

ANNUAL PROJECT STATEMENTS 1969 - '70

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**FOREST RESEARCH LABORATORY
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CALGARY, ALBERTA**

**FORESTRY BRANCH
DEPARTMENT OF FISHERIES AND FORESTRY
MAY, 1969**

PROBLEM AREA PROGRAM

Reduction of Losses from Bark Beetles

Bark beetles are the most destructive perennial insect pest in the coniferous forests of western North America. The most intensively studied insect in this group is the mountain pine beetle and the associated blue stain fungi which together are responsible for a significant annual loss of lodgepole, white and ponderosa pine. Objectives of the program are to determine the biology and ecology of the insect and to develop effective and economical means for preventing or controlling their outbreaks by biological, silvicultural or other direct means. Study areas are located in the East Kootenay region of British Columbia where relatively permanent mountain pine beetle populations are established and are accessible from the regional Calgary Headquarters. An important advance in the progress of the study was the recognition in 1960 that factors other than the beetle--pathogens vectored by the insect and response of the tree itself to the invading parasites--play an important, if not a major part, in the death of affected trees. As a result the study was re-organized and the objectives expanded to facilitate reduction in the losses to western pine forests caused by the mountain pine beetle and its associated blue stain fungi.

A premise central to the study is recognition that trees vary in their resistance to attack and infection. Resistance takes the form of resin and resin-like compound formations and it is known that trees vary in their ability to produce these substances. To date studies have emphasized the physical relations between the insect, fungi and the tree. This work is now mainly completed and biochemical and physiological aspects of the study are being expanded. The ultimate aim is a guideline for managing pine forests which will include rating of pine trees and stands as to their potential for supporting mountain pine beetle populations and the selection of trees resistant to bark beetles and blue stain fungi.

Investigations are also being conducted and more are planned for damage appraisal and control of the spruce bark beetle. Aerial and ground surveys have revealed heavy tree mortality in the Crowsnest Forest and other high hazard areas throughout the foothills of southwest Alberta. Methods of insect detection and damage control are known and have been given to forest management. Investigations on the development periods of the spruce bark beetle are being conducted to determine when other major attacks can be expected.

For several years the regional program has included taxonomic studies on the bark beetle genus Ips. These bark beetles are particularly destructive in young pine stands and the increasing proportion of such stands resulting from regeneration of logged and burned areas amplifies

the economic importance of the insect. An objective definition of the *Ips* species is fundamentally important to most studies of the biology and ecology of the insect.

Research now related to the bark beetle problem includes the following projects:

- A 229 : Role of Blue Stain Fungi in Bark Beetle Infested Pinus contorta - H. S. Whitney
- A 245 : Biology of the mountain pine beetle - J. H. McGeheey
- A 246 : Population studies of the mountain pine beetle - L. Safranyik
- A 247 : Factors affecting the attraction of mountain pine beetle - R. F. Shepherd
- A 248 : Climate in relation to the mountain pine beetle - J. M. Powell
- A 253 : Resistance of Pinus contorta to mountain pine beetle and blue stain fungi - R. W. Reid and D. M. Shrimpton
- A 249 : Biosystematics of the pine beetle genus Ips - G. N. Lanier
- A 237 : *Annual forest insect survey - H. A. Tripp
- Extra Mural Research - F 22 - Biochemical compounds in the bark and sapwood of lodgepole pine - H. M. Benn, Department of Chemistry, University of Calgary.

* Project statement appears under Problem-Detection and Estimation of Tree Pest Damage.

PROJECT REVIEW STATEMENT

1. Establishment : Alberta/NWT/Yukon Date: February, 1969
2. Title : Role of blue-stain fungi in bark beetle infested Pinus contorta.
3. Investigator : H. S. Whitney
4. Year of Commencement : 1959
5. Anticipated Year of Completion: Original - 1972
6. Key Words not in Title: Pathogenesis, mycangia, host resistance, symbiosis, axenic insects, SA 1, CL.
7. Activity : Pathology
8. Problem Area Program : Reduction of losses from bark beetles.
9. Establishment Project No. A 229 Branch Project No. A 229
10. Status : Active
11. Man-years Utilized in Past Year: Professional - 1 Other - 1.25
12. Cooperating Agency : British Columbia Forest Service.
13. Location of Work : Calgary; East Kootenay Region of British Columbia.
14. Abbreviated Background Statement: The objective of this project is to elucidate the role of blue-stain fungi in the mortality of lodgepole pine and the relation between these organisms and the associated bark beetles. It is believed that this knowledge will assist in attaining the objective of the integrated multidiscipline investigation which is to facilitate a reduction in the losses to western pine forests caused by the mountain pine beetle and its associated fungi.
15. Summary of Progress up to One Year Ago: The blue-stain fungi and yeasts associated with mountain pine beetle attacks on lodgepole pine have been identified. This involved the description of four blue-stain fungi new to science. Ceratocystis montia and Europhium clavigerum were the most frequent blue-stain fungi and Hansenula capsulata, H. holstii and Pichia pini the most common yeasts. Inoculation of healthy lodgepole pine with C. montia and E. clavigerum resulted in resinous reactions in the stem similar to those produced by unsuccessful beetle attacks. Uninoculated controls produced a very minor reaction. It was concluded that the blue-stain fungi were largely responsible for the resinous resistant response of the tree. The greater the reaction to fungus inoculation, the greater the resistance to induced beetle attack. Trees were rated resistant or non-resistant but intermediates were not rated satisfactorily. The more apparent cytological

and histological changes in tissues associated with beetle and fungus colonization were described.

Addition of resinous sapwood to growth media inhibited growth of blue-stain fungi whereas non-resinous sapwood enhanced growth; however, volatile components in extracts from both resinous and non-resinous sapwood inhibited growth. There was an apparent direct relationship between severity of stem wounding and success of insect and blue-stain fungi tested on the tissues affected by the wounding. Variations between insects was important in assessing insect-tree interactions in predisposed tree stems.

Axenic bark beetles were produced from surface sterilized eggs in thirty days in autoclaved lodgepole pine phloem supplemented with autoclaved brewers' yeast. Larvae did not grow or pupate in this medium without added yeast. C. montia could be substituted for brewers' yeast but E. clavigerum could not.

Larvae of bark beetle broods raised in slabs became temporarily separated from all culturable micro-organisms and fed in axenic phloem. Normal appearing adult insects were produced when this separation was made permanent. Nine publications and five reports were published up to 1968.

