. Larvae of forest tent caterpillar, *Malacosoma disstria* Hübner, and gypsy moth, *Lymantria dispar* (L.), feeding on transgenic leaves consumed significantly less foliage and experienced reduced wet-weight gains compared with larvae fed control foliage. Mortality of early 3rd-instar forest tent caterpillar and gypsy moth feeding on transgenic foliage was greater than for larvae feeding on foliage of controls. Mortality of late 3rd-instar gypsy moth feeding on transgenic foliage did not differ from control larvae."

Control - 6

212. Klomp, H. 1979. **Trend prediction in forest insects.** Pages 6-18 *in* W.E. Waters (ed.). Current topics in forest entomology. Selected Papers from the XVth Congress of Entomology, Washington, D.C., Aug. 19-27, 1976. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. WO-8.

This paper deals primarily with mathematical models used to predict population trends in forest insects. However, it does contain a reference to the use of correlation between egg density and larval density in prediction of larval density in the forest tent caterpillar, *Malacosoma disstria* Hbn. The use of this correlation in prediction proved only 65% accurate in the field.

Outbreaks - 6

213. Knight, G.A.; Lavigne, R.J.; Pogue, M.G. 1991. **The parasitoid complex of forest tent caterpillar, *Malacosoma disstria* (Lepidoptera: Lasiocampidae), in eastern Wyoming shelterbelts.** Gt. Lakes Entomol. 24(4): 255-261.

"A parasitoid complex affecting the forest tent caterpillar, *Malacosoma disstria*, was investigated during 1978-79 in shelterbelts in eastern Wyoming. Egg parasitoids included five species: *Ablerus clisiocampae, Ooencyrtus clisiocampae, Telenomus clisiocampae, Tetrastichus* sp. 1 and *Telenomus* sp. Thirteen hymenopterous species and five dipterous species were reared from larvae and pupae of the forest tent caterpillar. The most common 5th-instar larval parasitoids were the tachinid flies *Lespesia archippivora* and *Archytas lateralis*. Of the pupal parasitoids reared, 64% were Diptera and 36% Hymenoptera. Four previously unrecorded parasitoids of *M. disstria* were reared: *Cotesia atalantae, Macrocentrus iridescens, Pimpla sanguinipes erythropus* and *Lespesia flavifrons*."

Biology - 2

214. Krywienczyk, J.; Angus, T.A. 1969. **Some behavioural and serological observations on the response of larvae of *Bombyx mori* and *Malacosoma disstria* to *Bacillus thuringiensis*.** J. Invertebr. Pathol. 14(1): 105-107.

Susceptible insects have one of two responses to *Bacillus thuringiensis*. Type I insects such as the silkworm, *Bombyx mori*, show a rapid inhibition of feeding, increasing alkalinity of hemolymph, and general paralysis by 60 - 90 min after ingestion. Type II insects, such as the forest tent caterpillar, *Malacosoma disstria*, show rapid inhibition of feeding, but the pH of the hemolymph remains constant and general paralysis does not occur. The midguts of Type I insects are damaged much more quickly than those of Type II insects; this may be because of differences in gut structure and composition or because of differences in the gut juice enzymes. To determine which of these differences apply, *B.t.* was dissolved separately in the gut juice of each species and then each mixture fed to larvae of both species. Results showed that "...although the gut juices of different Lepidoptera produce from the same protein some fractions that are antigenically different, the response of an insect (as Type I or Type II) when fed dissolved crystal protein is a quality of the host and is not directly dependent on derived fractions."

Biology - 1,3

215. Krywienczyk, J.; Hayashi, Y. 1971. **Specificity of serological cross-reactions between insect viruses and ribosomes.** J. Invertebr. Pathol. 17(3): 321-326.

"Ribosomes from guinea pig liver, *Cavia cobaya*; frog liver, *Rana pipiens*; midgut of silkworm, *Bombyx mori*; an earthworm, *Lumbricus terrestris*; a bacterium, *Escherichia coli*; a fungus of the genus *Lactarius*; and also the synthetic polyribonucleotides poly A and poly U were serologically compared with the cytoplasmic polyhedrosis viruses from *B. mori*, the tent caterpillar, *Malacosoma disstria* and the tussock moth *Orgyia leucostigma*. The method of double diffusion on cellulose acetate membranes was used. Extensive cross-reactivity was observed and it was attributed to the ribose phosphate backbone of RNA as a common antigen."

Biology - 3,7

216. Krywienczyk, J.; Hayashi, Y. 1972. **Serological investigations of subcellular fractions from *Malacosoma disstria* larvae infected with cytoplasmic polyhedrosis**. J. Invertebr. Pathol. 20(2): 150-156.

"Subcellular fractions from *Malacosoma disstria* larvae, both healthy and infected with cytoplasmic poyhedrosis virus, were examined by double diffusion in agarose, immunoelectrophoresis, acrylamide gel electrophoresis and combined methods. An antigen of viral origin was detected in the soluble fraction from the infected larvae. The mitochondrial fraction contained virions. Microsomal fractions showed nonspecific reactions."

Biology - 3

217. Krywienczyk, J.; Hayashi, Y.; Bird, F.T. 1969. **Serological investigations of insect viruses. I. Comparison of three highly purified cytoplasmic-polyhedrosis viruses.** J. Invertebr. Pathol. 13(1): 114-119.

"Cytoplasmic-polyhedrosis viruses from *Bombyx mori*, *Malacosoma disstria* and *Orgyia leucostigma* were isolated and purified by zonal sucrose gradient centrifugation. They were tested in double diffusion and immunoelectrophoresis on cellulose acetate membranes. It was found that the viruses from *M. disstria* and *O. leucostigma* are very closely related, and share at least five antigens one of which, at least, is shared with the virus from *B. mori*."

Biology - 3

218. Krywienczyk, J.; Sohi, S.S. 1973. **Serologic characterization of a *Malacosoma disstria* Hubner (Lepidoptera: Lasiocampidae) cell line.** In Vitro 8(6): 459-465.

"The identity of a cell line derived from hemocytes of *Malacosoma disstria* was investigated serologically by using complement fixation, double diffusion, immunoelectrophoresis in agarose, and acrylamide gel electrophoresis. The *M. disstria* cell line antiserum gave a specific cross-reaction with its homologous antigen and with *M. disstria* larval antigen, although cross reactions with cell lines from *Aedes aegypti*, *Bombyx mori* and *Choristoneura fumiferana* and with larval antigens of *B. mori* and *C. fumiferana* were also produced. Antisera against *A. aegypti* and *B. mori* cell lines showed a very similar cross-reaction with both the cell line antigens. Also, these two antisera gave a strong reaction with *B. mori* larval antigen, but no reaction with *A. aegypti* larval antigen. These tests

confirm the identity of our *M. disstria* cell line. Also, they indicate: (a) that the *A. aegypti* and *B. mori* cell lines tested are similar, and (b) that they are closely related to *B. mori*, but not at all related to *A. aegypti*."

Biology - 7

219. Krywienczyk, J.; Sohi, S.S. 1976. **Serologic characterization of four lepidopteran cell lines.** Can. J. Zool. 54(9): 1559-1564.

"The identity of four cell lines (Cf124, Md63, Md108 and Md109) was investigated using the technique of double diffusion. The absorbed antiserum of Cf124 cells formed strong precipitin lines with *Choristoneura fumiferana* antigen, and the absorbed antisera of Md63, Md108, and Md109 cells gave a strong reaction with the *Malacosoma disstria* antigen, thus substantiating their species identity. Although the *M. disstria* cells lines did not show any tissue specificity, they differed from each other in at least one antigen. The antigens from whole larvae of *C. fumiferana* and *M. disstria* were more suitable than their hemolymph for serological reactions with the antisera of tissue cultures by double diffusion."

Biology - 7

220. Kukan, B.; Myers, J.H. 1995. **DNA hybridization assay for detection of nuclear polyhedrosis virus in tent caterpillars.** J. Invertebr. Pathol. 66(3): 231-236.

"A DNA dot-blot hybridization assay to monitor the distribution of nuclear polyhedrosis virus in populations of tent caterpillars [*Malacosoma disstria* and *M. californicum pluviale*] was developed and tested. No differences were found between results using DNA extraction with phenol-chloroform and crudely homogenating caterpillars. Dot-blot hybridization of field-collected caterpillars, frozen immediately after collection, showed the same levels of infection as microscopic examination for polyhedral inclusion bodies of field-collected caterpillars reared in the laboratory which had died by 5 or 6 days. However, reared field caterpillars showed higher levels of viral infection on microscopic examination of dead caterpillars by 10 to 13 days. With surface sterilized eggs reared to third instar and infected with virus, 79% of infection could be identified by 5 days. Most infected caterpillars died by 8 days. Molting to fourth instar was delayed or prevented in infected caterpillars, suggesting that western tent caterpillar virus has the *egt* gene."

Biology - 3

221. Kulman, H.M. 1971. **Effects of insect defoliation on growth and mortality of trees.** Annu. Rev. Entomol. 16(0): 289-324.

"The most important ensuing effects from insect defoliation are mortality, growth loss, rotation delays, and increased susceptibility to secondary insects and disease... . [This] review is limited to quantitative studies of tree mortality and increment reduction related to measured amounts of insect and artificial defoliation in which the foliage is removed at the time of treatment. The effects of defoliation on seed production, epicormic branching, wood quality, attack by secondary organisms,

and foliation timing are often mentioned, but not extensively reviewed." Records of defoliation, growth loss and mortality caused by various insects, including *Malacosoma disstria*, are also reviewed.

Outbreaks - 3

222. Kulman, H.M. 1974. **Comparative ecology of North American Carabidae with special reference to biological control.** Pages 61-70 *in* Chiang, H.C. (ed.) Recent advances in research on predation on insect pests in North America. Proc. joint symp. Entomol. Soc. Am. and the Entomol. Soc. Can., Montreal, Que., Nov. 30, 1972. Entomophaga Mem. Hors Ser. 7.

This paper deals with the effects of forest habitats, including recent work on the Carabidae of Minnesota in relation to soil, forest type and defoliation by *Malacosoma disstria*, as well as the influence that insecticides and pollutants have on carabid beetles in forests treated to control spruce budworm.

Biology - 2

223. Kulman, H.M.; Brooks, M.A. 1965. **Dosages of nuclear polyhedrosis virus effective against *Malacosoma disstria* with notes on interspecies susceptibility.** J. Econ. Entomol. 58(5):1008-1110.

This report contains additional information on dosage of nuclear-polyhedrosis viruses required to cause polyhedrosis in *Malacosoma disstria.* It also reports a case in which virus effectiveness was retained after passage through two species of *Malacosoma.*

Biology - 3

224. Kurtti, T.J.; Brooks, M.A. 1970. **Growth and differentiation of lepidopteran myoblasts *in vitro*.** Exp. Cell. Res. 61(2/3): 407-412.

"Myoblasts from pupae of three species of Lepidoptera [*Trichoplusia ni*, *Malacosoma disstria*, and *Dasychira plagiata*] were cultured in the Wyatt-Grace medium. Clusters of myoblasts within a heterogeneous monolayer of cells (obtained from the developing head) grew and differentiated *in vitro*. Extensive networks of myotubes surrounded by proliferating myoblasts were formed. Myotubes became striated by the third day and contractile by the sixth day. Myoblasts isolated from thoracic dorso-longitudinal muscle anlage and cultured as a homogeneous population of cells failed to grow and differentiate."

Biology - 7

225. Kurtti, T.J.; Brooks, M.A. 1971. **Growth of a microsporidian parasite in cultured cells of tent caterpillars (*Malacosoma*).** Curr. Top. Microbiol. Immunol. 55(0): 204-208.

This report presents the results of studies on creating and cultivating cell lines from two species of tent caterpillars, *Malacosoma disstria* Hübner and *M. americanum* (Fabricus). The best results were

obtained when either haemocytes or imaginal tissues were used. The microsporidian parasite associated with *M. disstria* was successfully cultivated intracellular from the silk glands of *M. disstria*. However, whole cell lines from both *M. americanum* and *Galleria mellonella* were exposed to the microsporidian, active growth and development of the parasite took place only on cells from *M. americanum*.

Biology - 3,7

226. Kurtti, T.J.; Brooks, M.A. 1976. **Propagation of a microsporidian in a moth cell line.** Pages 395-398 *in* E. Kurstak and K. Maramorosch (eds.). Invertebrate Tissue Culture: Applications in Medicine, Biology and Agriculture. Proc. 4th Internat. Conf. on Invertebr. Tissue Culture, Mont Gabriel, Que., 1975. Academic Press, New York, N.Y.

Heliothis zea cells derived from the ovaries of pupae (cell line IPLB 1075) were infected with a microsporidian by adding a solution of bacteria free spores obtained from organ cultures of salivary glands from naturally infected *Malacosoma disstria*. Replicate monolayer cultures of the cell and spore mixture were set up on coverslips. Spores were also harvested from infected cultures after the third to fifth subculture and tested for their infectivity of *H. zea* cells. Initial level of infection was dependent on the proportion of mature spores to host cells and the number of cells and spores in the mixing medium. A high incidence of infection was fostered by mixing a high density of spores and cells in a small volume. Microsporida were not detected in cells 6 and 12 hours after inoculation but after 24 hours one parasite was found in each cell that was infected. Infected cells were capable of mitoses and spores harvested after several transfers could be used to infect other cultures of *H. zea* cells . Growth characteristics of the microsporidian obtained from cell cultures were similar to those obtained from the salivary gland cultures.

Biology - 3,7

227. Kurtti, T.J.; Brooks, M.A. 1977. **The rate of development of a microsporidan in moth cell culture.** J. Invertebr. Pathol. 29(2): 126-132.

"A microsporidan parasite of the forest tent caterpillar *Malacosoma disstria* infected cells and replicated in vitro in a line from the moth *Heliothis zea*. After spore germination, the incidence of infected cells increased with time until leveling off with sporulation. During the first 24 hr, there was a static number of parasites, followed by a 2-day logarithmic growth phase during which the population doubled five to six times. The growth rate was 9 to 11 hr per population doubling. Sporulation commenced on day 3, and 40 to 50 spores were recovered from each infected cell. The life cycle was completed within 6 days, culminating in spores that were infectious for cultured cells. The antibiotic fumagilin at a dose of 1 ppm in the culture medium was microsporida-static."

Biology - 3

228. Kurtti, T.J.; Tsang, K.R.; Brooks, M.A. 1983**. The spread of infection by the microsporidian, *Nosema disstriae*, in insect cell lines**. J. Protozool. 30(4): 652-657.

"*Nosema disstriae*, a parasite of the forest tent caterpillar, *Malacosoma disstria*, was cultured with cell lines UMN-MDH-1 (*Malacosoma disstria*), IPLB-1075 (*Heliothis zea*), and BTC-*32 (Triatoma infestans*). Infected cultured cells were used to infect the healthy cell lines. Electron micrographs of thin section

of 6-day-old cultures revealed infected cells that exocytosed vesicles containing vegetative and immature sporulating forms of the parasite. Some of these forms were believed to be responsible for intercellular transmission of the parasite. The spread of infection was augmented by culturing the cells at high densities; if the density was too low, there was little or no cross infection. Cross infection was inhibited, but not blocked completely, by high osmolality of the culture medium. The yield of spores form a confluent cell monolayer at the end of growth was generally 1-4 x 10^7 per ml of culture medium."

Biology - 3,7

229. Lachance, D.; Monnier, C.; Berube, J.-P.; Paquet, R. 1990. **Forest insects and diseases in the Gaspe/Lower St. Lawrence region 1936-1987.** For. Can., Can. For. Serv., Laurentian For. Cent., Inf. Rep. LAU-X-93E. pp. 136-137.

"This is an exhaustive report of the forest insect and disease situation in the years between 1936 and 1987 for Quebec's Administrative Region 01. It presents an orderly synthesis of all observations made in the region. This report will enable foresters, researchers, and woodlot owners to better assess the importance of forest pests and the potential danger they represent, and to quickly find complete and precise information on problems that may appear in the region's forests.

The entomological and pathological problems are arranged one after another in alphabetical order for each tree species, which are also in alphabetical order. There are 13 maps indicating major problems, an alphabetical list of codes, and an index of both Latin and common names of species."

Outbreaks - 3

230. Lachance, D.; Thibault, J.; Monnier, C. 1991. **Forest insects and diseases in the Quebec Region 1936-1988.** For. Can., Can. For. Serv., Laur. For. Cent. Inf. Rep. LAU-X-97E. pp. 145-148.

"This is an exhaustive report of the forest insect and disease situation in the years between 1936 and 1988 for Quebec's Administrative Region 03. It presents an orderly synthesis of all observations made in the region. This report will enable foresters, researchers and woodlot owners to better assess the importance of forest pests and the potential danger they represent, and to quickly find complete and precise information on problems that may appear in the region's forests.

The entomological and pathological problems are arranged in alphabetical order for each tree species, which are also in alphabetical order. There are nine maps indicating major problems, an alphabetical list of codes, and an index of both Latin and common names of pest species."

Outbreaks - 3

231. Lambert, R. 1951. **Inventaire des insectes forestieres du Quebec en 1950.** Ann. ACFAS [Association Canadienne Française pour Avancement des Sciences] 17(0): 133-138.

"A distribution map and table showing number of collections in 21 localities for 1948, 1949 and 1950, with number of individual insects found, indicate that the epidemic of infestation by *Choristoneura fumiferana*, which began in Ontario in 1935, is decreasing. There has been a sudden multiplication of *Malacosoma disstria.* New centres of infestation were found for *Neodiprion swainei. Pristiphora*

erichsonii and *Gilipinia hercyniae* are becoming much more rare. *Stilpnotia salicis* has continued to spread, but a parasite imported from Europe, *Compsilura concinnata*, has proved quite effective for natural biological control. *Galerucella decora* has been noted in Quebec, in 1950, for the first time, as a destructive pest."

Outbreaks - 1

232. Langston, R.L. 1957. **A synopsis of hymenopterous parasites of *Malacosoma* in California (Lepidoptera: Lasiocampidae).** Univ. Calif. Publ. Entomol. 14(1): 1-50.

This report is a compilation of records of parasites of *Malacosoma* that have appeared in the literature for the western states. Included also are eastern records where they are pertinent either to the distribution of the host or to the known range of the parasite. The original work, which is based almost entirely on two seasons (1954 and 1955), is of necessity quite limited compared to the possibilities of a long range study. To clarify host-parasite relationships, it is necessary not only to be positive of the identity of the parasite, but also of the determination of the host. A synopsis is given of the host insects, including their distribution, description, food plants, and the known and newly discovered parasites pertinent to California.

Biology - 2

233. Larochelle, A. 1976. **Further swarmings of *Calosoma frigidum* Kirby (Coleoptera: Carabidae).** Cordulia 2(2): 55-56.

"Two *Calosoma frigidum* swarmings were observed in southern Quebec, Canada. In many cases the beetles were eating the forest tent caterpillar, *Malacosoma disstria* Hubner. According to the literature, carabid beetle swarmings are rare."

Biology - 2

234. Larsen, E.L. 1951. **Pehr Kalm's description of the forest tent caterpillar, *Malacosoma disstria* Hubn., which during certain years does great damage to both fruit trees and forests in North America.** Am. Midl. Nat. 46(3): 760-765.

"In 1750, while Pehr Kalm was in America, he had the opportunity to study a heavy infestation of *M. disstria*. His observations were published in "Kongl. Svenska Vetenskaps Academiens Handlingar" 25: 124. 139. 1764. The life history and feeding habits of the insect are discussed in the article, which is translated here in its entirety. A brief biography of Pehr Kalm serves as an introduction."

Outbreaks - 1

235. Lewis, F.P.; Fullard, J.H. 1996. **Neurometamorphosis of the ear in the gypsy moth, *Lymantria dispar*, and its homologue in the earless forest tent caterpillar moth, *Malacosoma disstria*.** J. Neurobiol. 31(2): 245-262.

Adult *Lymantria dispar* have a pair of metathoracic tympanic ears containing a two-celled auditory chordotonal organs, whereas *Malacosoma disstria* are earless and have a pair of nonauditory three-celled chordotonal organs. If the precursor chordotonal cells in *L. dispar* larvae are severed from the homologue auditory nerve (IIIN1b1) prior to metamorphosis, the adult *L. dispar* develops an ear lacking the auditory organ.

Biology - 8

236. Lewis, F.P.; Fullard, J.H.; Morrill, S.B. 1993. **Auditory influences on the flight behaviour of moths in a Nearctic site. II. Flight times, heights, and erraticism.** Can. J. Zool. 71(8): 1562-1568.

"While moths that possess ears protect themselves from bats by listening for their echolocation calls, earless species presumably use different defences. Tent caterpillar moths (Lasiocampidae) are earless and emerge in very large numbers at our Nearctic site. One species, *Malacosoma americanum*, has a nightly peak emergence time mismatched to the peak activity of certain sympatric bats, while that of another, *M. disstria*, is more coincident with that of the bats. These data suggest that while both species swamp bats with their large numbers, *M. americanum* gains additional protection by temporally separating itself from bats. Empirical flight observations and sticky-trap captures indicate that earless moths fly closer to the ground and more erratically than eared moths, although exceptions exist (e.g., high-flying sphingids and erratic geometrids). The foraging habits of most sympatric bats predict that small moths, in particular, will benefit from this behaviour. We suggest that low-altitude erratic flight in moths is a protean insurance defence against bats, as it should reduce the chance of their being detected by these predators."

Biology - 1,2

237. Lewis, R., Jr.; Oliveria, F.L. 1979. **Live oak decline in Texas.** J. Arboric. 5(11): 241-244.

The symptoms of live oak (*Quercus virginiana*) decline, a vascular wilt, are described and the fungi most frequently isolated from diseased trees listed. Pathogenicity tests implicated *Ceratocystis fagacearum* (and not *C. diospyri)* as the primary cause of the disease, but various canker fungi (most frequently *Botryodiplodia theobromae*) were isolated from dieback in trees with advanced but inactive wilt symptoms. Stresses that can be confused with the disease, and associated insects (defoliators such as *Malacosoma disstria,* leaf miners, and twig girdlers), are discussed.

Outbreaks - 3

238. Licari, P.J.; Jarvis, D.L.; Bailey, J.E. 1993. **Insect cell hosts for baculovirus expression vectors contain endogenous exoglycosidase activity.** Biotechnol. Progr. 9: 146-152.

"Four different insect cell lines that can be used as hosts for baculovirus infection were assayed for the presence of endogenous exoglycosidases. All four cell lines, derived from *Spodoptera frugiperda*, *Trichoplusia ni*, *Bombyx mori*, or *Malacosoma disstria*, contained N-acetyl-β-glucosaminidase, N-acetyl-β-galactosamanidase, β-galactosidase, and sialidase activities. Exoglycosidase activities were found in cell lysates as well as cell-free supernatants from uninfected and wild-type baculovirus infected cells. Oligosaccharide analysis of cellular glycoproteins using lectins recognizing Galβ1,3GalNAc,

Galβ1,4GlcNAc, and NeuAcα2,6Gal demonstrated that only Galβ1,3GalNAc was present. The demonstration that these cells contain exoglycosidases raises the possibility that the oligosaccharides of baculovirus-expressed glycoproteins are subject to enzymatic degradation. "

Biology - 3

239. Lindquist, O.H.; Miller, W.J. 1976. **Keys to insect larvae feeding on aspen foliage in Ontario.** Environ. Can., Can. For. Serv., Gt. Lakes For. Res. Cent., Rep. O-X-247. 32 p.

"A series of keys and drawings permits the identification of larvae feeding on the foliage of trembling aspen (*Populus tremuloides* Michx.) in Ontario. Included are 118 species or species groups of insects in the orders Lepidoptera, Hymenoptera, Coleoptera and Diptera. Seasonal occurrence of the larval stage is indicated for each species."

Biology - 1

240. Lindroth, R.L. 1991. **Biochemical ecology of aspen-Lepidoptera interactions.** J. Kans. Entomol. Soc. 64(4): 372-380.

A review of recent research on the chemical and biochemical components of interactions between *Populus* spp. and the Lepidoptera that feed on them indicated that phenolic glycosides are the principal secondary compounds occurring in the Salicaceae that mediate interactions. They are toxic to non-adapted insects and their mode of action appears to involve the formation of degenerative gut lesions. Adapted insects detoxify phenolic glycosides by the action of midgut esterases. Evolution of an enzyme system capable of detoxifying them played an important role in the evolution of host range among subspecies of *Papilio glaucus.* The efficacy of this esterase enzyme system is affected by several factors, including genetic variation in baseline activity, the capacity for induction of activity and changes in activity due to the presence or absence of other constituents (allelochemicals, nutrients) of the diet. Aspen-adapted species, such as *Lymantria dispar* and *Malacosoma disstria,* show differential abilities to use aspen as a food source, possibly because of factors affecting the concentration of foliar phenolic glycosides and nutrients or the activity of the insect esterases.

Host Relationships - 1

241. Lindroth, R.L.; Bloomer, M.S. 1991. **Biochemical ecology of the forest tent caterpillar: responses to dietary protein and phenolic glycosides.** Oecologia 86(3): 408-413.

"Interactions between quaking aspen (*Populus tremuloides*) and the forest tent caterpillar (*Malacosoma disstria*) are likely influenced by leaf protein and phenolic glycoside levels, and insect detoxification activity. We investigated the direct and interactive effects of dietary protein and phenolic glycosides on larval performance and midgut enzyme activity of forest tent caterpillars. We conducted bioassays with six artificial diets, using both first and fourth stadium larvae. Four of the diets comprised a 2 X 2 factorial design - two levels of protein [1.0 and 3.5% (wet weight) casein] each with and without phenolic glycosides. Additionally, we assayed high protein diets containing S,S,S-tributylphosphorotrithioate (DEF, an esterase inhibitor) and DEF plus phenolic glycosides. Enzyme solutions were prepared from midguts of sixth instars and assayed for β-glucosidase, esterase and

glutathione transferase activities. First instar mortality and development times were higher for larvae on diets low in protein or containing phenolic glycosides. Effects of phenolic glycosides were especially pronounced at low protein levels and when administered with DEF. Fourth instar development times were prolonged, and growth rates reduced in response to consumption of low protein diets. Effects of phenolic glycosides on growth were less pronounced, although the effect for larvae on the low protein diet was almost significant. Activity of each of the enzyme systems was reduced in larvae reared on low protein diets, and esterase activity was induced in larvae fed phenolic glycosides. Our results suggest that larval performance may be strongly affected by levels of protein and phenolic glycosides commonly occurring in aspen foliage, and that these factors may play a role in differential defoliation of aspen by forest tent caterpillars."

Host Relationships - 1

242. Lindroth, R.L.; Kinney, K.K.; Platz, C.L. 1993. **Responses of deciduous trees to elevated atmospheric CO_2: productivity, phytochemistry, and insect performance.** Ecology 74(3): 763-777.

Performance was evaluated of three tree species — quaking aspen (*Populus tremuloides*), red oak (*Quercus rubra*), and sugar maple (*Acer saccharum*) — that span a range from fast to slow growing - and two species of leaf-feeding insects (gypsy moth, *Lymantria dispar*, and forest tent caterpillar, *Malacosoma disstria*). One-year-old seedlings were grown for 60 days under ambient or elevated CO_2 regimes at the University of Wisconsin Biotron. After 50 days, feeding trials were conducted with penultimate-instar gypsy moth and forest tent caterpillars. After 60 days, a second set of trees was harvested and partitioned into root, stem, and leaf tissues. Leaf material was analyzed for a variety of compounds known to affect performance of insect herbivores. In terms of actual dry-matter production, aspen responded the most to enriched CO_2 atmospheres, whereas maple responded the least. Proportional growth increases (relative to ambient plants), however, were highest for oak and least for maple. Effects of elevated CO_2 on biomass allocation patterns differed among the three species: root-to-shoot ratios increased in aspen, decreased in oak, and did not change in maple. Enriched CO_2 altered concentrations of primary and secondary metabolites in leaves, but the magnitude and direction of effects were species-specific. Aspen showed the largest change in defensive carbon compounds (condensed and hydrolysable tannins). Consumption rates of insects fed high-CO_2 aspen increased dramatically, but growth rates declined. The two insect species had different responses to oak and maple grown under enriched CO_2. Gypsy moth grew better on high-CO_2 oak, whereas the forest tent caterpillar was unaffected; forest tent caterpillars tended to grow less on high-CO_2 maple, whereas gypsy moth was unaffected. Changes in insect performance parameters were related to changes in foliar chemistry. Responses of plants and insects agreed with some, but not all, of the predictions of carbon-nutrient balance theory. This study illustrates that tree productivity and chemistry, and the performance of associated insects, will change under CO_2 atmospheres predicted for the next century.

Host Relationships - 1,4,5

243. Lorimer, N. 1979a. **Differential hatching times in the forest tent caterpillar (Lepidoptera: Lasiocampidae).** Gt. Lakes Entomol. 12(4): 199-201.

"The daily pattern of larval emergence was determined for 36 egg masses collected from Ontonagon County, Michigan. Duration of hatching ranged from 6 to 16 days. Peak emergence occurred 3 and 4 days after the beginning of hatch."

Biology - 1

244. Lorimer, N. 1979b. **Genetics of superoxide dismutase in the forest tent caterpillar and other organisms.** J. Hered. 70(3): 199-204.

Eggs, larvae, and pupae of *Malacosoma disstria* (and a few *M. americanum* pupae) were collected in Michigan, Indiana, Alabama, and Minnesota from 1975 to 1977. Extracts were prepared from whole adults reared in the laboratory, and analyzed by gel electrophoresis. Superoxide dismutase activity was demonstrated in 13 bands arranged in 9 patterns. Frequencies and patterns varied with geographical origin and 3 bands appeared to be alleles of a polymorphic locus. [See abstract 245.]

Biology - 8

245. Lorimer, N. 1979c. **The genetics of melanism in *Malacosoma disstria* Hübner (Lepidoptera: Lasiocampidae).** Genetics 92(2): 555-561.

"The forest tent caterpillar is polymorphic for two melanic genes affecting wing color of moths. These are the first genetically determined morphological traits reported for the genus. Dark (D) is a sex-limited, autosomal dominant [gene] with a phenotype of dark brown males. Frequencies in population samples ranged from 8 to 44%. Characteristics of Dark and non-melanic males were compared. Larval development times, larval survival and pupal weights were not significantly different, but mean fecundity was higher for females with Dark progeny. Band (b), a darkened area across the forewings, occurred in low frequency in both sexes."

Biology - 1,8

246. Lorimer, N. 1979d. **Patterns of variation in some quantitative characters of *Malacosoma disstria* (Lepidoptera: Lasiocampidae).** Ann. Entomol. Soc. Am. 72(2): 275-280.

"*Malacosoma disstria* Hübner egg-masses were collected from 2 locations and reared in the laboratory on prepared diet. Measurements of 6 characters were tested for significant differences at 4 levels of organization. Populations differed in larval survival, sex ratio and development time but not in hatchability and pupal weight. Sibling groups were significantly different for all characters except fecundity. Males and females differed in development time and pupal weight. Eggs and weights were significantly correlated in all but one group, but their relation varied between populations. This paper reports the first evidence for genetic determination of quantitative characters in the forest tent caterpillar."

Biology - 1,8

247. Lorimer, N.; Mattson, W.J., Jr. 1979. **Prediapause hatching of the forest tent caterpillar (Lepidoptera: Lasiocampidae) in the laboratory.** Gt. Lakes Entomol. 12(3): 119-121.

"Forest tent caterpillar (*Malacosoma disstria* Hübner) eggs collected from Minnesota in July hatched in August and the larvae survived to the third instar. Many eggs from the same collection did not complete embryogenesis. Unusually high temperatures were probably responsible for both phenomena."

Biology - 4,6

248. Lyon, R.L.; Brown, S.J.; Robertson, J.L. 1972. **Contact toxicity of sixteen insecticides applied to forest tent caterpillars reared on artificial diet.** J. Econ. Entomol. 65(3): 928-930.

Describes laboratory tests to find a substitute for DDT in the control of *Malacosoma disstria.* All 16 preparations tested equalled or exceeded DDT in toxicity. Compounds at least 10 times more toxic at LD_{90} were: prethrins, methomyl, chlorpyrifos, Landrin, Zectran, aminocarb, tetramethrin and naled.

Control - 1,2

249. MacAloney, H.J. 1966. **The impact of insects in the northern hardwoods type.** U.S. Dep. Agric. For. Serv., Res. Note NC-10. 3 p.

