Due to its polyembryonic development, *M. gifuensis* can be reared in the laboratory in quite large numbers. Most of the difficulties encountered are those relating to the rearing of the host both before and after parasitism. At times when good host food is available and the handling of the host larvae is carefully done, it has been found possible to secure over fifty per cent as many parasite cocoon masses as there were larvae parasitized. In so far as the parasite itself is concerned, the only critical point is in securing a good sex ratio. This can be secured by proper mating.

LITERATURE CITED

1. Briand, L. J. Laboratory breeding of the European corn borer (*Pyrausta nubilalis* Hubn.) with special reference to equipment and cages. Can. Ent. 61:51-54, 1929.
2. Clarke, Charles A. The European corn borer and its controlling factors in the Orient. U. S. Dept. Agr. Tech. Bull. 455, 1934.
3. Flanders, S. E. Sex differentiation in the polyembryonic proclivity of the Hymenoptera. Journ. Econ. Ent. 35:108, 1942.
4. Parker, H. L. *Macrocentrus gifuensis* Ashmead, a polyembryonic braconid parasite in the European corn borer. U. S. Dept. Agr. Tech. Bull. 230, 1931.
5. Patterson, J. T. Polyembryony and sex. Journ. Hered. 10:344-352, 1919.
6. Thompson, W. R. and H. L. Parker. The European corn borer and its controlling factors in Europe. U.S. Dept. Agr. Tech. Bull. 59, 1928.

THE INTRODUCTION OF INSECT PARASITES OF THE SPRUCE BUDWORM, *ARCHIPS FUMIFERANA* CLEM., INTO EASTERN CANADA*

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The extent and intensity of the present infestation of the spruce budworm, *Archips fumiferana* Clem., in eastern Canada has become a problem of immense national concern (1). The necessity for further knowledge in formulating adequate control programmes has emphasized the importance of considering the possible utilization of natural insect parasites. As part of the more comprehensive study of control being carried on by the Federal Division of Entomology, the Dominion Parasite Laboratory in cooperation with the Forest Insect Unit instituted a programme of parasite introduction in 1943. Since the importation of natural enemies of *A. fumiferana*, or closely related species with similar hosts and habits in other parts of the world, could not be attempted at that time, consideration was given to the possibility of parasite colonization by transferring certain species found to attack the budworm in other parts of this continent to areas in eastern Canada where the infestation was developing. It is the purpose of the present paper to give an outline of the work now in progress and to indicate briefly the results to date.

This work is being conducted with the co-operation of various members of the Division of Entomology. Special acknowledgment is made to Mr. W. G. Mathers of the Forests Insects Laboratory, Vernon, B. C., and to Mr. H. C. Coppel of the Dominion Parasite Laboratory for valuable help in organizing and carrying out the collections in British Columbia. Thanks are also extended to Mr. C. D. Orchard, Deputy Minister of the British Columbia Department of Forests, and to members of the Forest Service at Kamloops and Lillooet for their very generous cooperation.

Previous Records of Natural Control Factors

Published data do not give a clear picture of the effects of natural factors on the abundance of this insect in Canada, either during the present epidemic or on the rise and fall of past outbreaks. The decline of budworm abundance in some cases has been attributed to the presence of natural agents of control, while in others the natural checks have not been capable of suppressing the abundance of the insect before it has been starved out by lack of food-plants. As a result

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of the studies carried out by the Division of Entomology during the past outbreak, 1911-1922, Tothill (2) states that in New Brunswick, particularly in areas where the preferred food-plant was present in large numbers, the natural checks were not sufficient to control the outbreak. Whereas, at Lillooet in British Columbia, where Tothill and Baird conducted control studies between 1917 and 1920, Tothill (2) reports that natural control factors reduced the budworm population before any trees were killed and in the following year the outbreak completely subsided. The natural checks were found to consist almost entirely of birds and insect parasites; 38 per cent of the larvae and pupae were destroyed by birds and 60 per cent by parasites. Among the various parasite species recorded, an ichneumonid, *Phytodietus fumiferanae* Rohw., alone accounted for almost half of the budworms killed by insects. This species had never been found in eastern Canada and plans were therefore made to introduce as many as possible into New Brunswick the following year. Unfortunately, this project was never carried out due to the previously noted scarcity of the budworm in the years immediately following 1920.