16. Goals Set One Year Ago : To compare the colonization of predisposed and non-predisposed stem tissue by axenic, non-axenic and agnotobiotic bark beetles, and by the blue-stain fungi.
17. Accomplishments in Last Year: Additional evidence confirmed that colonization by the beetle and associated micro-organisms was greater on wounded than on non-wounded stem tissue, but conclusive results were not obtained in experiments designed to examine directly the role of blue-stain fungi. Contrary to previous indications limited growth of the mountain pine beetle was obtained in unsupplemented autoclaved ground phloem. Growth was greatly enhanced by the addition of killed brewers' yeast, mountain pine beetle associated yeasts or the blue-stain fungi. Two contaminants of broods, Trichoderma and Penicillium, inhibited production in the phloem plates. Axenic beetles reproduced axenically in fresh bolts of lodgepole pine.

Resinous reactions were twelve times longer from live than from killed inoculum of Europhium. High dilutions (1:10,000) of Europhium inoculum produced similar but smaller (1/3) resinous reactions compared to full strength. Europhium localized in resistant reactions in trees inoculated two years previously apparently began to grow into unoccupied sapwood after being removed from trees in slabs.

Blue-stain fungi and yeasts were isolated from mycangia in the cardo portion of the maxillae of the pine beetle. Mycangia were observed with a scanning electron microscope.

Cirri of ascospores of C. montia, which stick to the mountain pine beetle, disperse in lodgepole pine resin but not in water. Cultures from dispersed spores appear normal.

18. Goals for Next Year : I plan to undertake a post doctoral transfer of work at the University of California, Berkeley campus. I will join research in progress in a multidiscipline study of bark beetle/tree/disease interactions. Nutritional and environmental requirements for optimum growth and reproduction of blue-stain fungi and the nature of the stimulation produced by blue-stain fungi that cause trees to produce resin will receive special attention.

The following publications are to be completed:

- Whitney, H. S. Association of blue-stain fungi and other micro-organisms with mining larvæ of the mountain pine beetle. Proposed journal publication.
- Whitney, H. S. Rearing mountain pine beetles in autoclaved lodgepole pine phloem supplemented with blue-stain and other fungi. Proposed journal publication.
- Whitney, H. S. Growth and reproduction of the mountain pine beetle in lodgepole pine bolts in the absence of blue stain fungi. Proposed journal publication.
- Whitney, H. S. Response of lodgepole pine to axenic virgin mountain pine beetles. Proposed departmental Bi-monthly Res. Note.
- Whitney, H. S. Response of lodgepole pine to varying concentrations of blue-stain fungus inoculum. Proposed departmental Bi-monthly Res. Note.
- Whitney, H. S. A mycangium in Dendroctonus ponderosae with S. H. Farris. Proposed journal publication.
- Whitney, H. S. and R. A. Blauel. Dispersion of ascospores of Ceratocystis montia in pine resin. Proposed journal publication.



H. S. Whitney
Investigator

PROJECT REVIEW STATEMENT

1. Establishment : Alberta/NWT/Yukon Date: February, 1969
2. Title : Biology of the mountain pine beetle
3. Investigator : J. H. McGhehey (Resigned 1968)
4. Year of Commencement : 1955
5. Anticipated Year of Completion: Original - 1969
6. Key Words not in Title : Dendroctonus ponderosae, life cycle, fecundity
behaviour, survival, phenotypic population
SA 1, CL
7. Activity : Entomology
8. Problem Area Program : Reduction of losses from bark beetles.
9. Establishment Project No. A 245 Branch Project No. A 245
10. Status : Completed
11. Man-years Utilized in Past Year: Professional - 1 Other - 1.3
12. Cooperating Agencies : National Parks Branch; British Columbia
Forest Service.
13. Location of Work : Calgary; Eisenhower Forest Research Station;
East Kootenay Region of British Columbia.
14. Abbreviated Background Statement: This was the first project set up to
investigate the biology of mountain
pine beetle. In the earlier years it was believed studies on the insect
itself would yield all the information needed to predict tree mortality
and develop methods for reducing damage. The attainable objectives
originally set out for the study have been satisfied. Since the study
was taken over from R. W. Reid by J. H. McGhehey new objectives were
delineated. These have in part been fulfilled. An important unfulfilled
objective relates to influence of nutritive qualities of host to brood
establishment and survival. This objective will be added to Project A 246
with the termination of A 245.
15. Summary of Progress up to One Year Ago: Factors important to development
of broods and flight periods,
behaviour of adults beneath the bark and factors directing that behaviour
are known. The role of climate is broadly understood. The critical
factors determining population abundance are now recognized. Intensive
work on those factors is underway in Project No. A 246. During the course
of Project No. A 245, three major reports and eight scientific papers
have been published; five additional are in press.

16. Goals Set One Year Ago : Measure differences in reproductive potential and vigour within and between populations of the mountain pine beetle.
17. Accomplishments in Last Year: Preparation of the following publications -
- Reid, R. W. The influence of humidity on incubating bark beetle eggs. Can. Ent. (in press).
- Reid, R. W. and H. Gates. The effect of temperature and resin on survival of mountain pine bark beetle eggs. Can. Ent. (in press).
- McGhehey, J. H. Territorial behaviour of bark beetle males. Bi-monthly Research News.
- McGhehey, J. H. Sex ratios of individual broods of the mountain pine beetle. Bi-monthly Research News (in press).
- McGhehey, J. H. Female size and egg production of the mountain pine beetle. Can. Ent. (in press).
18. Goals for Next Year : None - Project to be closed, 1969.

"J. H. McGhehey" *per R. W. Reid*

 J. H. McGhehey
 Investigator

PROJECT REVIEW STATEMENT

1. Establishment : Alberta/NWT/Yukon Date: February, 1969
2. Title : Population studies of the mountain pine beetle.
3. Investigator : L. Safranyik
4. Year of Commencement : 1955
5. Anticipated Year of Completion: Original - 1970 Revision I - 1973
6. Key Words not in Title : Dendroctonus ponderosae, sampling, spatial pattern, insect population quality, lodgepole pine, SA 1, CL
7. Activity : Entomology
8. Problem Area Program : Reduction of losses from bark beetles.
9. Establishment Project No. A 246 Branch Project No. A 246
10. Status : Active
11. Man-years Utilized in Past Year: Professional - 1 Other 1.6
12. Cooperating Agencies : B. C. Forest Service; Crestbrook Forest Industries Ltd., Cranbrook, B. C.
13. Location of Work : Canal Flats; Invermere, B. C.; Eisenhower Field Station; Calgary.
14. Abbreviated Background Statement: The need for studying year-to-year population changes of the mountain pine beetle and for evaluating the importance and mode of action of its various mortality factors are based on the following considerations: The formation of effective control measures have to be based, to a large degree, on the evaluation of the importance of the various mortality factors affecting the population. Also the evaluation of the effectiveness of a control method as well as the establishment of the need for control, must be based on prediction of population levels. This study is also related to Projects A229 and A253 in that the prediction of outbreaks requires, in addition to predicting population levels, an estimate of the proportion of trees which will be in a "susceptible" condition during the flight period of the adult beetles. R. F. Shepherd was responsible for this project until 1964. In 1964 the original project title was retained but the objectives were changed as follows:

- (1) Describe the distribution of beetle attacks over the host and the factors that influence this distribution;
- (2) Develop a sampling system which will be of sufficient sensitivity to permit detection, evaluation and prediction of population changes within

limits of practicability; (3) Assess the effects of various mortality factors on beetle populations; (4) Relate the effects of mortality factors to population changes.

