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Pacific Forest Research Centre

The Striped Ambrosia Beetle

Trypodendron lineatum (Olivier)

An Annotated Bibliography

W.W. Nijholt

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VICTORIA, B.C.
BC-X-121, JANUARY, 1979.

Environment Canada / Environnement Canada
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ABSTRACT

Literature, from several countries, that appeared during the last century, dealing with many aspects of the ambrosia beetle Trypodendron lineatum Olivier, has been reviewed. This bibliography contains 208 references, and an author and subject index. Its purpose is to provide a comprehensive background for the study of the insect, as well as easy access to information of practical use to those in forestry practices.

RÉSUMÉ

L'auteur énumère la documentation publiée dans plusieurs pays et parue depuis un siècle, traitant de plusieurs aspects du Scolyte birayé, Trypodendron lineatum Olivier. Cette bibliographie contient 208 références et des index par noms d'auteurs et par sujets. Elle veut servir d'outil général pour l'étude de l'insecte et de moyen facile d'information pratique pour le forestier.

REVISED EDITION

The annotated bibliography on Trypodendron lineatum was originally published in micro-fiche form as Report BC-X-121 in 1975. In response to the demand an updated version is issued in print and contains 208 references. The literature review was completed on December 1, 1978.

am-bro-sia (am brō/zh ə), n. 1 Class,Myth. the food, drink, or perfume of the gods. Cf. nectar (def. 2). 2. anything imparting the sense of divinity, as poetic inspiration, music, etc. 3. something especially delicious to taste or smell.[L Gk: immortality, food of the gods,........]

The Random House Dictionary
of the English Language

FOREWORD

Biologically, ambrosia beetles play an integral and discrete part within the forest ecology. In contrast to beetles that kill trees, they mainly infest standing or fallen trees recently killed by other agents, including insects and man. They provide for their own nutrition in the form of "ambrosia"* fungus, hence the name ambrosia beetle. In nature, the overall results of their activities in the tree host seem to be that they open up the wood by making numerous galleries in the sapwood, leaving the host exposed to further deteriorating agents. In commercial timber-producing areas, their infestations result in degraded lumber, various hidden costs in extra processing of infested material, and rejection of export-bound products.

As the economic importance of ambrosia beetles is closely related to the activities of man, in particular his forest practices, it has drawn the attention of researchers in many countries. Our knowledge of ambrosia beetles has increased greatly over the years, particularly of Trypodendron lineatum (Olivier), the most damaging species.

In addition to information about its taxonomy and geographical distribution, many facets of its life history have been revealed, such as those related to overwintering, spring emergence and flight activity, selection of host material by employment of primary (host odors) and secondary (aggregation pheromones plus host odors) attractant properties. Observations have been made on the manner of attack and penetration of the wood, the cultivation of the nutritional fungus, brood establishment and productivity as well as the post-attack activities, mainly entry into overwintering habitats. Several studies are reported on estimation of population densities and damage assessment. Ever since T. lineatum came to be considered an economic pest, methods have been proposed and tested to protect the forest products and to decrease the beetle population. These methods fall into three main categories: 1) forest management, 2) chemical control, and 3) population manipulation measures, e.g. with synthetic attractants (pheromones). Research on the ambrosia beetle has now reached a stage where, with the current knowledge of the insect and the availability of tested protective measures, it can be effectively controlled without endangering the environment. No doubt ongoing and future research will add to this knowledge and improve the control capabilities.

This annotated bibliography presents a collection of publications, dealing with this insect, that have appeared over the years in several countries. The notations are mainly confined to the part of the publication that deals with this insect, which is referred to herein as Trypodendron lineatum (Olivier). It has been known in the past, and in certain countries may still be, under one of the following synonyms:

Bostrychus lineatus Olivier
Xyloterus lineatus, Hamilton
Apate bivittata Kirby
Xyloterus bivittatus, Mannerheim
Trypodendron bivattatum, Provancher
Bostrychus cavifrons Mannerheim
Trypodendron cavifrons, Swaine
Trypodendron vittiger Eichhoff
Trypodendron borealis Swaine

Some publications cited in this bibliography provide easy access to information of practical use to industrial forestry personnel, e.g. on beetle attack in relation to felling date of trees, assessment of economic losses and applied control measures, on field identification of the insect, construction of flight traps, damage hazard assessment around dryland, log-sorting areas, and the application of a water misting control system. These practically oriented publications are grouped into a separate category in the subject index, even though they may also be listed under other categories.

