Not for publication

ADELGES PICEAE (RATZ.) STUDIES IN NEWFOUNDLAND

REVIEW OF ASSOCIATED PREDATORS, INTRODUCED AND NATIVE, FROM 1952 TO 1962

by

D.G. Bryant

INTERIM REPORT 1963-1

FOREST ENTOMOLOGY AND PATHOLOGY LABORATORY

CORNER BROOK, NFLD.

CANADA

DEPARTMENT OF FORESTRY

[redacted]

SEPTEMBER 1963

Not for publication

ADELGES PICEAE (RATZ.) STUDIES IN NEWFOUNDLAND

REVIEW OF ASSOCIATED PREDATORS INTRODUCED AND NATIVE FROM 1952 to 1962

by

D. G. Bryant

INTERIM REPORT 1963-1

FOREST ENTOMOLOGY AND PATHOLOGY LABORATORY

CORNER BROOK, NFLD.

CANADA

DEPARTMENT OF FORESTRY

September, 1963

INDEX

FIGURES

INTRODUCTION

The balsam woolly aphid, Adelges piceae (Ratz.), probably entered eastern Newfoundland on European nursery stock before 1915 and western Newfoundland on dunnage or wind currents from Nova Scotia around 1939 (4). Infestations in the two areas were discovered in 1949 (18). New outbreaks were found on the Burin Peninsula in 1955, around the Bay of Exploits in 1961, and in the Lloyds River Watershed in 1962. Presently about one-fifth of the Provincial forests contain infested balsam fir, Abies balsamea (L.) Mill., trees; the largest area occurs in western Newfoundland. Tree crown deterioration caused by aphids feeding on branches is the most extensive form of injury to balsam fir. Stem attack has been found only in widely dispersed spots. Investigations have shown that crown deterioration first becomes apparent in the subapical quarter, and that aphid density is highest in the subperipheral area of a branch. An account of studies of aphid distribution in the crowns and on stems of balsam fir trees will be given in a later report.

This report reviews the biological control program since its inception in 1952 and includes details of release and recovery techniques. The effectiveness of introduced species has been assessed from recovery data and the condition of balsam fir stands in and near release areas; an adequate branch sampling system does not exist for a quantitative assessment. Some of the data in a 1958 report (3) will be repeated. Prior to 1958, Survey personnel

conducted the biological control program. The author has been responsible for the program since 1958 and has been assisted by John Carter since 1960.

METHODS

Predators were usually released freely on the stem or in the crown of an infested tree. The opened containers were placed at the base of the tree for stem releases or taped to the branch for crown releases. After 30 minutes they were examined and living predators were removed with a camel hair brush or light tension forceps and dead specimens placed in 70 per cent alcohol. In a few instances the opened containers were left in the field overnight, or shipments were kept overnight in the laboratory cold room at 40° F.

In recent years, predators have been shipped in tin or wooden containers packed in cooled insulated cardboard cartons. Damage to the cartons has occurred on two occasions but without visibly affecting the predators. The tin container, about six inches long and three inches in diameter, was superior to the wooden ones. It was easy to carry into the crowns of trees and the small opening of the uncovered tin permitted intensive inspection for contaminant species. The European and Australian wooden containers, measuring eight inches on a side, were awkward to handle and predators had to be transferred to smaller containers for crown liberations.

Also, the large eight-inch square opening made it easy for insects to escape before a thorough search could be made for contaminants. In the European box, predators often crawled under an inner ledge from which it was difficult to dislodge them. The white interiors of the Melrose boxes, in which Aphidoletes thompsoni Moehn. were shipped, made the checking and sorting of material relatively easy.

Several or all of the predators in some shipments were caged on the branches or stems of infested trees. Branch cages were triangular in shape with a side wall of about six inches. The cage was made of 14-mesh, fibre-glass window screening with an 18-inch zipper along the top and partially down the basal side of the triangle (Figure 1); the closed zipper formed a hole at the base that encircled the main stem of the branch. The cage was supported by a string tied to the apex and onto a higher branch in the crown (Figure 1). Cylindrical cages (7) of similar material were used to confine predators on the tree stem.

Establishment and dispersal data were obtained from branch and stem samples used in intra-tree aphid distribution studies, traps, samples submitted by Survey personnel, and periodic inspections of stems and branches in release areas. The intensive intra-tree branch samples ranged from four to all the nodes on a branch. The node, though satisfactory for aphid counting was too small for sampling motile predators; the predator sample unit should consist of a large portion or all of a branch. The stem area examined for

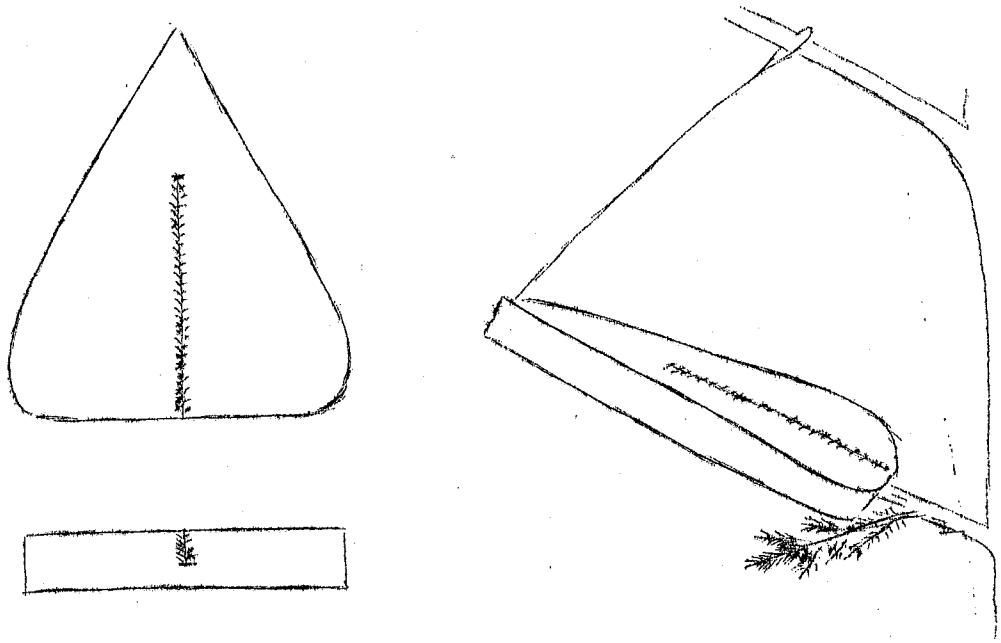


Figure 1: Diagram of a Branch Cage Showing top, end, and *in situ* views

for predators ranged from about 500 square inches per tree to the entire tree stem. Several bark and branch samples submitted by survey crews for verification of aphid occurrence and density have provided predator dispersal data. Tree stems and branches at most current liberation sites were inspected three days, one week, two weeks and one month after the release. Examinations at old release sites were made at the most optimum time, usually the larval period for predator recovery. The stage and number of predators

found were recorded and in some cases notes were made of the time and the size of trees involved.

Several types of traps were used to recover predators. Seven 14-mesh screen cages, measuring one foot in each dimension and similar to one described by Nichols (16) were placed at Laricobius erichsonii Rosen. and A. thompsoni release sites to trap soil-emerging adults in 1960. The experiment was unsuccessful although the traps remained in position from April 27 to August 6.

Eight cloth-and-wood, ground emergence traps (Figure 2) were placed in pairs at intervals of 500 feet at Frenchman's Cove in 1961. The area was a 1959 A. thompsoni release site that was clearcut in 1960-61. Each trap consisted of a wooden basal frame enclosing one square foot, a 15-inch vertical wood side, and a black painted cloth which covered the remaining sides and sloped from the base to the top. A two-inch diameter hole near the top of the wooden side admitted light and emerging insects were trapped in a Mason jar covering the hole. A small, ventilated tin containing potassium cyanide was placed in one jar of each pair of traps.

Fifteen soil samples, nine and one-half square feet, averaging 3.3 inches thick, were collected at an A. thompsoni release site at Frenchman's Cove in 1961. In the same year, five samples, five square feet and six inches deep, were collected near a L. erichsonii site at Steady Brook. The samples were sealed in boxes with a glass vial inserted in a corner to admit light and retain the emerging

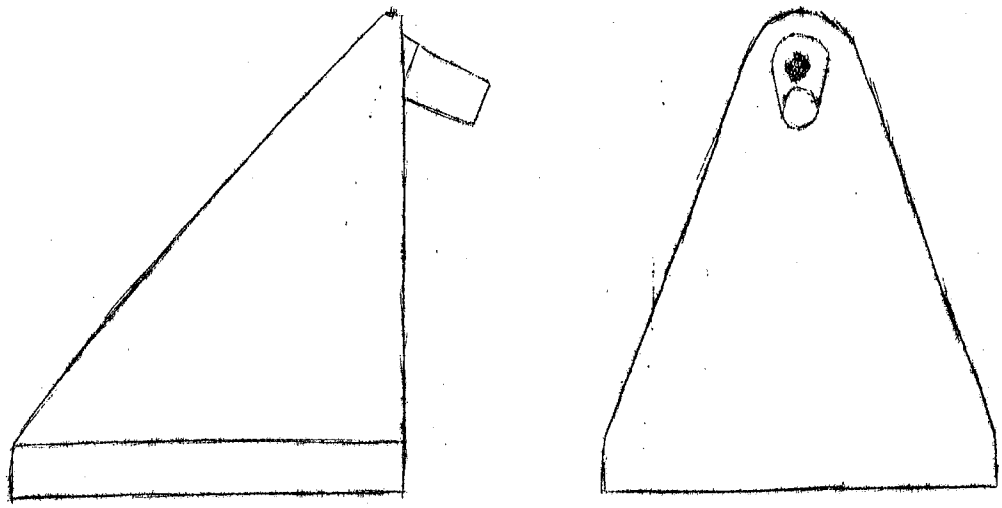


Figure 2: Diagram of a Cloth-and-Wood Ground Emergence Trap

insects. The boxes were kept at 72° F. and 70 per cent relative humidity in the laboratory rearing room and inspected daily. The emerged Cecidomyiidae were preserved in 70 per cent alcohol and the L. erichsonii were pinned. Two additional samples from Steady Brook, amounting to two square feet, were sifted and inspected but did not contain any L. erichsonii pupae.

