

JACK-PINE BUDWORM CONTROL: II. A SAMPLING TECHNIQUE FOR
ESTIMATING NUMERICAL TRENDS IN LARVAL POPULATIONS

by

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INTRODUCTION

Established practices for estimating larval population levels in both ecological and chemical control work on certain forest insect defoliators require careful and tedious visual examinations of representative branch samples. In most cases, samples are collected from trees in distant field plots and transported in sealed bags to a laboratory facility (Morris, 1955). There, a large staff is required to examine each individual branch and to sort and count specimens. Cold storage often is necessary to ensure survival of the insect collections as large samples accumulate. In addition, special training and close supervision is required to minimize error on the part of seasonal employees (usually student assistants). Accurate estimates of live insect populations thus are expensive, time-consuming and may be subject to considerable human error.

Staff of the Forest Insect and Disease Survey utilize the beating-sheet method for rough estimations of abundance (a branch is beaten vigorously with a stick while held over a suitable cloth or canvas sheet to dislodge insects, spiders, etc.). This well-established method provides a quick numerical index of population levels through the efforts of only one or two well-trained personnel. The method, however, is not designed for the extensive sampling requirements of experimental control work or for the quantitative data requirements of detailed ecological investigations. The samplers must work crouched over the beating sheet on the ground exposed to the vagaries of nature, undetected larvae may move rapidly off the beating sheet introducing error, the procedure permits the examination of only one branch at a time, and often the sample is taken only from branches within arms-reach of the sampler.

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Experiences in Manitoba during recent population outbreaks of the jack-pine budworm² (DeBoo and Hildahl 1967, 1968) clearly indicated that a more practical method was required, preferably incorporating the accuracy of conventional detailed branch examination with the time-saving advantages of the beating-sheet method. A combination fume chamber-funnel apparatus (Figure 1) utilized in invertebrate predator studies of the larch sawfly³ (Ives, 1967) was adapted for mobile sampling of budworm larvae. The objectives were: (1) to obtain an accurate estimate of population levels of various larval instars; (2) to decrease time and cost factors and manpower requirements; and (3) to provide immediate results for computation in predicting numerical trends where repeated population samples are required (as in pre- and post-spray sampling in insecticide applications).

The study was extended to include a comparative evaluation between this experimental method and conventional branch sampling during a demonstration spray program for control of the spruce budworm.⁴

MATERIALS AND METHODS

Preliminary assessment of the experimental sampling technique was undertaken at the Spruce Woods Provincial Forest near Brandon, Manitoba, from June 9-11, 1969. At this time light infestations of jack-pine budworm had reached 3rd larval instar. Concurrently, severe population levels of the spruce budworm had peaked at the 5th larval instar.

Branch samples from the mid-crown region of sample trees (30-50' jack pine and white spruce) were processed in groups of 10 (2-18" branches from each of 5 trees) following the instructions of Ives (1967). Briefly, the method involves: (1) spreading the branches on the grill separating hood and funnel; (2) successive treatments of pyrethrin (20 sec. application from a 40% aerosol bomb) and carbon dioxide (2 min.) followed by a 3 min. pause to allow dislodged insects to collect in a container at the base of the funnel; (3) the hood door is opened and branches are beaten vigorously on the grill; (4) the interior walls of the funnel are brushed down and the sample container is removed. The method differs chiefly from conventional sampling in that branches are processed in batches of 10 and laboratory facilities and staff are unnecessary.