The Collection and Transfer of Parasites from Western Canada.

In the summer of 1943 the author in co-operation with Mr. W. G. Mathers of the Vernon Forest Insect Laboratory succeeded in locating a light infestation of budworm in the mountains near Lillooet, British Columbia, where *P. fumiferanae* had been found 25 years previously. A small collection of parasites was made and brought back to Belleville for further study. It was found that in addition to *Phytodietus fumiferanae* there were also two of the tachinid parasites which had not been found in the East. These were *Ceromasia auricaudata* Tns. and *Phorocera incrassata* Smith, of which the former was present in considerable numbers.

As a result of these findings a more extensive programme of collecting parasites in British Columbia was undertaken in 1944 and continued in 1945. Although considerable difficulty was experienced in securing adequate field collectors, by using school boys and Japanese from a local internment centre, 220,000 budworms were collected in 1944 and 251,000 in 1945. The budworm collections were shipped to Belleville and reared for parasite recovery and for release of certain selected species.

(a) Methods of Collecting and Rearing the Parasites.

The method used in collecting the budworm was modified somewhat from time to time depending on the age of the collectors and nature of the forest. In general, each collector was provided with a small canvas haversack, two light-weight metal screen covered cages, and a larger cardboard box, each of which fitted into separate pockets of the haversack. Both the cages and boxes had a one-inch hole in the upper side and were provided with cork stoppers. The straps of the haversack were carried around the neck and the bag allowed to hang free in front of the collector.

In making the collections, the branches of the trees were closely examined and the budworm larvae, pupae, and free parasites carefully removed by hand. The larvae were dropped into the cardboard box with an abundant supply of foliage and the budworm pupae and parasites placed separately in the screened cages. With but moderate supervision only a very small proportion of the insects collected were injured, although they were held in the boxes until the end of the day.

Rearing of the collections was carried out at a central field station near Lillooet. The budworm larvae were reared to the pupal stage in covered trays. The framework of the trays was wood, measuring 42 by 36 by 3 inches; the bottom was covered with cloth and could readily be replaced when necessary. All the trays were furnished with tightly fitting cloth lids made with frames of wood which fitted into a groove on the upper edge of the trays. When in use

the trays were provided with an abundant supply of foliage and stored in a protected spot under canvas.

Incubation for parasite recovery was not attempted in the field. All field-collected pupae and those taken from the rearing trays were shipped by air-express to Belleville at approximately two-day intervals. Ordinary mailing tubes, 3.5 inches in diameter and 8 inches long, with metal screw tops, were used with great success for the shipment of material from the field. Fine sawdust was mixed with the pupae to prevent mechanical injury and to provide protection from extreme temperatures.

On receipt of the collections at the laboratory the budworm pupae were sorted and placed in either 1-inch shell vials or wooden boxes with sliding glass tops for rearing. Small samples of each collection were reared individually in the shell vials and the remainder placed directly en masse in the boxes. The parasite emergents were sorted as they appeared each day, identified, and in the case of those selected for release, placed in small screened cans for shipment to the field in specially constructed iced containers.

Budworm larvae parasitized by *Phytodietus fumiferanae* were reared in 3 by 1-inch shell vials, plugged with cotton stoppers. Little mortality occurred when the foliagae was replaced at frequent intervals. As the *Phytodietus* cocoons were formed in the vials, they were transformed to small cardboard boxes and shipped by air-express to Belleville.

(*b*) Parasites Recovered for Release

During the course of the present study, 45 species of parasites have been recovered from the collections made in British Columbia. A detailed account of the species taken is now in preparation and will be published at a later date. The most numerous species reared from the collections were the three previously mentioned and a sarcophagid, *Pseudoscarcophaga affinis* (Fallen). The number reared in shown in table 1.