This note condenses information on insects in northern hardwoods that has recently been reviewed, including material concerning sugar maple and yellow birch. The available data indicate that insects attack these species from regeneration to maturity. For ease in presentation, the type of insect damage has been placed in four stages of a tree's development: (1) damage to seeds and natural reproduction that modifies future stand composition; (2) defects causing poor tree form in the early growth stages and resulting in reduced values as the stands develop; (3) growth reduction leading up to tree mortality and deterioration; and (4) defect and degrade affecting all stages of growth but most noticeable and of greatest importance in merchantable trees and logs.

Outbreaks - 3

250. MacLeod, D.M. 1951. **Fungus diseases of the forest tent caterpillar.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 7(1): 2.

Three species of fungi were recovered from tent caterpillar populations in Ontario: *Beauveria bassiana, B. globulifera,* and an *Empusa* [*Entomophthora*] species. In one collection 47% of larvae were killed by the *Empusa* sp. Apart from this last record, there was little evidence that the fungi were responsible for any marked mortality on the forest tent caterpillar populations.

Biology - 3

251. MacLeod, D.M. 1953. **The virulence of the parasitic fungi, *Beauveria* spp.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 9(1): 2.

Beauveria bassiana strains were isolated from 63 different insects representing species from the orders Orthoptera, Coleoptera, Lepidoptera, and Hymenoptera. In species in which larger numbers of

individuals were infected (not just one or two insects), the infection rate by *B. bassiana* varied from 0.5 to 13.1%. In the laboratory mortality generally developed 6-10 days after larvae of *Pristiphora erichsonii, Choristoneura fumiferana, Carpocapsa pomonella, Malacosoma disstria* and *Diprion hercyniae* were dusted or sprayed with *B. bassiana* spores. Feeding *P. erischsonii* larvae exposed to the spores under field conditions did not develop significantly higher rates of infection. However, results were more promising when the fungal spores were applied to the ground just prior to the larvae spinning down to the ground to pupate.

Biology - 3

252. MacLeod, D.M. 1956. **Notes on the genus *Empusa* Cohn.** Can. J. Bot. 34(1): 16-26.

"*Empusa* species were found on 44 different species of insects representing 20 families from the following orders: Lepidoptera, Hymenoptera, Diptera, Orthoptera, Coleoptera, Hemiptera, and Homoptera. The isolates without spores were identified as *Empusa* [*Entomophthora*] by the presence of characteristic coenocytic hyphae ca. 13µ in diameter. *E. sphaerosperma* and forms of the "*E. grylli*" type were the most predominant ones among the isolates with spores. Other species included: *E. bullata, E. aphidis, E. erupta,* and *E. muscae.* Two unusual forms, one from *Sarcophaga aldrichi* , and the other from *Malacosoma americanum*, *M. disstria* and *M. pluviale,* are described. The effectiveness of *Empusa* species as insect control agents is briefly mentioned."

Biology - 3; Control - 6

253. MacLeod, D.M.; Tyrrell, D. 1979. ***Entomophthora crustosa* n. sp. as a pathogen of the forest tent caterpillar, *Malacosoma disstria* (Lepidoptera: Lasiocampidae).** Can. Entomol. 111(10): 1137-1144.

"*Entomophthora crustosa* n. sp. pathogenic for *Malacosoma* species (principally *M. disstria* Hbn.), is described. It is characterized in the conidial state by a hymenial coating which, at maturity, forms a crust-like covering, cinnamon brown, over the surface of infected insects, and by conidial size. In the resting spore (zygospore) state the distinguishing attributes are ornamentation of the zygospores and their mode of development. The pathogen grows readily on coagulated egg-yolk media. The fungus is briefly compared with 10 other closely related *Entomophthora* species. *Entomophthora crustosa* seems to be of widespread occurrence in eastern North America."

Biology - 3

254. MacLeod, D.M.; Tyrrell, D.; Soper, R.S.; De Lyzer, A.J. 1973. ***Enteromorpha bullata* as a pathogen of *Sarcophaga aldrichi*.** J. Invertebr. Pathol. 22(1): 75-79.

"Adults of *Sarcophaga aldrichi* killed by *Enteromorpha bullata* were found in the field 7 days after emergence. Resting spores were not found until 6 days later, although conidia were formed from the first incidence of mortality. It is suggested that the life cycle of the fungus involves alternating generations of conidia and thick-walled overwintering resting spores."

Biology - 2,3

255. Manitoba and Saskatchewan. 1953-1969. **Annual report of the forest biology rangers.** Can. For. Serv.

These are a series of unpublished reports, by various authors over the years. They include information on occurrence , populations, locality and extent of infestations of major insect pests of Manitoba and Saskatchewan. References to the forest tent caterpillar occur in the following years and pages.

Year	Page Numbers
1953	9-14, 30-34, 52, 66, 85, 101-110, 130-134
1954	2, 19, 40, 58, 71, 76, 77, 114, 136, 137, 151, 172-179, 186
1955	43, 60, 78, 89, 142, 159, 169
1956	36, 70, 90, 117, 138, 160, 225
1957	20, 21, 35, 36, 67
1958	34, 43-45, 54, 60, 61, 84-86, 97, 99, 111, 129, 141, 142
1959	32, 45, 57, 65, 70, 81, 91, 104, 114, 124, 136, 142, 148
1960	33, 46, 55, 66, 75, 81, 96, 111, 121, 130, 143, 144, 152, 156, 162, 171, 177
1961	2, 13, 22, 35, 45, 54, 63, 72, 82, 95, 102, 111
1962	
1963	12, 27, 44, 55, 72, 84, 101, 114, 124, 133
1964	7, 25, 43, 67, 87, 110, 137, 147, 169, 185, 198, 210
1965	8, 22, 38, 75, 90, 120, 139, 160, 177
1966	3, 130
1967	12
1968	17, 38, 132, 142
1969	15, 36, 72, 116, 140

Outbreaks - 1,3

256. Maritime Provinces. 1953-1994. **Annual district report, forest insect and disease survey (also Annual report of forest biology rangers).** Dep. For., Fredericton, N.B. Interim Rep. (unpublished).

By various authors over the years, these reports contain information on occurrence, population levels and locality of collections and infestations of major insect pest of the Maritimes. From 1962-1964 the reports were published and from 1965 onward the reports were published as Information Reports (Canadian Forest Service, Department of the Environment, Maritimes Forest Research Centre, Fredericton, New Brunswick). From 1973-1993 the reports were published as **Forest Pest Conditions in the Maritimes.**

Year	Interim Report Number (unpublished)	Author	Region	Page Numbers
1953	1953	Harrington, W.	W Nova Scotia	12
		Coady, L.J.	E Nova Scotia	37
		Arthurs, C.A.	NW New Brunswick	44
1953	1953	Fraser, K.A	NE New Brunswick	64
		Seaton, J.H.	SE New Brunswick and P.E.I	74

Year	Interim Report Number (unpublished)	Author	Region	Page Numbers
1954	1954-3	Fraser, K.A.	NE New Brunswick	23
		Arthurs, C.A.	NW New Brunswick	30
		Seaton, J.H.	S New Brunswick and P.E.I.	38
		Coady, L.J.	E Nova Scotia	58
		Harrington, W.	W Nova Scotia	65
1955	1955-11	Fraser, K.A.	NE New Brunswick	9
		Arthurs, C.A.	NW New Brunswick	17
		Seaton, J.H.	S New Brunswick and P.E.I.	26
		Coady, L.J.	E Nova Scotia	36
		Harrington, W.	W Nova Scotia	68
1956	1956-8	MacCall, C.D.	NE New Brunswick	10
		Estabrooks, G.F.	NW New Brunswick	19
		Fraser, K.A.	S New Brunswick and P.E.I.	32
		Coady, L.J.	E Nova Scotia	48
		Harrington, W.	W Nova Scotia	68
1957	1957-7	Estabrooks, G.F.	NW New Brunswick	11
		MacCall, C.D.	NE New Brunswick	21
		Harrington, W.	W Nova Scotia	46
1958	1958-5	Harrington, W.	W Nova Scotia	51
1959	1959-3	Estabrooks, G.F.	NW New Brunswick	13
		MacCall, C.D.	NE New Brunswick	26
		Fraser, K.A.	S New Brunswick and P.E.I.	38
		Harrington, W.	W Nova Scotia	58
1960	1960-3	MacCall, C.D.	NE New Brunswick	29
		Dobson, C.M.	S New Brunswick and P.E.I.	43
		Harrington, W.	W Nova Scotia	78
1961	1961	Estabrooks, G.F.	NW New Brunswick	13
		MacCall, C.D.	NE New Brunswick	36
		Dobson, C.M.	S New Brunswick and P.E.I.	55
		Harrington, W.	W Nova Scotia	85
1962	1962	Estabrooks, G.F.	NW New Brunswick	13
		MacCall, C.D.	NE New Brunswick	37
		Dobson, C.M.	S New Brunswick and P.E.I.	59
		Harrington, W.	W Nova Scotia	89
			E Nova Scotia	133
1963	1963	Estabrooks, G.F.	NW New Brunswick	12
		MacCall, C.D.	NE New Brunswick	39
		Dobson, C.M.	S New Brunswick and P.E.I.	61
		Harrington, W.	W Nova Scotia	92
			E Nova Scotia	141
1964	1964	Estabrooks, G.F.	W New Brunswick	12
		Dobson, C.M.	S New Brunswick and P.E.I.	63
		Harrington, W.	W Nova Scotia	89
			E Nova Scotia	133
1965	M-X-5	Dobson, C.M.	W New Brunswick	13
		MacCall, C.D.	S New Brunswick and P.E.I.	63
			E Nova Scotia	145

Year	Interim Report Number (unpublished)	Author	Region	Page Numbers
1966	M-X-10		W New Brunswick	17-18
			S New Brunswick and P.E.I.	54
			Central Nova Scotia	72
			E Nova Scotia	127
1967	M-X-16		W New Brunswick	21
			SE New Brunswick and P.E.I.	51
			Central Nova Scotia	67
			W Nova Scotia	87
			E Nova Scotia	111
1968	M-X-18		SW New Brunswick	17
			NW New Brunswick	37
			SE New Brunswick and P.E.I.	62
			W Nova Scotia	79
			Central Nova Scotia	107
			E Nova Scotia	126

Year	Report Number	Author	Page Number(s)
1974	M-X-43	Forbes, R.S.; Underwood, G.R.; Van Sickle, G.A.	7
1975	M-X-53	Forbes, R.S.; Underwood, G.R.; Van Sickle, G.A.	12,13
1976	M-X-57	Magasi, L.P.; Sterner, T.E.; Moran, G.V.	18-20
1977	M-X-68	Magasi, L.P.; Sterner, T.E.; Newell, W.R.	10-11
1978	M-X-82	Magasi, L.P.	20
1979	M-X-98	Magasi, L.P.	22
1980	M-X-106	Magasi, L.P.,	11-13
1981	M-X-118	Magasi, L.P.,	8-10
1982	M-X-135	Magasi, L.P.	11-13
1983	M-X-141	Magasi, L.P.	15
1984	M-X-149	Magasi, L.P.	16-18
1985	M-X-154	Magasi, L.P.	16-18
1986	M-X-159	Magasi, L.P.	22-25
1987	M-X-161	Magasi, L.P.	20-22
1988	M-X-166	Magasi, L.P.	93
1989	M-X-174	Magasi, L.P.	66
1990	M-X-177	Magasi, L.P.	66
1991	M-X-178	Magasi, L.P.	58
1992	M-X-181E	Magasi, L.P.	20
1993	M-X-183E	Magasi, L.P.	19-20
1993	M-X-183F	Magasi, L.P.	20
1994	M-X-188E	Magasi, L.P.; Hurley, J.E.	23

Outbreaks - 1,3

257. Markovic, I.; Haanstad, J.O.; Norris, D.M. 1993. **Chemical correlates of alpha-tocopherol (vitamin E) altered *Malacosoma disstria* herbivory in *Fraxinus pennsylvanica* var. *subintegerrinia*, green ash.** J. Chem. Ecol. 19(6): 1205-1217.

"The antioxidant α-tocopherol (vitamin E), applied in a basal trunk band to the green ash tree, *Fraxinus pennsylvanica* var. *subintegerrinia*, elicited an alteration of foliar feeding by *Malacosoma disstria* larvae (Lepidoptera: Lasiocampidae). The bioassayed effects were dependent on the dosage of elicitor, the time after elicitation, and the position in the tree. Leaves for chemical analysis were collected from trees receiving two dosages [25.0 or 50.0 IU/ml in heavy mineral oil] and at 2 intervals [8 and 16 days] after elicitation. Compounds in the ethyl acetate extracts from the ash tree leaves were separated by TLC and HPLC. TLC separations showed differences in the nonhydrolysed extractables attributable to elicitor dosage and time after elicitation. TLC-resolved differences were also evident among acid-hydrolysed samples. HPLC-resolved profiles revealed eight peaks in the nonhydrolysed extractables that were quantitatively negatively correlated with larval feeding preference between elicited versus control foliage on at least one of the two sampling dates. Results from this study and other investigations reported in the literature indicate that the antioxidant α-tocopherol (vitamin E) can function as an environmental-stress elicitor of alterable defensive chemistry in green ash and other plants."

Host Relationships - 6

258. Martin, M.A.; Cappuccino, N.; Ducharme, D. 1994. **Performance of *Symydobius americanus* (Homoptera: Aphididae) on paper birch grazed by caterpillars.** Ecol. Entomol. 19(1): 6-10.

"The potential for host plant-mediated interactions between leaf-chewers and *Symydobius americanus* on paper birch (*Betula papyrifera*) was investigated experimentally. *Datana ministra* and *Malacosoma disstria* caterpillars were caged on randomly chosen, undamaged branches until they had eaten 30-50% of the leaf area. Control branches received cages but no larvae. Alates of *S. americanus* were then caged on the experimental and control branches to assess the effect of chewing damage on colony performance. Chewing damage had no detectable effect on the initiation of alate reproduction, development time, mortality of nymphs or colony growth rate."

Host Relationships - 2

259. Martinat, P.J. 1987. **The role of climatic variation and weather in forest insect outbreaks.** Pages 241-268 *in* P. Barbosa and J.C. Schultz (eds.). Insect outbreaks. Academic Press, Inc., San Diego, Calif.

The theory of climatic anomalies triggering outbreaks of forest insects is examined. Three case histories are discussed, involving *Choristoneura fumiferana*, *Malacosoma disstria* and *Dendroctonus frontalis*. A summary of studies attempting to relate forest insect outbreaks to climatic conditions is included. The author suggests that more attention should be paid to the possible effects of catastrophic weather events of short duration, such as frosts in late spring or early autumn, excessive cloudiness, rain, or cold spells of short duration during critical windows of vulnerability in the herbivore life cycle; such effects would not be accounted for in monthly weather summaries.

Biology - 4

260. Martineau, R. 1984. Insects harmful to forest trees. Supply and Services Canada, Ottawa, Ont. For. Tech. Rep. 32. pp. 134, 152, 189, 206, 210, 211.

Gives a brief description of the life stages, history of outbreaks and relative importance as defoliators of different forest insects, including *Malacosoma disstria.* There is a French version of this book (Martineau, R. 1985. **Insectes nuisibles des forêts de l'est du Canada.** Marcell Broquet Inc, LaPrairie, Que. For. Tech. Rep. 32F. pp. 148, 167, 208, 225, 230, 231.)

General Background

261. Martineau, R.; Benoit, P. 1974. **Principaux insectes forestiers au Québec en 1973 [Principal forest insects in Quebec in 1973].** Ann. Entomol. Soc. Quebec 19(3): 100-105.

"[Except for some locations, populations of this tent caterpillar did not increase in 1973. The trembling aspen had defoliation varying from 60 to 100 per cent with a surface area of 35 square miles along the Outaouais River and north of Lake Temiscaming. One other infestation marked the length of Route 11 between Lacs Ecores and Mont-Laurier, where trembling aspen and sugar maple were seriously defoliated. Several collections of this insect were carried out in Lac Saint-Jean.]"

(Entire reference pertaining to *M. disstria* included in annotation. Translated from original French.)

Outbreaks - 1

262. Mason, W.R.M. 1979. **A new *Rogas* (Hymenoptera: Braconidae) parasite of tent caterpillars (*Malacosoma* spp. Lepidoptera: Lasiocampidae) in Canada.** Can. Entomol. 111(7): 783-786.

"*Rogas malacosomatos* sp.n. is described and differentiated from the closely related *R. stigmator* (Say)." *R. malacosomatos* is a parasite of *Malacosoma americanum* (F.), *M. disstria* Hbn., *M. californicum lutescens* (Neumoegen & Dyar) (*M. lutescens*), and *M. californicum pluviale* (Dyar) (*M. pluviale*) in forests in various provinces of Canada.

Biology - 2

263. Masteller, E.C. 1967. **Influence of temperature on diapausing forest tent caterpillar, *Malacosoma disstria* Hbn. (Lepidoptera: Lasiocampidae).** Ph.D. thesis. Iowa State Univ. 93 p.

Two separate populations of *Malacosoma disstria*, both sharing the same geographic region but having different host associations, were examined. The population that had two hosts was found to have a greater variation in the duration of its diapause than the population associated with only one host. Eggs from both populations were subjected to different temperature regimes during diapause. The hatching success and nutritional condition of the larvae were examined to determine the effects of these regimes.

Biology - 1

264. Mattson, W.J., Jr.; Addy, N.D. 1975. **Phytophagous insects as regulators of forest primary production.** Science 190(4214): 515-522.

The intent of this article is to "...examine the evidence for the hypothesis that insects can act as regulators of primary production and nutrient cycling and thus perform a vital function in ecosystem dynamics." In one section, annual biomass production in an aspen (*Populus tremuloides*) with and without forest tent caterpillar (*Malacosoma disstria*) was simulated and compared in order to evaluate the qualitative and quantitative nature of interactions between overstory trees and insects.

Host Relationships - 1; Outbreaks - 3

265. Mattson, W.J., Jr.; Erickson, G.W. 1978. **Degree-day summation and hatching of the forest tent caterpillar, *Malacosoma disstria* (Lepidoptera: Lasiocampidae).** Gt. Lakes Entomol. 11(1): 59-61.

An account is given of studies carried out in Minnesota in 1967-74 on the relation between *Malacosoma disstria* egg hatch in the field and degree day summation prior to hatch. The data indicated that the mean temperature sums for overwintering periods beginning on 13 October and 13 November were 614.8 and 416.0 degree days, respectively, above a threshold of 32°F, and 261.1 and 178.0 degree days above a threshold of 40°F.

Biology - 4

266. Mazzone, H.M.; Engler, W.F.; Zerillo, R.; Bahr, G.F. 1982. **Periodic structure in the matrix protein of an insect virus.** Pages 302-303 *in* G.W. Bailey (ed.). 40th Annu. Meet. Electron Microscopy Soc. Am. [EMSA], Washington, D.C. Aug. 9-13, 1982. Claitor's Publishing Division, Baton Rouge, La.

This article describes size and shape of the nucleocapsid and bundle. Properties of the subunits of the dissolved matrix protein of NPV inclusion bodies are listed (includes two figures).

Biology - 3

267. McBay, L.G.; Allen, R.H., Jr. 1963. **The effects of forest tent caterpillar [*Malacosoma disstria*] control experiment on fish and wildlife.** J. Ala. Acad. Sci. 34(2): 58-64.

Eleven plots containing tupelo, *Nyssa* sp., and sweetgum, *Liquidambar styraciflua*, ranging in area from 40 to 320 acres, were sprayed with chemical insecticides to examine their effects on fish and wildlife. Test boxes containing fish (species not given) or aquatic invertebrates (freshwater shrimp, dragonfly and damselfly larvae), were placed within the plots. Wildlife within the treated areas were also monitored. The plots were treated either with DDT was applied in oil at rates of 1/8, 1/4 and 1/2 lb./acre, Sevin in oil at 1/2 and 1 lb./acre, Dibrom in oil at 1 lb./acre or malathion in oil at 1 lb./acre. Mortality of test fish exposed to DDT at 1/2 lb./acre ranged from 4 to 76% within 30 hours of treatment, and several free-swimming fish, as well as 3 cardinals, *Richmondena cardinalis*, and two buffalo, *Ictiobus* sp., were found dead within this plot. Malathion was found to cause 30% of dragonfly larvae in the insect boxes. None of the other insecticides or concentrations used were found to affect the wildlife or test organisms. The authors felt that the rising and falling of water

lead to continually changing environments and concentrations of insecticides, that the flooding conditions in these plots made monitoring of wildlife and fish difficult, and that further studies were required.

Control - 1,2

268. McCown, B.H.; McCabe, D.E.; Russell, D.R.; Robison, D.J.; Barton, K.A.; Raffa, K.F. 1991. **Stable transformation of *Populus* and incorporation of pest resistance by electric discharge particle acceleration.** Plant Cell Rep. 9(10): 590-594.

"Three different target tissues (protoplast-derived cells, nodules and stems) and two unrelated hybrid genotypes of *Populus* (*P. alba* x *P. grandidentata* 'Crandon' and *P. nigra* 'Betulifolia' x *P. trichocarpa*) have been stably transformed by electric discharge particle acceleration using a 18.7 kb plasmid containing NOS-NPT, CaMV 35S-GUS and CaMV 35S-BT [the δ-endotoxin of *Bacillus thuringiensis*]. Four transformed plants of one hybrid genotype, NC5339, containing all 3 genes were recovered and analyzed. Two expressed GUS and one was highly resistant to feeding by 2 lepidopteran pests (the forest tent caterpillar, *Malacosoma disstria*, and the gypsy moth, *Lymantria dispar*). Pretreatment of the target tissues, fine-tuning of the bombardment parameters and the use of a selection technique employing flooding of the target tissues were important for reliable recovery of transformed plants."

Host Relationships - 1

269. McGuffin, W.C. 1946. **Forest insect survey.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 2(5): 2-3.

“The poplar along the east shore of Lake Winnipeg, from Berens River south as far as Hole River, suffered some defoliation by the forest tent caterpillar, *Malacosoma disstria* Hbn. In some spots this infestation was quite heavy, and extended inland for about one mile. Many trees in the vicinity of Washbow Bay, and around Riverton on the west side of the lake were stripped, and around Rosenburg there was a heavy infestation of this insect.”

(Entire reference pertaining to *Malacosoma disstria* included in annotation)

Outbreaks - 1,3

270. McGuffin, W.C. 1952a. **Forest insect survey.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 8(1): 3.

“In Alberta several outbreaks of the forest tent caterpillar, *Malacosoma disstria* Hbn., were reported in 1951, after low populations for several years. Aspen was completely defoliated a few miles west of Rimbey and a severe infestation was found about 30 miles northwest of Smith. More widespread and severe outbreaks are expected in 1952.”

(Entire reference pertaining to *Malacosoma disstria* included in annotation)

Outbreaks - 1,3

271. McGuffin, W.C. 1952b. **Forest tent caterpillar in Alberta.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 8(3): 2-3.

Egg-mass surveys conducted in Alberta suggest that the severity of the outbreak would increase in 1952. Complete defoliation of same areas was expected in a large area west of Rimbey. Infestations in McKay were expected to be light to medium in intensity, and near Smith light defoliation was expected.

Outbreaks - 4a

272. McGuffin, W.C. 1952c. **Forest tent caterpillar.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 8(6): 2.

Egg-mass surveys were made to determine the probable trend of the outbreak in 1953. The percentages of egg masses per tree were lower than those of 1951 but still sufficient to cause complete defoliation under certain conditions. The majority of the egg masses were distributed in the upper two-thirds of the crown except on open-grown aspen, where egg masses were distributed more evenly throughout the crown. Not a single egg mass was found on a dead twig.

Outbreaks - 4a

273. McGuffin, W.C. 1953a. **Forest insect survey.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 9(1): 3.

"In 1952 the forest tent caterpillar, *Malacosoma disstria* (Hbn.), infestations occupied considerably more territory than they did in 1951. West of Rimbley the outbreak spread south to Ferrier and Saunders. The infestation in the vicinity of McKay and Chip Lake covered a large area; it may even extend to Whitecourt. The outbreak near Smith decreased in intensity."

(Entire reference pertaining to *Malacosoma disstria* included in annotation.)

Outbreaks - 1

274. McGuffin, W.C. 1953b. **Forest insect survey, most important outbreaks.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 9(6): 3.

"The forest tent caterpillar, *Malacosoma disstria* Hbn., occurred in spotty outbreaks over a great stretch of west central Alberta. From Medicine Lodge, west of Edson, the northern boundary ran east and north beyond Chip Lake and then to within a few miles of Edmonton, south to Gull Lake west to Bearberry and northeast to Rocky Mountain House. The heaviest defoliation was north of Chip Lake."

(Entire reference pertaining to *Malacosoma disstria* included in annotation)

Outbreaks - 1,3

275. McGugan, B. M.; Coppel, H.C. 1962. **Forest tent caterpillar, *Malacosoma disstria* Hbn.** Pages 39, 64-65, 67, 180-181, 185-187 *in* J.H. McLeod, B.M. McGugan and H.C. Coppel (eds.). A review of the biological control attempts against insects and weeds in Canada. Part II. Biological control of forest insects, 1910-1958. Commonwealth Inst. Biol. Control, Trinidad. Tech. Communication No. 2.

This publication includes records of releases made and summary accounts of projects undertaken.

Biology - 3; Control - 3

276. McGugan, B.M.; MacDonald, J.E. 1951. **Forest tent caterpillar.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 7(1): 2.

This article is a short summary of the 1950 Ontario forest tent caterpillar surveys. There were three different classes of forest tent caterpillar infestation: old infestations which were established over large areas, heavy infestations that originally occurred in scattered pockets but which had now coalesced, and heavy infestations, either new or recurrent, that were occurring in scattered pockets. The average number of egg clusters per tree sampled was greater than 100 in many areas. Egg clusters contained an average of 150-200 eggs. Late larval, larval/pupal and pupal surveys were also conducted. Some 70% of the larvae that were collected pupated successfully while 65% of the pupae survived to adulthood. There was a predominance of dipterous over hymenopterous parasites in both larvae and pupae.

Outbreaks - 1,4abc

277. McLaughlin, D.L.; Linzon, S.N.; Dimma, D.E.; McIlveen, W.D. 1987. **Sugar maple decline in Ontario.** Pages 101-116 *in* T.C. Hutchinson and K.M. Meema (eds.). Effects of atmospheric pollutants on forests, wetlands and agricultural ecosystems. NATO ASI Series G (Ecological Sciences) 16. Springer-Verlag, Berlin.

Data from the first year of a survey at 7 sites in central Ontario suggest that a severe epidemic of forest tent caterpillar [*Malacosoma disstria*] in the late 1970s, and spring droughts in 1976, 1977 and 1983 were the main factors in the decline of *Acer saccharum*. *Armillaria* root rot, tree age and site management were contributing factors, and acid precipitation is an additional environmental stress.

Biology - 4; Outbreaks - 1,2b

278. McLeod, J.H.; Ayre, G.L. 1956. **Parasites of tent caterpillars (Lepidoptera: Lasiocampidae) in the lower Fraser Valley of British Columbia, Canada.** Proc. 8th Pac. Sci. Congr. and 4th Far East. Prehist. Congr., Manila, Philippines. Nov. 16-28, 1953. 3A: 1547-06.

"From 1950 to 1953 there was a rapid increase in the populations of the tent caterpillars *Malacosoma disstria* Hbn and *Malacosoma pluviale* (Dyar) in the lower Fraser Valley of British Columbia. From representative collections of eggs, larvae, and pupae obtained during the three years, 23 species of primary and secondary parasites were reared; and of these, 14 species were Hymenoptera and 9 were Diptera. In 1950 the dipterous parasites were much more numerous than the hymenopterous parasites. By 1953 the hymenopterous parasites had increased but were still fewer than the

dipterous parasites. The hymenopterous species that increased most rapidly were those that completed their development and emerged from the host larvae or pupae before they could be destroyed by sarcophagid larvae. The species of dipterous parasites that became abundant as the tent caterpillar infestation intensified were those that have a single generation per year. The populations of the species that require alternate hosts to complete their life-cycles were apparently restricted by the scarcity of alternate hosts." [from summary]

Biology - 2

279. McManus, M.L. 1979. **Dispersal of forest insects.** Pages 35-39 *in* C.R. Vaughn, W. Wolf, and W. Klassen (eds.) Radar, Insect Population Ecology, and Pest Management. Proc. workshop Wallops Island, Va, May 2-4, 1978. Nat. Aeronautics and Space Administration, Wallops Island, Va.

"The author gives an account of dispersal in forest insects. In general, passive dispersal of immature stages is a more important process in the dynamics of forest insects than is adult dispersal. The lepidopterous defoliators are the best examples of forest insects that exhibit significant dispersal. *Lymantria dispar* (L.), *Choristoneura fumiferana* (Clem.) and the forest tent caterpillar [*Malacosoma disstria* Hb.] are dealt with in detail. Dispersal flights of such species are usually associated with periodical outbreaks that occur over large forest areas. The economic significance of these occurrences is not so important in those species in which only the males disperse, with the exception of *L. dispar*. On the other hand, dispersal of females of *C. fumiferana* in eastern and western North America is critical to the development and spread of outbreaks.

Biology - 1

280. Melvin, J.C.E.; Murray, D.W.; Harding, J.; Wong, H.R. 1969. **The insect collection of the forest insect and disease survey in Manitoba and Saskatchewan. Part 1. Lepidoptera.** Can. For. Serv., For. Res. Lab., Winnipeg, Man. Inf. Rep. MS-X-22. 29 p.

This report lists adults and inflated or preserved larvae of Lepidoptera held in the Winnipeg reference collection.

Biology - 1

281. Milne, R.E.; Pang, A.S.D.; Kaplan, H. 1995. **A protein complex from *Choristoneura fumiferana* gut-juice involved in the precipitation of δ-endotoxin from *Bacillus thuringiensis* ssp. *sotto*.** Insect Biochem. Molec. Biol. 25(10): 1101-1114.

"A 75 kDa protein from spruce budworm (*Choristoneura fumiferana*) gut-juice has been isolated and shown to cause a protein-specific precipitation of the δ-endotoxin from *Bacillus thuringiensis* subsp. *sotto*. This 75 kDa protein, separated by either column chromatography or SDS-PAGE, caused precipitation of the *sotto* toxin in both agarose diffusion gels and the PAGE gels. The precipitation event leads to limited proteolysis of the toxin and loss of larval toxicity. SDS-PAGE analysis of the precipitated toxin indicates that proteolysis of the toxin is not a prerequisite for precipitation. The protein responsible for precipitation, exhibits elastase-like activity and appears to be a complex which partially dissociates during boiling in SDS-PAGE sample buffer. Gut-juice from gypsy moth, forest tent caterpillar and white marked tussock moth also precipitated δ-endotoxin, but silkworm

gut-juice gave a much weaker response. These results provide further evidence that, in the larval gut, differential processing of δ-endotoxin may play a role in the expression of activity towards various insect larvae.

Biology - 8; Control - 3

282. Mitsuhashi, J. 1996. **A continually growing cell line from larval haemocytes of *Malacosoma neustria testacea*.** Jap. J. Entomol. 64(3): 692-699.

"Larval haemocytes of *Malacosoma neustria testacea* were cultured in MGM-450 medium added with 5% foetal bovine serum (FBS) and 3% *Antheraea pernyi* haemolymph. Out of thirty primary cultures set up, a continuous cell line was obtained, and designated as FIR-MntH-520A. Cells of this cell line could grow in MGM-450 medium fortified with 10% foetal bovine serum alone, and the population doubling time was 6.93 days. Spherical cells were predominant, but sometimes odd-shaped cells appeared. The karyotype of the cell line was typical of lepidopteran cell lines and consisted of numerous small chromosomes. The cell line could be discriminated from other lepidopteran cell lines by comparing the pattern of isozymes of several enzymes. *M. neustria testacea* nuclear polyhedrosis virus (NPV) infected the cell line, while *Autographa californica, Malacosoma disstria* and *Lambdina fiscellaria somniaria* NPVs did not."

Biology - 3,7

283. Moody, B.H. (compiler) 1988. **Forest tent caterpillar.** Pages 23-25 *in* Forest insect and disease conditions in Canada, 1987. For. Can., Can. For. Serv., Petawawa Nat. For. Cent., Chalk River, Ont.

"The forest tent caterpillar again caused moderate-to-severe defoliation on trembling aspen, as well as a variety of other hosts in many areas of Canada. Although outbreaks of this insect can look spectacular, there have been few reports of appreciable tree mortality. The main effect of outbreaks has been the reduction in annual growth of severely defoliated trees. The significance of this reduction is difficult to assess. The affected tree species comprise a major portion of the hardwood volume in Canada, yet a relatively small portion of it is harvested each year. As the utilization and management of aspen intensify, the impact of aspen defoliators will become more significant."