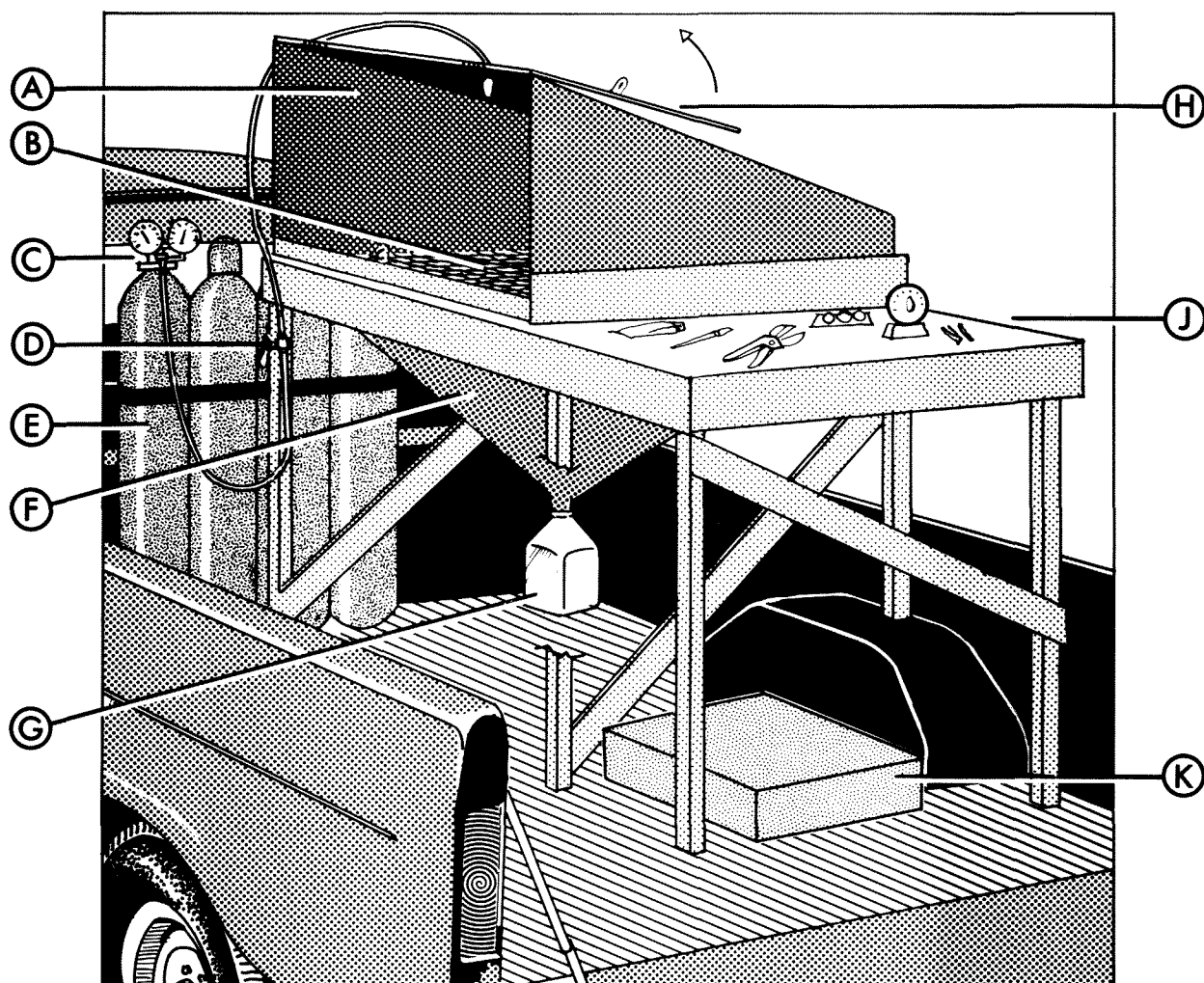
Examination, sorting and tally of the specimens in the sample container takes place on the table extension of the hood-funnel apparatus. The apparatus, CO₂ cylinders and all other equipment were mounted or stored in the 8' box of a pick-up truck for mobility between sampling stations. The effectiveness of the fumigation component (pyrethrin and CO₂) was evaluated separately, as was branch-beating, for comparison with the complete treatment.