In assembling this work, I have included, as much as possible, these publications that help to present an overall picture of the knowledge of this insect. Although hypotheses differ and interpretations of experimental results are sometimes at variance, I have let each item stand on its own. An author and subject index are included and the entries were concluded at the end of 1974.

This work was done, in part, to acknowledge the substantial and significant contribution to the current understanding of this insect by the late J.A. Chapman. I am most grateful for the privilege of having worked with Dr. Chapman.

ACKNOWLEDGMENT

I thank Dr. J.H. Borden, whose comments, based on his authoritive knowledge of the insect, were of great value.

* Schmidberger in 1836 discovered and named the fungus "ambrosia" (see No. 81).

1. Annila, E. 1975.
Effect of felling date of trees on the attack density and flight activity of Trypodendron lineatum (Oliv.)(Col., Scolytidae).
Commun. Inst. For. Fenn. 86(6): 1-16.

Logs from Norway spruce trees, felled from August to September in southern and northern Finland were infested by Trypodendron lineatum the following spring. Those cut in October and November were most susceptible. Logs cut in January and March became susceptible by the end of the flight period. Suggests that bark beetles prefer recently felled material to living trees and recommends fast processing of logs cut in the critical period to avoid damage due to ambrosia beetles as well as increases in bark beetle populations.

2. Annila, E., A. Bakke, B. Bejer-Petersen and B. Lekander. 1972.
Flight period and brood emergence in Trypodendron lineatum (Oliv.)(Col., Scolytidae) in the Nordic countries.
Commun. Inst. For. Fenn. 76(4): 7-28.

A study of flight, attack and emergence from brood logs of T. lineatum (Oliv.) in Denmark, Finland, Norway and Sweden. Information is given on flight and emergence in relation to temperature. More males than females were noted during spring flight and emergence. The times of first flight varied for the different countries. In some cases, emergence from brood logs occurred until September-October.

3. Austarå, Ø. and T. Saether. 1965.
Angrep av den stripete vedboreren i ubarket grantømmer hogd til forskjellig årstid.
(Infestation by Trypodendron lineatum Ol. of unbarked spruce logs felled at different seasons.)
Norsk Skogbruk 4: 121-122.

Trees felled from September to November were heavily attacked by T. lineatum. Those felled from December 2 to March 31 contained few entrance holes. Those felled on April 29 received heavy attacks with successful brood production. No explanation is given for this unusual occurrence.

4. Baker, J.M. 1963.
Ambrosia beetles and their fungi, with particular reference to Platypus cylindrus Fab.
Symp. Soc. Gen. Microbiol. 13: 232-265.

Distribution and general biology of the ambrosial habit in the Coleoptera is reviewed, with some mention of Trypodendron lineatum.

5. Bakke, A. 1960.
Insektskader på ubarket gran- og furutømmer i Norge.
(Insect injuries to unbarked spruce and pine timber in Norway.)
Medd. Nor. Skogforsøksvesen, 16: 281-333.

Report based on data from investigations on storing of unbarked sawn logs in various parts of Norway. Information is presented on the distribution of insects. Trypodendron lineatum (Ol.) was present only in spruce. Three insecticides were tested: DDT, Xylamon GI and 3-Frisk T, with good protection reported. Log piles of several layers were less infested than those of one layer.

6. Bakshi, B.K. 1950.
Fungi associated with ambrosia beetles in Great Britain.
Trans. Br. Mycol. Soc. 33: 111-120.

Describes fungi isolated from galleries of Trypodendron lineatum in Great Britain as Ceratocystis piceae (Münch) Bakshi, Leptographium lundbergii Lagerberg and Melin, and Oedocephalum lineatum n.sp. The symbiotic relationship between beetles and fungi is discussed.