Outbreaks - 3

284. Moody, B.H.; Cerezke, H.F. 1984. **Forest insect and disease conditions in Alberta, Saskatchewan, Manitoba, and the Northwest Territories in 1983 and predictions for 1984.** Can. For. Serv., North. For. Cent., Inf. Rep. NOR-X-261. pp. 5, 7, 8.

The status of the pests and diseases occurring in forests in Alberta, Saskatchewan, Manitoba, and the Northwest Territories in 1983 is summarized. Detailed reports are provided on the tortricids *Choristoneura fumiferana, Choristoneura pinus* and *Choristoneura conflictana;* the lasiocampid *Malacosoma disstria,* a lyonetiid (probably *Lyonetia prunifoliella*); the gelechiid *Coleotechnites starki;* the scolytids *Dendroctonus ponderosae, D. rufipennis,* and *Ips* spp.; species of the cerambycid genus *Monochamus;* the tenthredinid *Pristiphora erichsonii;* the fungi *Ceratocystis ulmi, Chrysomyxa* spp., and *Lophodermella*

spp.; and dwarf mistletoes (*Arceuthobium americanum* and *A. pusillum*). The report on *M. disstria* includes a map showing the areas most affected by the outbreak.

Outbreaks - 1,3

285. Moran, G.V. 1965-1975. **Summary report of the forest insect and disease survey, Maritime Provinces.** Can. Dep. For., Maritime Region.

These reports are short summaries of the forest insect and disease surveys in the Maritime Provinces. References to *Malacosoma disstria* occur in the following reports and page numbers.

Year	Report	Page Number
1965	-	-
1966	May - June	2
1967	-	-
1968	May - June	3
	July	3
1969	May - June	3
1970	May - June	2
	June - July	3
1971	May - June	2
1972	May - June	2
	July	3
1973	-	-
1974	-	-
1975	June	2

Outbreaks - 1,3

286. Morris, O.N. 1972. **Susceptibility of some forest insects to mixtures of commercial *Bacillus thuringiensis* and chemical insecticides, and sensitivity of the pathogen to the insecticides.** Can. Entomol. 104(9): 1419-1425.

Populus tremuloides foliage was treated with mixtures of Thuricide 90TS at 1:100 or 1:1000 dilutions with either malathion or phosphamidon and fed to 50–100 *Malacosoma disstria* larvae. For all mixtures of Thuricide with phosphamidon there was a subadditive effect, although it was shown that this combination caused more septicimea in *M. disstria* larvae. Malathion appears to have had a more detrimental, possibly even antagonistic, effect at higher concentrations. Mixtures of *Bacillus thuringiensis* and malathion had no measurable effect at lower concentrations.

Control - 2,3

287. Morris, O.N. 1983. **Microorganisms isolated from forest insects of British Columbia.** J. Entomol. Soc. B.C. 80(0): 29-36.

"Pathogenic and non-pathogenic microorganisms, including fungi, bacteria, viruses, microsporidia and nematodes, were isolated from 14,000 specimens representing 108 pest species of insects

collected from British Columbia forests between 1949 and 1969. *Entomophthora* sp. and *Beauveria* sp. were the most widely distributed fungal organisms isolated, occurring in 14 and 29 insect species, respectively. Nuclear polyhedrosis and granulosis viruses were isolated from 53 species, microsporidia from 26, pathogenic bacteria from 12 and nematodes from 2 species. A new variety of *Bacillus thuringiensis*, viz. *canadensis*, was isolated from *Lambdina fiscellaria lugubrosa* (Hlst.) and a *Neophasia* sp. The largest numbers of species of microorganisms were found in *Melanolophia imitata* (Wlk.), *Malacosoma disstria* Hbn., *M. pluviale* (Dyar), *L. f. lugubrosa*, *Acleris variana* (Fern.), *Hyphantria cunea* Dru., *Choristoneura fumiferana* (Clem.), *Orgyia pseudotsugata* (McD.) and *Neophasia menapia* Feld."

Biology - 3

288. Morris, R.C. 1975. **Tree-eaters in the tupelo swamps.** Forests and People 25(1): 22-24.

"Better control agents are needed for the forest tent caterpillar, a hardwood defoliator whose feeding has reduced host diameter growth 50 percent or more and prevented seed production in one-half million acres of water tupelo forests in southern Louisiana. Trichlorphon (Dylox®) applied at three-quarters of a pound per acre provided nearly 100 percent control of this insect with minimal effect on associated nontarget organisms. It is now registered by EPA. Forest managers now have an effective, environmentally acceptable insecticide to protect water tupelo from forest tent caterpillar."

Outbreaks - 3; Control - 2

289. Muggli, J.M. 1974. **Sex identification of *Malacosoma disstria* pupae (Lepidoptera: Lasiocampidae).** Ann. Entomol. Soc. Am. 67(3): 521-522.

The position and size of the genital openings on abdominal segments 8 and 9 were found in the laboratory in Minnesota to be reliable characters for determining the sex of pupae of *Malacosoma disstria* Hbn.

Biology - 1,6

290. Muggli, J.M.; Miller, W.E. 1980. **Instar head widths, individual biomass, and development rate of forest tent caterpillar, Malacosoma disstria (Lepidoptera: Lasiocampidae), at two densities in the laboratory.** Gt. Lakes Entomol. 13(4): 207-209.

"Two colonies of forest tent caterpillar were reared at different densities on trembling aspen foliage in an environment chamber programmed for natural temperatures. Based on direct observation of molting, both colonies underwent five instars which overlapped negligibly in head width. Instar head widths were relatively stable between colonies, but individual biomass was sensitive to the different densities. Instars 3-5 in the less dense colony were heavier than those of the more dense by factors of 1.3-1.9. Development to 10-20% of larvae spinning cocoons took 40 days in the less dense colony and 45 days in the more dense. Size of larvae and adults resembled that of field samples. "

Biology - 1,6

291. Myers, J.H. 1988. **Can a general hypothesis explain population cycles of forest Lepidoptera?** Adv. Ecol. Res. 18(0): 179-243.

This paper describes the characteristics of population cycles of forest Lepidoptera and evaluates mechanisms proposed to explain them. (*Malacosoma disstria* is listed as an example of a species with cyclic population fluctuations.)

Outbreaks - 5

292. Myers, J.H.; Kukan, B. 1995. **Changes in the fecundity of forest tent caterpillars: a correlated character of disease resistance or sublethal effect of disease?** Oecologia 103(4): 475-480.

"Over the fluctuation in population density of tent caterpillars, *Malacosoma californicum pluviale* and *M. disstria,* fecundity changes from being high at peak density to low for several years during the decline. During the increase phase, fecundity rapidly returns to moderately high levels with a further increase occurring toward the end of the increase phase. Two hypotheses which might explain these shifts are that (1) mortality from viral disease which is common during population declines selects for resistant individuals with low fecundity as an associated characteristic, and (2) sublethal viral disease reduces fecundity of moths during population decline. In this study we observed rapid shifts in the frequencies of large and small egg masses and in the mean fecundity between different phases of the population fluctuation. Viral disease was more common in caterpillars from small egg masses of the forest tent caterpillar. These observations are consistent with the hypothesis that sublethal effects of virus reduce the fecundity of moths during the population decline, but high fecundity is quickly restored when disease is rare during the population increase."

Biology - 3; Outbreaks - 5

293. Naugler, C.T.; Leech, S.M. 1994. **Fluctuating asymmetry and survival ability in the forest tent caterpillar moth *Malacosoma disstria*: implications for pest management.** Entomol. Exp. Appl. 70(3): 295-298.

"Fluctuating asymmetry of the first tarsal segment of the proleg of the forest tent caterpillar moth *Malacosoma disstria* Hbn. (Lepidoptera: Lasiocampidae) was significantly inversely related to survival ability in the laboratory. The monitoring of population levels of fluctuating asymmetry could have important implications in pest management of this and other species by providing an indication of the health of a population."

Biology - 1; Outbreaks - 5

294. Neill, G.B.; Reynard, D.A. 1989. **Insect and disease projects.** Agric. Can., Prairie Farm Rehabilitation Administration, Indian Head, Sask., Annu. Rep. pp. 22-32.

The status of pests and pesticides used in 1989 on the trees of Saskatchewan, Canada, are summarized. Experiments on the monitoring of spring cankerworm (*Paleacrita vernata*), cottonwood crown borer {*Sesia tibilis*) and ash borer (*Podesia syringae*) and control of forest tent caterpillar

(*Malacosoma disstria*) with *Bacillus thuringiensis* ssp. *kurstaki*, of cottonwood leaf beetle (*Chrysomela scripta*) larvae and adults with *B. thuringiensis* ssp. *san diego* and of poplar bud gall mite (*Aceria parapopuli*) and boxelder bug (*Leptocoris trivittatus*) with insecticides are described.

Outbreaks - 1; Control - 3

295. Nigam, P.C. 1968. **Laboratory screening of insecticidal compounds for comparative contact toxicity against sawflies and forest tent caterpillar.** Can. For. Serv., Bi-mon. Res. Notes 24(1): 4-5.

Ten compounds (9 organophosphorus and 1 carbamate) tested against *Neodiprion pratti banksianae*, *Pristiphora erichsonii*, and five (Anthio, Cyan 47931, Dibrom, Thimet and DDT) against *Malacosoma disstria*, were all superior to DDT in toxicity. Dibrom was the most effective against the three species. Abate and Zytron were not worthy of further testing. The relative toxicity to wildlife of Dibrom compared with phosphamidon and DDT is very low; it acts as a contact insecticide and has a residual life of less than 4 days.

Control - 1,2

296. Norris, D.M. 1996. **A redox-based mechanism by which environmental stresses elicit changes in plant defensive chemistry.** Pages 46-54 *in* W.J. Mattson, P. Niemelä, and M. Rousi (eds.). Dynamics of forest herbivory: Quest for pattern and principle. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. NC-183.

The effects of anti-oxidants (reducing agents) on eliciting defensive plant mechanisms of 'Summit' mountain ash, *Fraxinus pennsylvanica* var. *subintegerrinia* against the *Malacosoma disstria* was examined. Addition of the anti-oxidant α-tocopherol (vitamin E) resulted in reduced feeding preference by *M. disstria* larvae. A mechanism by which anti-oxidants may elicit changes in insect feeding responses is given.

Host Relationships - 6

297. Nova Scotia Department of Lands and Forests. 1945. **Report of the Department of Lands and Forests, 1944.** King's Printer, Halifax, N.S. pp. 41, 43.

"Local infestations of the forest tent caterpillar occurred this year throughout the Province, and at several points it was particularly noticeable. Just outside Wolfville a farm lot was severely attacked. Poplar, grey and white birch were completely stripped of foliage. At Antagonish defoliation varied from 25 to 100 per cent. Hosts noted were maple, elm, birch, mountain ash, locust, apple, and wild and cultivated cherry." Reference contains map showing location and severity of infestations.

(Entire reference pertaining to *M. disstria* included in annotation.)

Outbreaks - 1,3

298. Nyrop, J.P. 1979. **Comparison of four sequential sampling plans applied to forest tent caterpillar eggs on sugar maple branches.** M.Sc. thesis, Mich. State Univ., East Lansing, Mich. 35 p.

"Sequential sampling is a valuable tool for classifying population density. To date, all applications in insect sampling have used Wald's Sequential Probability Ratio Test (SPRT). Use of the procedure necessitates knowing the distribution of the underlying population and requires that the distribution be constant in time and space. When these assumptions are not met sequential t-tests and a new sequential test proposed by Iwao provide alternatives. Four sequential procedures were compared through simulation. These were the SPRT, Iwao's test and two sequential t-tests proposed by Barnard and Fowler and O'Regan. Forest tent caterpillar (*Malacosoma disstria*) egg band sampling was used as a test case. Though not universally true, in this instance SPRT was robust to changes in k of the negative binomial distribution. Fowler's and O'Regan's t-test and Iwao's procedure were comparable to the SPRT. Fowler's and O'Regan's t-test required the least information about the population distribution for construction."

Outbreaks - 4a, 6

299. Nyrop, J.P.; Murray, R; Mosher, D. 1979. **Predicting forest tent caterpillar defoliation on sugar maple.** Mich. Dep. Nat. Resourc., For. Pest Manage. Misc. Rep. MR-2-79. 4 p.

This report presents a sequential sampling scheme developed for forest tent caterpillar egg bands on sugar maple (*Acer saccharum*) and combines this with an index of population quality and historical records to arrive at a prediction for future defoliation.

Outbreaks - 2a,5

300. Oliver, A.D. 1964. **Control studies of the forest tent caterpillar, *Malacosoma disstria*, in Louisiana.** J. Econ. Entomol. 57(1): 157-60.

Control was achieved by spraying fourth and fifth instars from the air with 3 gal./acre of water containing 1 lb. of phosphamidon or 0.25 lb. of Bidrin (3-hydroxy-N-N-dimethyl-cis-crotonamide dimethyl phosphate). Wildlife was not affected even when crayfish and fish were fed with the killed larvae. Though a wide range of insects was killed there was no sustained residual kill of non-phytophagous species, and sarcophagid flies parasitized ca. 41% of the mature larvae and pupae nearby.

Control - 2

301. Ontario Region 1953-1992. **Annual regional and district report** (also Annual forest biology ranger district reports), Forest Insect and Disease Survey. Dep. For. (also Can. For. Serv.), Sault Ste. Marie, Ont.

These reports contain information on occurrence, population levels, locality, and extent of infestations of major insect pests of Ontario, according to district. (indicates that there is a reference to *M. disstria*, but the page number is not specified)

Year	South Eastern	South Western	South Central	Central	North	North Western	North Central
1953							
1954	3, 10-12, 41	46,57,61,79-82,91	96,100-104,119,136, 154,155	161-169,179,216, 225,236	240-246,261,270, 279	284,285,310	315,327,335, 346,356
1955	17,25	61,77,86	87,90,91,136	138-143,160,183, 193,201	203-207, 224,231	265	277,284,310
1956	30	-	66,69,70	113,117-120,148,155	165-168,179	217	221,229-231,237,242
1957	-	-	85,86,136	159,178	212,215	-	265,275,276, 277,290
1958	-	81,90	-	-	-	-	321,329,330, 345
1959	-	93,108	-	192,206	-	323	346,359,363
1960	54	120	147,182	219,223-225	-	352,365	384,397,411
1961	57	89,110	148,169,184	-	-	-	412,422-426

Page Numbers in Sections

	A	B	C	D	E	F	G
1962	15,26,31,41	22,35,51	8,9,28	14,26,27	16,30,36	18,19,28	1-5
1963	9,20,39	27	10,25	23,33,49,57	2	13,20	2
1964	3	25,43,59	9,20	15,39,57	3	18,32	3
1965	1	22	6,16	2	11,22,34	11,20	1
1966	25,37,46	20	9,21	1	13,24	11,19	1
1967	23,41	44	10,21,38	13,23	33,44	10	13,22,30
1968	30,37	49	23,42	10,19,37	31	-	13,20,24
1969	-	-	-	9,21	-	-	18

Numbers given for each survey region are O-X- Information Report number and page number respectively.

	Southern		Eastern		Central		Northern		Western	
1970	142	14	143	-	144	6	145	-	146	7

	Southeastern		Southwestern		Eastern		Central		Northern		Western	
1971	157	12	158	-	159	8	160	-	161	4	162	4
1972	174	14	175	-	176	4	177	-	178	4	179	5
1973	194	4	195	-	196	4	197	3	198	-	199	4

	North Western		North Central		Northern		North Eastern		Algonquin		Eastern		Central		South Western	
1974	220	3	221	4	222	4	223	6-8	224	3-4	225	3-4	226	13	22	3-4

Page numbers are given for each survey region.

	North Western	North Central	Northern	North Eastern	Algonquin	Eastern	Central	South Western
1975	3,4	3	3-5	5-7	4	3,4,5	3,4	3-5
1976	2	3	3,4	5,6	5,6	3,4	5	4
1977	2,3	2,3	4	4,5	4-10	3	4,5	4

	North Western	North Central	Northern	North Eastern	Algonquin	Eastern	Central	South Western
1978	3,4	3-5	5,6	3-5	5-7	3	4	4-6
1979	3, 5-7,9,10	3,4,6	4,5	3,4	17	4,5	13	8
1980	1-3	1-3	1-3	2,3-5	13	-	-	-
1981	4	3-5	4	5-7	-	-	-	-
1982	-	3-6	4,5	5,8	-	9	-	-
1983	**missing**							
1984	-	7	11	13	-	22	14	-

Numbers given for each survey region are Miscellaneous Report number and page number respectively.

	North Western		North Central		Northern		North Eastern		Algonquin		Eastern		Central		South Western	
1985	36	14	37	8-10	38	10-13	39	16	40	9, 12	43	15	41	15	42	-
1986	48	-	49	7	50	14	51	13-18	52	8, 10, 11-14	55	18	53	6,9, 10, 11	54	8
1987	77	15	79	11-13	78	5-9	76	11-17	74	11, 13 -15	81	10, 13 14	75	9	80	11
1988	87	19	83	10	82	7-10	86	7,10 -16	84	10-16	89	11-15	85	10-12	88	5,7 8
1989	95	9-13	92	12-17	94	7-10	97	13-21	96	9, 14-18	93	7, 10 -13	90	8-11	91	7-11
1990	101	11-15	106	10-15	102	7-12	100	11-20	104	17-20	107	9, 11-14	103	11-14	105	8-11
1991	116	9	112	7-10	111	10, 11	114	12-15	117	13-16	110	5-8	115	9-11	113	6

Numbers given for each survey region are O-X- Information Report number and page number respectively.

	North Western		NorthEastern		Central		Southern	
1992	428	6-10	430	9-11	427	17-19	429	8,9
1993	435	5,6	436	6,8	438	15-17	437	11-13
1994	445	5,6	447	10-12	448	28	446	10,11

Outbreaks - 1,3

302. Pacific and Yukon Region. 1947-1994. Forest insect and disease survey district reports (also Annual report - Forest insect ranger activities and Annual report of forest biology rangers). Can. For. Serv., Victoria, B.C.

These are a series of published and unpublished reports, by various authors over the years. They include information on occurrence, populations, locality and extent of infestations of major insect pests of British Columbia and the Yukon. References to the forest tent caterpillar occur in the following years and pages. () indicate part within the report. No reference to *M. disstria* was found in the Yukon reports.

year	Report number	Vancouver	Kamloops	Nelson	Cariboo	Prince Rupert	Prince George
1949	unpubl	-	-	-	-	-	188
1950	unpubl	-	-	-	-	-	177,180
1951	unpubl	-	-	96	-	-	4
1952	unpubl	-	38,52	79,98	-	44	5
1953	unpubl	35	24,38	49,61	-	78	5
1954	unpubl	7	67,81	90,95,101	-	-	113
1955	unpubl	-	59	97,110	-	-	119,125
1956	unpubl	-	73	-	-	-	-
1957	unpubl	6	73	-	-	42	127
1958	unpubl	40	94	-	-	62	150
1959	unpubl	42	101	142,151	-	70,82	161
1960	unpubl	55	155	213	-	113,129	231
1961	unpubl	13,49,65	131	174,191,198	-	96,105	215,239
1962	unpubl	11,44,58	132	160,178,188	-	83,97	208,226,240
1963	unpubl	14,46	139	173,188,200	-	86,100	234,254,267
1964	unpubl	11	-	172,192,205	-	100	235,261
1965	unpubl	9	-	142,146, 162,179	-	63,68	200,225
1966	BC-X-11	-	-	-	-	66	-
1967	BC-X-16	-	115	194	-	61	-
1968	BC-X-33	38	111	-	-	62	-
1969	BC-X-41	(1)1, (2)16	(4)3,8	-	-	-	-
1970	BC-X-51	-	(4)9	-	-	(2)4	-
1971	BC-X-64	-	(4)10	(5)9	-	(2)4	-
1972	BC-X-77	-	(4)17	(5)14	(6)7,9	-	(3)7

	Vancouver		Kamloops		Nelson		Cariboo		Prince Rupert		Prince George	
year	BC-X	pg	BC-X	pg	BC-X	pg	BC-X	pg	BC-X	pg	BC-X	pg
1973	-	-	93	14	92	10	96	4	-	-	94	3
1974	-	-	-	-	-	-	116	16	-	-	114	3
1975	-	-	-	-	-	-	-	-	-	-	135	3
1976	-	-	159	10	158	6	-	-	-	-	160	3
1977	-	-	172	5-6	171	8	-	-	-	-	173	4
1978	-	-	-	-	191	11	-	-	-	-	193	4

year	Report number	Vancouver	Kamloops	Nelson	Cariboo	Prince Rupert	Prince George
1979	unpbl	-	(4)31	-	-	-	-
1980	unpbl	-	-	-	-	-	-
1981	unpbl	-	-	-	-	(2)22	-
1982	unpbl	-	-	-	(6)25	(2)27	-
1983	unpbl	-	-	-	(6)19	(2)26	(3)13
1984	unpbl	-	-	(5)30	-	(2)28	(3)18
1985	FIDS rep 86	-	-	(5)25	-	(2)34	(3)20

year	Report number	Vancouver	Kamloops	Nelson	Cariboo	Prince Rupert	Prince George
1986	FIDS rep 87	-	-	(5)28	-	-	(3)22
1987	FIDS rep 88	-	(4)34	(5)29-31	-	-	(3)26
1988	FIDS rep 89	(1)27	-	(5)38	(6)21	-	(3)23
1989	FIDS rep 90	(1)30	(4)32	(5)39	(6)18	(2)20	(3)18
1990	FIDS rep 91	(1)41	(4)41	(5)47	(6)25	(2)22	(3)28
1991	FIDS rep 92	-	(4)42-43	(5)40	(6)29-31	-	(3)29-34
1992	FIDS rep 93	-	(4)29,31	(5)36	(6)28	-	(3)25,27,29
1993	FIDS rep 94	-	-	-	(6)31-34	-	(3)34-38
1994	FIDS rep 95	-	-	-	(6)28-31	-	(3)31-34

Outbreaks - 1,3

303. Palaniswamy, P.; Chisholm, M.D.; Underhill, E.W.; Reed, D.W.; Peesker, S.J. 1983. **Disruption of forest tent caterpillar (Lepidoptera: Lasiocampidae) orientation to baited trap 1976s in aspen groves by air permeation with (5Z,7E)-5,7-dodecadienal.** J. Econ. Entomol. 76(5): 1159-1163.

"Orientation of *Malacosoma disstria* males to traps baited with live female moths or a three-component lure (5Z,7E-12:aldehyde + 5Z,7Z-12: aldehyde + Z7-12:aldehyde) was disrupted when 5Z,7E-12:aldehyde was released from a varying number of releasers (rubber septa or Hercon plastic laminates) uniformly spaced in plots (9 by 9 m) in the field. Release rates of more than 300 µg per plot per 24 h effected > 85% disruption. At these release rates, variation of the number of release points from 10 to 100 per plot had no significant effect on percentage disruption. Behavioural observations indicated that, at lower release rates per releaser (3 or 6 µg per 24 h), disruption was partly due to confusion and partly due to a reduction in search effort by the moths; at higher release rates, disruption was mainly due to reduction in searching effort. A 7-year blacklight trapping record suggests the *M. disstria* population was generated locally. Potential control of the population with synthetic pheromone is discussed."

Biology - 5; Control - 5

304. Palli, S.R.; Sohi, S.S.; Cook, B.J.; Lambert, D.; Ladd, T.R.; Retnakaran, A. 1995. **Analysis of ecdysteroid action in *Malacosoma disstria* cells: cloning selected regions of E75- and MHR3-like genes.** Insect Mol. Biol. 25(6): 697-707.

"IPRI-MD-66 (MD-66) cells respond to 20-hydroxyecdysone (20E, 4 x 10^{-6} M) in the medium by producing cytoplasmic extensions, clumping and attaching themselves to the substrate. These morphological changes are at a maximum by 6 days post treatment. Degenerate oligonucleotides, designed on the basis of conserved amino acid sequences in the DNA and ligand binding regions of the members of the steroid hormone receptor superfamily, were used in RNA-PCR to isolate two cDNA fragments, *Malacosoma disstria* hormone receptor 2 (MdHR2) and *Malacosoma disstria* hormone receptor 3 (MdHR3) from the MD-66 cells. Comparison of deduced amino acid sequences of these cDNA fragments with the members of the steroid hormone receptor superfamily showed that MdHR2 is most closely related to E75 proteins of *Manduca sexta*, *Galleria mellonella* and *Drosophila melanogaster*. The MdHR3 is most closely related to *Manduca* hormone receptor 3 (MHR3), *Galleria* hormone receptor 3 (GHR3) and *Drospohila* hormone receptor 3 (DHR3) proteins. At a concentration of 4 x 10^{-6} M, 20E induces the expression of MdHR2 and MdHR3 beginning at 3h, reaching maximum

levels in 12h and declining in 24h. MdHR2 binds to a 2.5 kb mRNA, whereas MdHR3 binds to a 4.5 kb mRNA. Based on sequence similarity, RNA size and ecdysone inducibility, we conclude that these cDNA fragments, cloned from MD-66 cells, are regions of E75- (MdHR2) and MHR3- (MdHR3) like genes."

Biology - 7

305. Parker, B.L.; Teillon, H.B. 1982. **Forest tent caterpillar control in Vermont: Orthene and Bt**. Vermont Agric. Exp. Sta. Res. Rep. 12 p.

"Orthene, an organophosphate insecticide, and *Bacillus thuringiensis*, a biological insecticide, were field tested for efficacy against *Malacosoma disstria*, the forest tent caterpillar. Both materials were compared with carbaryl, our insecticide standard, and a no-spray check in Stockbridge, Benson, and Gaysville, VT. It was not possible to compare data between areas because a significant interaction between treatment and area occurred. We felt this was caused by insect population differences such as density, age of infestation, and population vigor. Data were confounded by the occurrence of a nuclear polyhedral virus disease in the insect population at each location. Initially, Orthene and carbaryl caused high knockdown of caterpillars, but it was not possible to detect and peak of Bt-caused larval knockdown in any of the areas. Orthene caused less caterpillar feeding as reflected in frass collections at each location, while carbaryl's effect on feeding was not consistent at any location. Bt did not immediately stop feeding, and data collections from one sampling period to the next were extremely variable. Diseased forest tent caterpillars were found in each area and in all plots, which influenced the frass weight parameter and defoliation estimates. Defoliation in all plots did not exceed 25% of the total foliage. From a practical standpoint this degree is not considered to significantly affect tree vigor and growth. The sprayed plots had less defoliation than the no-spray check plots. The efficacy of Bt was extremely variable and, at a rate of 4 BIU / acre, is not considered an acceptable alternative to carbaryl for controlling the forest tent caterpillar. Orthene, at a rate of 0.5 lb a.i.[active ingredient] / acre is considered an acceptable alternative to carbaryl for the control of forest tent caterpillar in Vermont."

Control - 2,3

306. Parry, D. 1994. **The impact of predators and parasitoids on natural and experimentally created populations of forest tent caterpillar, *Malacosoma disstria* Hubner (Lepidoptera: Lasiocampidae).** M.Sc. thesis, Dep. Entomol., Univ. Alberta, Edmonton, Alta. 91 p.

The impacts of parasitoids on endemic, outbreak and post-outbreak populations of *Malacosoma disstria* were examined at 20 locations in Alberta. Eighteen parasitoids were identified in this study, the most abundant being the tachinid *Leschenaultia exul* (Townsend), which attacked more than 60% of larvae in some populations. Another tachinid, *Patelloa pachypyga* (Aldrich & Webber) was also abundant, but parasitism by this species decreased in older outbreaks. None of the other parasitoids, including *Arachindomyia* [*Sarchophaga*] *aldrichi* (Parker) were considered to be important. The principal avian predator of *M. disstria* larvae and pupae was the northern oriole, *Icterus galbula* (L.).

Biology - 2

307. Parry, D. 1995. **Larval and pupal parasitism of the forest tent caterpillar, *Malacosoma disstria* Hubner (Lepidoptera: Lasiocampidae), in Alberta, Canada.** Can. Entomol. 127(6): 877-893.

"Larval and pupal parasitoids were studied from collections made in endemic, outbreak and post-outbreak populations of forest tent caterpillar (FTC), *Malacosoma disstria*, at 21 sites in Alberta, Canada, from 1989 to 1994. The parasitoid complex included 18 identified species. *Aleiodes malacosomatos* (Mason) (Hymenoptera: Braconidae) was common in low density populations and was the only species to attack FTC larvae prior to the fourth instar. *Leschenaultia exul* (Townsend) (Diptera: Tachinidae) was the most abundant larval parasitoid in endemic populations and after the 2nd year of outbreak. Although prevalent early in outbreaks, *Patelloa pachypyga* (Aldrich and Webber) (Diptera: Tachinidae) declined in older outbreaks possibly because it completes larval development later than other tachinids, leaving it vulnerable to competition from aggressive pupal parasitoids. I hypothesize that early initiation of oviposition allows *L. exul* to be more successful than *P. pachypyga* in low density populations because caterpillars have dispersed before the latter species initiates oviposition. I recorded lower pupal parasitism by *Arachnidomyia* [*Sarchophaga*] *aldrichi* (Parker) (Diptera: Sarcophagidae) in Alberta than has been recorded in other regions, although it was still the most abundant parasitoid reared in this study. Parasitism by *A. aldrichi* was significantly higher in cocoons collected from undergrowth vegetation than from the forest canopy. Other pupal parasitoids contributed relatively little to FTC mortality."

Biology - 2

308. Parry, D.; Spence, J.R.; Volney, W.J.A. 1992. **Effects of host species on development and oviposition of the forest tent caterpillar (*Malacosoma disstria*).** Page 163 *in* D.C. Allen and L.P. Abrahamson (eds.). Proc. N. Am. For. Insect Work Conf., Denver, Colo. Mar. 25-28, 1991. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. PNW- 294 .

"Larval survivorship, development time, pupal mass, and sex ratios of forest tent caterpillars were compared among populations fed on trembling aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), Alaska birch (*Betula neoalaskana*), Saskatoon service berry (*Amelanchier alnifolia*) and wild rose (*Rosa acicularis*). Observations were made on larvae reared from the first instar and on wild-caught fourth instars that had developed on aspen, but were transferred to an experimental food treatment at the fifth molt. Early instars were highly selective in host species requirements, but later instars were more catholic feeders and did not suffer reduced survivorship from feeding on other hosts. Fecundity was related to host, even in the transfer experiments. Although field egg band surveys suggested that females oviposited preferentially on aspen in central Alberta we were unable to demonstrate a preference for aspen in laboratory oviposition tests." (Poster Abstract)

Host Relationships - 1,2,6

309. Parry, D.; Spence, J.R.; Volney, W.J.A. 1997. **Responses of natural enemies to experimentally increased populations of the forest tent caterpillar, *Malacosoma disstria*.** Ecol. Entomol. 22(1): 97-108.

“The responses of predators and parasitoids to increased forest tent caterpillar populations were studied by introducing eggs to two trembling aspen, *Populus tremuloides* Michx., forests where natural populations were at very low density. Of five parasitoid species recovered, only the braconid *Aleiodes malacosomatos* (Mason) and the tachinid *Patelloa pachypyga* (Aldrich & Webber) exhibited spatially density-dependent responses, in dry upland forest and mesic lowland forest, respectively. Forest type restrictions on the abundance of these species and the weak density-

dependent response of *A. malacosomatos* suggests that parasitoids may not be capable of regulating low-density tent caterpillar populations. Predation of final-instar larvae and pupae by birds, in particular the northern oriole, *Icterus galbula* (L.), virtually eliminated the experimental populations. Avian predation was widespread and dominated mortality at all densities. Implications for the initiation of outbreaks of cyclic defoliators are discussed."

Biology - 2

310. Payette, S.; Fortin, M.-J.; Morneau, C. 1996. **The recent sugar maple decline in southern Quebec: probable causes deduced from tree rings.** Can. J. For. Res. 26(6): 1069-1078.

Tree-ring chronologies of both sugar maple (*Acer saccharum* Marsh.) and American beech (*Fagus grandifolia* Ehrh.) were compared to determine which factors caused the decline of sugar maple during the 1980s. It was determined that the decline in sugar maple growth was the result of a synergistic effect from a combination of natural disturbances, such as insect infestation (particularly *Malacosoma disstria*), drought, and possible winter thaw-frost, rather than from the effects of pollution.

Host Relationships - 5

311. Peirson, H.B. 1945a. **Forest tent caterpillar.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 1(2): 3.

"A heavy flight occurred at Ashland with fairly large numbers at Jackman, Seboomook, Greenville, and Princeton. There will probably be outbreaks on poplar and white birch in these areas this year."