²

Choristoneura pinus pinus Freeman

³Pristiphora erichsonii (Hartig)

⁴Choristoneura fumiferana (Clemens)



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|-------------------------------|-------------------------|
| A. Fume chamber | F. Funnel |
| B. 1" X 1" Wire grill | G. Sample container |
| C. Pressure indicators | H. Hinged door |
| D. CO ₂ flow valve | J. Work table and tools |
| E. CO ₂ cylinders | K. Equipment box |



The comparative appraisals of time, cost and accuracy factors for both experimental and conventional methods of branch sampling were undertaken at the Rocky Lake Provincial Camp Grounds, located about 30 mi. north of The Pas, Manitoba, from June 15-19. Representative samples (2-18" branches from mid-crowns of 15-50' white and black spruce) were collected before and after a demonstration spray application (phosphamidon, hydraulic sprayer, 20 acres accessible trees) for control of a moderate infestation of 4th-instar spruce budworm larvae. Two experienced staff members (C.F.S.) collected and processed branches for the experimental method; three inexperienced personnel assigned by the Manitoba Parks Branch worked on the conventional method under the supervision of an experienced technician from C.F.S.

Equipment and procedural requirements for each sampling method are summarized in Table I. Time and cost factors were recorded by one member of each sampling crew.

Table I. Sampling Equipment and Procedure Requirements

Conventional method	Experimental method
<p>A. <u>Personnel</u> 4</p> <p>B. <u>Transportation</u> Car, station wagon, or pick-up truck</p> <p>C. <u>Field equipment</u> Pole pruners (6x6' lengths), bag attachment plastic bags (200-12"x 24"), ties, tags, hand pruners, yardstick, flagging ribbon</p> <p>D. <u>Laboratory facilities and supplies</u> Bench space, chairs, desk lamps tally forms, pencils collecting and sorting materials (i.e., vials, 70% ethyl alcohol, probes, forceps, hand lenses, etc.)</p> <p>E. <u>Procedure</u> <ol style="list-style-type: none"> 1. Establish sample trees 2. Collect branch samples with pole pruner; trim to 18"; bag, tag, and tie sample (1/bag) 3. Transport samples to lab. facility, refrigerate if necessary 4. Untie bags, remove sample, clip branch into 6-8" pieces 5. Examine branch pieces (and empty bag) for specimens 6. Sort, tally and preserve specimens 7. Return pieces and tag to bag, tie and store 8. Re-examine samples (steps 6 and 7) for error check </p>	<p>A. <u>Personnel</u> 2</p> <p>B. <u>Transportation</u> Pick-up truck with 8' box</p> <p>C. <u>Field equipment</u> Pole pruners (6x6' lengths), bag attachment plastic bags (10-24"x 36"), ties, tags, hand pruners, yardstick, flagging ribbon, fume chamber-funnel apparatus CO₂ and pyrethrin supply, clock timer (1 hr.) tally forms, pencils, folding chair, collecting and sorting materials</p> <p>D. <u>Laboratory facilities</u> nil</p> <p>E. <u>Procedure</u> <ol style="list-style-type: none"> 1. Establish sample trees 2. Collect branch samples with pole pruner; trim to 18", bag and tag samples in lots of 10 3. Carry samples to apparatus mounted in truck; remove samples, place on grill over funnel 4. Treat with pyrethrin and CO₂; beat each branch vigorously, and replace in bag 5. Collect sample in container; examine and sort insects and debris; tally and preserve specimens 6. Examine samples (steps 4-6 in conventional method) for error check </p>

RESULTS

Larval population levels obtained from 120 jack pine branch samples and 50 white spruce samples taken at the Spruce Woods and a summation of time expenditures for the preliminary analysis of the experimental technique are found in Tables II and III below. The comparative evaluations of the two methods used at Rocky Lake are summarized in Tables III (comparing larval recovery and time expended) and IV (time and cost factors). Comparative population decline curves are depicted graphically in Figure 2.