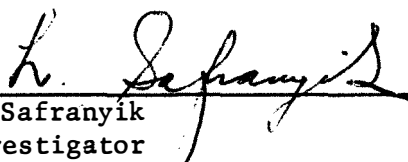
In 1969 an important objective from a terminated project (A245) was incorporated into A 246 in the following form:

Objective 5 - Assess the role of variations in mountain pine beetle phenotypes and abundance in relation to the physical and nutritional quality of the host.

15. Summary of Progress up to One Year Ago: The size, shape and orientation of the optimum "sampling unit" was established by studies of the relation between sampling variance unit, mean clump size and clump orientation of late stage brood and by a time study of sampling units of various sizes by fixed shapes. The gradients of brood and attack density, both vertically and around the circumference of infested trees, were described and a mathematical description of attacks over the host, in terms of bark thickness and d. b. h. was developed. A two-stage sampling system was developed to measure within generation mortalities and population trend. An equation was developed to predict infested bark surface area of lodgepole pine. Three years' data have been collected on woodpecker predation and insect predation and parasitism.
16. Goals Set One Year Ago : Prepare analyzed data for thesis (Ph. D.) and publications. Test various X-ray sampling techniques. Develop equipment to study the colonization of host trees by the attacking female beetles.
17. Accomplishments in Last Year: Experiments were initiated and equipment tested to study the method of colonization of individual tree bark surfaces by the attacking female beetles. The vertical flight intensity profile was studied in relation to wind speeds and temperatures. Two methods of estimating landing frequency, within the clear bole zone, were tested and compared. A thirty-foot-high rotating system of fifteen nets, arranged at two-foot intervals, was tested for studying the vertical flight frequency of beetles in the clear bole zone. The relations between beetle size and height level on the infested stem, beetle size and sex ratio and between speed of emergence and aspect on the stem were studied using "emergence" traps. A study was initiated to investigate the accuracy and efficiency of sampling unit enumeration by X-ray techniques. Ph. D. thesis: "Development of a technique for sampling mountain pine beetle populations in lodgepole pine", prepared and accepted by the Faculty of Forestry, University of British Columbia.
18. Goals for Next Year : (a) Continue studies of the method and factors affecting colonization of the tree stem by the mountain pine beetle. (b) Complete study on the evaluation of the accuracy and efficiency of sampling unit enumeration by X-ray techniques. (c) Commence studies on the effect of seasonal changes within the host upon brood establishment and survival.


Publications:

- Safranyik, L. and K. Graham. 1968. Studies of the relations between the shape and size of the sampling unit and the edge-effect bias of mean brood density. Proposed journal publication.
- Safranyik, L. and R. Jähren. 1969. The relations between beetle size and height above ground level in infested lodgepole pine stems. Proposed journal publication.
- Safranyik, L. 1969. Mathematical description of vertical attack density gradients on the infested stem. Proposed journal publication.


 L. Safranyik
 Investigator

PROJECT REVIEW STATEMENT

1. Establishment : Alberta/NWT/Yukon Date: February, 1969
2. Title : Factors affecting the attraction of the mountain pine beetle.
3. Investigator : R. F. Shepherd
4. Year of Commencement: 1956
5. Anticipated Year of Completion: Original - 1969
6. Key Words Not in Title: insect behavior, external tree characteristics, attack pattern, SA1, CL
7. Activity : Entomology
8. Problem Area Program: Reduction of losses from bark beetles.
9. Establishment Project No. A 247 Branch Project No. A 247
10. Status ; Completed
11. Man-years Utilized in Past Year: None
12. Cooperating Agency : British Columbia Forest Service.
13. Location of Work : Invermere, B. C.; Eisenhower Field Station.
14. Abbreviated Background Statement: Project was initiated to determine the influence of insect behavior and the influence of external tree characteristics of the tree on the attack pattern of the mountain pine beetle.
15. Summary of Progress up to One Year Ago: Most of the work was completed and presented in publication. Shepherd, R. F. 1966. Factors influencing the orientation and rates of activity of Dendroctorus ponderosae Hopkins (Coleoptera:Scolytidae) Can. Ent. 98(5) 507-518.
16. Goals Set One Year Ago: None. Investigator was away on transfer of work.
17. Accomplishments in Last Year: None.
18. Goals for Next Year : Some data on external tree characteristics remain to be analysed and will be combined with similar data collected by L. Safranyik. Future reporting of this will be done under Project A 246.



R. F. Shepherd,
Investigator.

PROJECT REVIEW STATEMENT

1. Establishment : Alberta/NWT/Yukon Date: February, 1969
2. Title : Climate in relation to the mountain pine beetle
3. Investigator : J. M. Powell
4. Year of Commencement: 1960
5. Anticipated Year of Completion: Original - 1964 Revision I - 1969
6. Key Words not in Title: Dendroctonus ponderosae, Pinus, outbreaks, habitat temperatures, valley climate, SA 1, CL.
7. Activity : Entomology
8. Problem Area Program: Reduction of losses from bark beetles.
9. Establishment Project No. A 248 Branch Project No. A 248
10. Status : Reactivated in 1969
11. Man-years Utilized in Past Year: None
12. Cooperating Agency : None
13. Location of Work : Calgary Laboratory; Eisenhower Field Station; Invermere, B. C.
14. Abbreviated Background Statement: Observations have indicated that outbreaks of D. ponderosae and other Dendroctonus species are often associated with prolonged drought periods. The important role of certain climatic factors in the rate of development of the various stages of the life cycle of the beetle has been shown, and also their effect on its mortality. Climatic factors may also affect the susceptibility of the pine trees to attack. If a method of predicting possible outbreaks based on climatic conditions could be developed, control and management methods may be utilized to good effect.

Initially the project had wide objectives, but these were abbreviated after the first year of study, because of the pending reassignment of the investigator. The objectives were revised to determine: (1) the historic relationship between the important climatic factors and the occurrence of beetle outbreaks; (2) the relationship between air and sub-cortical temperatures of attacked and unattacked trees at different heights in the stand; (3) the variability in summer climate in a mountain valley.
15. Summary of Progress up to One Year Ago: Data for all phases of the project have been collected

and analysed. Nothing further has been done since 1964 as the project was on a maintenance basis. Several reports and publications have been made. Records of D. ponderosae outbreaks in western Canada were extracted from the literature and a detailed history of outbreaks and timber losses occurring in 15 physiographic regions from 1906 to 1960 was published. A paper giving distribution of the beetle and a cartographic history of outbreaks was also published as a report. A study was made of the climatic fluctuations and trends in British Columbia since the keeping of records, as part of an investigation to show whether relationships exist between trends in climate and beetle populations. Two papers were published, one on annual and seasonal temperature and precipitation trends in British Columbia since 1890, and the other on changes in amounts of sunshine. An unpublished report discussed the occurrence of drought in British Columbia. An analysis of the correlation of fluctuations of seasonal weather and beetle populations produced no significant results when considered over a time scale of 60 years, although many outbreaks occurred during periods of above normal spring and summer temperatures and below normal spring and summer precipitation.