7. Balfour, R.M. 1962.
Concerning the number of larval instars in Trypodendron lineatum (Oliv.)(Coleoptera: Scolytidae).
Entomol. Mon. Mag. 98: 52-53.

Presents results from head capsule measurements confirming the number of larval instars of T. lineatum as two, in agreement with Novák (1960) and at variance with Hadorn's (1933) opinion that there were four.

8. Balfour, R.M. and A. Paramanov. 1962.
Is the flight of Trypodendron lineatum (Oliv.)(Coleoptera: Scolytidae) strictly necessary?
Entomol. Mon. Mag. 98: 66-67.

Reports that adult T. lineatum, taken from their galleries before emergence, kept at 25-30°F during the winter and released under conditions where flight was restricted, actively started boring into wood after 2 days. Though no oviposition took place during 10 days of boring activity, the author questions the necessity of flight before boring activity can be initiated by the beetle.

9. Balfour, R.M. and R.C. Kirkland. 1962.
The effect of creosote on populations of Trypodendron lineatum breeding in stumps.
G.B. For. Comm. Rep. For. Res. 1961/1962: 163-166.

The incidence of attack by T. lineatum was low in Sitka spruce stumps, whether or not creosoted, and the successful emergence of adults was rare compared with that from logs.

10. Batra, L.R. 1963.
Ecology of ambrosia fungi and their dissemination by beetles.
Trans. Kans. Acad. Sci. 66: 213-236.

Discusses and reviews various aspects of cultivation and dissemination of ambrosia fungi by beetles, including Trypodendron lineatum, the significance of mycangia, the nature of ambrosia, and the role of ambrosia fungi in the life of beetles.

11. Batra, L.R. 1967.
Ambrosia fungi: a taxonomic revision, and nutritional studies of some species.
Mycologia, 59(6): 976-1017.

Describes and discusses fungi associated with ambrosia beetles and provides keys to genera and species. Proposes a revision of the nomenclature of the ambrosia fungi. In the case of the symbiotic fungus of Trypodendron lineatum, a change from Monilia ferruginea to Ambrosiella ferruginea is suggested.

12. Bauer, J. and J.P. Vité. 1975.
Host selection by Trypodendron lineatum.
Naturwissenschaften 62: 539.

Demonstrate synergism between - pinene and ethanol in the attraction of field populations of Trypodendron lineatum and relate this to host recognition and selection.

13. Beling. 1873.
Beitrag zur Naturgeschichte des Bostrychus lineatus und des Bostrychus domesticus. (Contribution to the life history of Bostrychus lineatus and Bostrychus domesticus.)
Tharandt Forst. Jahrb. 23: 17-43.

Reports on observations made on several biological aspects of Trypodendron lineatum after a large population increase occurred in windfall trees after heavy storms in 1868 and 1869. This century-old publication notes that the Trypodendron beetle had already been recognized for a long time as a widespread and dangerous pest. Observes that beetles do not attack freshly felled trees and suggests debarking of logs as a preventative measure.

14. Belyea, R.M. 1952.
Death and deterioration of balsam fir weakened by spruce budworm defoliation in Ontario. Part I.
Can. Entomol. 84(11): 325-335.

Deals with seasonal history and habits of insect species' breeding in severely defoliated and dead balsam fir trees. In part, observes that attack by Trypodendron lineatum took place in early May and in June. Pupation occurred in early September and new adults were formed by mid-September. The beetles overwintered in their galleries and emerged again in June of the next year (sic).

15. Bennett, R.B. and J.H. Borden. 1971.
Flight arrestment of tethered Dendroctonus pseudotsugae and Trypodendron lineatum (Coleoptera: Scolytidae) in response to olfactory stimuli.
Ann. Entomol. Soc. Am. 64(6): 1273-86.

On an automatically recording flight mill, both species required pretest flight exercise of 30 and 90 min, respectively, before arrestment response to female frass occurred. The arrestment response is considered a key step in the sequence of behavioral events involved in host selection and secondary attraction. It provides a transitional mechanism whereby the orientation response to suitable hosts or mates (or both) is terminated and gallery construction or reproduction (or both) are initiated.