Table II. Experimental sampling for 3rd- and 4th-instar (peak 3rd) larvae of the jack-pine budworm at Spruce Woods Provincial Forest

Method	No. branches sampled	No. larvae recovered	No. larvae missed	Av. no. larvae /branch	Per cent recovery	Time expended (man- hrs.)	Av. time/ branch (man- min.)
A. Pyrethrin + CO ₂ + Branch beating	100	136	13	1.5	90	11.0	6.6
B. Pyrethrin + CO ₂ only	10	3	8	1.1	17	1.0	6.0
C. Branch beating only	10	9	1	1.0	90	0.8	4.8

Table III. Experimental sampling for 3rd- to 6th-instar (peak 5th) larvae of the spruce budworm at Spruce Woods Provincial Forest

Method	No. branches sampled	No. larvae recovered	No. larvae missed	Av. no. larvae/branch	Per cent recovery	Time expended (man-hrs.)	Av. time/branch* (man-min.)
A. Pyrethrin + CO ₂ + Beating	20	210	4	10.8	98	2.0	6.0
B. Pyrethrin + CO ₂ only	10	2	154	15.6	1	1.8	5.2
C. Branch beating only	20	447	16	23.1	97	1.3	4.0

*includes time to check branches for error

Table IV. Comparison of sampling methods for 4th-instar spruce budworm larvae at Rocky Lake, Manitoba

Method	No. branches sampled	No. live larvae recovered	No. live larvae missed	Av. no. larvae/branch	Per cent recovery	Time expended (man-hrs.)	Av. time/branch (man-min.)
(Pretreatment sample)							
A. Experimental	120	450	22	3.9	95	11.0	5.5
B. Conventional	120	537	-	4.5	-	66.2	33.1
(Post-treatment sample)							
A. Experimental	120	69	4	0.6	95	10.2	5.1
B. Conventional	120	84	5	0.7	94	44.0	22.0

Table V. Time and labor cost factors for sampling based on average expenditures to process one branch

Method	Time (min.)				Cost (\$)*man-hr.		
	Collect sample in field	Process sample	Check for error	Total	Field	Lab.	Total
A. Experimental	1.1	2.7	1.6	5.4	0.23	-	0.23
B. Conventional	3.0	15.3	4.5	22.8	0.13	0.83	0.96

*assuming rate of \$2.50/man-hr.