The habitat temperatures of the beetle in lodgepole pine trees was compared with temperatures in non-infested trees and the surrounding air, and published in a paper to satisfy objective (2). The effects of height above ground, aspect, shading, bark thickness and subcortical moisture conditions on temperatures were considered.

Meteorological studies were carried out in 1960 and 1961 using a network of 15 stations in a beetle infested area of the Rocky Mountain Trench to give a better interpretation of local valley conditions. The stations varied in elevation from 2,700 to 5,000 feet and, during the summer, recordings were made of soil temperature and moisture, air temperature, humidity and precipitation, and estimates were made of evaporation. Most of the data has been analyzed and eight of the stations formed the basis for an unpublished report on the summer climate of a tributary of the Upper Columbia River Valley.

16. Goals Set for Last Year: Further work on an information report to complete studies on aspects of objective (1).
17. Accomplishments in Last Year: Climatic data and trends of major beetle populations in three areas during the mid-1960's were extracted prior to up-dating the proposed information report on relation of major outbreaks to seasonal weather conditions.
18. Goals for Next Year : Complete the project by: preparing information report to complete objective (1) and revise the unpublished report on the summer climate of a

mountain valley to satisfy objective (3).

- Powell, J. M. Historical study of the relation of major mountain pine beetle outbreaks in western Canada to seasonal weather conditions. Proposed Information Report.
- Powell, J. M. Some topoclimatic features of the summer climate of the Frances Creek valley, a tributary of the Upper Columbia River valley. Proposed Information Report.

J. M. Powell

J. M. Powell
Investigator

PROJECT REVIEW STATEMENT

1. Establishment : Alberta/NWT/Yukon Date: February
2. Title : Biosystematics of the bark beetle genus Ips.
3. Investigator : G. N. Lanier
4. Year of Commencement : 1967
5. Anticipated Year of Completion: Original - 1969 Revision I - 1970
6. Key Words Not in Title: Coleoptera, Scolytidae, breeding experiments, sex, pheromones, sex ration, gunogenesis karyotypes.
7. Activity : Entomology
8. Problem Area Program : Reduction of losses from bark beetles.
9. Establishment Project No. A 249 Branch Project No. A 249
10. Status : Active
11. Man-years Utilized in Past Year: Professional - 1 Other - 1.3
12. Cooperating Agency : None
13. Location of Work : Calgary Laboratory; Eisenhower Field Station.
14. Abbreviated Background Statement: The increasing proportion of young forest stands resulting from re-generation of logged areas and aforestation of barren lands has amplified the economic importance of the genus Ips. These bark beetles are particularly destructive in young pine stands subjected to drought and in thinned or logged areas. Recent advances such as identification and synthesis of Ips sex pheromones and perfection of methods of sterilization have rendered sophisticated auticidal control techniques theoretically feasible. However, a clear conception of the distributions and definitions of species is paramount to undertaking such a program on a wide scale.

Workers in other regions are intensively studying the nematodes and mites associated with Ips or using these beetles as laboratory animals in basic studies of insect nutrition, host selection, sex pheromones and sound production. In these areas also objective definition of the Ips species is fundamentally important.
15. Summary of Progress up to One Year Ago: G. R. Hopping completed a taxonomic revision of the North American Ips (Project CZ-14, 1960-1964), but controversy over the status of several closely related species was only partially resolved.

Breeding and cytological studies of selected Ips species was the subject of my Ph. D. thesis at Berkeley. This work confirmed the validity of several controversial species and ratified certain of Hopping's synonymizations. Conversely, it demonstrated that six "species" of spruce-feeding Ips constituted a single valid species with polymorphic females and cast doubt upon the reality of several other species.

16. Goals Set One Year Ago : Commence breeding experiments and cytological studies with species currently available. Correspond with various workers to obtain other species.
17. Accomplishments in Last Year: During the past year over 2000 pairings (breeding tests) involving 12 species and 21 populations were completed. To date 28 of the currently recognized 32 North American Ips have been handled in the laboratory and the experimental phase of this work is 80% complete. The validity of two Ips species new to science and one species which had been synonymized was confirmed by breeding tests and analysis of morphological and cytological characters. Conversely, synonymy of three species was demonstrated. Of the currently recognized fourteen species of spruce infecting Ips, only five names are valid. Twelve of these fourteen names constitute three species with polymorphic females.

Gynogenetic strains of additional Ips species were found. These females invariably proved to be triploid. A cytoplasmic incompatibility system was detected in the I. plastographus group which is somewhat analogous to the "Rh" condition in man.

Publications:

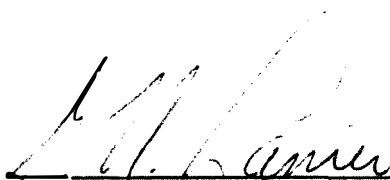
- Lanier, G. N. 1968. Ips plastographus (Coleoptera: Scolytidae) tunnelling in sapwood of lodgepole pine in California. Can. Ent. 99(12):1334-5.
- Lanier, G. N. and D. L. Wood. 1968. Controlled mating, karyology, morphology and sex-ratio in the Dendroctonus ponderosae complex. Ann. Ent. Soc. Amer. 61(2): 517-26.
- Lanier, G. N. and E. A. Cameron. 1968. (University of California) Secondary sex characters in the genus Ips de Geer (Coleoptera: Scolytidae). Can. Ent. (In press).

18. Goals for Next Year: (1) Complete experimental phase of this project including breeding tests, karyotype determinations, sex pheromones, specificity tests.

(2) Prepare large numbers of paratype and voucher specimens for distribution to museums.

(3) Prepare the following papers for publication:

- Lanier, G. N. Biosystematics of the genus Ips I. Group IX. Proposed journal publication.
- Lanier, G. N. Biosystematics of the genus Ips II. Groups III and IV. Proposed journal publication.
- Lanier, G. N. Specificity of sex pheromones produced by hybrid bark beetles. Proposed journal publication.
- Lanier, G. N. A pseudo-Rh factor in Ips plastographus. Proposed journal publication.
- Schofer, G. A. and G. N. Lanier. A character for sexing pupae of Dendroctonus ponderosae. Proposed departmental Bi-monthly Research Note.
- Wood, D. L. and G. N. Lanier. Interspecific response to the sex pheromone produced by males of the genus Ips de Geer. Proposed journal publication.