Window flight traps were used to obtain data on the occurrence and dispersal of introduced predators. The trap was described by

Chapman and Kinghorn (5) and consisted of a 5.7-square-foot glass pane over a tray of saponified water. Each trap was suspended between two trees in a relatively open area in the understory. Support trees with little or no stem attack were selected to reduce the attractant effects of a high local aphid infestation. Five traps were tested in July, 1961; the number was increased to ten for the remainder of the year and to sixteen in 1962. They were placed at various intervals in an east-west direction along the Humber River Valley. No predators were caught in three traps placed in the St. George's area in 1962.

Immature stages of predators were reared at 72° F. and 70 per cent relative humidity in the laboratory rearing room. Larvae and nymphs were reared in plastic boxes or lantern globe jars on aphid infested twigs or stem sections. The base of the infested material protruded through a hole in the container into a water reservoir. The pupae were kept in cotton-plugged novocaine carpules until adult emergence.

The effect of the native predator Tetraphleps canadensis Prov. on the neosistens stage only was assessed quantitatively in 1960. Two branch samples were taken from five eight- to fifteen-foot balsam fir trees at Wild Cove Point near Corner Brook. The sample consisted of the shoot tip (#1 node), shoot axis (#1 internode), and the first complete node (#2 node) on the main axis of the branch.

Aphid counts were kept separate for each sample section and recorded as living and dead neosistentes and living intermediates and adults. The dead neosistentes were tallied as (1) translucent (viscera missing and exoskeleton translucent), and dessicated (viscera present and neosistens dry).

RESULTS AND DISCUSSION

Contaminants in Shipments

No contaminants were recorded in predator shipments from 1952 to 1958. In 1958, one orange larva, possibly A. thompsoni, was found in a shipment of adults of the same species. A 1959 shipment of adult Aphidecta obliterata L. contained six unknown puparia that were returned to the Entomology Laboratory at Belleville for rearing. In the same year two shipments of adult Pullus impexus Muls. contained two living and six dead Cremifania nigrocellulata Cz. (determined by J. F. McAlpine) and one dead Laricobius erichsonii Rosen. Two living and one dead Chalcidoidea adults were seen in two releases of A. thompsoni adults; one of the living escaped and the other was identified as Platygaster sp. (determined by L. K. Smith). One Cerylon sp. (determined by W. J. Brown) was found in shipment #59-14 of L. erichsonii. A shipment of Exochomus uropygialis Muls. adults in 1960 contained one unknown emerged puparia. One Coccinellidae, possibly Pullus impexus Muls., was included in a shipment of L. erichsonii adults in 1962. No contaminants were recorded in 1961.

The contaminants recorded in 1958, 1960 and 1962 were relatively unimportant because they involved other stages of the species sent or other predator species that had been introduced in earlier years. The contaminations during 1959 were excessive and one was important. The black chalcid adult that escaped may have been a Platygaster sp. and possibly a parasite of A. thompsoni; no Aphanogmus nigrofornicatus P.-W. were found in Newfoundland shipments although this species was reported in New Brunswick shipments (9). It is probable that other Platygaster adults may have been released with the predator since the parasite was very small and readily visible only when at rest; Clark & Brown (9) made the same observation for A. nigrofornicatus.

Predator Mortality in Shipments

Predator mortality was not excessive except for half of the A. thompsoni shipments in 1959, for L. obscura in 1955, and C. nigrocellulata in 1961. Of 41,619 adult A. thompsoni sent, only

only 29, 076 were living upon arrival. Mortality was not related to any of the following factors:

(1) The level of the Melrose box in the shipping carton (Table 6),

(2) The number of adults in each box (Table 7),

(3) The time interval between adult emergence at the Belleville Entomology Laboratory to release in Newfoundland (Table 5),

(4) Condensation in the boxes,

(5) Male mortality following mating (Table 9),

(6) Boxes left open at the release site and collected at a later date (Table 8).

The autumn shipments originating in Czechoslovakia and retained at Belleville over the winter of 1958-59 had a mortality of 7.8 ± 2.0 per cent. The summer shipments from Germany and transhipped from Belleville upon adult emergence in 1959 had a mortality of 35.2 ± 11.2 per cent (Table 10). The Czechoslovakian material may have been a hardier strain or the overwintering generation can withstand the rigors of shipping. The high mortality of the German material may have been an early indication of the presence of a disease[1] or a change in the viability of the population. On the basis of the low shipment mortality, the author believes that more effort should be expended in collecting Aphidoletes from Czechoslovakia and that collections should be made of overwintering pupae.

---

[1]Mentioned by Belyea, Fredericton, N.B. in correspondence to McGugan, Ottawa, Ontario.

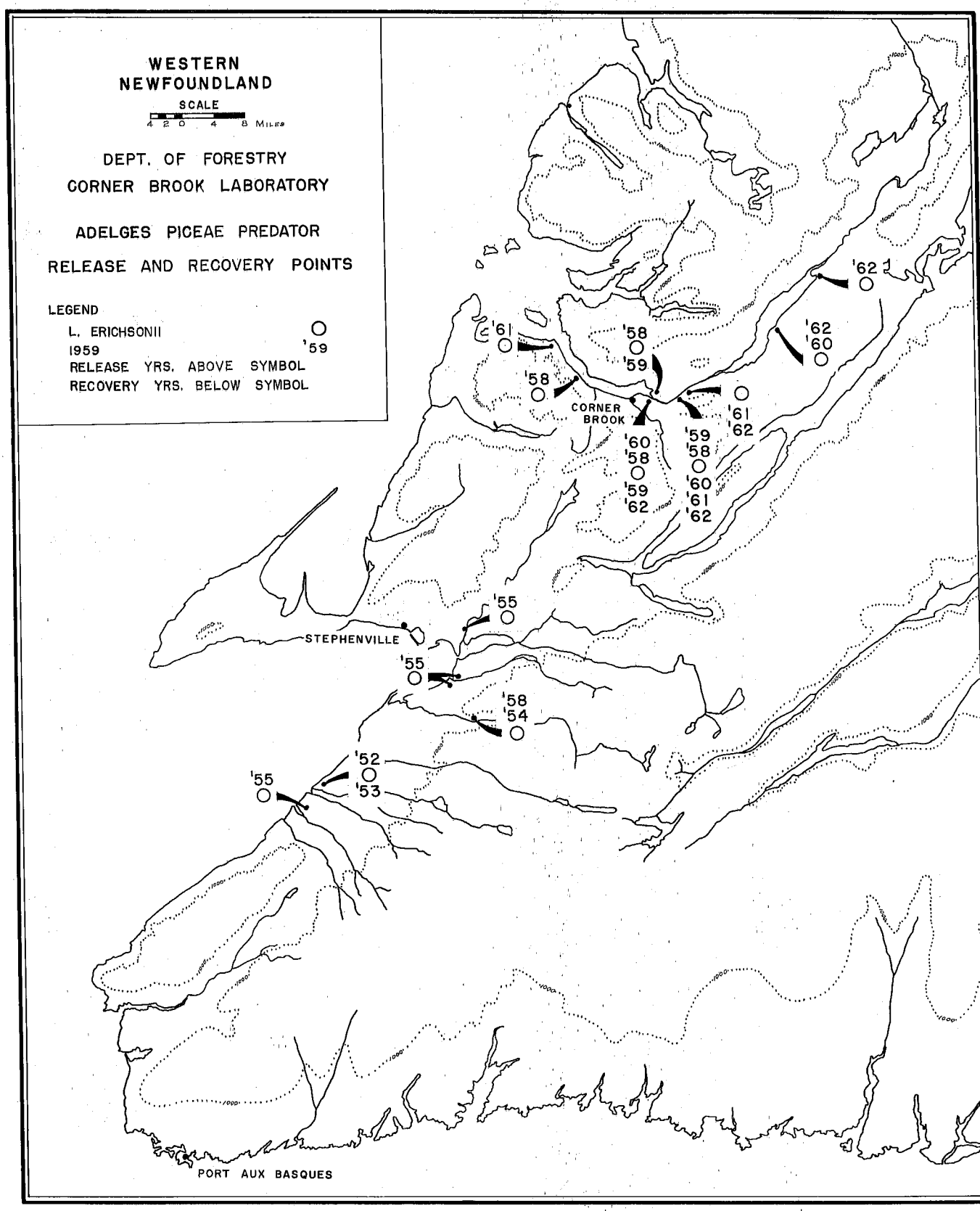
Some C. nigrocellulata were trapped in the condensation on the inside of the tin. The drowned specimens did not account for the high mortality of 56.4 per cent and the cause or causes of the mortality were not discernible.

Laricobius erichsonii Rosen. (Coleop: Derodontidae)

A total of 38,649 L. erichsonii adults (Table 1) has been released in twelve areas in Newfoundland since 1952 (Figure 3). One-third were released in the older infested region southwest of Stephenville Crossing and the remainder in the more recently infested stands of the Humber Watershed (Table 2). The majority of the shipments were released freely on trees having moderate to high numbers of aphids on the stems and branches. Four shipments, 60-20, -23, 62-8, and -13 were placed in trees with crown infestations only.

Recoveries have been made in four of twelve areas up to three years following release (Table 3). Window traps placed in an east-west direction from a 1958 and 1959 Humber Valley release site were very successful in 1961. Fifty-four callow adults were caught in 305 trap-days (Table 4); no captures were made west or beyond 1.65 miles east of the release site. Traps were placed again at various distances from the release site in 1962 and only five over-wintered and one callow adult were caught in 1,508 trap-days. The callow adult was obtained 0.75 miles west of the release site.

Figure 3: Release and Recovery Points of *Laricobius erichsonii* in Newfoundland


WESTERN
NEWFOUNDLAND
SCALE
4 2 0 4 8 MILES
DEPT. OF FORESTRY
CORNER BROOK LABORATORY
ADELGES PICEAE PREDATOR
RELEASE AND RECOVERY POINTS
LEGEND
L. ERICHSONII
1959
RELEASE YRS. ABOVE SYMBOL
RECOVERY YRS. BELOW SYMBOL
'59
'61
'58
'59
'58
'62
'62
'60
CORNER BROOK
'61
'62
'59
'58
'60
'58
'59
'60
'61
'62
'62
'55
STEPHENVILLE
'55
'58
'54
'52
'53
'55
PORT AUX BASQUES

Many of the early releases of L. erichsonii and other predator species were made in severely damaged balsam fir stands and the trees bore high numbers of aphids. These stands had peak aphid densities, and branch and tree mortality with a severe reduction in aphid numbers was imminent. Sampling and observations of recently infested areas have indicated that moderate and high numbers of aphids were present also when light to moderate symptoms of twig attack were evident. Therefore, releases should be made in light to moderately damaged stands for maximum chance of predator survival.