(Entire reference pertaining to *Malacosoma disstria* included in annotation.)

Outbreaks - 1

312. Peirson, H.B. 1945b. **Forest tent caterpillar.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 1(4): 4.

"Large areas of poplar and white birch are being defoliated in Northern Maine. This outbreak was predicted last year based on moths collected at light traps."

(Entire reference pertaining to *Malacosoma disstria* included in annotation.)

Outbreaks - 1

313. Peirson, H.B. 1946a. **Forest tent caterpillar.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 2(4): 4.

"Many thousand acres of poplar have been defoliated, in many places completely, in Northern Maine. The caterpillars have migrated in great swarms across highways. The infestation which for the past two years has been moving across the state is now well into New Brunswick."

(Entire reference pertaining to *Malacosoma disstria* included in annotation.)

Outbreaks - 1

314. Peirson, H.B. 1946b. **Forest tent caterpillar.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 2(5): 4.

"An outbreak of this insect has been building up in northern Maine and this year heavy to almost complete defoliation occurred on poplar and to some extent on birch in 12 areas. Parasites should bring this outbreak under control."

(Entire reference pertaining to *Malacosoma disstria* included in annotation.)

Outbreaks - 1

315. Pelech, S.; Hannon, S.J. 1995. **Impact of tent caterpillar defoliation on the reproductive success of black-capped chickadees.** Condor 97(4): 1071-1074.

The reproductive success and survival of chickadee chicks and adults were monitored during an outbreak of *Malacosoma disstria* in Alberta. Tent caterpillar outbreaks appeared to have no effect on either the timing of clutch initiation or on the size of egg clutches. Defoliation had no significant effect on the number of fledglings or their size.

Biology - 2

316. Pendrel, B.A. 1985. **Population distribution of the forest tent caterpillar - 1984 described through pheromone trapping.** Can. For. Serv., Marit. For. Res. Cent., Tech. Note No. 137. 4 p.

"Pheromones, chemicals used for communication between insects, can be used as survey tools to describe the distribution of insect populations. This Note is the third of three which presents results of initial surveys with sex pheromones on a large geographic scale within the Maritimes by the Forest Insect and Disease survey. Our objectives were to confirm that traps baited with synthetic pheromone lures were sensitive indicators of population levels and to see what type of pest distribution map could be produced. Our long term goals are to predict occurrence of pest outbreaks and the degree of injury to be expected."

Biology - 5; Outbreaks - 4d; Control - 5

317. Pendrel, B.A. 1991. **Insect and disease caused losses of wood volume in the forests of the Maritime Provinces, 1982-1987.** Can. For. Serv., Marit. For. Res. Cent., Inf. Rep. M-X-180E. p. 11.

This brief report contains a section describing the damage caused by *Malacosoma disstria* in the Maritimes from 1982 to 1987. The report also gives the average volume of aspen lost on a yearly basis during the outbreak.

Outbreaks - 3

318. Percy, J.E.; Weatherston, J. 1971. **Studies of physiologically active arthropod secretions. IX. Morphology and histology of the pheromone-producing glands of some female Lepidoptera.** Can. Entomol. 103(12): 1733-1739.

"The morphology and histology of the sex pheromone-producing gland in female s of *Choristoneura fumiferana* (Clemens.), *C. pinus* (Freeman) (Tortricidae), and *Malacosoma disstria* Hubner (Lasiocampidae) is reported. A review of literature relevant to such a study is presented in tabular form."

Biology - 5

319. Perkins, G.H. 1900. **The forest caterpillar (*Clisiocampa* [*Malacosoma*] *disstria*)**. Vermont Agric. Exp. Sta. Bull. 76. pp. 113-137.

This is a general bulletin containing information on the life history, hosts, behaviour, control methods and natural enemies of the forest caterpillar, *Clisiocampa* [*Malacosoma*] *disstria*. Notes on the history of an outbreak in Vermont are also included.

Biology - 1,2,3; Control - 2,6

320. Perry, D.F.; Fleming, R.A. 1989. ***Erynia crustosa* zygospore germination.** Mycologia 81(1): 154-158.

Laboratory experiments on stimulating zygospore germination are described on *Erynia crustosa* derived from dead larvae of *Malacosoma disstria* collected in a stand of *Populus tremuloides* in Ontario. Treatments that stimulated spores to germinate were those exceeding 3 months at 4 or 12°C. Models describing the results of 6-month treatments in soil at these 2 temperatures were developed using nonlinear regression analysis. These results are discussed in relation to the possibility of developing this fungal pathogen as a biological control agent against the lasiocampid.

Biology - 3; Control - 6

321. Pest Report. 1972-1995. **Forest insect and disease survey.** For. Can. (also Can. For. Serv.), Pac. For. Cent. (also For. Res. Lab.), Victoria, B.C.

The following are one- or two-page status reports on notable infestations of the forest tent caterpillar in various districts of British Columbia and the Yukon, listed by the date and authors. They include information on population levels, locality of infestations, and trend predictions.

Year	Date	Author / Title
1972	April 7	Monts, J.S.; Fiddick, R.L. Important forest insects and diseases in Mt. Revelstoke and Glacier National Parks
1972	July 4	Allen, S.J. Forest tent caterpillar infestations in the Prince George and North Cariboo Forest Districts, June 1972
1972	August 7	Doidge, D.F. Forest tent caterpillar near Vavenby, British Columbia, 1972
1973	March 2	Monts, J.S. Forest insect and disease conditions in Rocky Mountain National Parks
1973	June 18	Allen, S.J. Aspen defoliation in Prince George Forest District
1973	June 25	Doidge, D.F. Aspen defoliation in Cariboo District
1974	August 7	Allen, S.J.; Unger, L.S. Forest tent caterpillar in the Prince George Forest District, 1974
1975	June 24	Allen, S.J. Forest tent caterpillar infestation in McBride area
1976	June 5	Wood, R.O. Forest tent caterpillar in the McBride area, Prince George Forest District
1976	July 14	Cottrell, C.B. Tent caterpillar in the East Kooteney area
1984	July	Humphreys, N. Forest tent caterpillar infestation in the Hazelton-Kitwanga areas of the Prince Rupert Region, 1984
1985	June	Turnquist, R. Forest tent caterpillar, Trail, British Columbia, 1985
1986	December	Vallentgoed, J.; Garbutt, R. Forest tent caterpillar in British Columbia in 1986 and forecasts for 1987
1987	July	Wood, C.S. Tent caterpillars in British Columbia, 1987
1989	April	Turnquist, R.
1989	June	Turnquist, R.; Ferris, R.L. Forest tent caterpillar population increase in the Prince George forest region
1989	October	Turnquist, R.; Ferris, R.L. Forest tent caterpillar in the Prince George area, 1989 update and forecast for 1990
1990	June	Turnquist, R.; Ferris, R.L. Forest tent caterpillar in the Prince George area
1990	September	Turnquist, R.; Ferris, R.L. Forest tent caterpillar and large aspen tortrix in trembling aspen in the Prince George forest region
1990	October	Erickson, R.D.; Ferris, R.L. Summary of forest pest conditions in the Cariboo forest region
1990	October	Unger, L.; Vallentgoed, J. Summary of forest pest conditions on the Nelson forest region
1990	October	Turnquist, R.; Ferris, R.L. Summary of forest pest conditions, Prince George forest region
1990	November	Turnquist, R.; Ferris, R.L. Forest tent caterpillar in the Prince George forest region, 1990 update and forecast for 1991

Year	Date	Author / Title
1991	June	Humphreys, N.; Ferris, R.L.; Wood, C. Forest tent caterpillar in the Prince George region
1991	August	Humphreys, N. Forest tent caterpillar and large aspen tortrix in trembling aspen in the Prince George forest region
1991	September	Erickson, R.D. Summary of forest pest conditions, Cariboo forest region, 1991
1992	April	Humphreys, N. ; Ferris, R.L. Forest tent caterpillar, *Malacosoma disstria,* Prince George forest region, 1991 damage and forecast for 1992
1992	July	Erickson, R.S. Forest tent caterpillar in the Cariboo forest region
1992	August	Humphreys, N.; Ferris, R.L. Forest tent caterpillar in trembling aspen in the Prince George forest region
1992	September	Erickson, R.D. Summary of forest pest conditions in the Cariboo forest region
1992	September	Humphreys, N.; Ferris, R.L. Summary of forest pest conditions in Prince George forest region
1993	June	Erickson, R.D. Forest tent caterpillar infestation, Cariboo forest region
1993	July	Humphreys, N.; Ferris, R.L. Forest tent caterpillar in the Prince George forest region
1993	August	Hodge, J. Summary of forest pest conditions in Kamloops forest region, 1993
1993	September	Humphreys, N. Summary of pest conditions in the Prince George forest region
1993	September	Erickson, R.D. Summary of forest pest conditions in the Cariboo forest region
1994	June	Ferris, R.L.; Humphreys, N. Forest tent caterpillar in the Prince George forest region
1994	September	Erickson, R.D. Forest tent caterpillar in the Cariboo forest region
1994	September	Humphreys, N.; Ferris, R.L. Summary of forest pest conditions, Prince George, 1994
1994	September	Erickson, R.D. Summary of forest pest conditions, Cariboo, 1994
1994	November	Ferris, R.; Humphreys, N. Forest tent caterpillar, Prince George forest region, 1994 damage and forecast for 1995
1995	July	Humphreys, N. Forest tent caterpillar, Prince George forest region
1995	July	Erickson, R.D. Forest tent caterpillar outbreak, Cariboo forest region, 1995
1995	September	Humphreys, N. Summary of forest pest conditions in the Prince George forest region, 1995
1995	September	B. Erickson Summary of forest pest conditions in the Cariboo forest region, 1995

Outbreaks - 1,3

322. Philogène, B.J.R. 1975. **Observations sur la structure des ocelles larvaires (stemmates) de certains Lépidoptères.** Can. Entomol. 107(10): 1073-1080.

"Larval ocelli (stemmata) of 4 spp. of Lepidoptera (*Malacosoma pluviale, M. disstria, Isia isabella* and *Hypocrita jacobaea*) were examined under light and scanning electron microscopes. Two types of ocelli are present; one with three convexities, the other with a single one. Differences exist between species. Examination of the internal structure reveals the presence of two separate morphological units, related to external variations. The significance of these observations is discussed in the light of previous findings" Article in French.

Taxonomy, Biology - 8

323. Pinkham, J.D.; Frye, R.D.; Carlson, R.B. 1984. **Toxicities of *Bacillus thuringiensis* isolates against the forest tent caterpillar (Lepidoptera: Lasiocampidae).** J. Kans. Entomol. Soc. 57(4): 672-674.

"Ten isolates of *Bacillus thuringiensis* were bioassayed against *Malacosoma disstria.* The objective of the test was to determine a median lethal concentration value for each isolate. *Malacosoma disstria* was extremely susceptible to all of the isolates tested. Median lethal concentration values ranges from 0.9 µg/ml for HD-120 to 8.6 µg/ml for HD-201. Isolates HD-120 and HD-285 had the lowest LC_{50}'s and highest uniformity of response and are recommended for possible testing in field trials."

Biology - 3; Control - 3

324. Pollard, D.F.W. 1972. **Estimating woody dry matter loss resulting from defoliation.** For. Sci. 18(2): 135-138.

This article describes a rapid method for estimating past increments in biomass. A linear equation was developed for the regression of the logarithm of dry weight of aerial parts on the logarithm of DBH, from measurements on 30 trees of *Populus tremuloides* aged ca. 52 years in Ontario. Stem analyses of four trees sampled at a later date showed high correlations between annual ring widths at breast height (BH) and at other heights. The dry-weight increments (DELTA W) of the 30 trees during 1959-67 were estimated from their radial increments at BH. The data showed a marked fall in DELTA W from ca. 2-6 kg/tree in 1960 to <1 kg in 1963: the pattern of decline and subsequent recovery in DELTA W coincided with records for the index of infestation by *Malacosoma disstria.*

Outbreaks - 3

325. Prebble, M.L. 1975. **Forest tent caterpillar.** Pages 200-203 *in* M.L. Prebble (ed.). Aerial control of forest insects in Canada. Environ. Can., Ottawa, Ont.

This chapter briefly discusses the biology of *Malacosoma disstria* and the natural control agents (fungi, bacteria, parasitoids). Brief mention is made of parasitoid releases made in Canada between 1914 and 1919 and their success. The timing and effectiveness of aerial applications of DDT and nuclear polyhedrosis virus against the forest tent caterpillar are discussed.

General Background; Control - 1,4,6

326. Prentice, R.M. 1952. **The forest tent caterpillar outbreak in Manitoba and Saskatchewan.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 8(5): 2.

Infestations in Manitoba and Saskatchewan still persist. Despite the action of biological control factors, the adult population remained capable of extending the area of outbreak expected in 1953. Large moth flights have been observed both within and outside the areas infested in 1952.

Biology - 2; Outbreaks - 1,3

327. Prentice, R.M. 1953. **Egg parasitism of forest tent caterpillar.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 9(4): 2-3.

In 1951 and 1952, surveys of forest tent caterpillar (*Malacosoma disstria*) eggs were conducted in various forested areas of Saskatchewan and Manitoba with the intent of using these surveys to predict the distribution and abundance of *M. disstria* in the following year. In 1951, egg parasitism was low, with 5.1% of the bands attacked by parasites; of these only 5.9% of the eggs were parasitized. However, in 1952, egg parasitism was significantly higher with 56.3% of the bands attacked by parasites and of these 20.8% of the eggs were parasitized. The species most responsible for this increase was *Telenomus clisiocampae* Riley. Surveys also showed that the number of eggs parasitized in an individual band was closely related to the amount of spumaline (a protective coating) on the eggs. Parasitized eggs occurred frequently along the outer rows, an area where there is commonly very little or no spumaline covering.

Biology - 2

328. Prentice, R.M. 1954. **Decline of populations of the forest tent caterpillar in Central Saskatchewan.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 10(5): 2.

The decline is due to failure of egg bands to hatch in the spring of 1954. Egg bands collected in September 1953 and incubated in the laboratory hatched normally. Dissections of field collections showed heavy mortality of embryos, the cause of which is unknown.

Outbreaks - 1,4a

329. Prentice, R.M. (compiler) 1963. **Forest Lepidoptera of Canada recorded by the forest insect survey, Vol. 3.** Can. Dep. For. Publ. 1013. pp. 291-293.

This volume includes records on the distribution, hosts, feeding type, relative abundance, and seasonal occurrence of species within the families Lasiocampidae, Thyatiridae, Drepanidae, and Geometridae.

Biology - 1

330. Quebec Region. 1971-1994. **Insectes et maladies des arbres.** Can. For. Serv., Laurentian For. Cent., Ste. Foy, Que.

By various authors over the years, these reports contain information on occurrence, population levels, and locality of collections and infestations of major insect pests in Quebec. These reports were published as joint reports between the Canadian Forest Service and the various agencies of the Quebec provincial government.

Year	Author	Page Numbers
1971	Martineau, R; Lavallée, A.	10
1972	Lavallée, A.; Benoît, P.	11
1973	Martineau, R; Lavallée, A.; Béique, R.; Davidson, J.G.	8
1974	Martineau, R; Lavallée, A.; Béique, R.; Davidson, J.G.	8
1975	Martineau, R; Lavallée, A.; Béique, R.; Davidson, J.G.	7
1976	Lavallée, A.; Benoît, P.; Béique, R.; Davidson, J.G.	9
1977	Lavallée, A.; Benoît, P.; Lachance, D.; Béique, R.; Davidson, J.G.	10
1978	Lachance, D.; Benoît, P.; Bonneau, G.; Desaulniers, R.; Laflamme, G.	10
1979	Lachance, D.; Benoît, P.; Bonneau, G.; Laflamme, G.	7
1980	Lachance, D.; Benoît, P.; Bonneau, G.; Laflamme, G.	5-7
1981	Benoît, P.; Laflamme, G.; Bonneau, G.; Picher, R.	7
1982	Benoît, P.; Laflamme, G.; Bonneau, G.; Picher, R.	7
1983	Lachance, D.; Benoît, P.; Laflamme, G.; Bonneau, G.; Picher, R.	10
1984	Lachance, D.; Benoît, P.; Laflamme, G.; Bonneau, G.; Picher, R.	21
1985	Bonneau, G.; Picher, R.; Lachance, D.	11
1986	Anon.	9-10
1987	Bordeleau, C.; Guérin, D.; Innes, L.; Picher, R.; Lachance, D.	10-12
1988	Bordeleau, C.; Guérin, D.; Innes, L.; Lachance, D.; Picher, R.	12-14, A-1, A-2, A-4
1989	Bordeleau, C.; Guérin, D.; Innes, L.; Lachance, D.	10-12
1990	Anon.	7-10
1991	Anon.	9-11
1992	Anon.	9-10
1993	Anon.	8-9
1994	Anon.	7-8

Outbreaks - 1,3

331. Quebec Region. 1969-1978. **Inventaire des insectes et des maladies des arbres au Québec.** Can. For. Serv., Laurentian For. Cent., Ste. Foy, Que.

The following are short (under 10 pages), unpublished mid-year status reports on infestations of the various insects and pathogens in Quebec forests, including the forest tent caterpillar. The year-end reports do not contain any information concerning forest tent caterpillar. Published from 1969 to 1971 as **Rapport d'infestations du centre recherche forestière de Québec**.

Year	Author	Page Numbers
1969	Martineau, R.	2
1970	Martineau, R.	-
1971	**missing**	-
1972	Martineau, R.; Lavallée, A.	6
1973	Martineau, R.; Béique, R.; Lavallée, A.; Davidson, J.G.	6
1974	Martineau, R.; Béique, R.; Lavallée, A.; Davidson, J.G.	5
1975	Martineau, R.; Béique, R.; Lavallée, A.; Davidson, J.G.	2
1976	Martineau, R.; Béique, R.; Lavallée, A.; Davidson, J.G.	2-3
1977	Lavallée, A.; Benoît, P.; Lachance, D.; Béique, R.; Davidson, J.G.	8
1978	Benoît, P.; Lachance, D.; Desaulniers, R.; Bonneau, G.	5-6

Outbreaks - 1,3

332. Raheja, A.K. 1970. **A nuclear polyhedrosis virus disease of the forest tent caterpillar, *Malacosoma disstria* Hubner (Lepidoptera: Lasiocampidae), with notes on the microsporidian parasite, *Glugea disstriae* (Thomson).** Ph.D. thesis. Univ. Minn., St. Paul, 182 p.

This thesis is a detailed examination of the nuclear polyhedrosis virus of *M. disstria*. The thesis covers rearing the host on artificial diet, physical characteristics of the virus, optimal rearing conditions for the virus, transmission of the virus from adults to egg masses, infection, progress of the disease in the host, host resistance, and the effects of stress on the progress of the disease. The thesis also examines some aspects of the microsporidian parasite, including its infectivity, transmission transovarially from the adults to eggs, and its ability to retard the development of the virus. Possible avenues of research that could be pursued to examine the virus under field conditions are suggested.

Biology - 2,3,6; Control - 4

333. Raheja, A.K.; Brooks, M.A. 1971a. **Inability of the forest tent caterpillar, *Malacosoma disstria*, to acquire resistance to viral infection.** J. Invertebr. Pathol. 17(1): 136-7.

Early third-instar larvae were fed with initial doses of 7.53×10^3, 7.53×10^4, or 7.53×10^5 virus polyhedra (PIBs) per larva. The survivors were fed with a second dose five days later. Survivors from initial doses of 7.53×10^3 and 7.53×10^4 PIBs/larva were more susceptible to the second dose than were controls. No larvae survived a dose of 7.53×10^5 PIBs/larva. Mortality of insects given two separate feedings of 7.53×10^4 PIBs/larva was 43%, while that of controls receiving only one dose was only 20%. In no case was there any evidence of the build-up of a resistance during the five day interval. When using the virus in control operations, two applications would probably be more effective than one.

Biology - 3; Control - 4

334. Raheja, A.K.; Brooks, M.A. 1971b. **Infective hemolymph from forest tent caterpillars diseased by nuclear polyhedrosis virus.** J. Invertebr. Pathol. 17(2): 286-287.

Using hemolymph of diseased larvae to infect primary cells the authors conducted an experiment to identify the time at which the hemolymph was most infectious. Third-instar larvae were fed 7.53 x 10^7 polyhedra/larva. At given time intervals afterwards, their prolegs were cut and hemolymph extracted. The hemolymph was then concentrated and a bioassay for infectivity performed. Results showed the hemolymph to be infective as early as 12 hours after ingestion. Infectivity then increased up to 96 hours, decreased sharply from 96 to 108 hours and then plateaued between 108 and 144 hours.

Biology - 3,7

335. Ramachandran, R.; Raffa, K.F.; Bradley, D.; Miller, M.; Ellis, D.D.; McCown, B.H. 1993. **Activity of an insecticidal protein from *Bacillus thuringiensis* subsp. *thuringiensis* HD-290-1 strain to Coleopteran and Lepidopteran defoliators of poplars.** Environ. Entomol. 22(1): 190-196.

"In standardized laboratory bioassays, soluble protein extracted from *Bacillus thuringiensis* HD-290-1 was toxic to early larval instars of cottonwood leaf beetle, *Chrysomela scripta* F. (Coleoptera: Chrysomelidae) and forest tent caterpillar, *Malacosoma disstria* Hübner (Lepidoptera: Lasiocampidae) but was not toxic to first instars of fall webworm, *Hyphantria cunea* (Drury) (Arctiidae: Lepidoptera). Trypsin-digested toxin was slightly more toxic than undigested protoxin to cottonwood leaf beetles and forest tent caterpillars. Susceptibility of cottonwood leaf beetles decreased with increasing age (2- and 4-fold decrease in LC_{50} from first instars to third instars with protoxin and toxin, respectively). Adult cottonwood leaf beetle mortality did not exceed 30% when exposed to the highest dose of toxin tested (100 µg/ml for 96 h), but foliage consumption was decreased in a dose-dependent fashion. Adult beetles did not avoid leaf disks treated with *B. thuringiensis* extract in choice tests. These results are discussed with regard to genetic engineering of *Populus* with the gene coding for this protein."

Biology - 3; Control - 3

336. Ramse, D.A. 1972. **Biological control of the forest tent caterpillar, *Malacosoma disstria* Hbn., in North Dakota.** M.Sc. thesis. N.Dak. State Univ., Fargo, N.Dak. 91 p.

Several commercial formulations containing *Bacillus thuringiensis* Berliner were applied against an outbreak of *Malacosoma disstria* in an area near Fort Totten, North Dakota. The incidence of diseases infecting the larvae and the parasitoids and predators attacking *M. disstria* larvae during the summers of 1970 and 1971 were collected and recorded.

Control - 3

337. Raske, A.G. 1974. **Hatching rates of forest tent caterpillar in the laboratory.** Can. For. Serv., Bi-mon. Res. Notes 30(4): 24-25.

The rate of hatching of larvae of *Malacosoma disstria* Hbn. from egg bands collected in a healthy population in the field in Alberta in December 1966 and stored at 5°C was investigated by transferring eggs to room temperature on six dates in December-May. The average number of larvae hatching/band was about the same for all dates, but the incubation period decreased from 26 days for larvae in which incubation started in December to 2 days in which it began in May. Most

larvae hatched in a short period, and thereafter a few larvae hatched each day for a comparatively long period. Bands from crown tips differed little from bands from the lower crown, except that fewer larvae hatched / band in the latter group. In further tests in 1966, bands were collected in four places in Alberta where populations were in different stages of expansion or decline. The number of larvae that hatched / band averaged 162-178 for three sites (two with expanding populations and one with a declining population with over 95% mortality from parasites and disease), but only 129 / band for a declining population with about 70% mortality. For the expanding populations, hatching was 90% complete in 9 days, as compared with 14 days in the declining populations. These results are discussed in relation to the collection and storage of egg-bands for laboratory investigations.

Biology - 6; Outbreaks - 5

338. Raske, A.G. 1975. **Cold-hardiness of first instar larvae of the forest tent caterpillar, *Malacosoma disstria* (Lepidoptera: Lasiocampidae).** Can. Entomol. 107(1): 75-80.

"Unfed forest tent caterpillar (*Malacosoma disstria* Hbn.) larvae were subjected to temperature treatments of -18°, -12°, -7°, -1°, 4° or 22°C, each at durations of 2 days, 7 days and 14 days. Each temperature-duration treatment was initiated 3 days before expected hatch, and 3 days after hatch. Fed larvae were subjected to identical treatments 2 days after hatch. Temperature treatments of the before hatch group resulted in appreciable mortality only at -18°C for 7 days and at -18°C or -12°C for 14 days. Temperature treatments of the after hatch group resulted in nearly 100% mortality at -18°C for all durations, at -12°C for 14 days, and about 50% mortality at -7°C for 14 days. Other temperature-duration combinations caused little mortality. The mortality resulting from temperature treatments of fed larvae did not differ from unfed larvae of the after hatching group."

Biology - 4

339. Raske, A.G. 1976. **Forest tent caterpillar moths found in Newfoundland.** Can. For. Serv. Bi-mon. Res. Notes. 32(1): 1-2.

In July 1975, 8 adult male *Malacosoma disstria* Hbn. were captured at a light in Newfoundland. No other examples could be found in searches in the vicinity of trembling aspen (*Populus tremuloides*), the larval food-plant, and no other records are known since 1951, when one adult was taken at a light. It is suggested that the moths were carried to Newfoundland by air movements such as those that are associated with moving cold fronts. Since long-distance transport of females by air movements is unknown, it is considered unlikely that any infestations of *M. disstria* will occur in Newfoundland from these movements of adult moths.

Biology - 1,4

340. Reeks, W.A. 1946. **The forest tent caterpillar (*Malacosoma disstria* Hbn.).** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 2(5): 1.

An outbreak of *Malacosoma disstria* started in 1943 in the Maritimes, spreading into Quebec and Maine. It is believed the infestation reached its peak in 1945. The outbreak was less severe in 1946,

although some areas were still had heavy defoliation. A wilt disease and an increase in pupal parasitism were caused some reduction in *M. disstria* populations in some areas and were expected to be even more effective control agents in 1947.

Outbreaks - 1,3

341. Rejmánek, M.; Smith, J.D.; Goyer, R.A. 1987. **Population dynamics of the forest tent caterpillar (*Malacosoma disstria*) in a water tupelo (*Nyssa aquatica*) forest: a simulation model.** Ecol. Model. 39(3-4): 287-305.

"A population model of the forest tent caterpillar, *Malacosoma disstria* Hbn. [FTC], which simulates both larval grazing in the forest canopy in one season and population dynamics over several years, is presented ... The FTC population model consists of two submodels: the first one for larval mortality and grazing of growing foliage in the forest canopy, the second for year-to-year population dynamics under different levels of density-dependent pupal mortality due to parasitism. The model prediction of complete defoliation (over 98%) for >22 egg masses per tree is in agreement with available data. Under conditions of strong density-dependent pupal mortality (rather dry tupelo forests) the modelled population exhibits damped oscillations and approaches equilibrium in a few years. Weak density-dependent pupal mortality, which seems to be typical for permanently flooded forests, results in chaotic or pseudoperiodic model behavior. A method to achieve more regular dynamics through the introduction of spatial heterogeneity into the model is illustrated."

Outbreaks - 5,6

342. Remion, M.C.; Barry, P.J.; Smith, J.D. 1983. **Biological evaluation of an outbreak of the forest tent caterpillar (*Malacosoma disstria* Hbn.) in the town of St. George, South Carolina.** S.C. For. Commun. Rep. 8 p.

During the springs of 1981 and 1982, moderate to high defoliation of forest, shade, and ornamental trees and shrubs by the forest tent caterpillar was experienced in the town of St. George. As a result of egg surveys in early 1983, forest tent caterpillar populations are expected to remain at moderate to high levels during the 1983 growing season. Some tree mortality and decline can be expected as a direct result of defoliation. A series of recommendations are given regarding control of the forest tent caterpillar in urban areas and the surrounding forest lands.

Outbreaks - 1,3

343. Renault, T.R.; Magasi, L.P.; Marks, D.B. 1975. **Common pest problems of sugar maple in the Maritimes.** Can. For. Serv., Marit. For. Res. Cent., Inf. Rep. M-X-58. pp. 22-23.

This report comments briefly on the importance, destructiveness, appearance , life cycle, and control of the various pests of sugar maple in the Maritimes.

General Background

344. Retnakaran, A. 1978. **Conditioned feeding preference in the forest tent caterpillar.** Can. For. Serv. Bi-mon. Res. Notes. 34(5): 32.

In laboratory investigations in Ontario on the feeding preferences of *Malacosoma disstria* Hbn., first-instar larvae were fed for 10 days on an artificial diet or foliage of white birch (*Betula papyrifera*) and then given a choice of artificial diet or foliage of white birch, trembling aspen (*Populus tremuloides*), or sugar maple (*Acer saccharum*). At the end of 3-5 hours, the larvae tended to feed on maple, but after 24 hours most of the larvae that had been reared on artificial diet returned to that diet, and those reared on birch returned to birch. It is suggested that the conditioned response to a particular diet might partly explain the occurrence of larvae on particular tree species in mixed stands in the field.

Host Relationships - 1,2,5

345. Retnakaran, A.; Granett, J.; Robertson, J. 1980. **Possible physiological mechanisms for the differential susceptibility of two forest Lepidoptera to diflubenzuron.** J. Insect Physiol. 26(6): 385-390.

"In an attempt to explain the physiological mechanisms for the differential susceptibility of insects to the chitin synthesis inhibitor, diflubenzuron, chitin content, chitin synthesis and retention of ingested ^{14}C-diflubenzuron in two forest Lepidoptera were investigated. The spruce budworm, *Choristoneura fumiferana*, a refractory species, had less chitin and retained less of the ingested material than the forest tent caterpillar, *Malacosoma disstria* , a species highly sensitive to diflubenzuron. No difference in the chitin synthesis pattern during the 6th stadium was observed in the two species. It was concluded that the primary reasons for the increased susceptibility of the forest tent caterpillar to this compound was the increased retention of ingested diflubenzuron and, to a lesser extent, the increased chitin content."

Control - 6

346. Retnakaran, A.; Smith, L. 1976. **Greenhouse evaluation of PH 60-40 activity on the forest tent caterpillar.** Can. For. Serv., Bi-mon. Res. Notes 32(1): 2.

Groups of fourth-instar larvae of *Malacosoma disstria* Hbn. were confined in the greenhouse on potted trembling aspens (*Populus tremuloides*) that had been treated with three insect growth regulators in sprays at a concentration of 1%. Abnormal differentiation was observed in all treatments, and the percentage pre-emergence mortalities for R-20458-4E [(E)-3-(5-(4-ethylphenoxy)-3-methyl-3-pentenyl)-2,2-dimethyloxirane], methoprene (ZR-515-5E), and diflubenzuron (PH 60-40) were 55, 90, and 100, respectively, as compared with 34 for no treatment.

Control - 6

347. Retnakaran, A.; Smith, L.; Tomkins, B. 1976. **Application of Dimilin effectively controls forest tent caterpillar populations and affords foliage protection.** Can. For. Serv., Bi-mon. Res. Notes 32(5): 26-27.

In further investigations in the laboratory on the effects of diflubenzuron (Dimilin) on *Malacosoma disstria* Hbn., larvae aggregated and fed as readily on pellets of artificial diet that had been treated

with the growth regulator as on untreated ones indicating the absence of any repellent effect. In a field test on trembling aspen (*Populus tremuloides*) in Ontario, the application of a 1% suspension of diflubenzuron in sprays eradicated the larvae and prevented defoliation.

Control - 6

348. Retnakaran, A.; Smith, L.; Tomkins, W. 1979. **Absence from maple sap of Dimilin® applied as a soil drench.** Can. For. Serv., Bi-mon. Res. Notes 35(3): 16-17.

Dimilin (diflubenzuron) is usually applied in late spring to the foliage of *Acer saccharum* to kill first and second instar larvae of *Malacosoma disstria*; tapping for maple sap is carried out in early spring. To increase the likelihood of detecting Dimilin in the sap, a massive dose was applied to 10 m^2 of soil around each of six trees in autumn, followed by tapping and evaporation for maple syrup in spring. Dimilin was below detection limits in both 20- and 60-fold concentrated samples, with an extraction efficiency of 80%.

Control - 6

349. Retnakaran, A.; Smith, L.; Tomkins, B.; Granett, J. 1979. **Control of forest tent caterpillar, *Malacosoma disstria* (Lepidoptera: Lasiocampidae), with Dimilin.** Can. Entomol. 111(7): 841-846.