TABLE 1

Parasites reared for release from collections made at Lillooet, B. C.

	1943	1944	1945
Phytodietus fumiferanae cocoons collected*	338	6,251	4,547
Dipterous parasite puparia reared	123	45,011	56,676
Phytodietus fumiferanae adults emerged		124	2,848
Ceromasia auricaudata adults emerged		2,432	5,510
Phorocera incrassata adults emerged		157	47
Pseudosarcophaga affinis adults emerged		5	623

*This species is univoltine, passing the winter as mature larvae in cocoons on the trees. From records of laboratory rearing, some (20 to 40%) remain in diapause another year or longer.

In addition to the work done in British Columbia, through arrangements made with the Imperial Parasite Service and the United States Bureau of Entomology and Plant Quarantine, an area of budworm infestation in the Rocky Mountain National Park in Colorado was investigated during the past three years. While the budworm collections obtained from this area were not large, the studies showed that the parasites present were essentially the same as in British Columbia. There was little difference between the number of species recovered and the relative abundance of each. If a sufficient quantity of parasites cannot be obtained from British Columbia, the Colorado infestation might serve as an addition source of parasite material.

Biological Studies and Laboratory Rearing

When this work was instituted very little was known regarding the life history and habits of the western species of parasites attacking the budworm. It was, therefore, considered advisable to undertake studies to provide information on the most suitable conditions required by the parasites for their successful establishment in the field and to develop methods for their propagation in the laboratory and thus provide for their wider and more rapid distribution in

the field. Particular attention was paid to the study of probably the most important species, *Phytodietus fumiferanae,* and an economical method was developed for rearing it on budworm larvae in the laboratory.

The technique developed, although rather simple, requires very careful attention to details. The mated females secured early in the spring from overwintering cocoons are placed individually in cloth-covered cages measuring 4 by 4 by 3 inches. After a preoviposition period of 15 days the females are ready to lay their eggs. Three or four mature budworm larvae are then placed in the cage and allowed to remain until parasitized by the female. The eggs are usually attached to the integument of the host larvae on the pleural region of the second or third segment. After being parasitized the budworm larvae are removed from the cage and placed in 3-inch shell vials with spruce foliage for rearing. The foliage must be replaced every 24 hours. The parasite larvae soon emerge from the eggs and begin feeding on the body fluids of the budworm. On the eleventh day, at a rearing temperature of 75°F., the parasite leaves the host and constructs a white silken cocoon in which it remains in hibernation until the following spring. The cocoons, shortly after they are formed, are brought together and confined in small cardboard boxes for storage at 32° to 34°F. The adults are ready to emerge eight months later, when incubated for 15 to 20 days at a temperature of 74°F.

Propagation of this species has been carried out on an experimental basis for the past two years with very satisfactory results. In 1944 over 700 parasite cocoons were reared, the adults from which were released in 1945, largely in the Kabonga Reserve, Quebec. In 1945, 2,000 cocoons were propagated on spruce budworm larvae collected in the infested areas of Maniwaki, Quebec, and Port Arthur, Ontario. These will produce adults for release in 1946. Large scale production in the laboratory is planned for the coming year.

Distribution of Parasites

The number of parasites released in the field since the inception of the programme is somewhat small. After setting aside a small number for use in laboratory propagation and study, just over 10,000 adults were available for liberation. These have been liberated as shown in Table 2. Nearly half of the *Phytodietus fumiferanae* remained in diapause. These are being held in storage for later release.

TABLE II

Parasites from British Columbia released in eastern Canada.