Light to moderate symptoms of twig attack were present at Steady Brook when L. erichsonii was liberated at the site in 1958 and 1959. The number of predators decreased between 1961 and 1962 as shown by window trap records for the two years. The reduction in predator numbers was associated with the decline of aphid density caused by depletion of feeding sites; partial crown mortality had increased from about two per cent to 60 per cent of the trees in one window trap area in 1962. L. erichsonii had successfully reproduced for a few years after release in a light to moderate aphid damaged stand. Its rate of dispersal was apparently too low for it to become established in the more rapidly advancing aphid population.

L. erichsonii appears to be an inefficient predator of aphids feeding on branches. Balsam fir trees flowered in 1962 and several L. erichsonii larvae were found feeding on aphids that were among

the flowers. Aphid numbers are high at only the nodes in non-flowering years. Only one larva was found on several branch samples collected during the non-flowering years of 1960 and 1961. The aphids among the flower buds and cups are essentially exposed and probably more readily detected by L. erichsonii adults than the aphids under the bud scales at the nodes. Clark and Brown (6) have reported that the larvae of L. erichsonii move slowly, pass close to egg masses without apparently perceiving the prey, and appear to search at random. These behaviour patterns were apparently suitable for predation on the tree stem where there is a low ratio of bark surface to stem volume and the time used in retracing area searched, inherent in random searching, is at a minimum. The high ratio of bark surface to twig volume and the ramifying pattern of branches would decrease the efficiency of a random-searching predator by increasing the time required for searching.

There are indications that L. erichsonii liberations have been made too late in the season to allow time for egg-laying and larval development before the spring aphid generation was completed. A few first and second instar L. erichsonii larvae were found at Pynns Brook in 1962 after releases on May 18 and 25. The young larvae were found at the same time as last instar larvae nearing pupation were found at the Steady Brook release site. Six adult L. erichsonii were observed on the sunny southwest side of a balsam fir tree stem

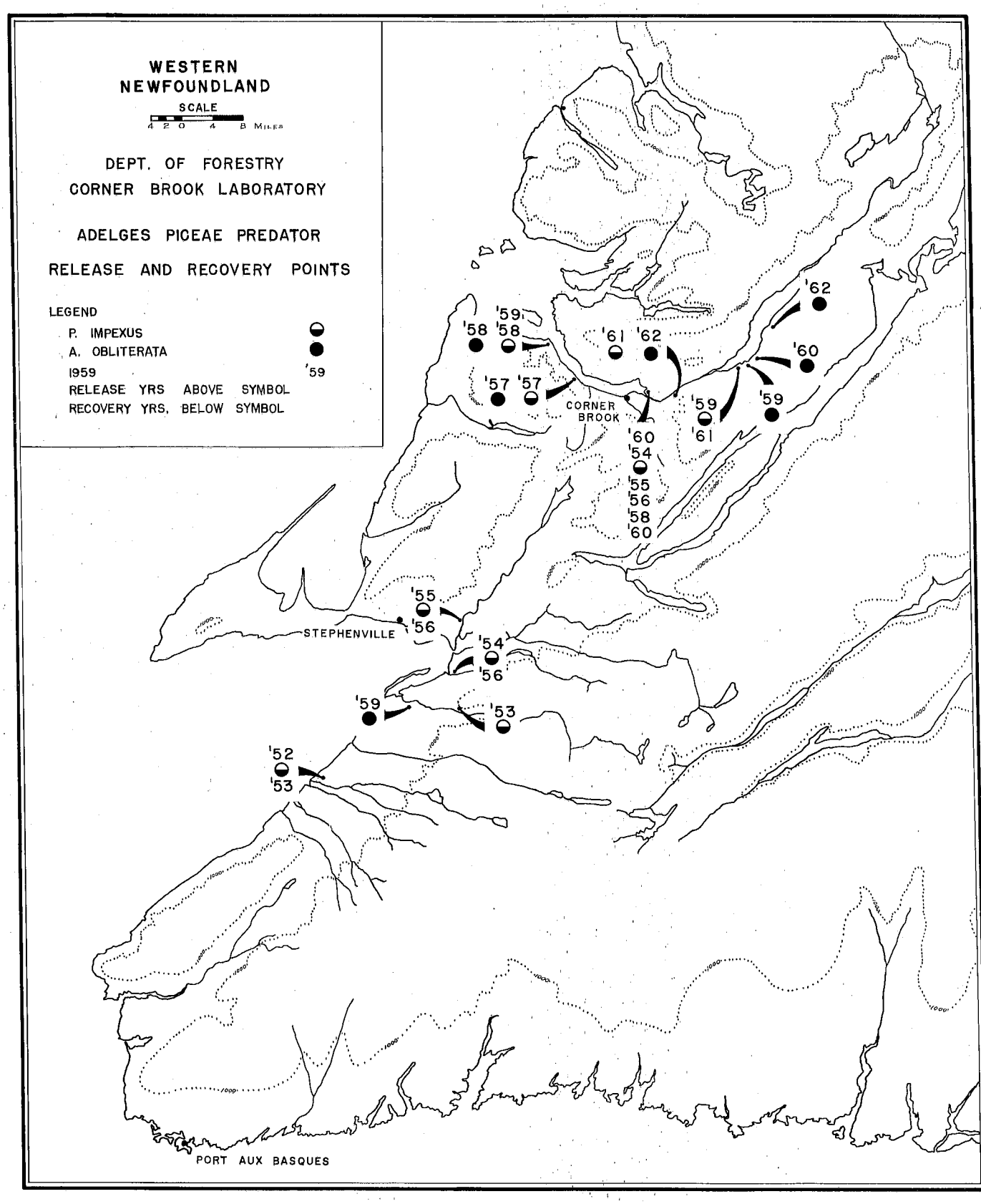
on April 29, 1960. Two of the adults were mating. Snow was still present on the ground except for a one-foot wide area around the bases of the trees. About 40 per cent of the aphids had commenced feeding and the remainder were dormant. L. erichsonii adults should be released when about 50 per cent of the overwintered neosistentes have broken diapause or when about 60 per cent of the forest floor remains covered with snow.

Several attempts were made to rear field-collected L. erichsonii larvae in the laboratory but none was successful. In the lantern globes the larvae lost the adhering aphid wool, appeared moist, maintained a U- or J-shaped position, and did not attempt to keep a foothold on the branch or stem bearing the aphids. The larvae generally became dessicated when placed in plastic rearing boxes. The failure to rear L. erichsonii larvae in the laboratory occurred possibly through inadequate ventilation of the rearing containers. The atmosphere in the plastic boxes was moistened only through transpiration of the plant tissue. The lantern globes were supplied with moist sand in the bottom, but this was apparently too wet and stagnant.

Pullus impexus Muls. (Coleop.: Coccinellidae)

A total of 20,208 Pullus impexus Muls. adults have been released in nine areas (Figure 4) in Newfoundland since 1952(Table 1).

Figure 4: Release and Recovery Points of *Pullus impexus* and *Aphidecta obliterata* in Newfoundland


WESTERN
NEWFOUNDLAND
SCALE
4 2 0 4 8 Miles
DEPT. OF FORESTRY
CORNER BROOK LABORATORY
ADELGES PICEAE PREDATOR
RELEASE AND RECOVERY POINTS
LEGEND
P. IMPEXUS
A. OBLITERATA
1959
'59
RELEASE YRS ABOVE SYMBOL
RECOVERY YRS. BELOW SYMBOL
'62
'59
'58 '58
'61 '62
'60
'57 '57
CORNER BROOK
'59 '59
'61
'60
'54
'55
'56
'58
'60
'55
'56
STEPHENVILLE
'54
'56
'59
'53
'52
'53
PORT AUX BASQUES

The details of each liberation are given in Table 2. The beetles were released freely in stands that showed moderate to severe symptoms of attack and had moderate and high numbers of aphids. Shipment 59-19 was liberated in a spot of four trees that had moderate numbers of aphids on the branches, negligible numbers on the stems, and light to moderate symptoms of aphid attack were visible in the crowns.

Recoveries have been made in five of the release areas (Table 3). The capture records for Wild Cove Point (Corner Brook, Table 3) showed a decline in predator numbers from 21 adults in 1955, to 29 larvae in 1956, to 4 larvae in 1958, and 1 larva in 1960. The same three trees were examined in each year with cursory inspections of other trees in the locality. Aphid numbers decreased during the same period because of a depletion of feeding sites, but the density had increased to moderate and high levels 0.25 miles southwest of the release site. No P. impexus were found in the new area. The greatest spread of the species was only about 500 feet recorded at Wild Cove Point. Six larvae from South Brook were successfully reared to the adult stage on aphid infested twigs enclosed in plastic boxes.

Delucchi (12) obtained 100 per cent survival of P. impexus eggs held at -12° C. (11° F.) for three weeks in the laboratory, then placed in the field for the remainder of the winter. There was 95 per cent survival of eggs held at -12°, -25° (-13°F.) and

-12° C. for three consecutive weeks and 97 per cent survival for eggs kept in the field which had a minimum recorded temperature of -9° C. (16° F.). Clark and Brown (8) stated, "In Europe studies have shown that it (P. impexus egg) is apparently unable to survive temperatures lower than -15° C. (5° F.) ....". They (11) referred to Delucchi's results and concluded that low winter temperatures probably cause a high egg mortality in New Brunswick since temperatures are considerably lower and as low as -20° to -32° F.

Low winter temperatures cannot be accepted as a consistent limiting factor of P. impexus in Newfoundland when local winter temperatures are compared with Delucchi's results. The lowest temperature recorded at Corner Brook each year since 1960 was -2°, -22°, -15°, and -6° F. The low temperatures rarely lasted for a period longer than three nights.

The reasons for the failure of P. impexus in Newfoundland are unknown. Many of the introductions probably failed because the releases were made in decadent stands; similar reasons were given for L. erichsonii. Essentially the predator was able to reproduce for a few years in the immediate area of release, but it was unable to increase in numbers to reduce aphid numbers so that tree decadence did not occur, and to disperse to other locations where high numbers of aphids occur.