G. N. Lanier,
Investigator.

PROJECT REVIEW STATEMENT

1. Establishment : Alberta/NWT/Yukon.
2. Title : Resistance of Pinus contorta to mountain pine beetles and blue stain fungi.
3. Investigators : R. W. Reid, D. M. Shrimpton.
4. Year of Commencement : 1965.
5. Anticipated Year of Completion: Original 1972.
6. Key Words not in Title: Terpenes, phenolics, carbohydrates, tissue culture, water, SAL, CL.
7. Activity : Tree Biology.
8. Problem Area Program : Reduction of losses from bark beetles
9. Established Project Number: A 253 Branch Project No. A 253
10. Status : Active.
11. Man Years Utilized in Past Year: Professional 1.5; Other 3.
12. Co-operating Agencies : British Columbia Forest Service.
13. Location of Work : Calgary, Kananaskis Forest Experimental Station, East Kootenay Region of B.C.
14. Abbreviated Background Statement: Previous studies on the relation between mountain pine beetle attacks and tree mortality suggested a major role was played by the tree in determining success of the beetle attack. In fact, it appeared success or lack of success by the beetle and its associated blue stain fungi was determined solely by the tree. Tree resistance was manifest by synthesis of resin and resin-like compounds, hence physiological and biochemical systems and cycles of the tree were involved. Studies into those aspects of resistance were undertaken.
15. Summary of Progress up to One Year Ago: Resistance by lodgepole pine to invasion by blue stain fungi is effected by initial flow of oleoresin followed by a gradual impregnation with heartwood substances of the tissues adjacent to the wound. Volatile components from this wound reaction zone cause inhibition of growth of blue stain fungi.
16. Goals Set One Year Ago: To determine the effectiveness of resins to act as physical barriers to fungal growth, also to test the effects of volatile resins upon the behaviour of

the invading insect. Establish lodgepole pine tissue cultures. Investigate the relation between seasonal xylem growth and the resistant/non-resistant tree response; also the relation of water stresses in the tree with those responses.

17. Accomplishments in Last Year: Shortage of natural resin last summer necessitated that the first two objectives above be postponed. The phenolics compounds produced by the resistant reaction reach a maximum concentration -- approximately $1/3$ the concentration observed in heartwood -- within 3 months following wounding. These phenolics are also produced in the non-resistant reaction. Techniques have been developed for a study of the sugars present in lodgepole pine stems. Tissues from lodgepole pine have been successfully cultured.

Resistant and non-resistant trees were found to differ in water stress; stress measurements were about equal between the two groups, during periods of adequate precipitation, but in hot, dry weather non-resistant trees exhibited a greater stress. During periods of hot dry weather stem shrinkage greatly exceeded radial growth. In 1968 the period of most extensive stem shrinkage and water stress coincided with the flight period of the mountain pine beetle. Variations in growth rhythm during the season could not be related with degree of tree resistance or non-resistance.

18. Goals for Next Year : The tissue culture program will be continued to increase growth rates of the cultures and examine their use as experimental material for the formation of wound response compounds. Sugars present in stems of lodgepole pine will be assayed throughout the growing season.

Finalize studies of tree response to blue stain inoculation, bark beetle attack and water stress. Commence exploratory studies of the gaseous environment beneath the bark of infested trees.



R. W. Reid,
Investigator.



D. M. Shrimpton,
Investigator.

PROBLEM AREA PROGRAM

Reduction of Losses from Defoliating Insects

The principal defoliating insects within the region are the spruce budworm in northern Alberta and Northwest Territories and the forest tent caterpillar on aspen. The spruce budworm is the most widely distributed destructive forest insect in North America. Since 1947 it has been found in most stands of white spruce in the Mackenzie, Liard, Lower Hay and Slave river drainages of the Territories and along the Athabasca, Peace, Wabasca and Chinchaga rivers of northern Alberta. Annual detection surveys since 1955 have provided estimates of the budworm distribution, relative abundance and damage. Endemic and epidemic budworm populations exist in areas presently supporting the main spruce resources of Alberta and the Northwest Territories. There is need for research in essentially three major subject areas: (1) the economic and ecological effect of the budworm on the commercial forest; (2) the biology of the insect and development of techniques for measurement of budworm populations and (3) the formulation of control measures. Up to 1968 the budworm investigations have come under the first item and carried out by the Insect and Disease Survey. To expand budworm research a second project was initiated in 1968 to determine and evaluate the biology of the insect and development of budworm populations. As these and earlier studies continue a technical, biological and economic basis for meaningful control will be possible.

Studies on the forest tent caterpillar in northern and central Alberta have been principally to improve our knowledge of the history of the current outbreak which was first noted in 1957 and reached a peak in 1962 encompassing about 75,000 sq. miles of central and northern Alberta. More specifically these studies have concerned the defoliation forecasts, hatching studies, the parasite complex and the effect of wind dispersal in the spread of insect outbreak. Plans for 1969 are to expand the studies of the forest tent caterpillar to investigate in depth the ecology of aspen defoliators. The forest tent caterpillar will be used to investigate the influence of weather, nutrition, disease and vigor upon the epidemiology of the insect populations. A model of these influences upon insect abundance will be developed to predict numerical changes of the tent caterpillar and other insect species. Emphasis will be given to improved sampling techniques and the establishment of control methods.

After many years investigations on the population dynamics of the lodgepole pine needle miner have been completed. The results of these studies are being published and the project will be terminated in 1969.

Established projects and project proposals related to the problem are:

- A 237*: Annual forest insect survey - H. A. Tripp
- A 255 : History and impact of the spruce budworm in northern Alberta and Northwest Territories - R. E. Stevenson.
- A 288 : Biology of the spruce budworm in northern Alberta and Northwest Territories - H. F. Cerezke.
- A 257 : Forest tent caterpillar investigations - A. Raske.
- A 242 : Population dynamics and sampling of the lodgepole pine needle miner - R. F. Shepherd.
- Project Proposal : Ecology of aspen defoliators - R. F. Shepherd.

* Project statement appears under Problem Detection and Estimation of Tree Pest Damage.