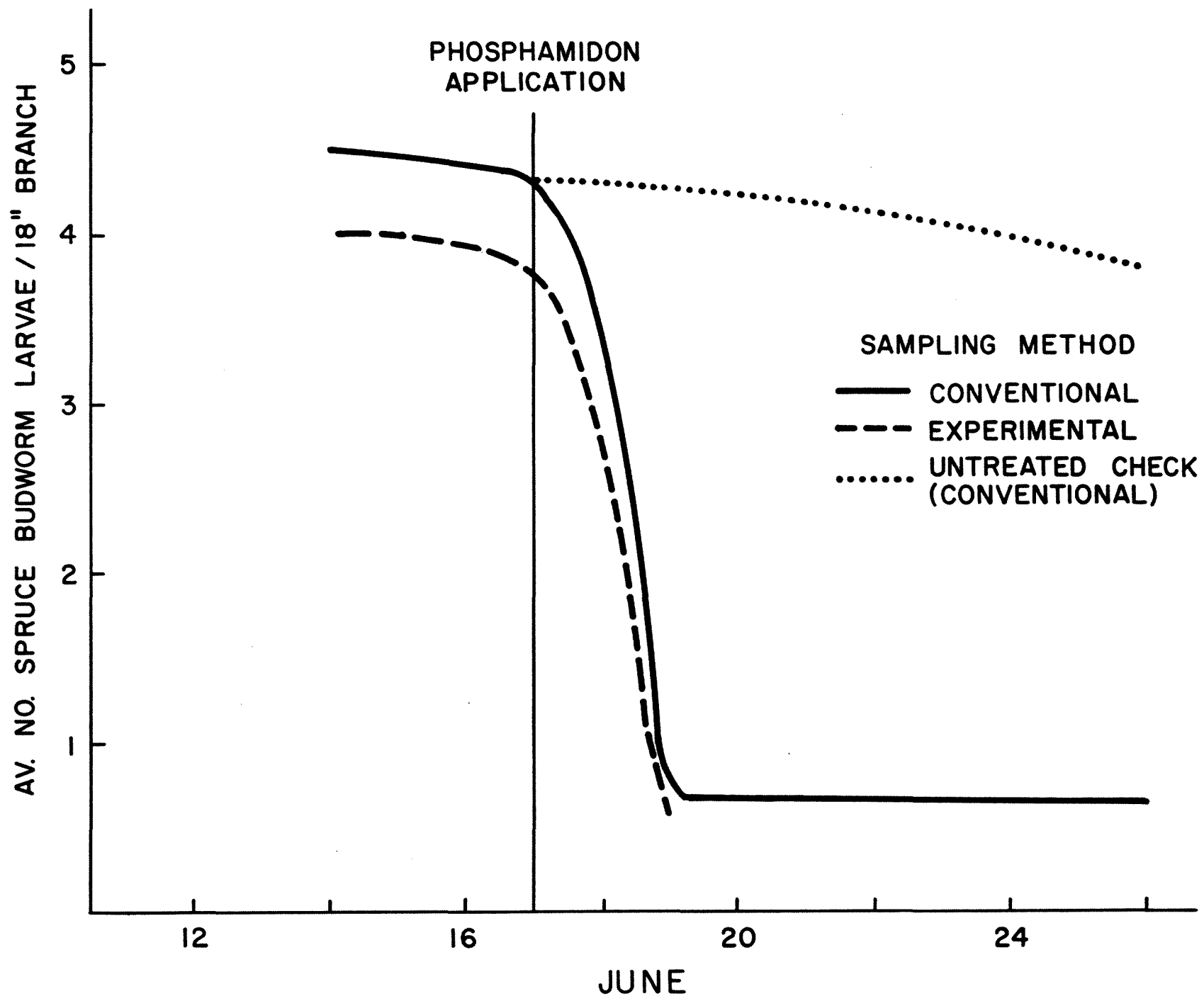


Figure 2. Population decline curves from samples taken before and after phosphamidon application.

DISCUSSION AND CONCLUSIONS

A. Preliminary Evaluation of the Experimental Method

The experimental sampling technique utilizing the fume chamber-funnel apparatus to determine population levels of jack-pine and spruce budworm larvae was found to provide the following desirable attributes:

- (1) The greatly reduced volume of branch material for examination reduces fatigue (based on previous experiences with either conventional or F.I.D.S. techniques) while providing a high degree of accuracy in recovering larvae (90% for 3rd-instar jack-pine budworm larvae, 97% for 5th-instar spruce budworm larvae).
- (2) A 10-branch sample lot is processed in less than 1/2 hr. by a two-man crew, immediately after which rough counts are available for calculation of the population level (e.g., Av. no. larvae/18" branch/collection date).
- (3) The procedure for processing branches is uncomplicated and requires only simple instructions to the field crew.
- (4) The inexpensive (less than \$100) apparatus is readily adaptable to field use in extensive (or intensive) sampling when mounted in a standard pick-up truck.

Evaluation of component parts of the method showed that larvae were affected by the pyrethrin-CO₂ treatment but most remained on branches beneath needles and flowers or under webbing in feeding sites until shaken off. Beating of the branches on the grill over the funnel provided recovery accuracy equivalent to the levels for the complete treatment. It is suspected that cold temperatures (34-40°F) at the time of evaluation hindered larval activity thereby rendering ineffective the fumigation component. The evaluation of the fumigation component (Method B, Tables II, III) therefore should be considered inaccurate as expressed by the very poor recovery figures shown. Under more agreeable conditions a larger percentage recovery would be expected.