"Dimilin (25% wettable powder) was mixed in water and sprayed from a Grumman Agcat aircraft equipped with four micronair units at the rate of 70 g (active ingredients)/4.67 L/ha (1 oz/0.5 U.S. gal per acre) on two stands of trembling aspen, *Populus tremuloides* Michx., heavily infested with forest tent caterpillar, *Malacosoma disstria* Hübner. The material was applied when the insects were in the first and second instars and the trees were starting to flush. Spray deposit analysis using a dye, Rhodamine-B, in the spray mix and spray plates in the plots indicated that conditions for spraying in the morning were better than those in the evening as expected. Total control of the forest tent caterpillar with very little defoliation of the trees was achieved."

Control - 2,6

350. Richards, W.C.; Hayashi, Y. 1971**. Effect of some organic solvents on the cytoplasmic-polyhedrosis virus of the forest tent caterpillar, *Malacosoma disstria*.** J. Invertebr. Pathol. 17(1): 42-47.

"Effect of ether, chloroform, fluorocarbon, and butanol on the cytoplasmic-polyhedrosis virion of the forest tent caterpillar, *Malacosoma disstria*, labeled with uridine-^{3}H for viral RNA, has been investigated by zonal sucrose gradient centrifugation. Free virions from the cytoplasm of midgut cells were not affected by ether treatment at room temperature (23°C), but about 50% were disrupted at higher temperature (37°C), releasing a light component, with the characteristics of viral RNA. Occluded virions liberated from polyhedra were fairly stable to ether treatment at 37°C. It is suggested that this difference was due to the difference in maturity of free virions in the cytoplasm and occluded virions within the polyhedra. Free virions were not affected by chloroform treatment at 23°C, but at 37°C they were completely disrupted, releasing a 148S component and viral RNA. Fluorocarbon caused only slight damage at 23°C but at 37°C two components were released, 175S

which is presumed to be part of the core, and viral RNA. Butanol disrupted intact virions completely at both 23°C and 37°C resulting in two distinct components similar to those obtained by fluorocarbon treatment at 37°C."

Biology - 3; Control - 2

351. Richards, W.C.; Hayashi, Y. 1972**. Preferential separation of cytoplasmic polyhedrosis virus (CPV) RNAs from infected midgut cells.** J. Invertebr. Pathol. 20(2): 200-207.

"Viral progeny, double-stranded RNA (dsRNA), and virus-specific single-stranded RNA (ssRNA) synthesized in midgut cells of *Malacosoma disstria* larvae infected with cytoplasmic-polyhedrosis virus (CPV), have been separated using Mg^{2+} for RNA aggregation, and lithium chloride for differential solubilization between the ds- and ss-RNA. Under high concentrations of Mg^{2+} (5×10^{-3} and 10^{-2} M $MgSO_4$), dsRNA was not affected, remaining positional at a sedimentation rate of 15S, but virus-specific ssRMA and host ribosomal RNA as single-stranded (rRNA), were separated from ds RNA by aggregation. After RNase treatment there was not appreciable contamination of virus specific ssRNA and rRNA. It was found that ds and ssRNA could be separated in 2M LiCl on the basis of their different solubilities. The ssRNA fraction obtained by such a procedure contained only 6% dsRNA, and the dsRNA fraction was free of ssRNA. Further separation of dsRNA by both the Mg^{2+} and the LiCl treatments was accomplished through prolonged centrifugation which yielded 12 and 15S components; these are the same characteristics found for viral genome RNA appearing in the sedimentation profile."

Biology - 3

352. Robertson, J.G. 1957. **Paper chromatography in insect taxonomy.** Can. J. Zool. 35(3): 411-419.

"Seventeen species of Coleoptera, Lepidoptera, Diptera and Hymenoptera showed chemical differences by the method of paper chromatography in an evaluation of the method for taxonomic purposes. The analyses were complicated by pattern differences evident in larval, pupal and adult stages of some species. Geographic isolates of *Malacosoma disstria* Hbn., as well as of *Chamaepsila rosae* (F.) and physiological entities within *Pristiphora erichsonii* (Htg.) show identical patterns; however, differences are found at specific levels. Paper chromatography is therefore a valuable taxonomic tool, especially as the technique is capable of considerable refinement."

Taxonomy

353. Robison, D.J. 1993. **The feeding ecology of the forest tent caterpillar, *Malacosoma disstria* Hubner among hybrid poplar clones, *Populus* spp.** Ph.D. thesis Univ. Wis., Madison, Wis. 227 p.

The development and behaviour of *Malacosoma disstria* larvae on 15 hybrid clones of *Populus* spp. were studied in laboratory and greenhouse trials. Five clones were chosen for more detailed studies. Feeding by *M. disstria* "... caused foliar changes which significantly reduced subsequent larval feeding preferences and development. Herbivory reduced foliar nitrogen and moisture, and increased fiber and toughness in some clones." Field trials using caged trees over a 2-year period showed that larval populations increased 9.7-fold on the highly suitable clone, and declined 2.7-fold

on the poor quality clone. Clonal productivity, tolerance to defoliation, and ability of the clones to resist insect attack are discussed.

Host Relationships - 1

354. Robison, D.J.; McCown, B.H.; Raffa, K.F. 1994. **Responses of gypsy moth (Lepidoptera: Lymantriidae) and forest tent caterpillar (Lepidoptera: Lasiocampidae) to transgenic poplar, *Populus* spp., containing a *Bacillus thuringiensis d*-endotoxin gene.** Environ. Entomol. 23(4): 1030-1041.

"Transgenic *Populus* plants (clone NC5339) expressing a *Bacillus thuringiensis d*-endotoxin [δ-endotoxin] gene significantly reduced feeding and weight gain by gypsy moth, *Lymantria dispar* (L.), and forest tent caterpillar, *Malacosoma disstria* Hübner. Forest tent caterpillar larvae also experienced significant mortality following exposure to the transgenic *d*-endotoxin. Gypsy moths were better able to recover after transfer to artificial diet than were the forest tent caterpillars. Transgenic leaves deterred feeding by both species in behavioral choice tests. Four additional transformants contained, but did not express, the *d*-endotoxin gene. Results are discussed in terms of efficacy, plant deployment strategies, ecosystem stability, and tree improvement."

Host Relationships - 1; Control - 3,6

355. Robison, D.J.; Raffa, K.F. 1990. **Hybrid poplar productivity and suitability for the forest tent caterpillar: a framework for evaluation.** Pages 155-162 *in* R.D. Adams (ed.). Aspen Symp. '89 Proc., Duluth, Minn. July 25-27, 1989. U.S. Dep. Agric. For. Serv., North Cent. For. Exp. Sta., Gen. Tech. Rep. NC-140.

"Fifteen hybrid poplar (*Populus* spp.) clones were evaluated for growth, tolerance to defoliation, and suitability for the forest tent caterpillar (*Malacosoma disstria*). Poplar clones were ranked according to their suitability for *M. disstria*, as indicated by behavioral and developmental bioassays. Patterns of poplar growth characteristics and *M. disstria* preference and performance among the 15 clones were used to construct a productivity-suitability matrix. This matrix provides a framework for evaluating insect pest resistance in selected poplar clones and for considering clonal contributions to poplar-*M. disstria* interactions. The matrix concept and design incorporates both biologically and economically important criteria, and may facilitate similar evaluations for other important pests and crops."

Host Relationships - 1

356. Robison, D.J.; Raffa, K.F. 1992. ***Populus* clonal effects on forest tent caterpillar.** Page 163 *in* D.C. Allen and L.P. Abrahamson (eds.). Proc. N. Am. For. Insect Work Conf., Denver, Colo. Mar. 25-28, 1991. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. PNW-294 .

Two hybrid clones, NC11382 (*Populus nigra* x *P. berolinensis*) and NE332 (*P. simonii* x *P. berolinensis*), were tested to determine what effects these crosses had on populations of *Malacosoma disstria.* The two clones were caged separately, with six trees of each clone being placed in a cage with two *M. disstria* egg bands. The populations of *M. disstria* were monitored for two seasons. Mean number of egg bands per clone after 1 year were 14 and 2 for NC11382 and NE332, respectively. After 2 years, the number of egg bands per clone were 22 and 1 for NC11382 and NE332, respectively. The same

pattern was observed for pupal populations. These differences were found to be statistically significant. The authors suggest that clones should be screened for their susceptibility to pests, and compared in a suitability matrix to determine if they should be outplanted. The proper use of clonal mixtures (those containing a wide variety of resistance factors), and mosaics of clonal types should enable one to employ a variety of options to prevent the onset of resistance in insect pests. These results show that different varieties of *Populus* can affect *M. disstria* populations. However, one should not equate clonal resistance to one pest as resistance to all pests.

Host Relationships - 6; Control - 6

357. Robison, D.J.; Raffa, K.F. 1994. **Characterization of hybrid poplar clones for resistance to the forest tent caterpillar.** For. Sci. 40(4): 686-714.

"Forest tent caterpillar, *Malacosoma disstria* Hbn., behavioral and developmental interactions with 15 hybrid *Populus* spp. clones were studied in laboratory and glasshouse trials. Significant differences in larval preference and performance among the clones were found. Larval development time ranged from 30 to 52 days. Second-instar preference and larval development were significantly correlated, but 4th-instar preference and larval development were not. Second- and fourth-instar preferences were not correlated. Clonal productivity and tolerance of defoliation varied significantly, but were not correlated. The relationships between productivity, defoliation tolerance, and insect resistance were examined in regard to plant defence theory, host plant resistance, clonal selections for tree improvement, and assay utility."

Host Relationships - 1

358. Roland, J. 1993. **Large-scale forest fragmentation increases the duration of tent caterpillar outbreak.** Oecologia 93(1): 25-30.

Historical data were examined from 1950 to 1984 "...on the duration of outbreaks of forest tent caterpillar (*Malacosoma disstria*) in northern Ontario, Canada. Outbreak duration was compared to host tree species dominance and forest structure over large areas of boreal forest partially cleared for agriculture. Abundance of the principal host tree species *Populus tremuloides* had no consistent effect on duration of outbreak within forest districts, and was negatively correlated with duration of outbreaks among the eight forest districts examined. The amount of forest edge per km^2 was the best, and most consistent, predictor of the duration of tent caterpillar outbreaks both within individual forest districts and among forest districts. Because forest tent caterpillar populations are driven largely by the impact of parasitoids and pathogens, results here suggest that large-scale increase in forest fragmentation affects the interaction between these natural enemies and forest tent caterpillar. Increased clearing and fragmentation of boreal forests, by agriculture and forestry, may be exacerbating outbreaks of this forest defoliator."

Host Relationships - 1,6; Outbreaks - 5

359. Roland, J.; Kaupp, W.J. 1995. **Reduced transmission of forest tent caterpillar (Lepidoptera: Lasiocampidae) nuclear polyhedrosis virus at the forest edge.** Environ. Entomol. 24(5): 1175-1178.

"Field experiments were conducted to determine the effect of forest edge, adjacent to clearings, in reducing the rate of transmission of nuclear polyhedrosis virus among forest tent caterpillar, *Malacosoma disstria* Hübner, larvae. Caterpillars on trees along a south-facing forest edge, picked up far less virus than did caterpillars on trees in the forest interior, and edge caterpillars died at a slower rate. Reduced transmission is presumed to result from the inactivation of virus by high UV radiation at the forest edge. The pattern of reduced transmission of virus at the forest edge may explain, in part, the pattern of prolonged outbreak of forest tent caterpillar in highly fragmented forests."

Biology - 3

360. Roland, J.; McKinnon, G.; Backhouse, C.; Taylor, P.D. 1996. **Even smaller radar tags on insects.** Nature (London) 381(6578): 120.

The movement of flying insects was successfully monitored using small (200 mg in the case of *Malacosoma disstria*) radar tags attached to either the thorax or abdomen of the insect. *M. disstria* adults were found to move up to 100 m from their release point after being released 48 hours.

Biology - 1; Outbreaks - 5

361. Roland, J.; Taylor, P.D. 1997. **Insect parasitoid species respond to forest structure at different spatial scales.** Nature (London). 386(6626): 710-713.

The results of a multi-year large-scale study demonstrate that parasitism of *Malacosoma disstria* by four dipterous parasitoids is reduced or enhanced by the proportion of forested to unforested land. Parasitism by *Patelloa pachypyga*, *Leschenaultia exul*, and *Arachinidomyia* (=*Sarcophaga*) *aldrichi* was greatest on hosts collected from contiguous forests and lowest in fragmented forests. Parasitism by *Carcelia malacosomae* was highest in fragmented forests. Parasitism by the two smallest species of Diptera varied greatly over relatively short distances (44 and 53 m for *C. malacosomae* and *P. pachypyga*, respectively), while the two larger species of Diptera showed differences in parasitism rates over much greater distances (approximately 400 m for both species).

Biology - 2

362. Rose, A.H. 1958. **The effect of defoliation on foliage production and radial growth of quaking aspen.** For. Sci. 4(4): 335-42.

Compares the phenologies of *Populus tremuloides* and *Malacosoma disstria* during an infestation in Ontario in 1950-53, and discusses the degree of defoliation and refoliation in three aspen stands during this period. True refoliation occurred only after complete destruction of the leaves and shoot tips. The new leaves are produced from buds that otherwise would not have developed until the following year. Partial defoliation by *M. disstria*, occurring when ca. 1/4 of the diameter growth had been laid down, reduced diameter growth throughout the remainder of the growing period. Growth ceased only on totally defoliated trees, and was not resumed for the rest of the season even after refoliation. Defoliation from frost, sleet, and hail occurred in 1953 before diameter growth had

begun, and growth recommenced after refoliation. Neither type of defoliation (i.e., by weather or insect) caused either the formation of a double growth ring or the absence of a growth ring in the lower part of the stem.

Outbreaks - 3

363. Rose, A.H. 1969. **Important forest insects of Ontario in 1967.** Proc. Entomol. Soc. Ont. 98(0): 8-10.

"Severe infestations of the forest tent caterpillar, *Malacosoma disstria* Hubner, remained active in different parts of the Province. Medium-to-heavy infestations persisted over 3,500 square miles of the southern part of the Fort Francis District and egg cluster counts indicate a similar potential for damage to aspen stands in 1968. Two infestations between Sault Ste. Marie and Elliot Lake which expanded, causing moderate to severe defoliation in a area of 1,000 square miles, are expected to persist. On the other hand, infestations in the Sudbury, Parry Sound, Pembroke, and Kemptville districts, except over relatively small areas at the east end of Lake Nipissing and near Pembroke, collapsed as a result of unfavorable spring weather conditions."

(Entire reference pertaining to *M. disstria* included in annotation)

Outbreaks - 1

364. Rose, A.H.; Lindquist, O.H. 1982. **Insects of eastern hardwood trees** (also **Insectes des feuillus de l'est du Canada**). Can. For. Serv., For. Tech. Rep. 29. pp. 19, 21, 105, 108. (French version: Rep. 29F. pp. 19, 21, 105, 109).

This handbook is designed to enable people who are interested in trees to identify the insects and mites causing damage to them. About 450 species of insects and mites that have caused noteworthy damage to hardwood trees in Canada east of the Rocky Mountains are included. Identification is based initially on the kind of tree damaged and the insects are grouped under 20 tree genera. Within each host tree section, flow chart keys understandable to the layperson are provided to lead the reader to individual species or groups of similar organisms, with full colour illustrations to confirm the identity of the insect or mite. The handbook also includes information on the necessity for control, based largely on Forest Insect and Disease Survey records. Where control is necessary, methods are suggested. Common names of insects are generally used but scientific names are given in the text.

General Background

365. Rose, M.R. 1975. **An experimental simulation and mathematical study of an outbreak insect: the forest tent caterpillar (Lepidoptera: Lasiocampidae).** M.Sc. thesis. Queen's Univ., Kingston, Ont. 431 p.

A model derived from experimental and simulation studies was developed to explain the population dynamics of forest tent caterpillar. A multiple factor hypothesis was examined to determine if the assumption that wet lowland areas act as mortality refugia. Sensitivity analysis of the model indicated that of the three possibilities examined (periodic outbreak, sustained outbreak, and sustained confinement to refugia), simulated periodic outbreaks were resistant to stochastic disruptions, while the other two, particularly sustained outbreaks, were less resistant. Elementary

catastrophe theory equations were developed from this analysis. These equations mimicked the hypothesized forest tent caterpillar outbreaks well, and explain the consistencies in the sensitivity analysis results and the effects of weather in the commencement and termination of outbreaks. It is suggested that this model may also apply to outbreaks of spruce budworm and European sawfly.

Outbreaks - 6

366. Rose, M.R.; Harmsen, R. 1978. **Using sensitivity analysis to simplify ecosystem models: a case study.** Simulation 31(1): 15-26.

"Theoretical ecology requires simulation because realistic ecosystem models are too complex for mathematical analysis. In this paper we propose a way of moving from a complex simulation model based on the 'mechanics' of an ecosystem to a much simpler model that exhibits behaviour similar to that of the original model in its major features. The tool used to isolate the key characteristics of the original model is sensitivity analysis. It enables the investigator to identify the variables and parameters that determine the essential behaviour of the original model and to formulate a clear picture of that behaviour. With this information in hand, the investigator can devise a simplified model that exhibits the same essential behaviour.

While the simplified model behaves like the original model, its inner workings only generally parallel those of the original. Its simplicity allows the investigator to test his intuitive ideas directly, clarifying understanding of the ecosystem originally modelled. Further, the investigator may be able to adapt the simplified model to other similar ecosystems. The methods outlined in this paper are illustrated by a case study of a forest infested by tent caterpillars. "

Outbreaks - 5, 6

367. Rose, M.R.; Harmsen, R. 1982. **Ecological outbreak dynamics and the cusp catastrophe.** Acta Biotheor. 30(4): 229-253.

"Many ecological processes exhibit trajectories which can be suitably represented by stable equilibria or smooth limit cycles. However, a third kind of ecological process involves intermittent, abrupt, and drastic changes in densities, here termed 'outbreak dynamics', which require different modelling frameworks. One such framework, the cusp catastrophe, is used here in a modelling study of a particular outbreak insect, the forest tent caterpillar. This model is then generalized to cover a set of related ecological systems. The particular form of the model for each system depends on whether the major controlling ecological variables are externally imposed, or are incorporated in the model equations. It is concluded that the simple cusp catastrophe is an appropriate metaphor for understanding outbreak dynamics."

Outbreaks - 6

368. Ross, D.A. 1952. **Key to the puparia of the dipterous parasites of *Malacosoma* spp., in British Columbia.** Proc. Entomol. Soc. B.C. 49(0): 19-23.

An illustrated key of the puparia of dipterous parasites reared by the Forest Insect Survey at Vernon from *Malacosoma disstria* Hbn., *M. pluviale* (Dyar), and *M.* sp. nr. *pluviale* (Dyar), collected in British Columbia.

Biology - 2

369. Rossi, R.; Carpita, A. 1983. **Stereospecific synthesis of (Z)-13-hexadecen-11-yn-1-yl acetate the sex pheromone of the processionary moth (*Thaumetopoea pityocampa*) and of (5Z, 7E)-5,7-dodecadien-1-ol, a sex pheromone component of the forest tent caterpillar (*Malacosoma disstria*).** Tetrahedron 39(2): 287-290.

"(Z)-13-hexadecen-11-yn-1-yl acetate, the sex pheromone of *Thaumetopoea pityocampa* and (5Z, 7E)-5,7-dodecadien-1-ol, a sex pheromone component of *Malacosoma disstria* were prepared in high chemical and stereoisomeric purity by synthetic schemes involving the sterospecific coupling of ω-functionalized 1-alkynes with (Z)- or (E)-1-iodo-1-alkenes in the presence of a catalytic amount of $(PPh_3)_4Pd$ and CuI, under phase transfer conditions."

Control - 5

370. Rossiter, M.; Cox-Foster, D.; Abou-Zaid, M.M.; Bergeron, D. 1996. **Egg protein insolubility in *Lymantria dispar* versus other forest Lepidoptera.** Chemoecology 7(2): 74-84.

"A standard buffer (5 nM phosphate at pH 7.0) which is used to extract protein from insect eggs provided complete protein solubility for eggs from 3 of 4 tree-feeding lepidopteran species (*Choristoneura rosaceana*, *Malacosoma disstria* and *Malacosoma americanum*). Under the same extraction protocol, egg proteins from *Lymantria dispar* remained nearly insoluable ... ."

Biology - 8

371. Sample, B.E. 1992. **Temporal separation of flight time of two sympatric *Malacosoma* species.** Environ. Entomol. 21(3): 628-631.

"*Malacosoma americanum* (F.) and *M. disstria* Hübner were collected by black-light traps in eastern West Virginia during 1988-1990. Ten locations were sampled in 1988 and 1989 and 27 locations in 1990. Traps were operated at each location for 0.5-h intervals centered at 2100, 2300, 0100, 0300, and 0500 hours. Factorial analyses of variance were performed on the quantity of each species collected in each time interval. Peak flight time for *M. americanum* occurred at 2300 and 0100 hours, whereas most *M. disstria* flew between 0300 and 0500 hours. Flight activity of *M. americanum* was unrelated to the presence of *M. disstria.* However, *M. disstria* flew significantly later at night, and was less abundant when *M. americanum* was present. Other research suggests that species within *Malacosoma* use similar sex pheromones. Separate flight activities of these species may help reduce interspecific pheromone attraction and aid the reproductive isolation of these species."

Biology - 1; Outbreaks - 4d

372. Samson, R.A.; Nigg, H.N. 1992. ***Furia crustosa*, fungal pathogen of forest tent caterpillar in Florida.** Fla. Entomol. 75(2): 280-284.

Furia crustosa, a fungal pathogen of *Malacosoma disstria*, is reported for the first time from Florida. The morphology of *F. crustosa* is described.

Biology - 3

373. Saskatchewan. 1936 - 1988. **Annual report of the Department of Natural Resources of the Province of Saskatchewan for the fiscal year ending April 30.** Queen's Printer for Sask., Regina, Sask.

These reports briefly mention the locations of *Malacosoma disstria* outbreaks. None of the other years examined contained any information concerning forest tent caterpillar outbreaks in Saskatchewan. This is due to the shift of emphasis in the reports by the Forestry Branch from reviewing all aspects of forestry to planting and harvesting only.

Year	Page
1940 / 41	14
1941 / 42	**missing**
1942 / 43	16
1954	23

Outbreaks - 1

374. Saunders, W. 1878. **The forest tent caterpillar**. Annu. Rep. Entomol. Soc. Ont. [later Proc. Entomol. Soc. Ont.] 9(0): 5, 28-30.

This report suggests possible non-chemical control methods for the forest tent caterpillar, *Clisiocampa sylvatica* Harr. [*Malacosoma disstria* Hbn.] and contains notes on the first observations of a mite associated with *C. sylvatica* egg masses. Observations were also made in October of fully developed larvae in egg masses. It is suggested that *C. sylvatica* populations may be decimated by two methods: the increase of predaceous mites or the occurrence of a severe frost following a few warm days in spring during which the larvae emerged and were then unprotected and destroyed by the cold.

Biology - 1,2,4

375. Schaffner, J.V., Jr.; Griswold, C.L. 1934. **Macrolepidoptera and their parasites reared from field collections in the northeastern part of the United States.** U.S. Dep. Agric., Misc. Publ. No. 188. 160 p.

"The purpose of this publication is to present a resume of data obtained from the studies of macrolepidoptera and their parasites so the it will be available to investigators, teachers, and students of biological control, as well as to others interested in the subject." Includes a host-parasite list as well as a parasite-host list.

Biology - 2

376. Schultz, P.B. 1989. **Forest tent caterpillar, its management as an urban pest in Virginia.** J. Arboric. 15(4): 92-93.

The effect of various insecticides was tested on willow oak (*Quercus phellos*) in Norfolk, Virginia, USA, infested with *Malacosoma disstria*. Active agents tested were acephate; cyfluthrin + tetramethrin + piperonyl butoxide + MGK 264 (a synergist); diazinon; pyrethrins + tetramethrin + piperonyl butoxide; phenothrin; carbaryl; and cyfluthrin alone. The field studies and a laboratory test showed that by 6 hours after application some treatments provided complete control, with all providing complete control 72 hours after application. Public complaints during an infestation in Norfolk in 1988 were in response to caterpillars migrating from unsprayed areas, not inefficient control treatments.

Control - 2

377. Schultz, P.B. 1990. **Forecasting flight activity of native parasitoids of oak lecanium (Homoptera: Coccidae).** J. Entomol. Sci. 25(4): 622-627.

"Flight activity of the major parasitoids of oak lecanium scale, *Parthenolecanium querciflex* (Fitch) was monitored for 6 years on willow oak, *Quercus phellos* L. in Virginia to establish base development temperatures and to forecast peak parasite activity. Base development temperatures of 8.3°C (47°F), 10.6°C (51°F) and 3.3°C (38°F) were established for *Encyrtus fuscus* L., *Eunotus lividus* Ashmead, and *Blastothrix* sp., respectively. Average degree day accumulations indicated that flight periods for all species occurred during early June, a time when pesticides are usually directed against the first instar scales. An early flight period of *E. lividus* also coincided with pesticide applications against two oak defoliators, *Lymantria dispar* (L.) and *Malacosoma disstria* Hübner."

Control - 2

378. Sealy, S.G. 1978. **Possible influence of food on egg-laying and clutch size in the Black-billed Cuckoo.** Condor 80: 103-104.

Observations made in 1976 on nesting Black-billed Cuckoos (*Coccyzus americanus*) on the forested ridge which separates Lake Manitoba and the Delta Marsh, Manitoba, prove that food supply influences both clutch size and timing of breeding. Early initiation of large clutches coincided with an infestation of *Malacosoma disstria* at the study site. Black-billed Cuckoos were observed eating the larvae and feeding them to their young. Clutches outside the *M. disstria* outbreak area were smaller and started later.

Biology - 2

379. Sealy, S.G. 1979. **Extralimital nesting of bay-breasted warblers: Response to forest tent caterpillars?** Auk 96(3): 600-603.

This short communication is a record of extralimital nesting by Bay-breasted Warblers (*Dendroica castanea*) on the Delta Beach Ridge, Manitoba. The nestings coincided with the first year of an outbreak of the forest tent caterpillar (*Malacosoma disstria* Hbn.). Although Bay-breasted Warblers

have not previously been recorded as predators of tent caterpillars, observations were made of Warblers feeding on tent caterpillar larvae. The apparent responses to tent caterpillars and the use of deciduous tree habitat reveals an unrecognized flexibility in the Bay-breasted Warbler's selection of both prey and habitat.

Biology - 2

380. Sealy, S.G. 1980. **Reproductive responses of northern orioles to a changing food supply.** Can. J. Zool. 58(2): 221-227.

"The response of the northern oriole (*Icterus galbula*) to an outbreak of the forest tent caterpillar (*Malacosoma disstria*) on the Delta Beach Ridge, Manitoba, was studied. Orioles responded in 1976 to the increased food supply by feeding on all life stages of the insect and by feeding late instar larvae and pupae to their young. The nesting density doubled in 1977, the 2nd year of the 2 year outbreak, but the caterpillar larvae died off before the orioles' chick-rearing period. The 1978 breeding density was back down to the level of 1976. Clutch sizes and body weights did not change despite the increase and eventual reduction in both food abundance and nesting density. Productivity was lower, and hatching failure and nestling death were higher, at the higher nesting density."

Biology - 2

381. Shepherd, R.F. 1977. **A classification of western Canadian defoliating forest insects by outbreak spread characteristics and habitat restriction.** Pages 80-88 *in* H.M. Kulman and H.C. Chiang (eds.). Insect ecology: Papers presented in the A.C. Hodson Ecology Lectures. Agric. Exp. Sta. Univ. Minn. Tech. Bull. No. 310.

"A classification of outbreak patterns of forest defoliators is proposed. Successive years of defoliation mapping were used to indicated the changes in pattern of outbreaks, and a comparison with ecological maps indicated the degree of restriction of outbreaks to forest communities or zones. The outbreak characteristics of 12 pest species [including *Malacosoma disstria*] are described and classified. The implications of such a classification upon control strategies are discussed."

Outbreaks - 1

382. Shepherd, R.F. 1979. **Comparison of the daily cycle of adult behavior of five forest Lepidoptera from Western Canada, and their response to pheromone traps.** Pages 157-168 *in* V. Delucchi and W. Baltensweiler (eds.). Dispersal of Forest Insects: Evaluation, Theory and Management Implications. Proc. [first] IUFRO Conf., Zurich and Zuoz, Switzerland, Sept. 4-9, 1978. Mitt. Schweiz. Entomol. Ges. [Swiss Entomol. Soc. Bull.] Vol. 52.

Differences in male and female behaviour patterns and in responses to environmental factors were important in interpreting data from pheromone trapping. Male *Malacosoma disstria* adults rest between leaves during the day, flying occasionally during the day but becoming increasingly active during the mid- to late afternoon. Females began emerging from their pupae in the late afternoon,

and begin calling the male moths. Male flight activity can continue as long as temperatures remain above 11°C, winds do not exceed 8 km/h, and at most only light precipitation occurs. Females can lure males for at least 5 days without loss of attractiveness.

Biology - 5; Outbreaks - 5

383. Shepherd, R.F.; Brown, C.E. 1971. **Sequential egg-band sampling and probability methods of predicting defoliation by *Malacosoma disstria* (Lasiocampidae: Lepidoptera).** Can. Entomol. 103(10): 1371-1379.

"A sequential egg-band sampling system for predicting defoliation of aspen by the forest tent caterpillar (*Malacosoma disstria* Hbn.) is described and its accuracy assessed. A probability method of predicting defoliation from the stage of the outbreak in each local area is also established. A third method, which promises to be the most accurate and consistent, is proposed. In this last system, egg-mass density is established and related to defoliation levels which are adjusted depending on the age of outbreak."

Outbreaks - 3,4a

384. Sippell, W.L. 1952**. Winter rearing of the forest tent caterpillar, *Malacosoma disstria* Hbn.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 8(4): 1-2.

In order to study the disease aspects of the forest tent caterpillar (*Malacosoma disstria*), researchers needed to develop a satisfactory rearing method for use during the winter. To rear *M. disstria*, three red oak acorns were germinated and placed in a cage with one egg band (details of the procedure for growing the oak is given in the reference). This rearing technique was used to investigate disease incidence within families. Egg clusters were taken from diseased and (relatively) non-diseased populations. A total of six diseased and six non-diseased clusters were obtained. Two clusters from each group were then reared on oak at 70°F, two on poplar at 70°F, and two on poplar at 85°F. Results showed that larvae did not complete satisfactory development on an oak diet. Additionally, larvae reared at 85°F had a slightly higher disease mortality and quicker knock-down than at 70°F. Similar diseases occurred in both the diseased and non-diseased populations. Finally, the incidence and variety of disease causing mortality was similar in all larvae coming from the same egg cluster, but different between clusters.

Biology - 6

385. Sippell, W.L. 1957a. **A study of the forest tent caterpillar and its parasite complex in Ontario.** Ph.D. thesis. Univ. Mich., Ann Arbor, Mich. 158 p.

This thesis reviews the life history and ecology of *Malacosoma disstria*, augmented by data derived from field observations and rearing experiments. Three outbreaks are compared, and common characteristics identified. Patterns of parasitism during the outbreak were identified. Four new

records of species parasitizing *M. disstria* are mentioned. The thesis also includes a taxonomic key devised for determination of 10 common dipterous parasitoids.

There is an unpublished report with the same title by this author (abstract 386).

Biology - 2; Outbreaks - 1,5

386. Sippell, W.L. 1957b. **A study of the forest tent caterpillar and its parasite complex in Ontario.** Agric. Can., Gt. Lakes For. Res. Cent., Ont. Region, Unpubl. Rep. 1957(12). 147 p.

This is a comprehensive review of the parasites of the forest tent caterpillar, *Malacosoma disstria*, in Ontario. As well as containing information on parasites, this report covers the following aspects of *M. disstria*: taxonomy, life history, host relationships, oviposition habits, disease, outbreaks, sampling methods, superparasitism and multiparasitism, individual parasite description, changes in parasite complex (over course of infestation), trends in aggregate parasitism (over course of infestation), changes in sex ratio (in both endemic and epidemic situations) and population cycling (of both host and parasite). The report contains a list of parasites and disease organisms.

Biology - 1,2,3

387. Sippell, W.L. 1961. **Key to the puparia of common dipterous parasites of the forest tent caterpillar, *Malacosoma disstria* Hbn., in Ontario.** Can. Entomol. 93(6): 433-6.