16. Bevan, D. 1962.
The ambrosia beetle or pinhole borer Trypodendron lineatum Ol.
Scott For. 16(2): 94-99.

Discusses the life cycle of the ambrosia beetle Trypodendron lineatum (Ol.) in West Scotland, the susceptibility of logs to attack, and gives some information about chemical control with B.H.C.

17. Binion, W. 1962.
Attraction of the ambrosia beetle, Trypodendron by beer dregs.
Proc. Entomol. Soc. B.C. 59: 52.

An observation that Trypodendron beetles had entered bottles with beer residues in which fermentation was taking place. It is interesting to note that ethanol was later found to be a primary attractant (See No. 136).

18. Bletchly, J.D. 1961.
A review of factors affecting ambrosia beetle attack in trees and felled logs.
Emp. For. Rev. 40(1): 13-18.

Physical, chemical and biological factors applying to ambrosia beetles in general are discussed. Specific relationships between beetle and host, such as attraction, moisture content and attack are identified as needing further clarification.

19. Bletchly, J.D. and M.G. White. 1962.
Significance and control of attack by the ambrosia beetle Trypodendron lineatum (Oliv.) (Coleoptera: Scolytidae) in Argyllshire forests.
Forestry 35: 139-163.

A general overview of the ambrosia beetle situation in Argyllshire forests, with comments on the biology of Trypodendron and recommendations as to inventory reduction, as well as chemical treatment with B.H.C.

20. Borden, J.H. 1973.
Pheromone mask produced by male Trypodendron lineatum (Coleoptera: Scolytidae).
Can. J. Zool. 52: 533-536.

This study was to verify the existence of a pheromone mask. In laboratory bioassays, the response of male Trypodendron lineatum was inhibited if gut extract from post-diapause males, removed from logs, was added to an attractive extract of guts from females. Emergent males did not possess the mask. Tests indicate that the mask is olfactory and that attraction to females in the host would persist if they were not accompanied by mask-producing males.

21. Borden, J.H. and R.B. Bennett. 1969.
A continuously recording flight mill for investigating the effect of volatile substances on the flight of tethered insects.
J. Econ. Entomol. 62: 782-785.

Describes development and operation of a rotary flight mill with a photocell-ratemeter-paper chart recording system that provides a permanent quantitative record of flight speed and duration. Dendroctonus pseudotsugae and Trypodendron lineatum ceased flight abruptly when attractive odors such as female frass are introduced into the flight-chamber.

22. Borden, J.H., R.G. Brownlee and R.M. Silverstein. 1968.
Sex pheromone of Trypodendron lineatum (Coleoptera: Scolytidae): production, bioassay, and partial isolation.
Can. Entomol. 100(6): 629-636.

Deals with collection, extraction and isolation of the attractive component produced by Trypodendron lineatum. Bioassays in a newly developed olfactometer showed that female frass was more attractive than sawdust from host logs. Concentrations as low as 10^{-6} g. equiv. of frass were still attractive. Two fractions of ether eluate were highly attractive.

23. Borden, J.H. and C.E. Fockler. 1973.
Emergence and orientation behavior of brood Trypodendron lineatum (Coleoptera: Scolytidae).
J. Entomol. Soc. B.C. 70: 34-38.

Emergent brood beetles were found to be hygronegative and strongly photopositive. A reversal is indicated, in which these beetles eventually orient to moist, dark overwintering sites. The humidity and photic responses of brood Trypodendron were different from those excised from host logs (See No. 161), but are explained through examination of the biology of the two stages.

24. Borden, J.H., J.R. Handley, B.D. Johnston, J.G. MacConnell, R.M. Silverstein, K.N. Slessor, A.A. Swigar and D.T.W. Wong. 1978.

Synthesis and field testing of lineatin, the aggregation pheromone of Trypodendron lineatum (Coleoptera: Scolytidae)
J. Chem. Ecol. In Press.