Other Coccinellidae

In 1960, 7,004 Scymnus pumilio (Ws.) (flavifrons (Blkb.) adults were released at Corner Brook and 2,683 adults at Gillams on the Humber Arm (Table 2). Part of the former number was confined in a 14-mesh screen cage on the stem of a heavily infested tree. Adults were present three days later but were seen crawling through the screen. Neither adults nor progeny were found at either release site two weeks after liberation. The infestation was well advanced and severe symptoms of attack were evident at Wild Cove Point; light symptoms of aphid attack on a few trees were evident at the Gillams release site.

Aphidecta obliterata L. has been liberated in low aphid population levels in old infestation areas (shipment 58-53, 59-41, Table 2), in aphid populations with declining numbers (shipments 57-33, 62-70), and in areas of increasing aphid densities where symptoms of attack were becoming apparent. The number of adults liberated in each of the above conditions was 569, 359, and 1,625 respectively. Neither the released adults nor their progeny have ever been recovered. The release areas of A. obliterata are shown in Figure 4. The causes for the non-success of A. obliterata in Newfoundland are unknown. Eickhorn (15) reported that this predator was the most widespread and effective predator on Adelges on branches of Abies spp. in Europe; it has

not become established in Newfoundland on either the branches or stems.

Several species of Coccinellidae from India and Pakistan were received in 1960 and released in stands with various degrees of aphid infestation. No recoveries have been made of any of the species. The release sites and origin of 33 Adalia tetraspilota Hope, 159 A. luteopicta Muls., 32 Ballia eucharis Muls., 88 Harmonia breiti Mader, 110 Exochomus lituratus Gorh., and 3,065 E. uropygialis Muls. are given in Table 2. About 100 adults of 1,250 E. uropygialis in shipment #60-66 were placed in a branch cage, and on May 2, 1961, dead adults and no progeny were found on the enclosed branch. Thirty-one adults of A. luteopicta were confined in a branch cage and no progeny were found during four inspections in a two-month period. The remaining predators were released freely around the stem or in the crowns of aphid-infested trees.

Sixty-seven Adalia ronina Lewis adults (Table 2) were placed in a branch cage on a tree at Deer Lake. Neither adults nor progeny were found on the enclosed branch during two inspections within 30 days following the release.

Leucopis obscura Hal. (Dipt.: Chamaemyiidae)

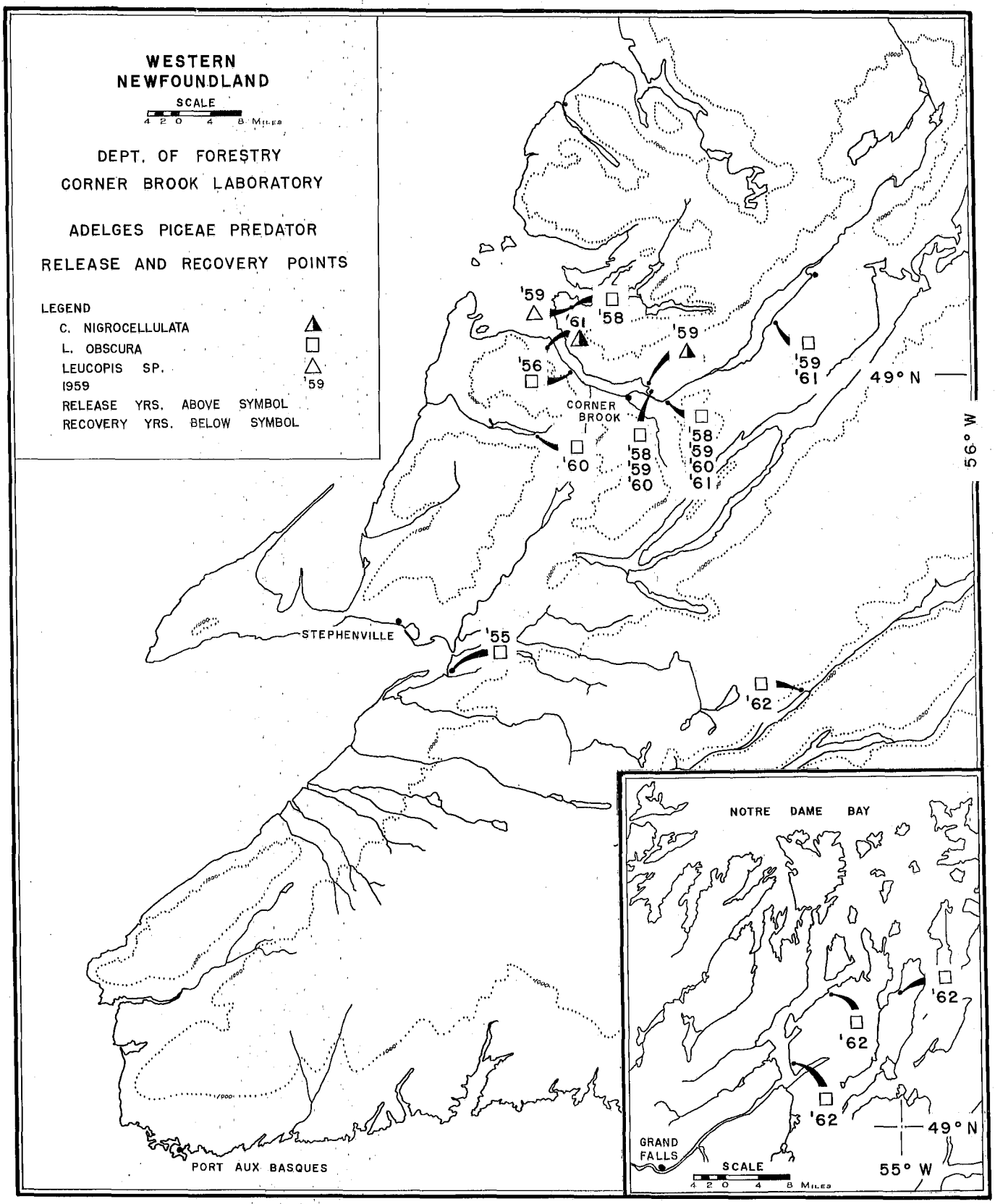
Two shipments of 2 and 19 Leucopis obscura Hal. adults were

released at Little Barachois Brook (St. George's) in 1955 (Table 2); no recoveries have been made in the area. A total of 342 adults was liberated in the Humber Arm area (Figure 5) in 1956; ninety-eight of these, progeny of introductions from England, were collected in New Brunswick.

L. obscura has been found throughout the Humber Valley, in the new infestations at Lloyds Lake, and in the Grand Falls area (Figure 5). The recovery data in Table 3 show that after two years the species was recovered at Steady Brook (Humber area), 13 miles from the nearest release site, at South Brook in 1959, 22 miles distant, and at Pynns Brook in 1962, 27 miles away. Larvae and pupae were found on samples from the Grand Falls and Lloyds Lake areas in 1962. The former area was 127 miles from the nearest release site, and the Lloyds Lake site was 42 miles west of the Little Barachois Brook release centre. The larvae and pupae were determined by the author on the bases of larval, puparial, and buccopharyngeal armature descriptions given by Brown and Clark (2); the Lloyds Lake samples included nine old puparia which were also used for species identification. The data showed that the predator dispersed at approximate rates of 5 miles per year in the Humber Valley and probably 6 miles per year to Lloyds Lake.

L. obscura has dispersed over a large part of the aphid-infested area in western Newfoundland and has apparently replaced

Figure 5: Release and Recovery Points of *Leucopis obscura*, *Leucopis* sp., and *Cremifania nigrocellulata* in Newfoundland


WESTERN
NEWFOUNDLAND
SCALE
4 2 0 4 8 Miles
DEPT. OF FORESTRY
CORNER BROOK LABORATORY
ADELGES PICEAE PREDATOR
RELEASE AND RECOVERY POINTS
LEGEND
C. NIGROCELLULATA
L. OBSCURA
LEUCOPIS SP.
1959
RELEASE YRS. ABOVE SYMBOL
RECOVERY YRS. BELOW SYMBOL
'59
'61
'58
'59
'56
'59
'61
49° N
CORNER BROOK
'60
'58
'59
'60
'58
'59
'60
'61
56° W
STEPHENVILLE
'55
'62
PORT AUX BASQUES
NOTRE DAME BAY
'62
'62
'62
49° N
GRAND FALLS
SCALE
4 2 0 4 8 Miles
55° W

the native predator, Leucopina americana Mall. In 1956, 286 L. americana were found on a heavily aphid-infested tree stem near Corner Brook; 286 L. obscura and only one L. americana were found in the same area in 1959. Although the introduced species has become established, it has not regulated aphid populations at low levels as indicated by the continuing spread of aphid damage to balsam fir stands. The predator has been found in large numbers on severely infested tree stems where it has caused a high aphid mortality with subsequent reduction of the second aphid generation. These apparently good results have only developed after the trees have been severely damaged by two to three generations of high numbers of aphids. L. obscura was regularly found on branches, but its distribution was too erratic and at times too sparse to reduce effectively the aphid numbers.

Balch (1) has stated that L. obscura has not given adequate control in New Brunswick because (a) the predator feeds mainly on adults that have already laid a large number of eggs, (b) it becomes numerous only on heavily infested trees, (c) it has poor searching ability to be effective on lightly infested trees, and (d) it probably maintains itself on the surplus aphid population. Observations to date suggest that these reasons are applicable to Newfoundland populations of the predator.