When rearing parasites isolated from forest tent caterpillar (*Malacosoma disstria*) larvae, researchers realized the need for a key to the pupal stages of common dipterous species of parasites. This was required to identify the parasites that failed to develop further than the pupal stage in laboratory readings. The key presented includes the ten most common dipterous parasites of the forest tent caterpillar in Ontario: *Sarcophaga aldrichi* Park., *Agria affinis* (Fall.), *Exorista mella* Wlk., *Neophorocera edwardsii* (Will.), *Leschenaultia exul* (Tnsd.), *Euexorista futilis* (O.S.), *Patelloa pachypyga* (A. & W.), *Carcelia malacosomae* Sellers, *Achaetoneura melalophae* Allen, and *Achaetoneura frenchii* (Will). Although pupae in laboratory rearings are often malformed, the malformation does not occur to such an extent that the accuracy of the key is affected (of 12,000 puparia reared, only 1% were unrecognizable because of severe malformation).

Biology - 2

388. Sippell, W.L. 1962. **Outbreaks of the forest tent caterpillar, *Malacosoma disstria* Hbn., a periodic defoliator of broad-leaved trees in Ontario.** Can. Entomol. 94(4): 408-416.

This article presents a history, illustrated by maps, of the 1948-56 outbreak of *M. disstria*. It is noticeable that high population densities usually persist in extensive stands or groups of stands for a period of five years, and that the outbreaks usually extend from their centre in a southerly and easterly direction. No definite pattern of duration, location, or intervals between outbreaks could be established.

Outbreaks - 1,5

389. Sippell, W.L.; Ewan, H.E. 1967. **Forest tent caterpillar *Malacosoma disstria* Hbn.** Pages 126-129 (pages 135-137) *in* A.G. Davidson and R.M. Prentice (eds.). Important forest insects and diseases of mutual concern to Canada, the United States and Mexico. Queen's Printer and Controller of Stationery, Ottawa, Ont. Dep. For. Rural Dev., Publ. No. 1180 (118F).

Describes distribution, hosts, damage, life history and control of *Malacosoma disstria*. A French version of this report (118F) was published in 1973.

General Background

390. Smirnoff, W.A. 1962. **A nuclear polyhedrosis of *Errannis tiliaria* (Harris) (Lepidoptera: Geometridae).** J. Insect Pathol. 4 (4): 393-400.

The disease caused high mortality during a recent outbreak in sugar maple stands in Quebec covering more than 1,000,000 acres. In the laboratory, 8000 polyhedra / mL of water were highly pathogenic. Two other geometrids were susceptible, but most larvae tested, including *Malacosoma disstria* and *Choristoneura fumiferana*, were not.

Biology - 3

391. Smirnoff, W.A. 1965. **Some diseases affecting larvae of *Malacosoma americanum* and *M. disstria* in the province of Quebec.** Abstr. in Ann. ACFAS [Association Canadienne Française pour Avancement des Sciences] 1965 / 1966. 33(0): 67.

Both species, and particularly *M. disstria*, showed large population increases in southern Quebec in spring 1966, in spite of the presence of a variety of pathogens. A cytoplasmic polyhedrosis is reported for the first time on *Malacosoma*, and is only found on *M. americanum*. A protozoan, *Perezia disstriae*, is found chiefly on *M. disstria*. The larvae of *M. americanum* are the more sensitive to the pathogens, particularly to a nuclear polyhedrosis. Various virus strains are being tested, particularly on *M. disstria*, the more harmful defoliator and the more resistant to the polyhedrosis.

Biology - 3

392. Smirnoff, W.A. 1968. **Adaptation of the microsporidian *Thelohania pristiphorae* to the tent caterpillars *Malacosoma disstria* and *Malacosoma americanum*.** J. Invertebr. Pathol. 11(2): 321-5.

"*Thelohania pristiphorae*, a microsporidian pathogen of the larch sawfly, *Pristiphora erichsonii*, has been successfully adapted to the tent caterpillars *Malacosoma disstria* and *Malacosoma americanum*. The development of the pathogen in *M. americanum* was accompanied by the development of a nuclear polyhedrosis. The microsporidian remained virulent for the original host after six passages on both *Malacosoma* species. A method to obtain large quantities of spores for use against either the host of origin or the two new hosts is described."

Biology - 3

393. Smirnoff, W.A. 1968. **Microorganisms isolated from *Malacosoma americanum* and *Malacosoma disstria* in the province of Quebec.** Can. For. Serv., Bi-mon. Res. Notes. 24(1): 4.

The most important diseases found in field populations of *M. disstria* and *M. americanum* are recorded. A nuclear polyhedrosis may have contributed to the population collapse of *M. americanum*, while the reduction in populations of *M. disstria* was attributable, at least in part, to *Nosema disstriae*.

Biology - 3

394. Smirnoff, W.A. 1975. **Histological studies on the development of the microsporidian *Thelohania pristiphorae* in larvae of *Malacosoma disstria* and *Malacosoma americanum*.** J. Invertebr. Pathol. 26(3): 401-403.

Thelohania pristiphorae is a microsporidian parasite of the larch sawfly. Researchers infected forest tent caterpillar and eastern tent caterpillar (*Malacosoma disstria* and *M. americanum*) with *T. pristiphorae* to observe the mechanism of infection. They found that the infection developed in two stages. First, the midgut was infected, in the layer of high epithelial cells. Schizonts of the microsporidian formed rows of merozoites which grew towards the basal membrane. The spores concentrated in the basal portion of the cells and were shed in massive amounts on the third or fourth day after infection. In this way they were spread to the rest of the intestine. Some of the cells opened into the body cavity, distributing spores and vegetative stages into the hemolymph. They were then phagocytized by blood cells where they developed and eventually destroyed the cells, again becoming free in the hemolymph. The stages distributed in the hemolymph then invaded cells of the hypodermal tissue layer where they grew and multiplied, eventually producing large oval oenocytoidal cells that broke out of the host cells to float free through the hemolymph. These giant oenocytoidal cells were full of vegetative stages and spores of the parasite. The hypodermal tissue where they developed was in any number of locations throughout the caterpillar including the silk glands, fat bodies, Malpighian tubes, tracheae, muscles, connective tissues, and gonads.

Biology - 3

395. Smith, C.C. 1951. **Control of forest tent caterpillar, *Malacosoma disstria* Hbn., with DDT.** Dep. Agric. Can., Div. For. Biol., Bi-mon. Progr. Rep. 7(2): 1.

Complete control of *Malacosoma disstria* was obtained by spraying trunks and foliage thoroughly within 10 days after the bursting of the buds, using DDT in wettable powder form or in emulsion at 2.5 lb. actual DDT to 100 gal. of spray.

Control - 1

396. Smith, D.M. 1976. **Changes in eastern forests since 1600 and possible effects.** Pages 3-20 *in* J.F. Anderson and H.K. Kaya (eds.). Perspectives in forest entomology. Academic Press Inc., New York, N.Y.

This chapter reviews the effects of (a) agricultural clearance and abandonment, during the settlement of the United States of America, and (b) human intervention in the residual forest, and the

accompanying pest problems. It is concluded that these problems are generally related to a reduction in the mean age of stands, and that the pests of overmature stands have declined over the same period.

Outbreaks - 1,3

397. Smith, G.J.; Raske, A.G. 1968. **Starvation experiments with first instar forest tent caterpillar larvae.** Can. For. Serv., Bi-mon. Res. Notes. 24 (5): 39.

Results are given of an experiment designed to test the length of time that first-instar larvae of *Malacosoma disstria* can survive without food, and to observe their behaviour. Colonies of newly hatched larvae from egg bands collected in the field were subjected to starvation and exposed to various degrees of lighting, temperature and humidity. It was found that at constant high temperatures, when the metabolic rate was high for 24 hours each day, newly hatched larvae withstood a minimum of 9 days complete starvation, whereas at constant low temperatures most of the larvae lived for 30 days. It was concluded that starvation (due for example, to late leafing of *Populus tremuloides*) is unlikely to be the cause of the complete collapse of whole populations over wide areas, such as does sometimes occur. Starvation combined with other factors (such as weather or disease) may, however, influence mortality rate of first-instar larvae.

Biology - 1,4,6; Host Relationships - 1

398. Smith, J.D.; Goyer, R.A. 1985. **Rates of parasitism and sex ratios of *Ablerus clisiocampae* and *Ooencyrtus clisiocampae* egg parasites of the forest tent caterpillar, *Malacosoma disstria* in southern Louisiana.** J. Entomol. Sci. 20(2): 189-193.

"Populations of egg parasites, *Ablerus clisiocampae* Ashmead and *Ooencyrtus clisiocampae* Ashmead, of the forest tent caterpillar, *Malacosoma disstria* Hbn., were found to be 73% and 55%, females, respectively. These parasites emerged a mean of 31 days after the beginning of forest tent caterpillar eclosion under controlled laboratory conditions. Percentage parasitism was highest in upper tree crowns, in 1980-81 averaging 33.6%, and was highest at the middle crown levels in 1981-82, averaging 20.3%."

Biology - 2

399. Smith, J.D.; Goyer, R.A. 1986. **Population fluctuations and causes of mortality for the forest tent caterpillar, *Malacosoma disstria* (Lepidoptera: Lasiocampidae), on three different sites in southern Louisiana.** Environ. Entomol. 15(6): 1184-1188.

"Population fluctuations of forest tent caterpillar, *Malacosoma disstria* Hübner, were investigated at two permanently flooded plots and one plot that was dry during the summers of 1980-83 in southern Louisiana. Tupelo gum, *Nyssa aquatica* L., and swamp tupelo, *N. sylvatica* var. *biflora* (Walt) Sarg., made up 63% of the dry plot forest stand and 93.8 and 87% of the two wet plots. Egg parasitism ranged from 8.8 to 29.7%, and egg infertility varied from 1.2 to 6.7%. An analysis of egg mortality factors demonstrated no density-dependent relationships or significant plot differences. Pupal parasitism by *Sarcophaga houghi* Aldrich varied from 18 to 78% during 1981-82. Lower rates of parasitism were found on wet plots due, presumably, to drowning of parasite puparia. Populations of forest tent caterpillar at the dry plot were reduced by apparent density-dependent parasitism by

S. houghi. We found that a generation survival rate of 0.1% resulted in population decline and that survival of ≥0.7% resulted in a population increase the following season. Starvation may have been a major factor in population fluctuation at wet plots."

Biology - 2; Outbreaks - 5

400. Smith, J.D.; Goyer, R.A.; Woodring, J.P. 1986. **Instar determination and growth and feeding indices of the forest tent caterpillar, *Malacosoma disstria* (Lepidoptera: Lasiocampidae), reared on tupelo gum, *Nyssa aquatica* L.** Ann. Entomol. Soc. Am. 79(2): 304-307.

"Forest tent caterpillar, *Malacosoma disstria* Hübner, larvae were reared from eclosion to pupation on tupelo gum, *Nyssa aquatica* L., foliage in the laboratory. Instars were determined using both head capsule and frass measurements. Although others have reported six instars, we found five. Males generally consumed more foliage per day than females, but females took longer to develop and, consequently, consumed more total foliage. Relative consumption rate, relative growth rate, and approximate digestibility decreased from third to fifth instar. Efficiency of conversion of digested food increased except for the fifth instar. Efficiency of consumption of ingested food increased, then declined; but this was not unexpected."

Host Relationships - 3

401. Smith, R.K. 1962. **Forest pest losses in 1962.** South. Lumberman 205(2561): 113-116.

This paper gives a break-down of the losses of merchantable southern pine in the southeastern United States in 1962 through insect damage, ca. 90% of which is attributed to *Dendroctonus frontalis, D. terebrans,* and *Ips* sp. Other agents included *Neodiprion lecontei, Rhyacionia frustrana, Chermes piceae,* and, in hardwoods, *Ennomos subsigniarius, Prionoxystus robiniae,* and *Malacosoma disstria.*

Outbreaks - 3

402. Smith, S.M.; Strom, K.B. 1993. **Oviposition by the forest tent caterpillar (Lepidoptera: Lasiocampidae) and acceptability of its eggs to *Trichogramma minutum* (Hymenoptera: Trichogrammatidae).** Environ. Entomol. 22(6): 1375-1382.

"Studies were conducted to assess the availability and acceptability of eggs of the forest tent caterpillar, *Malacosoma disstria* Hübner, to *Trichogramma minutum* Riley for use in inundative releases. Oviposition by the forest tent caterpillar occurred during 4-19 July and lasted 7-10 d [days] in southern Ontario. At least 50% of oviposition occurred during the first 3-4 d. Oviposition was initiated on the same day as female emergence, 2 d after male emergence. Pheromone traps baited with two-component lures predicted oviposition within 2 d. No *Trichogramma* emerged successfully from 0- to 7-d-old host eggs, although the survival of tent caterpillar embryos exposed at this age to the parasitoids was reduced significantly (from 97.5 to 42.3%). The greatest number of *Trichogramma* emerging from caterpillar egg masses (72.7%) was observed in those eggs exposed to parasitoids 21 d after oviposition, with 43.5 and 12.5% emergence from egg masses exposed at 14 and 28 d after oviposition, respectively. A tent caterpillar egg mass contained 109.8 ± 14.8 (mean ± SE) eggs; parasitoids emerged from 14.4 ± 3.5 of these eggs (13.1% egg parasitism). The number of parasitoids emerging from each parasitized egg ranged from 5.0 to 11.0; 69.5% were female and development at

20°C took 14.2 ± 0.2 d. Removal of the spumaline layer from the egg masses increased emergence of parasitoids very slightly. No *Trichogramma* successfully overwintered in forest tent caterpillar eggs, although a single dead parasitoid (0.2%) was observed infrequently in eggs simultaneously with a dead pharate larva. *Trichogramma* possibly can be used in inundative releases against *M. disstria*; however, further studies are needed to determine why the parasitoid kills but does not emerge from tent caterpillar eggs <14 d old."

Biology - 2

403. Sohi, S.S. 1971a. **In vitro cultivation of hemocytes of *Malacosoma disstria* Hübner (Lepidoptera: Lasiocampidae).** Can. J. Zool. 49(10): 1355-1358.

"Prolonged culturing of the hemocytes of *Malacosoma disstria* has been accomplished using Grace's insect tissue culture medium supplemented with fetal bovine serum (5%) and *Bombyx mori* hemolymph (3%). The cultures started to grow after 3-6 months. These cells have now been in vitro for over 16 months, and have been subcultured 35 times. Three types of cells were present in primary cultures, but only one type, prohemocytes, persisted and grew after subculturing. The *M. disstria* larvae that were used as the original source of hemocytes were naturally infected with the microsporidian *Glugea disstriae.* The microsporidian also grew in the cell culture, and the cells are still infected."

Biology - 7

404. Sohi, S.S. 1971b. **Establishment of cultures of *Malacosoma disstria* Hubner (Lepidoptera: Lasiocampidae) hemocytes in a hemolymph-free medium.** Pages 27-39 *in* J. Rehacek, D. Blaskivic, and H.F. Hink (eds.). Proc. 3rd. Int. Colloq. Invertebr. Tissue Cult., Smolenice, Czechoslovakia. June 22-25, 1971. Slovak Acad. Sci., Bratislava, Czechoslovakia.

"To initiate cultures of *Malacosoma disstria* hemocytes, surface sterilized full grown *M. disstria* larvae were bled into 30 ml polystyrene flasks (5 larvae/flask) each containing 3 ml Ringer-Locke balanced salt solution (RLS). The cultures were allowed to stand for 10-15 min. during which time the hemocytes settled and attached to the bottom of culture flasks. The RLS was then removed, and cultures were rinsed 3 times with RLS and once with Grace-Wyatt medium supplemented with 20% fetal bovine serum but without hemolymph. Then the medium was added, and cultures were incubated at 28°C. The medium was changed every 1-2 weeks. The cells have not been *in vitro* for 21 months and have been transferred 25 times during the last 18 months. They are strongly attached to the culture vessels. They appear to be prohemocytes, and are of 3 shapes: (1) round, (2) elongated, and (3) irregular in appearance."

Biology - 7

405. Sohi, S.S.; Bird, F.T. 1976. **Replication of a nuclear polyhedrosis virus of *Choristoneura fumiferana* (Lepidoptera: Tortricidae) in *Malacosoma disstria* (Lepidoptera: Lasiocampidae) hemocyte cultures.** Pages 361-367 *in* E. Kurstak and K. Maramorosch (eds.). Invertebrate Tissue Culture: Applications in Medicine, Biology and Agriculture. Proc. 4th Internat. Conf. Invertebrate Tissue Cult., Mont Gabriel, Que., 1975. Academic Press, New York, N.Y.

Using hemolymph from *Choristoneura fumiferana* larvae infected with NPV, two cell lines of *Malacosoma disstria* hemocytes (IPRI 66 and IPRI 108) at various subcultures were tested for susceptibility to the *Cf*NPV. Polyhedra were observed in cells of both lines when the hemocytes were in early subcultures (IPRI 66 25-27th subcultures and IPRI 108 2,3, 5-7th subcultures), however no polyhedra were observed after inoculation of IPRI 108 subcultures 31, 37, 43, 49, 50, 51, 66, 67, 73 and 74. The cells appeared to have lost susceptibility to the virus. Two tests were also conducted to determine if *C. fumiferana* NPV propagated in tissue cultures was still pathenigenic to the host insect. In the first test, 4th instar larvae were inoculated *per os* with NPV in the first passage of tissue culture. In the second test, 5th instar larvae were inoculated *per os* and by intrahemocoelic injection of NPV after its second passage in tissue culture. "...No virus infection was seen in test 1, but some infection and mortality was observed in the 2nd test in the larvae that were injected intrahemocoelically with the virus ... It seems that the small amount of virus administered *per os* was not sufficient to cause infection, but the same amount was adequate to initiate infection when injected intrahemocoetically."

Biology - 3

406. Sohi, S.S.; Bird, F.T.; Hayashi, Y. 1971. **Development of *Malacosoma disstria* cytoplasmic polyhedrosis virus in *Bombyx mori* ovarian and tracheal tissue cultures.** Pages 340-351 *in* Proc. 4th Int. Colloq. Insect Pathol., College Park, Md., Aug. 25-28, 1970.

"Ovarian and tracheal tissue cultures of *Bombyx mori* were successfully infected with a cytoplasmic polyhedrosis virus (CPV) from *Malacosoma disstria*. The inoculum was free virions isolated from infected guts using sucrose density gradients. Large masses of electron-dense viroplasm containing complete and incomplete virions appeared in the cytoplasm of infected cells. Proteinaceous material accumulated to make the crystalline matrix which occluded the virions and formed the polyhedron. As polyhedra matured they attained an angular shape and a smoother outline. Crystalline inclusions and spherical bodies were observed in the nuclei of some infected cells. The shape and size of the intranuclear crystalline inclusions were the same as those of cytoplasmic polyhedra, but spherical bodies were much smaller. No virions were seen in the intranuclear inclusions."

Biology - 3,7

407. Sohi, S.S.; Cook, B.J. 1992. **Multiplication of a baculovirus of *Malacosoma disstria* (Lepidoptera: Lasiocampidae) in a homologous cell line.** In Vitro Cell. Dev. Biol. 28: 89A.

"Outbreaks of the forest tent caterpillar, *Malacosoma disstria*, appear at irregular intervals throughout much of the United States and Canada. Heavy infestations cause considerable defoliation and loss of growth in host trees, and the migrating larvae are a great nuisance around houses, and in parks and campgrounds in infested areas. Also, defoliation by *M. disstria* reduces the yield of non-fibre products, such as maple syrup and syrup products. We have established a continuous cell line, IPRI-MD-66, from the hemocytes of this insect (S.S. Sohi, Can. J. Zool 49: 1355-1358, 1971 [abstract 403]) and have reported the multiplication of a microsporidium in it (S.S. Sohi and G.G. Wilson, Can. J. Zool. 54: 336-342, 1976 [abstract 410]). Here, we report the replication of *M. disstria* nuclear polyhedrosis virus in this cell line. The virus inoculum was prepared by homogenizing *M. disstria* larvae infected with the virus. Cells in log phase were centrifuged at 135 xg for 5 min and the cell pellet was resuspended in 1 ml of virus inoculum. The cells were kept at 28°C before and after inoculation with virus. Occlusion bodies appeared in the nuclei of cells one day post inoculation,

and cytopathological changes were typical of NPV infection. The virus has been serially passaged eight times and the level of infection fluctuated from 40 to 67%."

(Entire reference included in annotation [poster contribution].)

Biology - 3,7

408. Sohi, S.S.; Cunningham, J.C. 1972. **Replication of a nuclear polyhedrosis virus in serially transferred insect hemocyte cultures.** J. Invertebr. Pathol. 19(1): 51-61.

"The nuclear polyhedrosis virus (NPV) of *Lambdina fiscellaria somniaria*, propagated in *L.f. fiscellaria* larvae, was found to infect two cell lines of *Malacosoma disstria* hemocytes. The two cell lines, IPRI 66 and IPRI 108, had previously been subcultured 25 times and 5 times, respectively. Three days after inoculation of the cultures, polyhedra were seen in the nuclei and rhomboidal crystalline inclusions, typical of this virus, were seen in the cytoplasm of cells. Replication of virus and occlusion of virions in polyhedra was confirmed in infected cultures by electron microscopy. Healthy *L.f. fiscellaria* larvae became infected when they were fed or injected intrahemocoelically with infected cultures. Microscopical examination of infected cultures, and larval infectivity tests, indicated that viral replication was greater in IPRI 108 cells than in IPRI 66 cells."

Biology - 3,7

409. Sohi, S.S.; Palli, S.R.; Cook, B.J.; Retnakaran, A. 1995. **Forest insect cell lines responsive to 20-hydroxyecdysone and two nonsteroidal ecdysone agonists, RH-5849 and RH-5992.** J. Insect Physiol. 41(6): 457-464.

“The effects of 20-hydroxyecdysone (20E) and two substituted dibenzylbutylhydrazines, R5849 and RH-5992, were investigated *in vitro* using three forest insect cell lines. Two of these cell lines, IPRI-MD-66 (MD-66) from the forest tent caterpillar, *Malacosoma disstria* and IPRI-CF-1 (CF-1) from the spruce budworm, *Choristoneura fumiferana*, grow freely suspended, whereas the cells of the third line, FPMI-CF-70 (CF-70) from *C. fumiferana*, stay attached to the culture flask. MD-66 cells responded to all three compounds by forming clumps and by producing filamentous extensions. In addition, these compounds produced increased cell attachment and reduced cell proliferation in this cell line. CF-70 cells also responded to all three compounds although to a lesser extent. On the other hand, CF-1 cells showed little or no morphological response. The above effects of RH-5992 on MD-66 cells were both dose and time dependent. This compound also induced the expression of the *Malacosoma disstria* hormone receptor (MdHR3) in these cells in a dose dependent manner, as was the case with 20E. This result indicated that the effect of RH-5992 on MD-66 cells is specific and related to their response to 20-E. These phenotypic and molecular observations indicate that MD-66 cells and RH-5992 will be an excellent *in vitro* model system for studying the mode of action of ecdysteroid agonists.

Biology - 7

410. Sohi, S.S.; Wilson, G.G. 1976. **Persistent infection of *Malacosoma disstria* (Lepidoptera: Lasiocampidae) cell cultures with *Nosema* (*Glugea*) *disstriae* (Microsporida: Nosematidae).** Can. J. Zool. 54(3): 336-342.

"Cell lines were developed from hemocytes and ovarian tissues of *Malacosoma disstria* larvae that were naturally infected with *Nosema disstriae.* The infection was carried over into the cell cultures. *N. disstriae* disappeared from the ovarian cultures after several passages in vitro involving a period of more than 2 years, but hemocyte cultures are still infected after 6 years (199 passages). The spores produced in cell cultures were infectious for *M. disstria* larvae."

Biology - 3,7

411. Sohi, S.S.; Wilson, G.G. 1979. **Effect of antimicrosporidian and antibacterial drugs *on Nosema disstriae* (Microsporida) infection in *Malacosoma disstria* (Lepidoptera: Lasiocampidae) cell cultures.** Can. J. Zool. 57(6): 1222-1225.

"Continuous hemocyte cultures (IPRI-MD-66) established from *Malacosoma disstria* (Lepidoptera: Lasiocampidae) and persistently infected with *Nosema disstriae* were treated separately with two antimicrosporidian drugs, fumagillin and benomyl, and an antibacterial drug, gentamicin. Treatment with fumagillin (2, 5, and 10 µg/mL) or benomyl (25 µg/mL) for 35 days permanently eliminated the microsporidium without adversely affecting the host cells. The use of benomyl for 7 days considerably reduced infection, but infection levels increased to that of the untreated controls when the drug treatment was discontinued. Gentamicin (50 and 100µg/mL) used for 35 days had no adverse effect on *Nosema* or the host cell."

Biology - 3,7

412. Stairs, G.R. 1964a. **Infection of *Malacosoma disstria* Hübner with nuclear-polyhedrosis viruses from other species of *Malacosoma* (Lepidoptera, Lasiocampidae).** J. Insect Pathol. 6(2): 164-169.

"Nuclear-polyhedrosis viruses from *Malacosoma americanum* (Fabricus), *Malacosoma pluviale* (Dyar), and *Malacosoma disstria* Hübner were equally infectious for *M. disstria* larvae. The virus from *Malacosoma alpicola* Staudinger was infectious for *M. disstria* larvae but acted much more slowly than any of the native viruses. The rate of mortality from all the viruses varied directly with concentration. The significance of these results is discussed."

Control - 4

413. Stairs, G.R. 1964b. **Dissemination of nuclear polyhedrosis virus against the forest tent caterpillar, *Malacosoma disstria* (Hübner) Lepidoptera: Lasiocampidae.** Can. Entomol. 96(7): 1017-1020.

"A nuclear polyhedrosis virus was disseminated into field populations of an incipient outbreak of the forest tent caterpillar, *Malacosoma disstria* (Hübner). Mortality varied with the concentration of virus used and the age of larvae at the time of spraying. Larvae showed symptoms of infection more rapidly when sprayed with the higher concentrations and secondary infection and mortality occurred in areas where initial mortality developed during early larval stages."

Control - 4

414. Stairs, G.R. 1965a. **Quantitative differences in susceptibility to nuclear-polyhedrosis virus among larval instars of the forest tent caterpillar, *Malacosoma disstria* (Hübner)**. J. Invertebr. Pathol. 7(4): 427-429.

"The relative susceptibility of various instars of *Malacosoma disstria* (Hübner) to a nuclear-polyhedrosis virus was studied quantitatively. It was found that susceptibility decreased markedly as larvae grew older. Some fourth-instar larvae survived dosages two billion times higher that those required to kill first-instar larvae."

Biology - 3; Control - 4

415. Stairs, G.R. 1965b. **Artificial initiation of virus epizootics in forest tent caterpillar populations.** Can. Entomol. 97(10): 1059-62.

"Nuclear-polyhedrosis virus, introduced into virus-free populations of the forest tent caterpillar, *Malacosoma disstria* (Hübner), in 1963, was carried over into the 1964 host generation and was spread into the surrounding areas from the points of introduction. The extent of spread in 1964 appeared to be influenced by the size of the area treated in 1963. In 1964 the epizootics developed slowly during the early instars and reached the highest levels late in the last instar. Many infected larvae crawled to the tops of the trees and died while eggs were being laid, thus, some egg masses were contaminated. This is one means by which virus may be spread from one generation to the next, but egg-transmission by adults appears to be the main method of spread over wide areas. Adults of the dipterous parasite *Sarcophaga aldrichi* Park. may be important dispersal agents of disease in localized areas because they feed on virus-diseased larvae and are present from the time larvae enter the third instar until after adults have oviposited."

Biology - 3; Control - 4

416. Stairs, G.R. 1966. **Transmission of virus in tent caterpillar [*Malacosoma disstria*] populations.** Can. Entomol. 98(10): 1100-1104.

"The transmission of nuclear polyhedrosis virus in populations of the forest tent caterpillar, *Malacosoma disstria* (Hübner), was studied in Sudbury district, Ontario. Virus was transmitted from generation to generation by infected adults. Their progeny died from virus disease during the second and third larval instars. Adult flies of *Sarcophaga aldrichi* Parker, a dipterous parasite, were attracted to these dead, diseased larvae, became contaminated with virus, and spread the virus to foliage on which healthy larvae were feeding. The importance of these disseminating agents in the development of virus epizootics is discussed."

Biology - 3

417. Stairs, G.R. 1967a. **The study of virus epizootics in insect populations.** Pages 273-279 *in* P.A. van der Laan (ed.). Insect Pathology and Microbial Control. Proc. Int. Colloq. on Insect Pathology and Microbial Control, Wageningen, the Netherlands, Sept. 5-10, 1966. North Holland Publishing Co., Amsterdam, Netherlands.

This paper gives a general overview of knowledge concerning insect viruses up until September 1966. Among the topics examined in the paper are the differences in susceptibility of instars of *Malacosoma disstria* to viruses, transmission of viruses through the adult stages to the eggs themselves, virus transmission via biotic and abiotic factors, behaviour of infected larvae, and transmission of epizootics from one species to another (the example given being transmission of virus from *Malacosoma americanum* to *M. disstria*).

Biology - 3

418. Stairs, G.R. 1967b. **Quantitative aspects of virus dispersion and the development of epizootics in insect populations.** Pages 19-23 *in* G.R. Stairs and K. Aizawa (eds.). Proc. Joint U.S.-Japan Seminar on Microbial Control of Insect Pests, Fukuoka, Japan. Apr. 21-23, 1967. The United States - Japan Committee on Scientific Cooperation.

Using examples of studies conducted mainly on *Malacosoma disstria* and its nuclear polyhedrosis virus, the author discusses variations in host susceptibility, transmission of the virus by adult dissemination as well as other modes of virus transmission important to the development of epizootics, to explain the survival of both the host and the virus populations during outbreak and endemic host populations.

Biology - 3

419. Stairs, G.R. 1972. **Pathogenic microorganisms in the regulation of forest insect populations.** Annu. Rev. Entomol. 17(0): 355-372.

This is a general paper discussing microorganisms as regulators of forest insect populations. Several specific pathogen-host insect associations are discussed. Disease symptoms and pathogenicity to various life stages is described and use of certain microorganisms as biological control agents are also discussed.

Biology - 3

420. Stairs, G.R. 1989. **Effects of a nuclear polyhedrosis virus isolate from *Malacosoma disstria* on *Lymantria dispar* larval growth pattern**. J. Invertebr. Pathol. 53(2): 247-250.

"A nuclear polyhedrosis virus isolated from a larval population of the Forest Tent Caterpillar, *Malacosoma disstria* , was fed to first- and second-instar gypsy moth, *Lymantria dispar*, larvae where it caused tissue damage and low mortality. Growth of most individuals was retarded until they reached the last instar when recovery of the growth loss was rapid and nearly complete. The infected individuals reached the adult stage 3 to 4 days later than the controls; otherwise they appeared normal."

Biology - 3

421. Stark, E.J.; Harper, J.D. 1982. **Pupal mortality in forest tent caterpillar (Lepidoptera: Lasiocampidae): causes and impact on populations in southwestern Alabama.** Environ. Entomol. 11(5): 1071-1077.

"Analyses of pupal mortality factors were made in six subpopulations of forest tent caterpillar (FTC), *Malacosoma disstria* Hübner (Lepidoptera: Lasiocampidae), in Baldwin and Mobile Counties in southwestern Alabama in 1977, 1978 and 1979. Infestations were confined to a cypress-tupelo deltoid swamp with water tupelo, *Nyssa aquatica* L., as the predominant host species. Major identifiable mortality factors included predation, disease and parasitism. Pupal predation was attributable predominantly to birds and ants, whereas the entomogenous fungus *Beauveria bassiana* (Balsamo) Vuillemin caused all observed mortality attributable to disease. Fifteen parasitic insects were reared from FTC pupae; nine were considered primary parasites, and six were hyperparasites. Rate of pupal parasitization was less than 60% in 17 of 18 temporally or spatially distinct samples during the 3 year study. Although parasitism was the most important cause of pupal mortality, it did not appear to be a dominant regulatory factor for FTC in this ecosystem. Neither host population quality nor density was highly correlated with degree of parasitism. The aquatic habitat places severe restrictions on the species of parasites which can effectively utilize FTC as a host, which in turn limits total parasite impact."

Biology - 2,3

422. Stehr, F.W. 1964. **A revision of the genus *Malacosoma* Hübner (Lepidoptera: Lasiocampidae) in North America.** Ph.D. thesis. Univ. Minn. 375 p.

This thesis is a revision of the genus *Malacosoma*, based on 2 years of field study, rearing of all life stages, and examination of museum specimens. Six species and 11 subspecies are recognized in the paper. Keys for adult, mature larvae, and egg mass identification are also given.