PROJECT REVIEW STATEMENT

1. Establishment : Alberta/NWT/Yukon Date: February, 1969
2. Title : Population dynamics and sampling of the lodgepole needle miner.
3. Investigator : R. F. Shepherd
4. Year of Commencement: 1947
5. Anticipated Year of Completion: Original - 1970
6. Key Words not in Title: Pinus contorta, life tables, behavior, climate, mortality, SA 1.
7. Activity : Entomology
8. Problem Area Program: Reduction of losses from defoliating insects.
9. Establishment Project No. A 242 Branch Project No. A 242
10. Status : Active
11. Man-years Utilized in Past Year: Professional - .5 Other - None
12. Cooperating Agencies: National Parks and Historic Parks Branch.
13. Location of Work : Eisenhower Field Station; Banff National Park; Calgary.
14. Abbreviated Background Statement: Two main objectives have been involved: to determine the impact of needle miner defoliation upon stands in the National Parks and to build a body of information which will significantly contribute to the understanding of epidemiology of pest species. Studies have been under the stewardship of R. W. Stark, J. A. Cook, C. E. Brown and R. F. Shepherd.
15. Summary of Progress up to One Year Ago: Forty-three scientific papers and ten reports were published up to 1967. Studies and data collection are complete.
16. Goals Set One Year Ago: Synthesise the data and complete a mass multiple regression analysis.
17. Accomplishments in Last Year: No progress was made on this project. The investigator was absent on a transfer of work.
18. Goals for Next Year: Complete report and terminate project.

Shepherd, R. F. Monograph on epidemiology of lodgepole needle miner.
Proposed Journal publication.

A handwritten signature in cursive script that reads "R. F. Shepherd". The signature is written in dark ink and is positioned above a horizontal line.

R. F. Shepherd
Investigator

PROJECT REVIEW STATEMENT

1. Establishment : Alberta/NWT/Yukon Date: February, 1969
2. Title : History and impact of the spruce budworm in northern Alberta and Northwest Territories.
3. Investigator : R. E. Stevenson.
4. Year of Commencement: 1967
5. Anticipated Year of Completion: 1970
6. Key Words not in Title: Choristoneura fumiferana, Picea glauca, survey, B.18, 19, growth, loss.
7. Activity : Forest Insect and Disease Survey.
8. Problem Area Program: Reduction of losses from defoliating insects.
9. Establishment Project No. A 255 Branch Project No. A 255
10. Status : Active.
11. Man-years Utilized in Past Year: Professional - 1 Other - .7
12. Cooperating Agencies: National Parks and Historic Sites Branch; Alberta Forest Service; Mackenzie Forest Service.
13. Location of Work : Calgary, Northern Alberta, N. W. T.
14. Abbreviated Background Statement: Annual detection and appraisal surveys indicate growth loss, top killing and/or tree mortality is occurring within extensive areas of merchantable white spruce stands. Regeneration within and adjacent to infested mature stands is subject to injury, sometimes lethal. To properly utilize the spruce in the affected areas the Alberta Forest Service has had to re-align cutting priorities and increase the allowable cut.

Short term objectives of this project are:

- (1) Carry out an annual survey on the geographic distribution and relative abundance of spruce budworm in the Alberta/NWT/Yukon region.
- (2) Determine the history of the spruce budworm infestation in different regions.
- (3) Assess the impact of spruce budworm attacks on growth pattern and survival of spruce stands subjected to varying degrees of prolonged defoliation.

15. Summary of Progress up to One Year Ago: In addition to annual detection and mapping of budworm infestations by aerial surveys, ground checks were conducted during 1967 in all major infested areas. Information revealed that even repeated light infestation as recorded from the air results in considerable top killing and mortality to regeneration.

A summary of the percentage damage in merchantable stands attributable to the spruce budworm is presented below:

Condition of merchantable white spruce

Area	dead trees	living trees	
		dead tops	no dead tops
	percent		percent
Mackenzie-Blackwater rivers area	30	60	10
Redstone-Mackenzie rivers area	67	8	25
Long Island-Slave River	77	16	7
Wabasca-Muddy rivers	63	27	10
Wabasca-Senex area (south)	10	34	55
Wabasca-Senex area (north)	21	44	34

16. Goals Set One Year Ago: Continue impact studies, growth loss and mortality. Cooperate in an aerial photography operation over infested spruce stands. Prepare a manuscript on the history of the spruce budworm outbreaks in Alberta and the N. W. T.
17. Accomplishments in Last Year: Annual aerial detection, mapping and ground surveys were continued in 1968. High hazard areas containing a high incidence of dead and badly deformed trees in the Wabasca management units were mapped for the Alberta Forest Service.

Data gathered from ground work in 1968 in the Wabasca outbreak at the epicentre indicated tree mortality at 39 percent while 44 percent of the trees had dead tops. Compared to 1967 this represents a slight increase in tree mortality (from 34%) and a decrease in dead tops (from 49%). At the periphery of the outbreak there has been no tree mortality although 30 percent of the stand, primarily in the co-dominant and intermediate classes have dead tops.

Cross-sectional discs were taken from 24 trees in the Wabasca outbreak to investigate decreases in radial annual increment. Complete stem analysis studies are almost complete. Preliminary investigations conducted in 1967 suggest no spruce budworm activity prior to 1935 in the Wabasca. These fluctuations in radial increment have coincided with fluctuation in severe defoliation as determined by aerial surveys commencing in 1955.

Aerial photography at scales 1:2640 and

1:1320 was taken over 18 sq. miles of the severest attacked area. Within this area a sample strip four miles by one-half mile through the epicentre was photographed in ectrachrome at scales 1:100, 1:200 and 1:300.

A manuscript on "History of spruce budworm outbreaks in Alberta and N. W. T. and their impact on the forest" has been completed for editorial review.

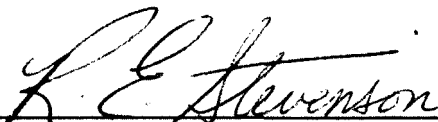
18. Goals for Next Year : Aerial surveys in northern Alberta and the Northwest Territories will be continued over major outbreak areas.

Analysis of stem data collected in 1968 show the Wabasca outbreak will be completed. Tree discs will be taken from outbreak areas in Chinchaga, lower Peace and lower Athabasca. In order to see if budworm attacks have occurred in central Alberta discs for stem analysis studies will be taken from three areas (Grande Prairie, Slave Lake and Lac La Biche) across Alberta some distance south of existing outbreaks.

Short-term appraisal studies and surveys will be conducted with provincial and federal personnel in high hazard areas, where necessary.

Aerial photographs taken in 1968 will be interpreted for incidence of tree mortality defoliation, volume loss and mapping of damage epicentres, and compared with companion data obtained from ground surveys. The economics of ground survey will be compared with aerial survey using photographs.

A report describing annual loss in increment and history of the spruce budworm in the Wabasca outbreak will be prepared.