Other Chamaemyiidae

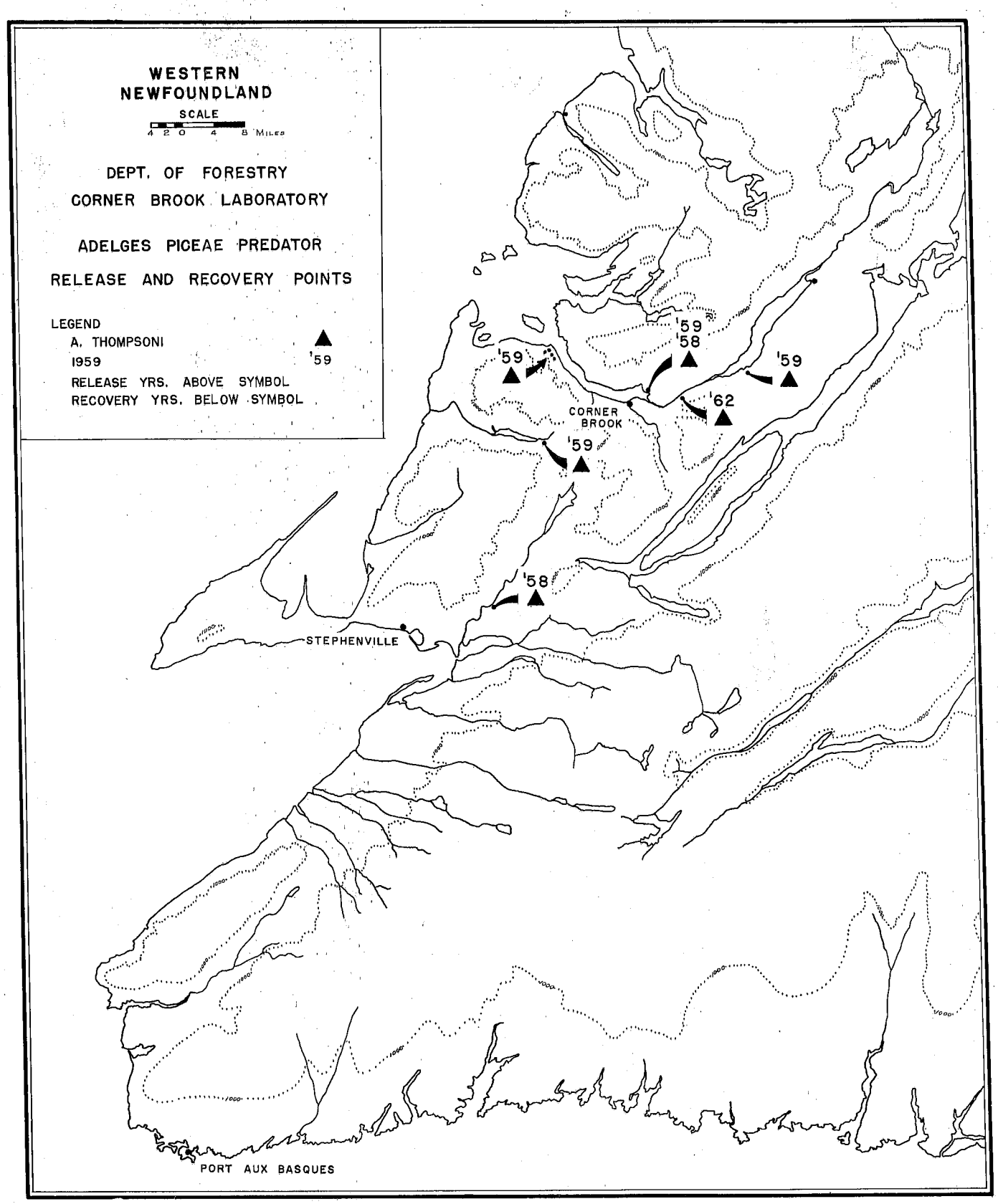
A total of 215 Cremifania nigrocellulata Cz. has been liberated in Newfoundland (Table 2, Figure 5); 198 were confined within a cage on the stem of a tree at Corner Brook in 1959. The remainder were released freely at Frenchman's Cove in 1961. Several larvae and pupae were found at the 1959 site two months after the release. Five puparia were taken to the laboratory for rearing, but no adults emerged. No recoveries were made in the following years.

In September, 1959, 160 adult Leucopis sp. were liberated on the stem and in the crown of a tree bearing light to moderate numbers of aphids. No progeny was seen in 1959 or recoveries made in 1960.

Aphidoletes thompsoni Moehn. (Dipt.: Cecidomyiidae)

Aphidoletes thompsoni Moehn. was first released in 1958 at Corner Brook and Stephenville (Table 2). In 1959, 29,076 adults were liberated in the Humber area, and 270 were released in 1962 at Steady Brook (Figure 6). Two adults from the 1961 cloth-and-wood emergence traps at Frenchman's Cove have been identified as A. thompsoni by J. R. Vockeroth, Canada Department of Agriculture, Systematics Unit, Ottawa. Several pink larvae were found on branch samples in 1959 from the Frenchman's Cove area. None of the larvae was seen feeding on aphids, and when transferred to

Figure 6: Release and Recovery Points of *Aphidoletes thompsoni* in Newfoundland


WESTERN
NEWFOUNDLAND
SCALE
4 2 0 4 8 MILES
DEPT. OF FORESTRY
CORNER BROOK LABORATORY
ADELGES PICEAE PREDATOR
RELEASE AND RECOVERY POINTS
LEGEND
A. THOMPSONI
1959
'59
RELEASE YRS. ABOVE SYMBOL
RECOVERY YRS. BELOW SYMBOL
'59
'58
'59
'59
'62
CORNER BROOK
'59
'58
STEPHENVILLE
PORT AUX BASQUES

an infested twig in a plastic rearing box, they tended to roll off and did not attempt to maintain a foothold on the bark surface.

NATIVE PREDATORS

Tetraphleps canadensis Prov. (Hemip.: Anthocoridae)

Only the adult and last two nymphal stages of Tetraphleps canadensis Prov. (see Kelton & Anderson (13) for synonymy of americana) have been found. The adult overwinters and a few have been seen ascending tree stems in the latter half of May. Egg laying probably occurred during May and late stadia nymphs became evident about the middle of June. It is unknown if the adults seen during the latter half of June belong to two successive generations. During weekly branch sampling for aphid development studies in 1961 and 1962, T. canadensis was most abundant during the last half of June and the first week of July, found occasionally during the remainder of July and infrequently in August and part of September. The period of abundance coincides with the dormant neosistens period of the aphid.

T. canadensis nymphs and adults move rapidly over the twig axes and continually probe into crevices and needle axils in search of prey. The predator probes with its proboscis in a posteroventral direction. A few that were kept in plastic rearing boxes were seen probing with the proboscis directed anteriorly. Upon contact with a prey, the bug pressed the

proboscis against it slightly one to several times. One adult, in a period of two minutes and twenty-five seconds, attempted piercing two neosistentes through the dorsum and failed after several attempts. In one instance, an adult T. canadensis came into contact with a neosistens but continued searching without giving any indication of having perceived the host. Another adult was observed probing at a neosistens and had completed feeding in 20 seconds. A fourth adult was seen commencing to insert its stylets into a third instar aphid; the feeding schedule of the predator is summarized below.

Elapsed time (minutes)	Remarks
0	Discovery of prey
0.25	Disturbed by another T. canadensis, fought it off, then relocated host.
?	Disturbed four more times, did not exsert stylets.
5.83	Collapsed body of host then inflated it with a colourless fluid.
6.33	Host recollapsed and predator exserted stylets.

The predator has been seen preying on the feeding neosistens, intermediate, adult, and egg stages of the aphid. There were indications in aphid mortality studies that the dormant neosistentes were preyed upon.

Aphid mortality due to T. canadensis was easily discernible for neosistentes but not for the intermediate and adult stages.

The exoskeletons of intermediates and adults were lightly sclerotized and could not be perceived because of the extreme transparency. Neosistens mortality from the bug was easily determined since aside from the exoskeleton being left attached to the bark by the stylets, the aphid was completely eviscerated and the sclerotization gave a translucent appearance to the exoskeleton. A total of 322 translucent neosistentes was present at the end of two T. canadensis rearing periods that started with 487 living neosistentes (Table 11). The check twigs bore two translucent exoskeletons out of an initial total of 92 living neosistentes; the error in initial examination of the aphid infested twigs was less than 3 per cent.

Late stage nymphs, presumably third and fourth stadia, and adults of T. canadensis were easily reared in plastic boxes, and in the individual rearings two adults survived for over thirteen days on a diet of neosistentes (Figure 7). Among the seventeen predators, seven did not survive and eleven completed one ecdysis, one completed two, and another died in the exuviae of its second moult. These data indicate that T. canadensis will survive and moult to subsequent instars while feeding on dormant and feeding neosistentes. Data were not obtained on predator success on other stages of A. piceae or other hosts. The predators alive at the end of 318 hours consumed an average of 11.5 ± 3.0