Taxonomy

423. Stehr, F.W.; Cook, E.F. 1968. **A revision of the genus *Malacosoma* Hübner in North America (Lepidoptera: Lasiocampidae): systematics, biology, immatures, and parasites.** U.S. Nat. Mus. Bull. No. 276. 321 p.

This book-length report, based on the thesis work by Stehr (abstract 422) reviews the genus *Malacosoma* Hübner in North America. It is comprehensive, covering all species and all life stages over the following subjects: taxonomy, economic importance, damage, life history, sampling, disease, parasites, and oviposition habits. It also contains identification keys and color photographs.

Taxonomy; Biology - 1,2,3,6; Outbreaks - 3,4abcd

424. Sterner, T.E.; Davidson, A.G. (compilers). 1982. **Forest insect and disease conditions in Canada 1981.** Environ. Can., Can. For. Serv., Ottawa, Ont. pp. 16-17.

The occurrence and effects of *Malacosoma disstria* are described for each affected region, with notes on control and forecasts for 1982.

Outbreaks - 1,3

425. Still, G.N. 1982**. 1982 forest tent caterpillar [*Malacosoma disstria*] infestation forecast for the Prairie Provinces.** Can. For. Serv., North. For. Res. Cent., For. Manage. Note No. 13. 2 p.

This article summarizes the expected infestation levels of *Malacosoma disstria* infestation across the Prairie Provinces in 1982. *M. disstria* was the primary cause of the extensive defoliation of trembling aspen that occurred in 1981 across the Prairies. The current *M. disstria* outbreak began in 1971 and collapsed in Manitoba in 1979, after peaking there in 1977. The outbreak peaked in Saskatchewan in 1980 and was at its highest levels since the outbreak began in Alberta in 1981. Egg band surveys were conducted across the Prairies in late 1981. Results from these surveys predicted that infestation levels and distribution patterns in 1982 would be similar to those experienced in 1981. However, population levels may not be exactly as predicted due to such factors as adverse weather, parasites, and diseases. In this respect, it is necessary to make post-hatch counts to determine the necessity of control programs.

Outbreaks - 1,3

426. Stille, J.K.; Groh, B.L. 1987. **Stereospecific cross-coupling of vinyl halides with vinyl tin reagents catalyzed by palladium.** J. Am. Chem. Soc. 109(3): 813-817.

"The palladium-catalyzed cross-coupling reactions of (E)- or (Z)-vinyl iodides with (E)- or (Z)-vinylstannanes gives good yields of stereoisomerically pure unsymmetrical dienes with the same double bond geometry as present in the coupling partners. The reaction takes place at ambient temperature in dimethylformamide in the presence of 1-2% bis(acetonitrile)dichloropalladium. Because this reaction is tolerant of a variety of functionality on either coupling partner, highly functionalized stereoisomerically pure E,E-, E,Z-, Z,E-, or Z,Z-1,3-dienes can be obtained under mild conditions by the coupling of the appropriate vinyl iodide with a suitable vinyl tin partner. The sex pheromone of the forest tent caterpillar, *Malacosoma disstria*, was synthesized by the coupling reaction of (Z)-1-iodo-1-hexen-6-ol with (E)-1-trimethylstannyl-1-hexene."

Biology - 5; Control - 5

427. Stoltz, D.B.; Cook, D.I. 1983. **Inhibition of host phenoloxidase activity by parasitoid Hymenoptera**. Experentia 39(9): 1022-24.

"Partial or complete inhibition of hemolymph phenoloxidase activity occurred in host species attacked by some parasitoid wasps. In one system, inhibition of enzyme activity could be achieved by injection of a virus purified from parasitoid ovaries."

Biology - 2

428. Stoltz, D.B.; Guzo, D. 1986. **Apparent haemocytic transformations associated with parasitoid-induced inhibition of immunity in *Malacosoma disstria* larvae.** J. Insect Physiol. 32(4): 377-388.

"The ichneumonid wasp, *Hyposoter fugitivus*, is an habitual parasitoid of tent caterpillar (*Malacosoma disstria*) larvae. Successful parasitism is associated with an apparent behavioural transformation of certain host haemocytes, and is in addition characterized by a suppression of immunity to foreign

objects such as parasitoid eggs, yeast, and Sephadex beads; it is suggested that transformation of haemocytes renders them incapable of participating in normal immune responses. Inhibition of some aspects of cellular immunity in host insects can also be induced by manual injection of a polydnavirus isolated from the ovaries of the parasitoid. It was observed that haemolymph from parasitized larvae does not melanize *in vitro*; this phenomenon may be associated with a greatly increased stability of oencytoids."

Biology - 2

429. Stoltz, D.B.; Xu, D. 1990. **Polymorphism in polydnavirus genomes**. Can. J. Microbiol. 36(8): 538-543.

"Polymorphisms were readily detected in polydnavirus DNA extracted from several different species belonging to two different families of parasitic Hymenoptera. Heterogeneity was observed as differences in electrophoretic profiles of genome segments, differences in the number of cross-hybridizing genome segments, and restriction fragment length polymorphisms; polymorphism was also detected at the level of an individual genome segment. Some implications drawn from these observations are discussed." Note: one of the species of parasite tested was *Hyposoter fugitivus*, a parasite of *Malacosoma disstria* Hbn.

Biology - 3

430. Strakhov, V.V. 1976**. The survival of larvae of lepidopterous forest pests.** Moskovskii-Lesotekhnicheskii-Institut. [Forest protection] Voprosy zashchity lesa. No. 90. Translated from Russian.

Empirical life tables (survival tables) are presented for the larvae of a number of important species of forest defoliators*: Bupalus piniarius, Panolis flammea, Hemerocampa pseudotsugata, Choristoneura occidentalis, C. fumiferana, Porthetria dispar, Operophtera brumata, Papilio xuthus, Malacosoma neustria* and *M. disstria*. The tables show the coefficients of survival of the larvae by instars, and equations in the form of survival polynomials are constructed for each of the 10 species.

Outbreaks - 5

431. Struble, D.L. 1970. **A sex pheromone in the forest tent caterpillar.** J. Econ. Entomol. 63(1): 295-296.

Adult virgin females of *Malacosoma disstria*, caged in the field, were effective in attracting males. An ether extract of the female abdomen tip caused males to respond in olfactometer tests.

Biology - 5

432. Sullivan, C.R. 1951. **Laboratory and field investigations of the influence of environmental factors upon the activity and behaviour of three species of tent caterpillars and the spotless fall webworm.** M.S.A. thesis. Univ. Toronto, Toronto, Ont. 109 p.

The effects of weather on the *Malacosoma disstria, M. americanum, M. pluviale,* and *Hyphantria textor* were examined during the summers of 1949 and 1950 near Sault Ste. Marie, Ontario.

Biology - 4

433. Sullivan, C.R.; Wellington, W.G. 1953**. The light reactions of larvae of the tent caterpillars, *Malacosoma disstria* Hbn., *M. americanum* (Fab.), and *M. pluviale* (Dyar) (Lepidoptera: Lasiocampidae).** Can. Entomol. 85(8): 297-310.

Larvae of all three species were found to be photopositive to discrete or diffuse sources of light at room temperatures. Starvation was found to emphasize this response. When overheated, larvae generally become photonegative, but later instar *M. americanum* and *M. pluviale* larvae become more strongly photopositive. On the ground, exposed to full sunlight or a clear sky, older larvae of all three species become photonegative when overheated. Differences in response to diffuse light and to that from an open sky are probably due to the fact that the diffuse light is unpolarized.

Biology - 1

434. Swain, A. 1966. **March of the caterpillars.** Audubon 68(3): 158-159.

Defoliation caused by a major infestation in Prince Albert Park, Saskatchewan, is described. The report suggests that the infestation would collapse in 1966 because of parasitism by *Sarcophaga aldrichi*. It is hypothesized that the defoliation may help the tree survive periods of lower than normal rainfall by removing the larger leaves, which then causes the tree to replace the lost foliage with smaller leaves that transpire less water.

Host Relationships - 1; Outbreaks - 3

435. Swaine, J.M. 1918**. Tent caterpillars.** Dep. Agric. Can., Entomol. Branch, Circ. No. 1. Revised ed. 12 p.

This document was "... prepared to render advice as to the methods of destroying the eggs and early stages of the caterpillars in localities where it is found that the natural means of control have not been effectual."

Biology - 1,2,3; Control - 2,6

436. Sweetman, H.L. 1940. **The value of hand control for the tent caterpillars, *Malacosoma americana* Fabr. and *Malacosoma disstria* Hbn. (Lasiocampidae, Lepidoptera).** Can. Entomol. 72(12): 245-250.

The various methods of controlling outbreaks of tent caterpillars are covered, including biological control by release of parasitoids, chemical applications, and physical removal of egg masses and nests. Larvae can be controlled by lead-arsenate sprays applied before serious defoliation occurs, but where such methods are not economic the collection and destruction of eggs and larvae is effective. Nests of *M. americana* that are close to the ground are easily destroyed by rolling between

the gloved hands, and those situated higher on the trees can be pulled down by means of a brush or nail-claws on the end of a pole. Larvae of *M. disstria,* though gregarious, do not form nests but frequently collect, especially on warm days, on the tree trunks, where they can be destroyed.

Biology - 2,3,4; Control - 2,6

437. Swenson, K.G. 1957. **Pest control in the Northwest.** Am. Nurseryman 106(5): 73-5.

This article summarizes control measures for *Dichomeris marginella, Halisidota argentata, Malacosoma disstria, M. pluvialis, Rhopobota naevana ilicifoliana,* and *Pulvinaria floccifera* based on investigations over 3 years at the Oregon Agricultural Experiment Station, Corvallis. For control of both *M. disstria* and *M. americanum* the recommended treatment is malathion "applied at a rate of four pounds of 25 per cent wettable powder to 100 gallons of water."

Control - 6

438. Teillon, H.B.; Burns, B.S.; Kelley, R.S. 1983. **Forest insect and disease conditions in Vermont: Calendar year 1982.** Vermont Agency of Environ. Cons., Dep. For., Parks and Recreation, Montpelier, Vt. pp. 4, 6-9.

The area defoliated by the forest tent caterpillar increased in northern Vermont in 1982, while populations collapsed in southern Vermont. Starvation due to poor foliage quality contributed to the population decline. Dieback and mortality were evident in sugar maple and white ash. Portions of stands with the heaviest losses are most often characterized by a dominance of pole sized sugar maple and low basal areas compared to the rest of the stand.

Outbreaks - 1,3

439. Teillon, H.B.; Burns, B.S.; Kelley, R.S. 1984. **Forest insect and disease conditions in Vermont: Calendar year 1983.** Vermont Agency of Environ. Cons., Dep. For., Parks and Recreation, Montpelier, Vt. pp. 3-6

Forest tent caterpillar populations completely collapsed, from a peak of 322 605 acres in 1982 to only 180 acres of moderate defoliation in Orleans County aerially visible in 1983. Unpublished data indicated that damaged trees in an area harvested just before or during the early years of an outbreak benefitted from increased light and nutrient availability.

Outbreaks - 1,3

440. Thomas, J.B. 1978. **A review of the economic impact of insects on the genus *Populus* in Ontario.** Can. For. Serv., Gt. Lakes For. Cent., Rep. O-X-271. 45 p.

"Information in the literature on the impact of insects on species of *Populus* was reviewed. Several hundred species of insects feed on various parts of the trees but only a few are known to cause severe damage by defoliation. The major defoliators in Ontario are the forest tent caterpillar, *Malacosoma disstria* Hbn., the large aspen tortrix, *Choristoneura conflictana* (Wlk.), and a leaf tier,

Enargia decolor Wlk. Reduced increment from defoliation by these species alone or in combination has been shown, but the evidence for mortality resulting from defoliation is inconclusive ..."

Outbreaks - 1,3

441. Thomas, J.B.; Rose, A.H. 1979. **Report 21: Insect damage to hybrid poplar plantings (*Malacosoma disstria, Choristoneura conflictana*).** 6 pp. *in* D.C.F. Fayle, L. Zsuffa, and H.W. Anderson (eds.). Poplar Research, Management and Utilization in Canada. Proc. N.A. Poplar Council Annu. Meet., Brockville, Ont. Sept. 6-9, 1977. Ont. Min. Nat. Res., For. Res. Inf. Pap. 102.

"Increment loss and mortality to trembling aspen by the major defoliator, the forest tent caterpillar, is discussed briefly to illustrate the difference between acceptable losses in natural stands under long rotations and unacceptable losses in hybrid poplar plantations on short rotations. Insects on hybrid poplars are not too well known in Canada, but species recovered in nurseries are discussed as well as the potential damage from insects common on the native aspens. Intensified surveys of hybrid poplar plantations are recommended as a first step in protecting this high-yield crop."

Outbreaks - 3

442. Thomson, H.M. 1959**. A microsporidian parasite of the forest tent caterpillar, *Malacosoma disstria* Hbn.** Can. J. Zool. 37(3): 217-221.

"The life cycle of a microsporidian parasite of the forest tent caterpillar is described. The microsporidian attacks primarily the silk glands and the mid-gut epithelium but other tissues are also infected. Observations are made on the ejection of the polar filament. It is apparent that the microsporidian is a new species and the name *Perezia disstriae* n. sp. is proposed."

Biology - 3

443. Tilman, D. 1978. **Cherries, ants and tent caterpillars: timing of nectar production in relation to susceptibility of caterpillars to ant predation.** Ecology. 59(4): 686-692.

"The North American black cherry, *Prunus serotina* Ehrh., has extrafloral nectaries which are most active during the first 3 wk after budbreak. These nectaries attract large numbers of the ant *Formica obscuripes* Forel, especially to trees within ≈20 m of an ant colony. The average number of ant visits per bud is highest just after budbreak, decreasing as the number of active extrafloral nectaries decreases. These ants are predacious on many species of insects found on *P. serotina*, including the eastern tent caterpillar, *Malacosoma americanum* Fabricius, the major defoliator of black cherry. *Formica obscuripes* is only able to prey upon *M. americanum* within ≈3 wk of budbreak, after which time, tent caterpillar larvae are large enough that most escape ant predation. Tent caterpillar survivorship was found to be positively related to distance from colonies of *F. obscuripes*. It is suggested that the ant-cherry relationship is a facultative mutualism and that nectar production is timed so as to maximize the chance of successful ant predation on tent-caterpillar colonies." Predation of *M. disstria* by ants has also been observed.

Biology - 2

444. Titus, F.A.; Meikle, O.A.; Harrison, K.J. 1985. **Scientific and common names of insects and mites of interest in the Maritime provinces.** Environ. Can., Can. For. Serv., Maritimes For. Res. Cent., Inf. Rep. M-X-155. 130 p.

An alphabetical listing, by scientific name, of forest insects and some agricultural and household species found in the Maritimes. Additional information includes a species code, taxonomical disposition (order, family), common name, importance rating, host(s) and, for some, the larval feeding period and overwintering stage.

General Background

445. Tomlinson, J.W.E., Jr. 1938. **Fluctuation in tent caterpillar abundance and some of the factors influencing it.** M.Sc. thesis. Mass. State College, Amherst, Mass. [later Univ. Mass., Amherst]. 43 p. + 7 figs.

"Both the eastern and forest tent caterpillars have cycles of abundance in the Northeast that occur at quite regular intervals. Peaks and hollows in abundance coincide quite closely in both species. The total parasitism and predatism for all stages is inadequate to explain this phenomenon as far as can be ascertained from the literature, in spite of numerous statements to the contrary. Cycles of abundance are not dependent upon precipitation at any season. They are dependent, however, upon temperatures after hatching in the spring months. Cold temperatures after hatching are more important limiting factors than parasitism and predators."

Biology - 2,4; Outbreaks - 5

446. Tothill, J.D. 1920. **Insect outbreaks and their causes.** Annu. Rep. Entomol. Soc. Ont. 1919 [later Proc. Entomol. Soc. Ont.]. 50(0): 31-33.

This paper reviews the definition of an outbreak and attributes species outbreaks to the relaxing of one or more of the environmental pressures which hold each species in equilibrium. This is illustrated using examples of past insect pest outbreaks. It was concluded that civilization is directly responsible for many of our notorious outbreaks. In the cases of the forest tent caterpillar and the spruce budworm, civilization has had the effect of removing one of the most powerful of the restraining bonds, namely, the absence of food.

Outbreaks - 5

447. Tothill, J.D. 1922. **Notes on the outbreaks of spruce budworm, forest tent caterpillar and larch sawfly in New Brunswick.** Proc. Acadian Entomol. Soc. 8(0): 172-182.

Changes wrought in the forests during the 1800s resulted in the checks operating against the spruce budworm, forest tent caterpillar and larch sawfly, often becoming inadequate in controlling their

respective insects. This paper contains suggestions that are aimed at re-establishing the ecological balance in the forests so that the natural control agents will be able to re-assert themselves and prevent serious outbreaks defoliating pests.

Biology - 2; Outbreaks - 5

448. Tremblay, G.B.; Sohi, S.S.; Retnakaran, A.; MacKenzie, R.E. 1995. **NAD-dependent methylenetetrahydrofolate dehydrogenase-methenyltetrahydrofolate cyclohydrolase is targeted to the cytoplasm in insect cell lines.** FEBS Lett. 368(1): 177-182.

"Cytosolic NADP-dependent methylenetetrahydrofolate dehydrogenase-cyclohydrolase synthetase and the mitochondiral NAD-dependent methylenetetrahydrofolate dehydrogenase-cyclohydrolase (NMDMC) are differently expressed during insect development although both enzymes are detectable at all stages. In contrast, cell lines derived from a variety of insect species [including *Malacosoma disstria*] express high levels of NMDMC but undetectable levels of the NADP-dependent enzyme. Northern analysis indicates the NMDMC message is expressed at levels 50-100 times higher in a *Drosophila* cell line compared to adult flies. RNase protection showed the predominance of shortened transcripts that require initiation at a downstream AUG producing a truncated protein that lacks a mitochondrial targeting sequence. These changes in expression effectively exchange the cytosolic NADP-dependent dehydrogenase for one with NAD specificity."

Biology - 7

449. Tsang, K.R.; Brooks, M.A.; Kurtti, T.J. 1982. **Culture conditions regulating the infection of cells by an intracellular microorganism.** Pages 125-157 *in* K. Maramorosch and J. Mitsuhashi (eds.). Invertebrate cell culture applications. Academic Press, New York, N.Y.

Two cell lines, one derived from *Malacosoma disstria* hemocytes, the other from the German cockroach, *Blatella germanica*, were used to study cross-infectivity of the microsporidian *Nosema disstriae*. The cockroach cells that had adapted to the medium favorable for rearing the moth cells became infected *in vitro* with the microsporidan when it was introduced from the moth cells. In addition, "Low osmotic pressure and high potassium ion concentration were the important regulatory factors in crossing host specificity barriers."

Biology - 3

450. Tunnock, S.; Hard, J.; Karch, T. 1979. **Potential deforestation [of *Populus tremuloides*] by the forest tent caterpillar [*Malacosoma disstria*] in the Turtle Mountains, North Dakota during 1979.** U.S. Dep. Agric. For. Serv., North. Region, Missoula, Mont., State and Private For. Rep. No. 78-19. 9 p.

"The forest tent caterpillar, *Malacosoma disstria* Hbn., began defoliating trembling aspen stands, *Populus tremuloides* Michx., in 1976 in the Turtle Mountains of North Dakota. Heavy defoliation was scattered through about 150,000 acres in 1978. Pupal mortality from parasites and disease was almost 100 percent in cocoons on understory shrubs and trees during July. However, biological evaluation in October showed egg masses present in tree crowns in 42 of 63 plots sampled throughout the infested area. Egg viability was high and averaged 91 percent. An average of 3 percent of the eggs were parasitized. Moderate defoliation is predicted for 1979 on 9 plots and light

defoliation on the other 33 plots. We predict defoliation in 1979 will be spotty and light throughout the aspen stands of the Turtle Mountains, but several spots of moderate defoliation are expected around Lake Metigoshe and east of Carpenter Lake."

Biology - 2; Outbreaks - 3,4a

451. Turnock, W.J. 1961. **Variability of parasitism and other pupal mortality of the forest tent caterpillar in relation to the cocooning site.** Dep. For. Can., For. Entomol. Pathol. Br., Bi-mon. Progr. Rep. 7(2): 2.

Studies of factors affecting mortality the cocoon stage of *Malacosoma disstria* were begun in 1960 in a mixed aspen / balsam-fir stand in Manitoba. Collections of cocoons were made from various levels in the different vegetation types occurring in an area of ca. 1/3 acre. Total parasitization varied from 24.7% in cocoons from understory ground vegetation to 8.3% in small (3-8 ft.) and 11.8% in larger (10-30 ft.) balsam fir.

Biology - 2; Outbreaks - 4c

452. Turnock, W.J.; Prentice, R. 1961. **Forest insect survey.** Dep. For. Can., For. Entomol. Pathol. Br., Bi-mon. Progr. Rep. 6(5): 3.

"The forest tent caterpillar, *Malacosoma disstria* Hbn., was widely distributed throughout Manitoba and was also present in the Meadow Lake District of Saskatchewan. This insect caused no serious defoliation this year."

Outbreaks - 1,3

453. Turnquist, R. 1987. **Maps of major forest insect infestations- Prince George Forest Region 1944 - 1986**. Can. For. Serv., Pac. For. Cent., Victoria, B.C. FIDS Rep. 87-11. pp. 30-34.

This report compliments the earlier published History of Population Fluctuations and Infestations of important forest insects in the Prince George Forest Region, as its boundaries exist today. The maps are based on aerially, and in some cases, ground visible damage as recorded in the Forest Insect and Disease Survey annual reports. Damage was not apparent or not recorded in those years not represented by a map. Area of infestation and number of trees are not available for some of the pre-1970 outbreaks and are noted as not being recorded. Note: maps of *Malacosoma disstria* infestations are provided.

Outbreaks - 1

454. Twinn, C.R. 1942. **A summary of the more important crop pests in Canada in 1941.** Annu. Rep. Entomol. Soc. Ont. [later Proc. Entomol. Soc. Ont.]. 72(0): 47-56.

"An extensive outbreak of the forest tent caterpillar occurred in northern Ontario, from Island Falls west to beyond Hearst, north to Smoky Falls and as far south as Missinaibi in northern Algoma. The species was somewhat less prevalent in the Prairie Provinces than in 1940, but severe infestations

occurred in a number of localities. The main area of the Western outbreak was in the Yorkton district of Saskatchewan, extending east to the Riding Mountain and Duck Mountain, Man. In eastern British Columbia, there was an extensive outbreak in the Cariboo district and several thousands of square miles of poplar and willow forest were reported to have been defoliated."

(Entire reference pertaining to *M. disstria* included in annotation.)

Outbreaks - 1

455. Tyrrell, D. 1977. **Transmission of *Entomophthora egressa* MacLeod and Tyrrell to *Malacosoma disstria* (Hbn.), a non-host species.** Can. For. Serv., Bi-mon. Res. Notes 33(1): 5.

Laboratory-reared *M. disstria* larvae were injected with protoplasts of *E. egressa* and were placed in open containers fastened to poplar trees. Samples of *M. disstria* from the trees showed the presence of the fungus in the population after the date that 100% mortality had occurred in artificially-infected insects in closed containers on trees in the same area. This indicates that the fungus was successfully transmitted to the natural population. However, although the fungus produced conidia on infected insects in the laboratory, the disease failed to maintain itself in the field population.

Biology - 3

456. Tyrrell, D. 1990. **Pathogenesis of *Entomophaga aulicae*. I. Disease symptoms and effect of infection on weight gain of infected *Choristoneura fumiferana* and *Malacosoma disstria* larvae.** J. Invertebr. Pathol. 56(2): 150-156.

"Larvae of the eastern spruce budworm, *Choristoneura fumiferana*, and the forest tent caterpillar, *Malacosoma disstria*, infected with strains of *Entomophaga* [*Entomophthora*] *aulicae* gained weight at the same rate as uninfected control larvae and larvae injected with sterile culture filtrates in which *E. aulicae* had been grown, until the day prior to their death. At this time, infected insects lost weight and exhibited a marked reduction in frass production. No evidence for toxic substances was found in culture filtrates of *E. aulicae* grown under a variety of environmental conditions nor in homogenates of near or freshly dead *E. aulicae*-infected budworm larvae. External symptoms of fungal infection on spruce budworm larvae, which first became evident about 4 hr prior to death of the larvae, are described."

Biology - 3

457. Tyrrell, D.; Ben-Ze'ev, I.S. 1990. **An emended description of *Furia crustosa* (Entomophthorales: Entomophthoraceae).** Mycotaxon 37(0): 211-215.

"Secondary conidia, cystidia and rhizoids of *Furia crustosa* (MacLeod & Tyrell) Humber are described. The morphology of the cystidia and rhizoids supports the assignment of this species to the genus *Furia* (Batko) Humber. An emended description of *F. crustosa* is given." Note: The *F. crustosa* used for this determination was isolated from infected *Malacosoma disstria* Hübner larvae.

Biology - 3

458. United States Department of Agriculture 1961-1986. **Forest insect and disease conditions in the United States.** For. Serv., Washington, D.C.

This publication contains reports of pest conditions in the United States of America. By various authors over the years, the reports give information on occurrences of major forest insects and the location and extent of outbreaks. References to the forest tent caterpillar occur in the following years and pages.

year	page	region	author
1961	20	Intermountain States	Washburn, R.I.
	33	Southern States	Wootten, J.F.
	35	Northeastern States	Freeman, W.L., Jr
1962	21	Lake and Central States	Adams, S.D.; Moore, L.H.
	24	Southern States	Wotten, J.F.
	26	Northeastern States	Bean, J.L.
1963			
1964			
1965	32	Lake and Central States	Vandenberg, D.O.
	36	South Region and Southeastern Area	Buchanan, W.D.
	39	Northeastern States	Bean, J.L.
1966	35	South Region and Southeastern Area	Landgraf, A.E., Jr
	37	Northeastern States	Bean, J.L.; McCowan V.F.
1967			
1968	17	Intermountain States	Klein, W.H.; Knopf, J.A.E.
	30	South Region and Southeastern Area	Downing, G.L.; Ciesla, W.M.; Rauschenberger, J.L.
	32	Northeastern States	Doerner, R.G.
1969	29	South Region and Southeastern Area	Downing, G.L.; Ward, J.D.; Ciesla, W.M.
	34	Northeastern States	Ford, R.P.
1970			
1971	28	Northern Rocky Mountains	Ciesla, W.M.; Bousfield, W.E.; Dewey, J.E.; Williams, R.E.; Carlson, C.E.; Dooling, O.J.
	48	South Region and Southeastern Area	Rauschenberger, J.L.; Overgaard, N.A.; Phelps, W.R.; Cordell, C.E.; Pawuk, W.H.
	57	Northeastern Region	Hanson, J.B.; Lautz, W.
1972	49	South Region and Southeastern Area	Forest Pest Management Staff
	61	Northeastern Region	Hastings; A.R.; O'Brien, J.T.
1973	25	Northern Rocky Mountains	McGregor, M.D.; Williams, R.E.
	40	South Region and Southeastern Area	Forest Pest Management Staff
	49	Northeastern Region	Doerner, R.G.
1974	25	Northern Rocky Mountains	McGregor, M.D.; Williams, R.E.; Carlson, C.E.; Dooling, O.J.; Hamel, D.P.
	42	South Region and Southeastern Area	Forest Pest Management Staff
1975	29	Northern Rocky Mountains	Turnock , S.; Dooling, O.J.
	42	South Region and Southeastern Area	Forest Pest Management Staff
	50	Northeastern Region	Hanson, J.B.; Hoffard, W.H.; Orr, P.W.
1976	25	South Region and Southeastern Area	Rogers, T.
	30	East Region and Northeastern Area	Hanson, J.B.
1977	17	Rocky Mountain Region	Johnson, D.W.; Creasap, V.L.M.
	51	Pacific Northwest Region	Gregg, T.F.; Goheen, D.J.; Bridgewater, D.R.
	58	East Region and Northeastern Area	Allison, J.R.

year	page	region	author
1978	6	North Region	Dewey, J.E.; Carlson, C.E.
	45	South Region	Anderson, R.L.; Barry, P.J.
	57	East Region and Northeastern Area	Snowden, P.; O'Brien, J.T.
1979	6	North Region	Dooling, O.J.
	47	South Region and Southeastern Area	Minstretta, P.A.; Anderson, R.L; Hoffard, W.H.
	60	East Region and Northeastern Area	Robbins, K.
1980	2	North Region	
	21	East Region and Northeastern Area	
1981	4	North Region	
	15	Intermountain Region	
	28	South Region and Southeastern Area	
	33	East Region and Northeastern Area	
1982	30	South Region	
	35	East Region and Northeastern Area	
1983	12	Rocky Mountain Region	
	43	South Region	
	51	East Region and Northeastern Area	
1984	23	Rocky Mountain Region	
	61	South Region	
	72	East Region and Northeastern Area	
1985	13	North Region	
	60	South Region	
	72	East Region and Northeastern Area	
1986	15	North Region	
	58	South Region	
	71	East Region and Northeastern Area	

Outbreaks - 1,3

459. Valero, J.R.; Letarte, R. 1989. **Diagnostic biochimique de la présence d'une intoxication par *Bacillus thuringiensis* sérotype "H3a,3b" chez deux lépidoptères. [Biochemical diagnosis of the presence of intoxication by *Bacillus thuringiensis* serotype 'H3a,3b' in two Lepidoptera.]** Can. J. Microbiol. 35(4): 444-449.

"A detailed biochemical analysis has shown that during larval development on artificial medium, the amounts of K^+, Na^+ and Ca^{2+} in the hemolymph of healthy *Choristoneura fumiferana* varied from 85 to 110 mg/100 ml, 29 to 33 mg/100 ml, and 4.8 to 7.3 mg/100 ml, respectively. Similar results were obtained with *Malacosoma disstria*. Intoxication by *Bacillus thuringiensis* "H3a,3b" (*B.t.*) considerably modified the amounts of the cations. Thus, after 4 h, the quantity of K^+ ions in *M. disstria* had increased from 99 to 229 mg/100 ml and Na^+ from 26.5 to 50.3 mg/100 ml, while that of Ca^{2+} had decreased from 5.8 to 1.2 mg/100 ml. Similar results were obtained for *C. fumiferana*, but these variations occurred after 2-4 days of *B.t.* intoxication. The variations detected during the bacillosis, with respect to the cationic composition of the insect hemolymph, are rapidly detectable, well before light microscope observation can confirm the presence of this intoxication. Aspartate aminotransferase, alanine aminotransferase, α-hydroxybutyrate dehydrogenase, and isocitrate dehydroganase activity fluctuated very slightly in the hemolymph of either healthy or bacillosed

larvae of the two insects under study. These results suggest that it is possible to diagnose biochemically the presence of a *B.t.* intoxication in lepidopteran forest pests following treatments by this biological insecticide for their control."

(Article in French with English abstract.)

Biology - 3

460. van Frankenhuyzen, K.; Gringorten, J.L.; Gauthier, D.; Milne, R.E.; Masson, L .; Peferoen, M. 1993. **Toxicity of activated CryI proteins from *Bacillus thuringiensis* to six forest Lepidoptera and *Bombyx mori*.** J. Invertebr. Pathol. 62(3): 295-301.

"The insecticidal activity of the CryIB, CryIC, CryID and CryIE δ-endotoxin proteins from *Bacillus thuringiensis* was investigated in force-feeding experiments with larvae of *Choristoneura fumiferana, Orgyia leucostigma, Lymantria dispar, Malacosoma disstria, Lambdina fiscellaria fiscellaria, Actebia* [*Ochropleura*] *fennica*, and *Bombyx mori*. The toxins were prepared by proteolytic activation of the protoxins expressed in *Escherichia coli* and quantified by scanning densitometry after separation on sodium dodecyl sulfate-polyacrylamide gels. All toxins retained full insecticidal activity during 7 months of refrigerator storage at pH 10.5. The most sensitive response was recorded by *B. mori*, the only species that exhibited sufficient mortality at generally <10 ng of toxin per larva to permit estimation of lethal dose (LD_{50}) requirements. In all forest insect species, low and variable mortality necessitated the use of a feeding inhibition response (frass failure dose, FFD_{50}). *C. fumiferana* and *M. disstria* were susceptible to all four toxins. *O. leucostigma* and *L. dispar* were not susceptible to CryIB and CryIE. *L. fiscellaria* and *B. mori* showed no response to CryIB but were highly susceptible to CryIE. None of the toxins elicited a response in *A. fennica*. Activity of the toxins was compared to previously published activity of the CryIA toxins by calculating potencies relative to the activated toxin mixture derived from native HD-1 crystals. The four proteins were in most cases less active than the individual CryIA proteins and were at best equally but usually less active than the HD-1 toxin mixture. A notable exception was CryID, which was about as potent as the most potent CryIA toxin against *M. disstria* and *B. mori*. Published bioassay data for seven CryI proteins against 16 target insects are summarized."