 R. E. Stevenson
 Investigator

PROJECT REVIEW STATEMENT

1. Establishment : Alberta/NWT/Yukon Date: February, 1969
2. Title : Forest tent caterpillar investigations.
3. Investigator : A. Raske
4. Year of Commencement: 1960
5. Anticipated Year of Completion: Original - 1968; Revision I - 1970
6. Key Words Not in Title: Malacosoma disstria, defoliation, sequential sampling, climate, mortality, epidemeology, Alberta.
7. Activity : Forest Insect and Disease Survey.
8. Problem Area Program: Reduction of losses from defoliating insects.
9. Establishment Project No. A 257 Branch Project No. A 257
10. Status : Active
11. Man-years Utilized in Past Year: Professional - .3; Other - .5
12. Cooperating Agency : None
13. Location of Work : Central Alberta; Calgary laboratory.
14. Abbreviated Background Statement: Investigations on the forest tent caterpillar were conducted from 1957 to 1965 under the direction of C. E. Brown with assistance from J. K. Robins. A number of special studies had been initiated as opportunities for profitable investigations arose. A. G. Raske studies two aspects; cold-hardiness of first instar larvae, and individual differences in vigor.
15. Summary of Progress up to One Year Ago: All field work has been completed and the data analyzed.
16. Goals Set One Year Ago: Summarize work done up to the present and prepare report for publication.
17. Accomplishments in Last Year: Data collected in past years have been analyzed. A start was made on the report of survey activities in relation to the forest tent caterpillar.

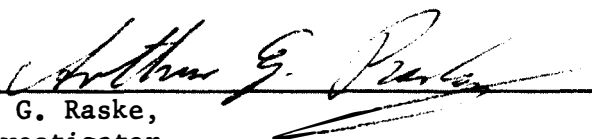
Publications:

Smith, G. J. and A. G. Raske. Starvation experiments with first instar forest tent caterpillar larvae Malacosoma disstria Hbn. Departmental Bi-Monthly Research Notes 24 (5) 39, 1968.

18. Goals For Next Year: Complete the report that will contain the results of the forest tent caterpillar investigations. Parts of the reports worthy of publication will be condensed for Journal publication.

Proposed Publications:


- Raske, A. G. and J. K. Robins. Forest tent caterpillar in Alberta. Departmental Information Report.
- Robins, J. K. and A. G. Raske. History of the forest tent caterpillar outbreak in Alberta, 1958-1968. Proposed journal publication.
- Raske, A. G. Cold hardiness of first instar larvae of the forest tent caterpillar. Proposed journal publication.
- Raske, A. G. Qualitative differences between individuals and colonies of the forest tent caterpillar. Proposed journal publication.
- Raske, A. G. The forest tent caterpillar in Alberta. Proposed departmental Information Report.
- Raske, A. G. Laboratory winter egg-hatch rate of the forest tent caterpillar. Proposed departmental Bi-Monthly Research Note.


A. G. Raske,
Investigator

PROJECT REVIEW STATEMENT

1. Establishment : Alberta/NWT/Yukon Date: February, 1969
2. Title : Biology of the spruce budworm, in northern Alberta and North West Territories.
3. Investigator : H. F. Cerezke
4. Year of Commencement : 1968
5. Anticipated Year of Completion: Original - 1973
6. Key Words Not in Title : Choristoneura fumiferana; Picea glauca; sample; defoliation; phenology; B 18, 19.
7. Activity : Entomology
8. Problem Area Program : Reduction of losses from defoliating insects.
9. Establishment Project No. A 288 Branch Project No. A 288
10. Status : Active
11. Man-years Utilized in Past Year: Professional - 0.4 Other - 1.1
12. Cooperating Agencies : Alberta Forest Service; McKenzie Forest Service.
13. Location of Work : High Level, Alberta; Fort Smith, N. W. T.
14. Abbreviated Background Statement: Important information is lacking on vital aspects of the biology of the spruce budworm. Studies are designed to provide biological and technical information essential to making decisions on control. Objectives are:
 - (1) To describe the life history of the budworm, its predators and parasites, and how its life stages relate to the seasonal phenological development of the host.
 - (2) To describe distribution of stages of the life cycle within the foliage of the host tree.
 - (3) To describe the foliage morphology and distribution on the host as it relates to the selection of the budworm sampling universe.
 - (4) To describe the behavior and development of larval stages with respect to their feeding and dispersal patterns.
 - (5) To develop methods of collecting, preserving and measuring foliage and budworm material.

15. Summary of Progress up to One Year Ago: Project commenced 1968.
16. Goals Set for Last Year : (a) Locate working areas suitable for field and laboratory studies. (b) Collect data on the budworm life history and on spruce phenology. (c) Set up basic weather recording instruments. (d) Examine methods of spruce foliage sampling and measurements. (e) Establish the feeding and dispersal behaviour of larvae on the host. (f) Test rearing methods for stages of the budworm life cycle and for predators and parasites. (g) Determine the presence of associated defoliator species whose life habits parallel those of the spruce budworm.
17. Accomplishments in Last Year: Budworm infested stands along the Peace, Chinchaga, Wabasca and Slave rivers were located and degrees of defoliation were observed from aircraft. Other infested stands were located from the ground. Pupae collections were made from two different areas, individuals were weighed and reared to determine size, parasitism and percent emergence. Collections of 360 branch samples were made from 30 non-infested trees and the following characteristics were measured on each: shoot length, numbers of terminal buds, branch surface area, number of needles and dry needle weights. Patterns of these characteristics within tree crowns were determined and are being used in the development of budworm sampling techniques. Thirty-two additional branches from budworm defoliated trees were examined similarly. Radial increment patterns were described for all sampled trees. Measurements of spruce phenological data were initiated but are incomplete due to late spring frost damage.
18. Goals for Next Year : (a) Semi-permanent field plots will be established for budworm population measurement. (b) Data will be gathered on the defoliation pattern within trees and between trees. (c) Measurements of spruce phenological development will be made concurrently with sample collections of budworm life stages and daily temperature recordings. (d) Data will be gathered on the within crown distribution pattern of 1-2 selected life stages. (e) Collections of pupae will be made for rearing moths, percentage moth emergence, parasitism and to test female moth attraction. This will contribute toward satisfying objectives 1, 2, 4 and 5.


 H. F. Cerezke
 Investigator

PROJECT PROPOSAL STATEMENT

1. Establishment : Alberta/NWT/Yukon Date: March, 1969
2. Title : Ecology of aspen defoliators
3. Investigator : R. F. Shepherd
4. Year of Commencement: 1969
5. Anticipated Year of Completion: 1979
6. Key Words Not in Title: population dynamics, insect behavior and vigor, weather, sample methods, defoliation and plant communities.
7. Activity : Entomology
8. Problem Area Program: Reduction of losses from defoliating insects.
9. Annual Man-year Requirements: Professional - 0.8 Other - 2.4
10. Major Equipment Purchases Required for Completion: Recorder \$3,500.,
Electrometer \$700.,
Portable rearing cabinets \$500., O & M either purchase or rental.
11. Cooperating Agencies:
12. Location of Work : Calgary and Central Alberta.
13. Background Statement: More than one-half of Alberta's forest resources are in aspen but less than five percent of the total annual wood utilization in the Province comes from this species. A great deal of knowledge needs to be obtained on the ecology of aspen as a basic requisite for the development of management principles. The forest tent-caterpillar is a conspicuous element in the ecology of aspen stands over wide areas, and many other defoliators occur which are of local importance.