Liberation Point	Kabonga Reserve, Quebec	Port Arthur, Ontario		Belleville, Ontario		Total
Year	1945	1944	1945	1944	1945	
ICHNEUMONIDAE						
Phytodietus fumiferanae	2,600	71		28	400	3,099
TACHINIDAE						
Ceromasia auricaudata	4,649	1,501	550	133		6,833
Phorocera incrassata		12		110		122
SARCOPHAGIDAE						
Pseudosarcophaga affinis	450					450
Total	7,699	1,584	550	271	400	10,504

From the collection obtained in 1943, one colony of *Phytodietus fumiferanae* was released in June, 1944, in an infestation at Black Sturgeon Lake near Port Arthur, Ontario, and a few individuals for observation purposes only in a small stand of infested white spruce near Belleville. The tachinid parasites obtained in 1944 were released a little later in the same year in the same general areas. Parasite releases in 1945 were concentrated largely in the Maniwaki and Kabonga Reserve areas of Quebec with only one colony of *P. fumiferanae* and *C. auricaudata* being liberated respectively at Belleville and Port Arthur. All liberations with the exception of those at Belleville were made by or under the direction of officers of the Forest Insect Unit at Ottawa.

No attempts have yet been made to make collections for the recovery of the parasite species liberated. During the summer of 1945 a few cocoons of *Phytodietus fumiferanae* were reared from a small collection of budworm larvae gathered in the white spruce stand near Belleville. These budworm larvae may have been parasitized by parasites liberated earlier that season less than a mile away. It is hoped that planned recovery studies can be undertaken in the near future.

SUMMARY

In 1943 a programme was instituted by the Dominion Parasite Laboratory for the transfer of spruce budworm parasites from British Columbia to eastern Canada. Over 10,000 adults of *Phytodietus fumiferanae, Ceromasia auricaudula, Phorocera incrassata* and *Pseudosarcophaga affinis* collected near Lillooet, B. C., were released in infested areas of Ontario and Quebec.

A short account is given of the methods of collecting and rearing the parasites.

The technique developed for the breeding of *Phytodietus fumiferanae* in the laboratory is described and an account given of the liberation of the parasites in the field.

LITERATURE CITED

1. Annual reports of the Forest Insect Survey, Division of Entomology, Science Service, Department of Agriculture, Ottawa, 1934-1944.
2. Tothill, J. D. 1922. Notes on the outbreak of spruce budworm, forest tent caterpillar and larch sawfly in New Brunswick. Proc. Acadian Entom. Soc., No. 8:172-182.

NEW NORTH AMERICAN EUPITHECIAS, II (LEPIDOPTERA GEOMETRIDAE) *

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Eupithecia plumasata n. sp.

Male. Closely allied to *gilata* C. & S. in both maculation and genitalia but considerably larger than this species. Palpi short, projecting only slightly beyond the flat front. Antennae moderately ciliate. Primaries with little trace of maculation, in color an even deep smoky-gray as compared with the brown shade of *gilata*. The only prominent feature is a black discal streak, slightly outwardly oblique. There are traces of a curved, dark basal line, some obscure small patches along costa of which a subapical one is largest and most prominent, slight blackish dashes on cubitus and indications of a t. p. line by faint dark streaks on the veins. Terminal area somewhat darker than remainder of wing with slight indication of a paler s. t. line culminating in a small spot above tornus. A broken, dark, terminal line. Fringes smoky with faint, pale basal line. Secondaries pale smoky with heavier dark shading along inner margin, cut by streaks of paler color which can be partially traced across outer area of wings as curved lines. A small dark discal dot; terminal area and fringes as on primaries. Beneath very pale smoky, somewhat silky in appearance with indications of the same obscure maculation as on the upper side. Expanse, 24 mm.

Genitalia. (fig.2). Very close to those of *gilata*, the claspers being asymmetrical, and that of the right side nearly similar to that of *gilata;* the left clasper, however, shows differences in the shape of the projections along the ventral border which can be noted by comparing the present figure with that given of *gilata* (1941, Can. Ent., 191). The apical margin of the vinculum is broadly truncate, much broader than in *gilata*. The sinuate aedeagus is wider with a distinct bulbous enlargement at base and is armed with a large, basal, partially hollowed,

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