Biology - 3

461. van Frankenhuyzen, K.; Gringorten, J.L.; Milne, R.E.; Gauthier, D.; Pusztai, M.; Brousseau, R.; Masson, L. 1991. **Specificity of activated CryIA proteins from *Bacillus thuringiensis* subsp. *kurstaki* HD-1 for defoliating forest Lepidoptera.** App. Environ. Microbiol. 57(6): 1650-1655.

"The insecticidal activity of the CryIA(a), CryIA(b) and CryIA(c) toxins from *Bacillus thuringiensis* subsp. *kurstaki* HD-1 was determined in force-feeding experiments with larvae of *Choristoneura fumiferana, C. occidentalis , C. pinus, Lymantria dispar, Orgyia leucostigma, Malacosoma disstria* and *Actebia fennica*. The toxins were obtained from cloned protoxin genes expressed in *Escherichia coli*. The protoxins were activated with gut juice from *Bombyx mori* larvae. Biological activity of the individual gene products as well as the native HD-1 toxin was assessed as the dose which prevented 50% of the insects from producing frass within 3 days (frass failure dose (FFD_{50})). The three toxins were about equally effective against *M. disstria*. In the Choristoneura species, CryIA(a) and CryIA(b) were up to fivefold more toxic than CryIA(c) to the lymantriid species, CryIA(a) and CryIA(b) were up to 100-fold more toxic than CryIA(c). The toxicity of HD-1 was similar to that of the individual CryIA(a) or CryIA(b) toxins in all these species. None of the CryIA toxins or HD-1 exhibited any

toxicity towards *A. fennica.* Comparison of the observed FFD_{50} of HD-1 with the FFD_{50} expected on the basis of its crystal composition suggested a possible synergistic effect of the toxins in the two lymantriid species [*L. dispar* and *O. leucostigma*]. Our results further illustrate the diversity of activity spectra of these highly related proteins and provide a data base for studies with forest insects to elucidate the molecular basis of toxin specificity."

Biology - 3; Control - 3

462. Varley, G.C.; Gradwell, G.R.; Hassell, M.P. 1974. **Insect population ecology: an analytical approach.** Blackwell Scientific Publications, London, U.K. pp. 140-142, 150.

This book uses *Malacosoma disstria* as an example of a pest species that has cyclical outbreaks. It is suggested that the factor driving the cyclical nature of the outbreaks is caused by the amount of parasitism by *Sarcophaga aldrichi*, but no conclusive information is available to prove this.

Outbreaks - 5

463. Vig, O.P.; Sharma, M.L.; Kapur, J.; Thapar, S.; Gupta, R. 1990. **Stereoselective synthesis of Z,E conjugated dienes: application to the synthesis of insect sex pheromones.** Indian J. Chem. Sect. B. Org. Chem. Incl. Med. Chem. 29(7): 606-610.

Stereoselective synthesis of insect pheromone components 1-5, possessing Z,E conjugated diene system has been developed using 1.3-enynes (generated by the *in situ* alkylation of dianion of prop-2-yn-ol followed by Horner-Wittig reaction) as precursors.

Biology - 5; Control - 5

464. Volney, W.J.A. 1988. **Insects and diseases of the mixedwood forest: Problems or opportunities?** Pages 99-109 *in* J.K. Samoil (ed.). Management and utilization of northern mixed woods. For. Can., North. For. Res. Cent., Info. Rep. NOR-X-296.

It is suggested that, depending on the goal of the forest manager, what is classified as a pest species may actually perform a beneficial function in the management of forests. If the forest manager is not looking for wood production from aspen, it is suggested that repeated outbreaks of forest tent caterpillar might serve as a method for thinning aspen stands, opening the canopy for the coniferous understory.

Outbreaks - 3

465. Wagner, D.L.; Peacock, J.W.; Carter, J.L.; Talley, S.E. 1996. **Field assessment of *Bacillus thuringiensis* on nontarget Lepidoptera.** Environ. Entomol. 25(6): 1444-1454.

"Nontarget effects of a single aerial application of *Bacillus thuringiensis* at 90 BIU / ha were studied on native Lepidoptera in west central Virginia in 1992 (treatment year) and in 1993 and 1994 (recovery years). Overall caterpillar abundance was lower on foliage collections from sprayed plots, but differences were modest and mostly not significant. Nineteen of 20 common species from foliage

decreased in relative abundance following the application of *B. thuringiensis*, although we could not demonstrate a significant treatment effect for any 1 of the 10. Greatest impacts were seen in the macrolepidoptera fauna beneath burlap bands. Eleven of the 12 more frequently encountered species were significantly less common on treatment plots in 1992. Taken collectively, 4 of our species [*Phoberia atomaris* Hübner and *Orthosia rubescens* (Walker) (both Noctuidae), *Malacosoma disstria* Hübner (Lasiocampidae) and *Satyrium calanus* (Hübner) (Lycaenidae)] were recovered 10 times more often from our control plots following the application of *B. thuringiensis*. Caterpillar numbers rebounded in the 1st post-spray year (1993), with only *M. disstria* and *P. atomaris* remaining significantly less common on treatment plots; reduced abundance of the latter continued through our 2nd post-year samples."

Control - 3

466. Wallner, W.E. 1971. **Suppression of four hardwood defoliators by helicopter application of concentrate and dilute chemical and biological sprays.** J. Econ. Entomol. 64(6): 1487-1490.

A single application of dilute or concentrated trichlorfon or dilute carbaryl greatly reduced populations of second-stage *Alsophila pometaria* and *Paleacrita vernata*, but carbaryl/oil concentrate was less effective. Carbaryl/oil concentrate greatly reduced populations *of Malacosoma disstria*, and dilute sprays of either carbaryl plus pinolene or *Bacillus thuringiensis* var. *thuringiensis* gave acceptable suppression of this pest, in spite of 1/4 in of rain 10 hours after application. Dilute and concentrated trichlorfon sprays were rather less effective against *M. disstria*. Populations of *Heterocampa guttavitta* were greatly reduced by carbaryl/oil and trichlorfon/oil concentrates. Dilute sprays of carbaryl or trichlorfon were less effective, and dilute sprays of *B.t.* var. *thuringiensis and B.t.* var. *kurstaki* gave inadequate reductions of larval numbers. Adults of the predatory beetles *Calosoma scrutator* and *C. calidum* were adversely affected by the dilute carbaryl spray, whereas other treatments, including carbaryl/oil concentrate, showed no effect. No treatment had any apparent effect upon a predatory erythraeid mite, *Leptus* sp., which attacks *H. guttavitta*.

Control - 2,3

467. Wellington, W.G. 1952. **Air-mass climatology of Ontario north of Lake Huron and Lake Superior before outbreaks of the spruce budworm, *Choristoneura fumiferana* (Clem.), and the forest tent caterpillar, *Malacosoma disstria* Hbn. (Lepidoptera: Tortricidae; Lasiocampidae).** Can. J. Zool. 30(2): 114-127.

"Previous work showed that ideal physical conditions for the development of the spruce budworm, *Choristoneura fumiferana* (Clem.), occur when the weather is relatively dry and clear. These conditions have tended to occur in summers when the annual number of cyclonic centres passing over the area was declining, and have preceded past outbreaks. On the other hand the physical requirements of the forest tent caterpillar, *Malacosoma disstria* (Hbn.), include warm, humid, cloudy weather during much of the larval stage, and outbreaks of this species in Ontario have begun after an increase in the annual number of cyclonic passages. While the annual number of cyclonic passes is declining in periods before spruce budworm outbreaks in northern Ontario, the number of these passages in the summer months falls below average. Furthermore, the majority of the centers that do pass in these months contain air masses of polar continental or maritime origin. The more humid southwestern air masses are usually barred from the area by a southward shift of the whole circulation pattern. This situation is reversed in periods before *M. disstria* outbreaks. While the annual number of passages is increasing, the number occurring in the summer months is above average, as is the proportion of southwestern air masses occurring in these months. Northern and

western air masses are usually active farther north, owing to a northward shift of the whole circulation pattern."

Biology - 4

468. Wellington, W.G. 1954a. **Atmospheric circulation processes and insect ecology.** Can. Entomol. 86(7): 312-233.

This article describes briefly the more important types of air mass affecting weather and climate in North America, with an example of how some principles of air-mass climatology may be used in investigating variations in insect mortality. An account is also presented of methods of studying climatic variations that show the part played by atmospheric circulation processes. An example illustrates the association between forest tent caterpillar outbreaks and increasingly frequent invasions of an area by southern and southwestern cyclonic centres. Indirect as well as direct effects of climate on population densities must be considered, and climate must be studied before, rather than during outbreaks. It is considered unwise to attempt direct correlations between population changes and variations in sunspots or ultraviolet radiation, when due regard for the effects of atmospheric circulation processes can often produce more trustworthy results. From author's summary.

Biology - 4

469. Wellington, W.G. 1954b. **Weather and climate in forest entomology.** Meteorol. Monogr. 2(8): 11-18.

"Some basic references to the general field of insects and climate are provided, and some of the more recent research trends indicated. However, to avoid compressed, confusing descriptions of the diversity in habits and requirements found among insects, the reactions of only two dissimilar species are described in detail, to show how field and laboratory observations lead to climatological investigations. The two species, the spruce budworm, *Choristoneura fumiferana* (Clem.), and the forest tent caterpillar, *Malacosoma disstria* Hbn., are both native to North America. Although active during the same part of the year, they have different physical requirements. For example, although both are adversely affected by prolonged rain, the tent caterpillar develops better during moderately warm, humid, partly cloudy weather, whereas the spruce budworm develops best in dry, sunny weather. Hence, in areas where both occur, their outbreaks begin during different years that, in each case, are preceded by a few years during which the specific favourable weather recurs. Before spruce budworm outbreaks, the area is influenced most by northern and western air, whereas, before tent caterpillar outbreaks, it is influenced more by southern and southwestern air. In general, tent caterpillar outbreaks tend to begin in suitable parts of the Boreal Forest two to four years after the continental complex of storm tracks has shifted northward, or after a marked increase in cyclonic activity. On the other hand, spruce budworm outbreaks tend to occur after southwards shifts of the tracks, or after decreased cyclonic activity. Several fields for further research are suggested, including a study designed to show effects of short-term climatic fluctuations on population trends of groups of insects occupying similar and dissimilar types of microhabitats on a single tree species."

Biology - 4

470. Wellington, W.G.; Fettes, J.J.; Turner, K.B.; Belyea, R.M. 1950. **Physical and biological indicators of the development of outbreaks of the spruce budworm, *Choristoneura fumiferana* (Clem.) (Lepidoptera: Tortricidae)**. Can. J. Res. Sect. D Zool. Sci. 28(6): 308-331.

"Biological and meteorological records were examined for periods when outbreaks of the spruce budworm, *Choristoneura fumiferana* (Clem.), were known to have occurred in northeastern North America. The survey showed that the following significant events occurred during the periods of three to four years preceding an outbreak. Decreasing annual numbers of low pressure centres passed over the area in which the outbreak later occurred. Therefore, the outbreak began at a time of decreased or minimal storminess. Drought occurred, chiefly in June and July, but also occasionally in spring and autumn. Annual increments of host trees on dry sites declined. Outbreaks of the forest tent caterpillar, *Malacosoma disstria* Hbn., occurred, particularly in Ontario. These events, in aggregate, occurred so consistently before spruce budworm outbreaks that they have a future predictive value. In addition, they reinforce some suggestions made by earlier authors and suggest modifications of hypotheses concerning the behavior of developing populations of spruce budworm."

Outbreaks - 3

471. Wellington, W.G.; Sullivan, C.R.; Green, G.W. 1951**. Polarized light and body temperature level as orientation factors in the light reactions of some hymenopterous and lepidopterous larvae.** Can. J. Zool. 29(6): 339-351.

Larvae of *Neodiprion banksianae, Malacosoma disstria,* and *Choristoneura fumiferana* were used to demonstrate the effects of heat and plane-polarized light upon the photic orientation of immature insects.

Biology - 1,4

472. Welton, M.A.; Tyrrell, D. 1975. **A note on the isolation of *Entomophthora* species on artificial media.** J. Invertebr. Pathol. 26(3): 405.

"Freshly dead fungus-killed insects are fastened to the center of a sterile 100mm Petri dish lid with sterile lanolin or petroleum jelly. Humidity in the dish is maintained at a high level... The dish is maintained in the light at room temperature until the fungus produces conidia, which are forcibly discharged from the conidiophores. The conidia are collected for short periods of time, 5-10 min, in tissue culture medium contained in a small (60mm) diameter petri dish which is placed beneath the conidia-producing cadaver in the larger dish. The medium is then transferred to a standard tissue culture flask and incubated as preferred. ... no surface sterilization or other special preparation techniques for the dead insects are necessary... cultures of *E. phytonomi* from the alfalfa weevil and a species of *Entomophthora* from the forest tent caterpillar ... " were isolated.

Biology - 3

473. Wetzel, B.W.; Kulman, H.M.; Witter, J.A. 1973. **Effects of cold temperatures on hatching of the forest tent caterpillar, *Malacosoma disstria* (Lepidoptera: Lasiocampidae).** Can. Entomol. 105(8): 1145-1149.

"Egg-masses of the forest tent caterpillar, *Malacosoma disstria* Hübner, were collected from new and old infestation areas of northern Minnesota before development started in the spring. Mortality of embryos was recorded after laboratory exposure to -10°, -15°, -20° or -30°C for 12, 24 or 72 h, 1, 2, 3 or 4 days before anticipated hatch. Length of treatment and temperatures of -10° and -15°C had minimal effect on survival. Mortality of embryos varied with days before hatch in an erratic cyclic pattern with temperatures and years. Temperature treatments of -20°, -25°, and -30°C caused about 50%, 66%, and 100% embryo mortality [respectively]. Mortality in new infestation areas was consistently higher than in older areas for all treatments."

Biology - 4

474. Williams, D.J.M.; Parry, D.; Langor, D.W. 1996**. Sampling and identification of the forest tent caterpillar parasitoids in the prairie provinces.** Can. For. Serv., North. For. Res. Cent., Inf. Rep. NOR-X-345. 27 p.

"Methods for sampling, collecting, and rearing parasitoids of eggs, larvae, and pupae of the forest tent caterpillar, *Malacosoma disstria* Hübner, in the prairie provinces are discussed. Illustrated keys are provided for the identification of 42 Diptera and Hymenoptera species, which are parasitoids, hyperparasitoids, and scavengers associated with the forest tent caterpillar. Twenty-nine of these species are known to associate with forest tent caterpillar in this region, and another 15 occur in adjacent regions and are likely to occur there as well. A brief discussion is given of the biology, abundance, and probable role of each species identified. A glossary is included."

Biology - 2; Outbreaks - 4abc

475. Wilson, G.G. 1977. **Effects of the microsporidia *Nosema disstriae* and *Pleistophora schubergi* on the survival of the forest tent caterpillar, *Malacosoma disstria* (Lepidoptera: Lasiocampidae).** Can. Entomol. 109(7): 1021-1022.

The microsporidian *Pleistophora schubergi*, originally found in field-collected spruce budworm, infected laboratory cultures of forest tent caterpillar, *Malacosoma disstria*. This prompted an investigation comparing the effects of *P. schubergi* on *M. disstria* development to the effects of *Nosema disstriae*, a natural pathogen of *M. disstria*. The spores were fed to the *M. disstria* larval subjects at various concentrations. Results showed that at all concentrations tested, *N. disstriae* and *P. schubergi* had "serious detrimental effects" on *M. disstria* survival. The author speculates that higher concentration would have resulted in earlier mortality of treated larvae. The larvae that did survive to pupation were either cocoonless (if treated *with N. disstriae*) or cocoonless and malformed (if treated with *P. schubergi*). *Pleistophora*-infected larvae fed less, were smaller and less active than control larvae. Because of these results, the author felt that both *N. disstriae* and *P. schubergi* might be suitable for *M. disstria* control.

Biology - 3; Control - 6

476. Wilson, G.G. 1979. **Effects of *Nosema disstriae* (Microsporida) on the forest tent caterpillar, *Malacosoma disstria* (Lepidoptera: Lasiocampidae).** Proc. Entomol. Soc. Ont. 110(0): 97-99.

"Spores of the microsporidium *Nosema disstriae* were fed to larvae of the forest tent caterpillar, *Malacosoma disstria* Hübner. The microsporidian adversely affected pupal weights, adult fecundity and longevity."

Biology - 3

477. Wilson, G.G. 1980. **Persistence of microsporidia in populations of the spruce budworm and forest tent caterpillar.** Can. For. Serv., For. Pest Manage. Inst., Rep. FPM-X-39. 6 p. + 3 tables.

"The microsporidian pathogens, *Nosema fumiferanae* and *Pleistophora schubergi* were tested against the spruce budworm (*Choristoneura fumiferana*) and a combination of *Nosema disstriae* and *P. schubergi* was similarly tested against the forest tent caterpillar, (*Malacosoma disstria*) during the years 1975 to 1977. A packsack-type mist blower was used to apply suspensions of microsporidian spores on individual white spruce, balsam fir and trembling aspen trees. Levels of *N. fumiferanae* were significantly higher in spruce budworm in the treated areas as compared to the checks. This higher level of infection persisted for about three years. Although infection by *P. schubergi* was higher than that of *N. fumiferanae*, there was no carry-over of *P. schubergi* to the next year. The application of mixtures of *P. schubergi* and *N. disstriae* significantly increased the levels of *P. schubergi* , but not *N. disstriae* in forest tent caterpillars. Here again there was no carry-over of *P. schubergi* ."

Biology - 3

478. Wilson, G.G. 1984. **Pathogenicity of *Nosema distriae, Pleistophora schubergi* and *Vairimorpha necatrix* (Microsporidia) to larvae of the forest tent caterpillar, *Malacosoma disstria*.** Z. Parasitenkd. [Parasitol. Res.] 70(6): 763-768.

"Instar larvae (3rd and 5th) of *M. disstria* are highly susceptible to infection by the microsporidian species *N. distriae*, *P. schubergi* and *V. necatrix*. More than 80% mortality occurred when 3rd-instar larvae received $5x10^4$ spores. The relative susceptibility of *M. disstria* to the 3 parasites is indicated by the number of spores needed to kill 50% of the treated 5th-instar larvae as follows: *V. necatrix*, $1.4x10^3$; *P. schubergi*, $2.3x10^4$ and *N. disstriae*, $2.3x10^5$ spores / larva. Days to death for *N. distriae* and *P. schubergi* generally decreased with increasing spore numbers; larger doses of *V. necatrix* caused much earlier death. [These results suggest that these protozoan species may be potential biological control agents.]."

Biology - 3

479. Wilson, G.G.; Kaupp, W.J. 1977. **Application of *Nosema disstriae* and *Pleistophora schubergi* (Microsporida) against the forest tent caterpillar in Ontario, 1977**. Can. For. Serv., For. Pest Manage. Inst., Rep. FPM-X-4. 9 p.

"A combination of two microsporidian parasites, *Nosema disstriae* (Thom.) and *Pleistophora schubergi* Zwölfer, were tested against the forest tent caterpillar, *Malacosoma disstria*, in Ontario during the summer of 1977. A packsack-type mist blower was used to apply suspensions of microsporidian

spores on individual trembling aspen (*Populus tremuloides* Michx.). An application rate of 1.8 x 10^{11} spores / tree consisting of mixtures of *P. schubergi* and *N. disstriae* significantly increased the incidence of *P. schubergi*, but *not N. disstriae*."

Biology - 3; Control - 6

480. Wilson, G.G.; Sohi, S.S. 1977. **Effect of temperature on healthy and microsporidia-infected continuous cultures of *Malacosoma disstria* hemocytes.** Can. J. Zool. 55(4): 713-717.

"The effects of constant temperatures on healthy and *Nosema disstriae* infected continuous cultures of *Malacosoma disstria* hemocytes were studied. Healthy cells grew best at 28°C, followed closely by those at 25 and 30°C. They grew very slowly at 20°C. Cell growth was good at 35°C for the first 4 days. If the medium was changed frequently cells could be kept at this temperature for a longer period without any adverse effect on their viability and growth. There were no significant differences in percentage infection and *Nosema* per cell in the infected cultures kept at 20, 25, 28, and 30°C. However percentage infection and *Nosema* per cell were greatly reduced after 1 week at 35°C, and eventually the microsporidia disappeared from the cultures kept at this temperature for 28 days. These observations support other reports to the effect that entomopathogenic microsporidia are unlikely to grow in warm-blooded vertebrates because of their high body temperature."

Biology - 3,7

481. Wilson, T. 1914. **The tent-caterpillar.** Proc. Entomol. Soc. B.C. 4(0): 36-38.

This paper contains a description of an outbreak of *Malacosoma disstria* in the Lower Fraser Valley from 1896 to 1912, and on Vancouver Island from 1908 to 1912.

Outbreaks - 1

482. Witter, J.A. 1971. **Bionomics of the forest tent caterpillar, *Malacosoma disstria* Hubner.** Ph.D. thesis. Univ. Minn., St. Paul, Minn. 99 p.

This thesis examined a method for estimating the number of eggs per egg mass, egg mortality factors and the use of life tables to identify important mortality factors affecting the forest tent caterpillar. The formula used for calculating the number of eggs per egg mass was N=pdln, where d=egg-mass diameter, l=egg-mass length and n=number of eggs per mm^2. This formula was found to have a correlation coefficient of 0.89 at P> 0.01. Egg parasitism and infertility were found to remain virtually the same throughout the 3 years they were studied. However, embyonic larval mortality was found to be very high (39%) in 1968, and only 9 and 3% in 1967 and 1969, respectively. The variation in embryonic larval mortality among egg masses collected the same year (either very low or very high) suggested that there may be a qualitative difference in the populations that were studied.

Biology - 2; Outbreaks - 4a,5

483. Witter, J.A. 1979a. **The forest tent caterpillar in Minnesota: a case history review.** School of Nat. Resour., Mich. Univ. 57th Annu. Conf. North Cent. States Entomol. Soc. Am. (1978) 33-44. [Abstract].

Studies carried out in Minnesota showed the following 4 factors acting alone or in combination to be the most important factors affecting the collapse of outbreaks of the forest pest *Malacosoma disstria* Hbn.: high pharate larval mortality due to low winter temperature; high early larval mortality due to harsh weather conditions during the first 3 weeks after hatch; high late larval mortality due to starvation; and a high rate of pupal parasitism by *Sarcophaga aldrichi* Parker.

Biology - 2,4

484. Witter, J.A. 1979b**. The forest tent caterpillar (Lepidoptera: Lasiocampidae) in Minnesota: a case history review.** Gt. Lakes Entomol. 12(4): 191-197.

"The research work conducted on the forest tent caterpillar during the last 40 years, with emphasis on Minnesota studies, is reviewed. The following areas are covered: range and hosts, life history, impact, Minnesota outbreaks, population dynamics, and pest management. The following four factors acting by themselves or in combination appear to be the most important factors affecting the collapse of forest tent caterpillar outbreaks: (1) high pharate larval mortality within the egg due to low winter temperatures, (2) high early larval mortality due to harsh weather conditions during the first three weeks after hatch, (3) high late larval mortality from starvation due to food depletion, and (4) high pupal parasitism by *Sarcophaga aldrichi*."

Biology - 1; Outbreaks - 1,3,5; Control - 6

485. Witter, J.A.; Kulman, H.M. 1969. **Estimating the number of eggs per egg mass of the forest tent caterpillar, *Malacosoma disstria* (Lepidoptera: Lasiocampidae).** Mich. Entomol. 2(3-4): 63-71.

"Calculation of the number of eggs per egg mass of the forest tent caterpillar, *Malacosoma disstria* Hübner, is required in survey and population studies. Eggs are usually laid in cylindrical masses around twigs of trees. Hodson (1941) determined the number of eggs in egg masses of the forest tent caterpillar by counting the number of eggs around the circumference and multiplying by the number of rows. This technique is apparently reliable for comparative counts, but because the eggs are frequently laid in oblique rather than straight rows on the twig, counts of both length and circumference are subject to error. In addition, adjacent rows are often offset to form a honeycomb pattern which leads to inaccuracies in length and circumference counts. Because of these shortcomings, we developed a quicker and more accurate method not subject to the effects of oblique or honeycomb egg patterns."

Outbreaks - 4a

486. Witter, J.A.; Kulman, H.M. 1972a. **A review of the parasites and predators of tent caterpillars (*Malacosoma* spp.) in North America.** Minn. Agric. Exp. Sta., Univ. Minn. Tech. Bull. 289.

All of the reports of natural enemies of tent caterpillars are listed along with information including (1) the status of natural control agents as parasites, predators, hyperparasitoid, associated insects of unknown status, etc.; (2) the tent caterpillar species or subspecies involved; (3) the status of the

paper as an original study where insects were reared and observed, or as a review of other work; (4) the literature reference; and (5) the geographic location of the work. A brief discussion of papers giving evaluations of parasitoids and predators along with other information that did not lend itself to tabular form precedes the list.

Biology - 2

487. Witter, J.A.; Kulman, H.M. 1972b. **Mortality factors affecting eggs of the forest tent caterpillar, *Malacosoma disstria* (Lepidoptera : Lasiocampidae).** Can. Entomol. 104(5): 705-710.

"Parasitism, infertility and death of fully developed first-stage larvae in eggs (pharate larvae) were the egg mortality factors encountered during a 1967-69 study on the bionomics of the forest tent caterpillar, *Malacosoma disstria* Hübner, in northern Minnesota. There was no significant difference in the average yearly per cent parasitization and infertility per egg-mass; these ranged from 7 to 10% and from 1 to 3%, respectively. There was a year-to-year difference in pharate larval mortality. It ranged from 39% in 1968 to only 9 and 3% in 1967 and 1969. Studies showed that egg masses had a tendency to be either nearly completely hatched or unhatched only in 1968. The variation in pharate larval mortality in these studies suggests qualitative differences in the population. The pharate larvae mortality has the potential of influencing population trends of the forest tent caterpillar."

Biology - 2; Outbreaks - 5

488. Witter, J.A.; Kulman, H.M. 1979. **The parasite complex of the forest tent caterpillar in northern Minnesota.** Environ. Entomol. 8(4): 723-731.

"The parasites of the forest tent caterpillar, *Malacosoma disstria* Hübner, were studied during the last 6 yr of the 1964-72 outbreak in northern Minnesota. Egg parasitism, only ca. 4-10%, involved 3 species: *Telenomus clisiocampae* Riley, *Ooencyrtus clisiocampae* (Ashmead) and *Tetrastichus silvaticus* Gahan. Twenty-five hymenopterous species and 13 dipterous species were reared from the larvae and pupae of the forest tent caterpillar. Six of the hymenopterous species were hyperparasites, while 6 of the dipterous species were scavengers. *Rogas* sp. was the only early larval parasite. The most abundant late larval parasites were *Patelloa pachypyga* (Aldrich and Webber), *Leschenaultia exul* (Townsend), *Lespesia frenchii* (Williston), and *Trichonotus analis* (Say). Pupal parasitism was highest on cocoons from the ground level and progressively lower in the shrub and crown levels. Pupal parasitism increased with age of the infestation until 1968, decreased significantly in 1969, then increased again until the population collapsed in 1972. *Sarcophaga aldrichi* Parker and tachina flies accounted for 98% of all parasitism in the late cocoon collection during 1967-71 except in 1970. *S. aldrichi* destroyed all other parasites in the pupae and became the overwhelmingly dominant parasite in pupae after the 1st year of heavy infestation. *Itoplectis conquisitor* (Say) was common during the 1st year of heavy infestation. Otherwise, ichneumon wasps were rare in the late cocoon collections except in areas at the edge of the outbreak. The biology and individual patterns of parasitism during the outbreak are discussed for the common parasites."

Biology - 2

489. Witter, J.A.; Kulman, H.M.; Hodson, A.C. 1972. **Life tables for the forest tent caterpillar.** Ann. Entomol. Soc. Am. 65(1): 25-31.

Data from a study of the population dynamics of *Malacosoma disstria* in *Populus tremuloides* stands in northern Minnesota during 1967-1969 are tabulated and discussed. From the results and an evaluation of the literature it is concluded that the factors most likely to influence populations of *M. disstria* during outbreaks in Minnesota, acting separately or in combination, are: mortality of pharate larvae; death of first-stage larvae from the effects of spring frosts (which either kill the larvae directly or destroy them by killing the foliage on which they feed); and parasitization of pupae by *Sarcophaga aldrichi*.

Biology - 2,4; Outbreaks - 5

490. Witter, J.A.; Mattson, W.J., Jr.; Kulman, H.M. 1975. **Numerical analysis of a forest tent caterpillar (Lepidoptera: Lasiocampidae) outbreak in northern Minnesota.** Can. Entomol. 107(8): 837-854.

"An outbreak of the forest tent caterpillar began in northern Minnesota in 1964 and ended abruptly in 1972. During 1968-71, when egg densities ranged from 1 to 9 million per acre, caterpillars caused virtually complete tree defoliation in all the study plots. As a result, tree-stem densities and basal areas were reduced per plot by 41 and 27% per plot, respectively. Tree mortality was most severe on plots with high water tables. Graphical and components of variance analyses both showed that (1) variations in annual egg densities were due mostly to variations in survival during the egg to 30 day larval stage (S1) and secondly to variations survival during the 30-day larval to adult stage (S2), (2) S2 tended change in the opposite direction from [be inversely proportional to] S1, (3) the net result was a tendency to produce a constant amount of eggs per unit area. Variations in S1 were due primarily to pharate larval mortality and mortality among larvae 2-3 weeks after hatch while variations in S2 were due mainly to unmeasured mortality factors such as starvation, disease, dispersal, etc. Survival during the egg stage (SE) and fecundity (F) varied significantly by years, but not by plots and both were apparently related to weather conditions. Plots of two simultaneous equations were presented to demonstrate the nature of population change in relation to the densities of eggs and 30-day larvae per acre.

Outbreaks - 3,5

491. Wood, C.S. 1992. **Forest tent caterpillar.** For. Can., Pac. For. Cent., Victoria, B.C. For. Pest Leafl. No. 17. 4 p.

This is a general paper describing hosts, damage, distribution, life history, and control of the forest tent caterpillar.

General Background

492. Xu, D.; Stoltz, D. 1991**. Evidence for a chromosomal location of polydnavirus DNA in the Ichneumonid parasitoid *Hyposoter fugitivus***. J. Virol. 65(12): 6693-6704.

"Evidence is presented in support of a chromosomal location for sequences homologous to polydnavirus DNA in the ichneumonid parasitoid *Hyposoter fugitivus.* In this study, four different viral genome segments were cloned and used as probes against genomic DNA extracted from male parasitoids and digested with a variety of restriction enzymes. Each probe typically identified a single off-size fragment (OSF) in the case of enzymes not cutting viral genome segments, while two OSFs were generated by enzymes cutting at one and two sites. While extra OSFs were occasionally

observed, these were invariably found to be due to the presence of polymorphic restriction sites in flanking chromosomal DNA. Analysis of these data suggests that a single, stable chromosomal locus exists for sequences homologous to each viral genome segment; the data also indicate that viral and cognate parasitoid genomic DNAs are largely if not entirely colinear." Note: *Hyposoter fugitivus* is a parasite of *Malacosoma disstria* Hbn.

Biology - 2,3

493. Yadwad, V.B.; Downer, R.G.H. 1993. **Phosphatidylinositol kinase and phosphatidylinositol-4-phosphate kinase activities in MD 66 insect cell line.** Arch. Int. Physiol. Biochim. Biophys. 101(3): 203-205.

"Phosphatidylinositol kinase (PI kinase) and phosphatidylinositol-4-phosphate kinase (PIP kinase) activities in an insect cell line (MD 66) [*Malacosoma disstria*] were studied by measuring the incorporation of 32P from (gamma-32P) ATP into phosphatidylinositol-4-phosphate (PIP) and phosphatidylinositol-4,5-biphosphate (PIP-2) respectively. The apparent Km values of phosphatidylinositol kinase and phosphatidylinositol-4-phosphate kinase for ATP were 78.5 mu-M and 71.7 mu-M respectively. PIP kinase activity was enhanced by GTP analogue guanosine 5-O(thio) triphosphate (GTP-gamma-S)."

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