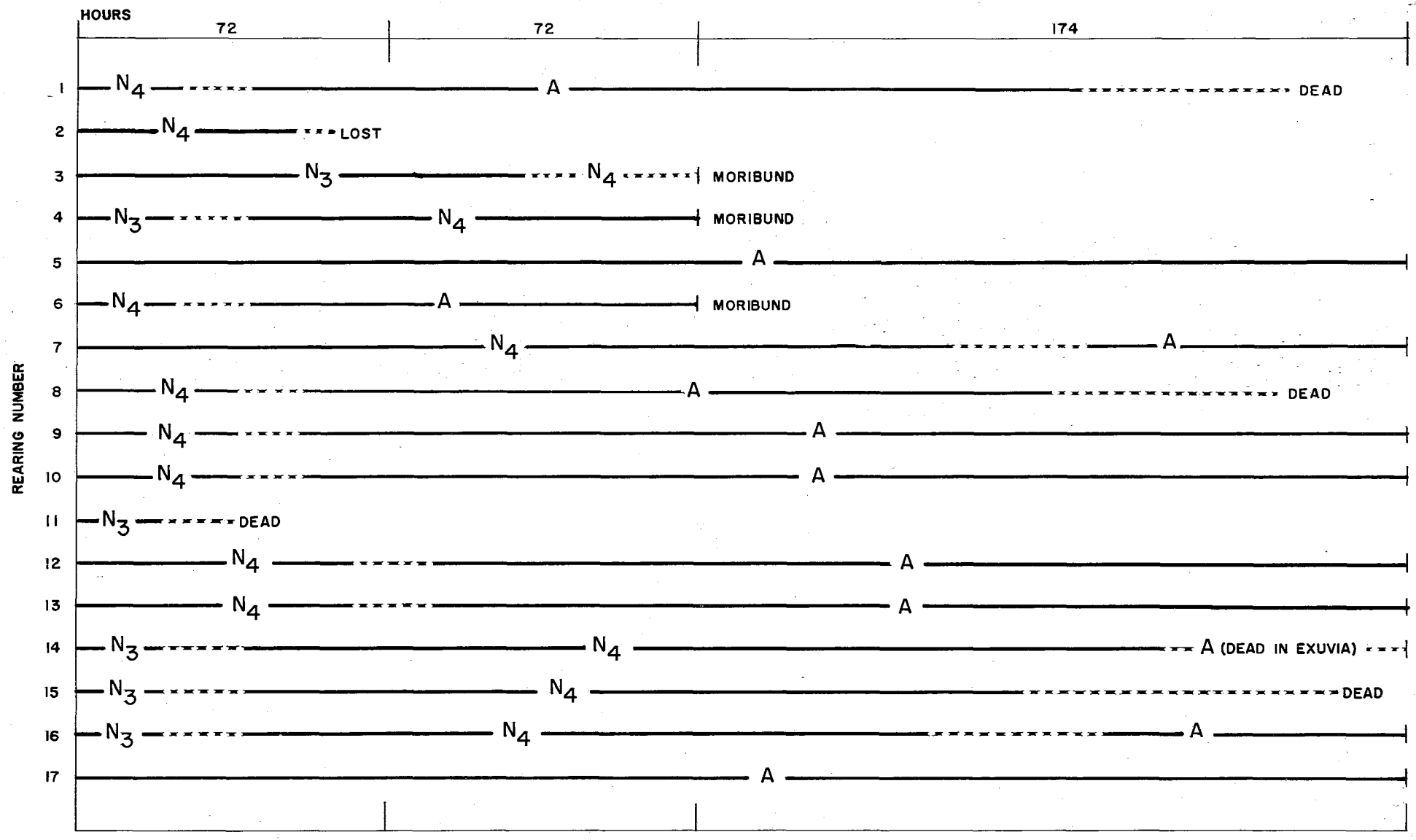


FIGURE 7

CONDITION OF REARED T. AMERICANA. SOLID LINE IS STATUS AS DESIGNATED; BROKEN LINE IS CHANGE OF STATUS. N IS NYMPH AND SUBSCRIPT NYMPHAL STADIUM; A IS ADULT.

neosistentes every 100 hours (Table 12, column 8 except numbers 1, 8 and 15). The data were inadequate to ascertain if the feeding rate increased before (predators 6, 12, 13, 14, 15, and 16) or after (predators 1, 9, 10, and 12) ecdysis.

There were 179 neosistentes, 48 intermediates and 4 adults of A. piceae on the nine branch samples collected for determining neosistens mortality caused by T. canadensis. The neosistens mortality caused by the predator on all samples was 27.6 per cent and averaged 21.8 ± 13.0 per sample (Table 13). The mortality data were affected probably by the intermediate and adult forms which were not included. The #1 nodes and internodes had only neosistentes and the mortality in each site was 75 and 41.7 per cent respectively (Table 14). The neosistens mortality was only 21.4 per cent at the #2 nodes which contained 52 intermediates and adults in a total of 224 living aphids. The decrease in per cent neosistens mortality towards the base of the branches may be due to (1) T. canadensis feeding on the larger aphid stages at the older sites, (2) T. canadensis having a higher searching ability at the branch tips, or (3) a bias in calculations caused by the low number of aphids at the branch extremities.

Although Tetraphleps canadensis was fairly common in most aphid infested areas, it alone has not shown an ability to reduce aphid density. It is the only native predator that has been

found consistently on samples from the Humber Valley, Grand Falls and Lloyds Lake areas.

Other Native Predators

Leucopina americana (Mall.) Dipt.: Chamaemyiidae) were often found in large numbers on stem infestations of aphids up to 1956 (Table 15). In 1958 and 1959, only 15 larvae and pupae were obtained in the Humber area. No recoveries of this species have been made in subsequent years. Synonymous with the decrease in L. americana (Table 15) has been the increase of Leucopis obscura (Table 3; see also pages 22 and 23).

Hemerobiidae (Neuroptera) have been found occasionally feeding on the balsam woolly aphid. Three first instar larvae were found at Steady Brook (Humber area) in early spring of 1959. One adult Hemerobius stigmaterus Fitch has been collected on branch samples from the same area in each year from 1958 to 1960 inclusive. One Chrysopidae pupa was obtained on July 18, 1960, on a branch sample and the adult emerged in the laboratory rearing room on July 30.

A few mites were seen on aphid infested tree stems during 1959 and 1960 at Corner Brook. They were not observed feeding on aphids.

CONTROL BY COMPETITION

The purpose of balsam woolly aphid control is to reduce the effect of the aphid on the host tree or to reduce the numbers of

aphids so that the tree is not seriously damaged. Throughout Mesnil's report (14) there is a suggestion that nusslini does not cause serious damage to its host trees. If this is true, then Eickhorn's program should be intensified with the object of introducing nusslini as a competitive control agent of piceae. The comments of Dr. Pschorn-Walcher to Dr. W. J. Carroll in Newfoundland in 1957 do not fully support the innocuous nature of nusslini. Pschorn-Walcher named nusslini as the Adelges pest when he saw the stands of damaged balsam fir in the Province. Pschorn-Walcher and Zwoelfer (17) stated that "D. nusslini typica occurs ... on all parts of young firs, preferably on their branches and twigs. As is commonly known, it causes severe damage there". The damage caused by D. nusslini schneideri (stem form) was not recorded. A. nusslini is apparently a pest of Abies spp. and not a harmless Adelges species as intimated by Mesnil (14).

REFERENCES

1. Balch, R.E. Studies of the Balsam Woolly Aphid, Adelges piceae and its Effects on Balsam Fir, Abies balsamea (L.) Mill. Canada Dept. of Agric. Publ. #867, 1952.

2. Brown, N.R. and R.C. Clark. Studies of Predators of the Balsam Woolly Aphid Adelges piceae (Ratz.) (Homop.: Adelgidae) 1. Field Identification of Neoleucopis obscura (Hal.), Leucopina americana (Mall.) and Cremifania nigrocellulata Cz. (Dipt.: Chamaemyiidae). Can. Ent. 88(6): 272-279, June, 1956.

3. Bryant, D.G. Studies of Adelges piceae (Ratz.) in Newfoundland. 1958 Interim Report, Forest Biology Laboratory, Corner Brook, Canada Dept. of Agric., April 1959 (unpublished).

4. Carroll, W.J. and D.G. Bryant. A Review of the Balsam Woolly Aphid in Newfoundland. For. Chron. 36(3): 278-290, Sept. 1960.

5. Chapman, J.A. & J.M. Kinghorn. Window Flight Traps for Insects. Can. Ent. 87: 46-47, 1955.

6. Clark, R.C. & N.R. Brown. Studies of Predators of the Balsam Woolly Aphid, Adelges piceae (Ratz.) (Homop.:Adelgidae) V. Laricobius erichsonii Rosen. (Coleop.:Derodontidae), an Introduced Predator in Eastern Canada. Can. Ent. 90(11): 657-672, Nov. 1958.

7. Clark, R.C. and N.R. Brown. A Field Cage for Rearing Syrphid Larvae and other Predators of the Balsam Woolly Aphid, Adelges piceae (Ratz.) (Homop.: Adelgidae) Can. Ent. 91(11): 723-725, 1959.

8. Clark, R.C. and N.R. Brown. Predator Introductions for Balsam Woolly Aphid Control. In Canada Dept. Agric., For. Biology Div., Bi-monthly Prog. Rept. 15(6), 1959.

9. Clark, R.C. and N.R. Brown. Studies on Adelges piceae (Ratz.) and its Predators. Interim Rpt. 1959-1, For. Biol. Lab., Fredericton, N.B., Can. Dept. of Agric., March 1960.

10. Clark, R.C. and N.R. Brown. Studies of Predators of the Balsam Woolly Aphid, Adelges piceae (Ratz.) (Homop.: Adelgidae) VII. Laricobius rubidus Lec. (Coleop.: Derodontidae), a Predator of Pineus strobi (Htg.) Homop.: Adelgidae) Can. Ent. 92(3): 237-240, 1960.

11. Clark, R.C. and N.R. Brown. Studies on Adelges piceae (Ratz.) and its Predators. Interim Rpt. 1960-1, For. Biol. Lab., Fredericton, N.B., Dept. of Forestry, March, 1961.

12. Delucchi, V. Pullus impexus (Muls.) (Coleop.: Coccinellidae) A Predator of Adelges piceae (Ratz.) (Hemip.:Adelgidae) with Notes on its Parasites. Bull. of Ent. Res. 45(2): 243-278, June, 1954.

13. Kelton, L.A. and N.H. Anderson. New Anthocoridae from North America with Notes on the Status of Some Genera and Species (Heteroptera). Can. Ent. 94(12): 1302-1309, Dec. 1962.

14. Mesnil, L.P. Commonwealth Inst. of Biol. Control Progress Report #20 (Season 1961-62) Feb. 6, 1962 (unpublished).

15. Mesnil, L.P. Commonwealth Inst. of Biol. Control Progress Report #7 (Season 1962-63) July 5, 1962. Delemont (unpublished).

16. Nicholls, C.F. A Roll-up Field Cage for Insects. Can. Ent. 92(3): 177-178. March, 1960.

17. Pschorn-Walcher, H. and H. Zwoelfer. Preliminary Investigations on Dreyfusia (= Adelges) - Populations Living on Trunks of the White Fir. European Laboratory, Commonwealth Inst., Biol. Control, Feldmeilen, Switzerland (unpublished), 1956.

18. Reeks, W.A., W.J. Carroll and R.D. Sheppard. Forest Insects in Newfoundland in 1949. In Ann. Rept. of Nfld. For. Prot. Assn., Nov., 1949.