During late spring and early summer sampling, large complements of staminate flowers on jack pine branches and tender new shoots on spruce became detached when samples are beaten on the grill. A large volume of branch material thus collects, at times clogging the base of the funnel. A larger funnel outlet (about 3" diam.) and more effective fumigation (thus requiring less vigorous beating of branches) would reduce the size of the collection for sorting and counting, and in turn speed up the procedure. The average time of about 6 man-min./branch is estimated to be very close to that time required to process a branch using the beating-sheet technique.

B. Comparative Analyses of Sampling Methods

Accuracy levels achieved for the experimental and conventional methods (based on 240 branch samples each, Table IV) were high and nearly identical (95%, 94%, respectively). The accuracy of the experimental method in recovery increased with age and size of larvae (i.e., 90% for 3rd-instar jack-pine budworm, 95% for 4th-instar spruce budworm, 98% for 5th-instar spruce budworm) and were similar to accuracies achieved by conventional sampling (Tables II, III, IV). The average numbers of larvae recovered were affected by pole-pruning bias¹, but the analysis of population decline (Figure 2) showed that differences were insignificant (t-test) for points on before- and after-spray curves.

Continued periodic evaluations of component parts of the experimental method showed the branch-beating portion to provide the largest part of the specimens collected. Very cold seasonal temperatures (30-40°F) hindered fumigation efficiency once again.

Efficiency of the student crew used for the conventional method increased by one-third in pre- and post-spray sampling. The time-saving of 11 man-min./branch (Table IV) was due primarily to increased experience and confidence. Using the prediction figure of 22.8 man-min./branch for this crew, the method still required about four times the time expenditure for an experienced crew using the experimental technique (Table V). Most of the time consumption for conventional sampling is tied into laboratory processing of the samples. Cost of branch sampling accordingly, is proportionally more also (Table V).

Several unfair comparisons must be mentioned, however, to clarify several obvious discrepancies. Foremost, any streamlining of the conventional method would have reduced time and cost factors; e.g., branch collecting in lost of 10 and utilization of the branch-beating technique at the laboratory would have been advantageous. The comparisons, however, have shown that critical branch examinations as used in many aspects of quantitative entomological research might be re-examined in light of the results presented here.

C. Practical Applications

The larval sampling investigation was undertaken primarily to supplement current studies designed for the improvement of entomological techniques. Jennings' (1968) work in Minnesota with ultra-violet light for jack-pine budworm egg sampling is a good example of this trend. Several practical applications for the fume chamber-funnel apparatus (subject to additional testing and modification) are listed below.

¹The average number of larvae recovered/branch is directly influenced by the cumulative branch selections of the pole-pruning individual. The sample branches must be selected at random if the results are to reflect the actual population level, e.g., an experienced eye for budworm infested branches will give higher average recovery than can be expected from a pole pruner unfamiliar with budworm.

1. Sequential sampling (i.e., in systematic surveys for predicting population trends).
2. Chemical control investigations (i.e., in obtaining indices of population levels before and after applications).
3. Predator-prey relationships (i.e., importance of polyphagous predators at different host densities over time).

SUMMARY

1. The major advantage of the experimental method over conventional sampling was the greatly reduced volume of branch material for examination. Time and cost expenditures accordingly were significantly reduced.
2. Accuracy was maintained at a high level; field experiences at two locations in Manitoba gave similar recovery percentages for both spruce and jack-pine budworm larvae.
3. Laboratory staff and space is not required, and long distant transportation of samples is unnecessary.
4. Tabulated results are immediately available after processing samples in the field.
5. The method has application in many areas of field research on forest defoliators.

ACKNOWLEDGMENTS

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