Only limited information is available on the influence of the forest tent-caterpillar on aspen stands, census techniques for predicting abundance and control methods. This species is ideal for investigating the influence of weather, nutrition, disease and vigor upon the epidemiology of insect populations. The development of a model of these influences upon insect abundance will be useful in predicting numerical changes of other species as well.

It is intended that close contact will be maintained and information exchanged with other researchers and survey personnel studying aspen and aspen insects in this and other regions.
14. Objectives : 1. Determine the impact of aspen defoliation

upon stand ecology. 2. Identify the main factors influencing epidemiology of the forest tent-caterpillar and build a predictive model of their combined effects. 3. Devise sampling techniques for determining and predicting population levels and defoliation mosaics. 4. Establish control techniques. 5. Gather background information on aspen defoliators in general.

15. Plan of Attack : Techniques and procedures common in studies of plant and insect communities will be used with emphasis upon biomathematical analysis. Control techniques may be either chemical or biological and applied to the tree or the insect.
16. Goals for Initial One-year Period: 1. Make ecological observations over a wide range of defoliation and stand conditions. 2. Commence studies on the effect of weather and nutrition on the survival, fecundity, vigor and occurrence of diseases of forest tent-caterpillar. 3. Begin a study on the practicability of various sampling and trapping methods for estimating population densities. 4. Initiate studies on the effect of chemical defoliant and/or bud inhibitors upon aspen trees.

R. F. Shepherd

R. F. Shepherd
Investigator

PROBLEM AREA PROGRAM

Reduction of Losses from Root Inhabiting Insects

Since 1960 research on root inhabiting insects has concentrated upon the Warren's collar weevil which attacks pines and spruce throughout the boreal forest. Objectives are to determine the biology and ecology of this insect, to obtain meaningful criteria to assess the need for control, and to develop effective biological, silvicultural or direct methods of control. Plans are to continue the biological and ecological studies, to continue evaluation of infestations, and to investigate prescribed silvicultural control methods of the collar weevil.

Two projects are associated with this problem.

A 237*: Annual Forest Insect Survey - H. A. Tripp.

A 244 : Biology and Control of Warren's Collar Weevil -
H. F. Cerezke.

* Project statement appears under Problem-Detection and Estimation of Tree Pest Damage.

PROJECT REVIEW STATEMENT

1. Establishment : Alberta/NWT/Yukon Date: February 19, 1969.
2. Title : Biology and control of Warren's collar weevil.
3. Investigator : H. F. Cerezke.
4. Year of Commencement: 1960.
5. Anticipated Year of Completion: Original 1968. Revision I 1980.
6. Key Words not in Title: Hylobius warreni, sampling, dispersal, Pinus contorta, regeneration, growth reduction, traumatic ducts, BL9.
7. Activity : Entomology.
8. Problem Area Program: Reduction of losses from root-inhabiting insects.
9. Establishment Project No.: A 244 Branch Project No.: A 244
10. Status : Active.
11. Man-years Utilized in Past Year: Professional 0.6 Other 0.2
12. Co-operating Agencies: Alberta Forest Service, North Western Pulp & Power.
13. Location of Work : Alberta foothills; Calgary Laboratory.
14. Abbreviated Background Statement: Warren's collar weevil attacks pines and spruces throughout the Boreal Forest Region of Canada. In Alberta lodgepole pine is the primary host. Larvae feed in the sub-cortical tissue of root and root collar regions of healthy trees, causing large open wounds and resinosis. Trees of nearly all age classes are susceptible. They may be killed directly from girdling, suffer accumulative growth loss from repeated attack or be exposed, through larval wounds, to root and stem diseases.

Ecological, behavioral and damage appraisal survey studies of H. warreni have progressed to the stage where the status of this pest can be viewed in perspective with regional management plans of lodgepole pine in Alberta. Additional information is now required on the behaviour of the insects within stands subjected to various treatments. Pilot control studies will be implemented when sufficient information is at hand. Remaining unfulfilled objectives within this study are as follows:

- (a) Determine the time of initial invasion of the weevil in pine stands subjected to various treatments, and to describe their subsequent pattern of spread as it relates to tree mortality.
- (b) Formulate recommendations for weevil control in problem areas.

15. Summary of Progress up to One Year Ago: The geographical distribution of H. warreni in Alberta has been described. Populations of the weevil were measured in a variety of untreated pine stands. Weevil abundance has been related to stand age, density, altitude, tree size, duff thickness, clearcutting practices and general site conditions of naturally stocked stands. The behavior, life activities and the sequential timing of these activities in the adult stage have been described. Mortality factors associated with all stages are largely known, as are the effects of larval feeding upon tree wounding and growth. A survey sampling technique was developed for estimating weevil abundance and damage, and was tested in the Alberta foothills. Study plots were established to determine weevil immigration into regeneration and to follow their subsequent attack behavior. Other plots are established to examine the effects of pre-commercial thinning upon population change and tree mortality.
16. Goals Set One Year Ago:
- (a) Complete field studies of adult longevity and egg laying patterns.
 - (b) Complete a survey of H. warreni abundance and damage in the Lower Foothills.
 - (c) Complete final draft of Ph.D. thesis on H. warreni and other related papers.
17. Accomplishments in Last Year: Goals (a), (b) and the first part of (c) were completed, and a first draft of one of the short papers was prepared. Cerezke, H. F. The distribution and abundance of the root weevil Hylobius warreni wood in relation to lodgepole pine stand conditions in Alberta. Ph.D. thesis submitted to the University of British Columbia, December, 1968.
18. Goals for Next Year: Establish sample plots in clearcut sites, thinned stands and in fertilized stands, where available, at several locations in the Alberta foothills. Gather weevil population and tree data within these plot areas and in those experimental plots established earlier in regeneration pine. Re-examinations of these plots will be required every second year for a period of up to 15 years to satisfy objectives (a) and (b). Prepare the following reports and papers:
- Cerezke, H. F. A survey sampling method for the root weevil Hylobius warreni wood in lodgepole pine. Proposed journal.
 - Cerezke, H. F. Silvicultural control of H. warreni in the foothills region of Alberta. Departmental.
 - Cerezke, H. F. Some weevil wounding effects upon resin duct numbers in young lodgepole pine. Proposed journal publication.

Cerezke, H. F. and B. Rowsell. Summary report of survey damage appraisal studies of H. warreni. Proposed Information Report.

Cerezke, H. F. Distribution patterns of the root weevil in lodgepole pine stands of Alberta. Proposed Journal Publication.



H. F. Cerezke,
Investigator.