Appendix A

Tables 1 - 15

TABLES

TABLE 1: SPECIES AND NUMBER OF PREDATORS RELEASED ANNUALLY AGAINST ADELGES PICEAE IN NEWFOUNDLAND SINCE 1952

	1952-54	1955-57	1958	1959	1960	1961	1962	Total
L. erichsonii	3,345	5,424	8,292	3,202	8,228	1,118	9,040	38,649
P. impexus	7,410	1,354	513	9,500	1,300	131	-	20,208
A. obliterata	-	16	20	735	1,175	-	848	2,794
S. pumilio	-	1	-	-	9,686	-	-	9,686
A. tetraspilota	-	-	-	-	33	-	-	33
B. eucharis	-	-	-	-	32	-	-	32
A. luteopicta	-	-	-	-	159	-	-	159
E. uropygialis	-	-	-	-	3,065	-	-	3,065
E. lituratus	-	-	-	-	110	-	-	110
H. breiti	-	-	-	-	88	-	-	88
A. conglomerata	-	-	-	-	-	67	-	67
L. obscura	-	363	-	-	-	-	-	363
Leucopis sp.	-	-	-	160	-	-	-	160
C. nigrocellulata	-	-	-	198	-	17	-	215
A. thompsoni	-	-	120	29,076	-	-	270	29,466

TABLE 2: LIBERATION DATA OF INTRODUCED PREDATORS OF *ADELGES PICEAE* (RATZ.) IN NEWFOUNDLAND

Species	Release Yr.-No.	Source	Number Sent	Number Released	Release date	Liberation area
Laricobius erichsonii Rosen.	52- 5	?	843	843	Jun 10	Robinsons
	54-24	?	2,522	2,502	" 1	St. George's
	55-12	?	450	445	May 17	" "
	55-13	?	450	447	" "	" "
	55-14	?	450	448	" "	" "
	55-15	?	456	451	" "	" "
	55-16	?	500	500	" "	" "
	55-17	?	250	250	" "	" "
	55-28	?	500	496	Jun 1	Robinsons
	55-29	?	500	495	" "	"
	55-30	?	500	494	" "	"
	55-34	?	500	496	" 7	St. George's
	55-35	?	500	492	" "	" "
	55-36	?	300	290	" "	" "
	55-38	?	134	120	" 20	Stephenville
	58- 1	Czech.	1,000	994	May 23	Corner Brook
	58- 2	Germ.	2,312	2,270	" "	Frenchman's Cove
	58- 4	Czech.	1,799	1,310	" 24	Corner Brook
	58- 5	Germ.	999	958	" "	" "
	58-11	"	1,396	1,255	" 28	St. George's
	58-15	"	1,156	1,130	" 30	Steady Brook
	58-17	"	389	375	" "	" "
	59-13	Czech.	1,189	1,043	" 27	" "
	59-14	Germ.	2,317	2,159	" "	" "
	60-20	Germ.	5,500	5,300	" 18	Pynns Brook
	60-23	"	1,100	1,078	" 25	" "
	60-26	"	1,950	1,850	" 26	Corner Brook
	61- 7	Germ.	1,271	1,118	" 24	Frenchman's Cove

TABLE 2 (continued)

Species	Release Yr.-No.	Source	Number Sent	Number Released	Release date	Liberation area
Laricobius erichsonii Rosen.	62- 8	Germ.	5,223	5,071	May 18	Deer Lake
	62-13	"	2,035	1,996	" 26	Pynss Brook
	62-19	"	929	873	" 31	Deer Lake
Pullus impexus Muls.	52-12	?	1,330	1,306	Jul. 1	Robinsons
	53- 9	?	784	784	Jun 12	St. George's
	53-13	?	750	750	" 17	" "
	54-46	?	2,581	2,570	Jul 9	" "
	54-53	?	2,015	2,000	" 16	Corner Brook
	55-43	?	300	297	" 11	Stephenville
	55-44	?	300	298	" "	"
	55-45	?	300	295	" "	"
	57-32	?	464	464	" 6	Frenchman's Cove
	58-52	?	540	513	Aug 1	" "
	59-19	Germ.	6,400	6,000	Jun 11	South Brook
	59-21	"	4,090	3,500	" 12	Frenchman's Cove
	60-40	"	450	420	" 18	Wild Cove Point
	60-44	"	850	726	" 23	Corner Brook
	61-19	"	131	131	" 26	Steady Brook
Aphidecta obliterata (L.)	57-33	?	16	16	Jul 6	Frenchman's Cove
	58-33	?	24	20	Aug 1	" "
	59-30	Czech.	187	186	Jun 24	Deer Lake
	59-41	"	560	549	Jul 16	St. George's

TABLE 2 (continued)

Species	Release Yr.-No.	Source	Number Sent	Number Released	Release date	Liberation area
Aphidecta obliterata (L.)	60-19	Germ.	1,175	934	May 19	Pasadena
	62-41	Czech.	153	153	Jun 29	Steady Brook
	62-46	"	365	352	Jul 5	" "
	62-70	"	343	343	" 25	Pynns Brook
Aphidoletes thompsoni Moehn.	58-47	Czech.	82	55	Aug 14	Corner Brook
	58-47	"	70	65	" 16	Stephenville
	59- A	"	152	141	May 21	Corner Brook
	59-18	"	994	887	Jun 9	" "
	59-22	"	332	309	" 12	Frenchman's Cove
	59-24	"	1,122	1,045	" 16	" "
	59-29	"	794	742	" 18	Deer Lake
	59-45	Germ.	5,127	3,091	Jul 21	Frenchman's Cove
	59-47	"	5,004	2,571	" 22	" "
	59-52	"	7,792	4,888	" 24	" "
	59-56	"	11,263	8,580	" 28	" "
	59-58	"	8,581	6,538	" 29	Corner Brook
	59-64	"	458	284	Aug 11	" "
	62-71	Germ.	325	270	Jul 25	Steady Brook
Leucopis obscura (Hal.)	55-33	?	4	2	Jun 7	St. George's
	55-62	?	27	19	Jul 26	" "
	56- 8	?	55	55	Jun 12	Frenchman's Cove
	56-14	?	193	189	" 15	Corner Brook
	F-56- 1	NB,Can.	149	98	Aug 5	" "
Cremifania nigrocellulata Cz.	59-65	Germ.	216	198	Aug. 11	" "
	61- 8	"	39	17	May 24	Frenchman's Cove

TABLE 2 (continued)

Species	Release Yr.-No.	Source	Number Sent	Number Released	Release date	Liberation area
Leucopis sp.	59-79	Germ.	174	160	Sep 3	McIvers
Scymnus pumilio (Ws.)	60-28	Australia	4,300	4,042	Jun 1	Corner Brook
	60-31	"	2,000	1,973	" 8	" "
	60-35	"	2,700	2,683	" 15	" "
	60-43	"	1,000	939	" 23	" "
Adalia tetraspilota (Hope)	60-32	India	19	19	" 8	" "
	60-59	"	15	14	Aug 10	" "
Ballia eucharis Muls.	60-34	"	33	32	Jun 9	" "
Adalia luteopicta Muls.	60-48	"	31	31	Jul 7	Steady Brook
	60-71	"	63	63	Sep 3	" "
	60-73	"	65	65	" 9	" "
Exochomus uropygialis Muls.	60-49	"	50	49	Jul 7	" "
	60-58	"	36	35	Aug 3	" "
	60-63	"	52	52	" 17	Frenchman's Cove
	60-66	Pakistan	1,292	1,250	" 25	" "
	60-67	India	93	90	" 29	Steady Brook
	60-70	Pakistan	1,761	1,589	Sep. 3	Frenchman's Cove
Exochomus lituratus Gorh.	60-68	Pakistan	113	110	Aug. 26	" "
Harmonia breiti Mader	60-69	"	90	88	" "	" "
Adalia conglomerata	61-37	Japan	74	67	Jul 14	Deer Lake

TABLE 3: BALSAM WOOLLY APHID PREDATOR RECOVERIES IN NEWFOUNDLAND

(A, adult; L, larva; P, pupa)

Species	Recovery Date	Stage	No.	Site	Spread Miles	Latest release year
L. erichsonii	? ? 53	L	1	Robinsons	0	1952
	21 Jun 58	A	1	Steady Brook	0	1958
	23 " 58					
	29 " 58					
	10 Jul 58	L	4	" "	0	1958
	11 " 58	L	4	John's Beach	0	1958
	14 " 58	L	1	Steady Brook	0	1958
	18 " 58					
	25 May 59	A	1	Corner Brook	0	1958
	27 Aug 59	A	2	" "	0.1	1958
	29 Apr 60	A	6	Steady Brook	0	1959
	16 May 60	A	1	" "	0	1959
	11 Jun 60	P	1	Corner Brook	0	1960
	6 " 61	L	1	Steady Brook	0.1	1960
	14 " 61	L	10	" "	"	1960
	17 " 61	L	113	" "	"	1960
	17 " 61	A	1	" "	"	1960
	1961 (see table 4 for others)					
	27 Jul 61	A	2	Steady Brook	0.25	1960
	2 Aug 61	A	1	" "	0.25	1960
	15 May 62	A	5	Corner Brook to Steady Brook	0 to 1.50	1960
	6 Jun 62	A	2	Steady Brook	0.90	1960
	27 Aug 62	A	1	" "	0.25	1960
P. impexus	? ? 53	L	6	Robinsons	0	1952
	? ? 53	P	3	"	0	1952
	10 Aug 55	A	21	Corner Brook	0.1	1954
	10 Jun 56	L	29	" "	0.1	1954
	17 " 56	L	2	Barachois Brook	0.02	1954
	17 " 56	L	2	Stephenville	0	1955
	4 " 58	L	4	Corner Brook	0.1	1954
	11 Jul 60	L	1	" "	0.1	1954
	17 Jun 61	L	10	South Brook	0	1959
L. obscura	? ? 58	L	5	Corner Brook	8.0	1956
	5 Sep 58	L	6	" "	8.0	1956
	18 " 58	L	3	" "	8.0	1956
	? ? 58	L	5	" "	8.0	1956
	23 Jun 58	P	1	" "	8.0	1956

TABLE 3 (continued)

Species	Recovery Date	Stage	No.	Site	Spread Miles	Latest release year
L. obscura	28 Aug 58	P	1	McIvers	2.0	1956
	2 Sep 58	P	1	Corner Brook	8.0	"
	5 " 58	P	3	" "	8.0	"
	5 " 58	E	6	" "	8.0	"
	15 " 58	P	3	" "	8.0	"
	17 " 58	L	3	Steady Brook	13.0	"
	17 " 58	P	1	" "	13.0	"
	18 " 58	P	1	Corner Brook	8.0	"
	18 " 58	L	3	" "	8.0	"
	21 May 59	L	1	" "	8.0	"
	25 " 59	L	14	South Brook	22.0	"
	24 Jun 59	A	1	Corner Brook	8.0	"
	6 Jul 59	A	2	" "	8.0	"
	6 " 59	P	3	" "	8.0	"
	29 Sep 59	L	127	" "	8.0	"
	29 " 59	P	151	" "	8.0	"
	12 Oct 59	P	2	" "	8.0	"
	10 Nov 59	P	1	Steady Brook	13.0	"
	23 Apr 60	?	2	Corner Brook	8.0	"
	29 " 60	L	1	" "	8.0	"
	13 May 60	P	1	Steady Brook	13.0	"
	30 Jun 60	P	1	Frenchman's Cove	5.0	"
	11 Jul 60	L	72	Corner Brook	8.0	"
	11 " 60	P	3	" "	8.0	"
	12 Aug 60	L	5	Frenchman's Cove	4.0	"
	8 May 61	P	30			"
	2 Aug 61	L	5			"
	2 " 61	P	1			"
	16 Aug 61	L	4	Steady Brook and South Brook	13.0 and 22.0	"
	22 " 61	L	7			"
	22 " 61	P	2			"
	28 " 61	L	9			"
	28 " 61	P	2			"
	11 Sep 61	A	1			"
	20 " 61	L	1	South Brook	22.0	"
	28 May 62	P	2			"
	11 Jun 62	L	2			"
	18 " 62	P	6			"
	25 " 62	L	1	Pynn's Brook	27.0	"
	25 " 62	P	7			"
	30 " 62	P	5			"
	16 Jul 62	L	2			"

TABLE 3 (continued)

Species	Recovery Date	Stage	No.	Site	Spread Miles	Latest release year
L. obscura	16 Jul 62	P	7			1956
	30 " 62	L	1			"
	9 Aug 62	L	4			"
	9 " 62	P	1	Pynn's Brook	27.0	"
	20 " 62	L	3			"
	29 " 62	L	4			"
	11 Sep 62	L	1			"
	20 " 62	L	4			"
	20 " 62	P	2			"
	11 Jul 62	L	1	Lloyds Lake	42.0	1955
	11 " 62	P	1	" "	42.0	"
	29 Sep 62	L	21	Norris Arm	127.0	1956
	29 " 62	P	1	" "	"	"
	1 Oct 62	L	1	" "	"	"
	1 " 62	P	1	" "	"	"

TABLE 4: WINDOW TRAP CAPTURES OF L. ERICHSONII ADULTS IN THE HUMBER VALLEY, JULY 19 - SEPT. 27, 1961. (NO ADULTS WERE CAUGHT AFTER AUGUST 31

Trap sites	Date							
	July	August						
	19-31	1-7	8-14	15-21		22-28		29-31
West and East of release site	Days interval							
	13	7	7	3	4	3	4	3
0.75 miles West #1	0	0	0	0	0	0	0	0
#2	0	0	0	0	-	-	-	-
Steady Brook Release Site	0	0	2	0	0	2	0	0
0.25 miles East #1	0	9	11	2	1	1	0	0
#2	2	5	9	0	0	0	0	1
0.50 miles East	-	-	-	2	0	4	0	1
0.90 " "	-	-	-	0	0	0	0	0
1.65 " "	-	-	-	1	1	0	0	0
2.65 " "	-	-	-	-	0	0	0	0
8.05 " "	-	-	-	0	0	0	0	0
9.55 " "	-	-	-	0	0	0	0	0

TABLE 5: A. THOMPSONI MORTALITY RELATIVE TO ELAPSED TIME FROM ADULT EMERGENCE TO RELEASE IN SHIPMENTS 59-45, 52, 56, and 58

Number of predators shipped	Number of boxes	Elapsed time	Average mortality/box
3,139	5	4 days	30.1 ± 21.7%
9,943	13	3 "	44.3 ± 20.5%
14,915	17	2 "	20.6 ± 16.9%
4,766	6	?	31.7 ± 17.9%

TABLE 6: A. THOMPSONI MORTALITY IN THE TOP, MIDDLE AND BOTTOM MELROSE BOXES IN SEVEN SHIPPING CARTONS[1]

Box level	Predators sent	Number of boxes	Average mortality
Top	6,373	7	16.8 ± 10.9%
Middle	7,316	9[2]	29.7 ± 19.6%
Bottom	6,155	7	27.0 ± 22.2%

[1] Assumes cartons remained upright during shipping.

[2] Two cartons contained four Melrose boxes

TABLE 7: A. THOMPSONI MORTALITY FOR PREDATOR DENSITY PER MELROSE BOX IN SHIPMENTS 59-45, 52,56 AND 58

Adults per box Class	Number of boxes	Average mortality (per cent)
451 - 550	6	38.2 ± 26.5
551 - 650	7	26.7 ± 13.7
651 - 750	3	18.6 ± 14.1
751 - 850	9	44.5 ± 20.7
851 - 950	7	24.8 ± 19.8
951 -1050	6	31.6 ± 21.3
over 1050	3	10.2 ± 6.1

TABLE 8: A. THOMPSONI MORTALITY IN BOXES COLLECTED ON AND AFTER THE RELEASE DAY

Release number	Release date	Boxes collected	Shipment mortality	Interval (Days)
59- A	May 21	May 21	7.2%	0
59-22	Jun 12	Jun 12	6.9%	0
59-24	" 16	" 16	6.9%	0
59-29	" 18	" 18	6.5%	0
59-45	Jul 21	Jul 21	39.7%	0
59-58	" 29	" 29	23.8%	0
59-18	Jun 9	Jun 15	10.8%	6
59-47	Jul 22	Jul 23	48.6%	1
59-52	" 24	" 25	37.3%	1
59-56	" 28	" 30	23.8%	2
59-64	Aug 11	Aug 12	38.0%	1

TABLE 9: SEX RATIOS OF DEAD A. THOMPSONI FOR EACH SHIPMENT TO NEWFOUNDLAND IN 1959

Shipment number	Adults dead	Males per 100 females	Shipment mortality (per cent)
59 -A	11	(Returned to Belleville)	7.3
59-22	23	6	6.9
59-18	107	9	10.8
59-29	52	24	6.5
59-24	77	57	6.9
59-52	2,904	74	37.3
59-47	2,433	82	48.6
59-64	174	125	38.0
59-45	2,036	156	39.7
59-58	2,043	160	23.8
59-56	2,683	247	23.8

TABLE 10: A. THOMPSONI MORTALITY FOR 1959 SHIPMENTS RELATIVE TO COUNTRY OF ORIGIN

Source	No. of shipments	Number sent	Shipment mortality (per cent)
Czech.	5	3,394	7.7 ± 1.7
Germ.	6	38,225	35.2 ± 3.9

TABLE 11: TRANSPARENT NEOSISTENTES AT THE BEGINNING AND END OF TWO REARING PERIODS OF T. CANADENSIS PROV.

Tetraphleps canadensis	vii/19 - 22			vii/22 - 29		
	Aphid total	Translucent aphids vii/19	vii/22	Aphid total	Translucent aphids vii/22	vii/29
Present	202	0	121	285	0	201
Absent	29	0	1*	63	0	1*

* Missed during initial inspection

TABLE 12: FEEDING RATE (APHIDS EATEN PER 100 HOURS) OF T. CANADENSIS ON NEOSISTENTES OF A. PICEAE DURING THREE CONSECUTIVE PERIODS

(N, nymph; subscript, nymphal stadium; A, adult)

	First period 72 hours		Second period 72 hours		Third period 173 hours		
Predator No.	Stage	Rate	Stage	Rate	Stage	Rate	Total Rate
1	N_4 & A	7.3	A	16.7	A	9.2[1]	10.7
2	N_4	2.4[1]	-	-	-	-	-
3	N_3	5.5	N_3 & N_4	0	-	-	-
4	N_3 & N_4	5.5	N_4	0	-	-	-
5	A	16.7	A	6.9	A	6.9	9.1
6	N_4 & A	15.3	A	6.9	-	-	-
7	N_4	15.3	N_4	12.5	N_4 & A	4.6	8.8
8	N_4 & A	15.3	A	15.3	A	34.6[1]	24.6
9	N_4 & A	9.7	A	22.7	A	8.7	12.0
10	N_4 & A	5.2	A	23.6	A	12.1	13.2
11	N_3	1.7[1]	-	-	-	-	-
12	N_4	19.5	N_4 & A	2.8	A	17.3	14.5
13	N_4	19.5	A	9.7	A	2.3	7.8
14	N_3 & N_4	26.4	N_4	8.3	N_4	0	9.4
15	N3 & N_4	26.4	N_4	11.1	N_4	4.5[1]	11.9
16	N_3 & N_4	18.1	N_4	13.9	N_4 & A	7.5	11.4
17	A	8.3	A	18.1	A	20.2	17.0

[1] Rate adjusted for condition of predator (see Figure 7).

TABLE 13: NEOSISTENS MORTALITY DUE TO T. CANADENSIS ON NINE BRANCH SAMPLES

Sample No.	Neosistens Dead				Mortality by T.c. (%)
	Living	T.c.	Other	total	
1a	1	0	1	2	0
1b	12	2	2	16	12.5
2a	7	2	4	13	15.4
2b	15	12	4	31	38.7
3a	48	33	26	107	30.8
3b	35	15	11	61	24.6
4a	30	4	1	35	11.4
4b	17	7	5	29	24.1
5	14	22	21	57	38.4
Total	179	97	75	351	27.6

[1] Neosistentes killed by T. canadensis

TABLE 14: NEOSISTENS MORTALITY DUE TO T. CANADENSIS FOR EACH UNIT IN A BRANCH SAMPLE

Unit		Neosistens				Mortality by T.c. (%)
			Dead			
Type	No.	Living	T.c.[1]	Other	Total	
#1 node	9	4	27	5	36	75.0
#1 internode	9	3	5	4	12	41.7
#2 node	9	172	65	66	303	21.4
Total		179	97	75	351	27.6

[1] Neosistentes killed by T. canadensis

TABLE 15: CAPTURES OF L. AMERICANA IN NEWFOUNDLAND TO 1962

Date	Location	Larvae and pupae Sub-total	Total
1955			483
?/?	Corner Brook	462	
	Stephenville Xing.	21	
1956			550
vi/10	Corner Brook	256	
vi/16	St. George's	5	
vi/17	Stephenville Xing.	36	
vii/31	Frenchman's Cove	76	
x/19	" "	177	
1957	-	-	-
1958			14
ix/19	Steady Brook	3	
x/9 - xi/4	Corner Brook	11	
1959 ix/29	Corner Brook	1	1
1960 to 1962			0