Describes and discusses production in low yield of authentic 4,6,6,–lineatin via three synthetic pathways. Microgram amounts of the product of these syntheses attracted large numbers of Trypodendron lineatum in field tests, confirming that 4,6,6,–lineatin is a true population aggregation pheromone for T. lineatum.

25. Borden, J.H. and C.E. Slater. 1969.

Sex pheromone of Trypodendron lineatum: Production in the female hindgut-Malpighian tubule region.
Ann. Entomol. Soc. Am. 62: 454-455.

Finds positive attraction in extracts from hindguts with Malpighian tubules of Trypodendron lineatum excised from host logs after 16 hr boring activity. Ingestion of host material is not considered a prerequisite to pheromone production as no apparent frass was in the gut. Suggests that the pheromone of Trypodendron lineatum is probably a true secretion.

26. Borden, J.H. and E. Stokkink. 1971.

Secondary attraction in the scolytidae: an annotated bibliography. Can. Dep. Fish. For., For. Serv. Inf. Rep. BC-X-57.

Lists in part significant publications on Trypodendron lineatum, emphasizing information dealing with secondary attraction.

27. Borden, J.H., T.J. VanderSar and E. Stokkink. 1975.

Secondary attraction in the Scolytidae: An annotated bibliography.
Simon Fraser University, Pestology Centre, Pest Management Papers No. 4.

An updated revision of an annotated bibliography published in 1971 (No. 26).

28. Bright, Jr., D.E. and R.W. Stark. 1973.

The bark and ambrosia beetles of California. Coleoptera: Scolytidae and Platypodidae. Bull Calif. Insect. Surv. V. 16.

Gives in part biological and taxonomic information on Trypodendron lineatum, in California.

29. Capecki, Z. 1966.

Obserwacje porõwnawcze nad śladami zerowania drwalnika paskowanego (Trypodendron lineatum Ol.) i rytla pospolitego (Hyelecoetus dermestoides L.) w drewnie iglastym oraz uwagi na temat ich mylenia.
(Comparative observations on evidences of feeding by Trypodendron lineatum Ol. and Hylecoetus dermestoides L. in coniferous wood and remarks concerning the confusion of these two species.)
Sylwan. 110(9): 23-34.

Describes the differences in biology and phenology of T. lineatum and H. dermestoides, as well as their common ecological characteristics. Both attack similar coniferous trees (H. dermestoides also occurs on deciduous trees), producing frass and feeding on fungus.

30. Capecki, Z. 1967

Drwalnik paskowany Trypodendron lineatum Ol. (Scolytidae: Coleoptera) na terenie polski.
(The lined ambrosia beetle Trypodendron lineatum Ol. (Scolytidae Coleoptera) in Poland.)
Lesnictri (Prague) 314: 3-80.

Describes various aspects of the life history of Trypodendron in Poland. Some predators and parasites are mentioned. Information on damage and protection is given.

31. Castek, K.L., J.F. Barbour and J.A. Rudinsky. 1967.

Isolation and purification of the attractant of the striped ambrosia beetle.
J. Econ. Entomol. 60(3): 658-660.

Describes extraction and isolation of attractant component of Trypodendron lineatum, using gas-liquid-chromatography. The mass spectrum of the attractive fraction is similar to that of B-ocimene which, however, is not attractive in field tests.

32. Chapman, J.A. 1955.

Physiological and biological studies on the ambrosia beetle, Trypodendron lineatum (Oliv.) and the Douglas-fir beetle, Dendroctonus pseudotsugae Hopk.
Can. Dep. Agric. For. Biol. Div. Interim Rep. 1954-2.

Reports and discusses in detail results from laboratory studies and field observations on T. lineatum and D. pseudotsugae in 1954. Investigations of different aspects of physiology and biology, such as adult survival, changes in internal organs and flight behavior, are preliminary or exploratory. In particular, notes presence of gas bubbles in the ventriculus of flying adults, sees no evidence of wood ingestion and observes the marked changes in fat body and reproductive organs during development.

33. Chapman, J.A. 1955.

Survival of Trypodendron sp.
Can. Dep. Agric. For. Biol. Div. Bi-Mon. Prog. Rep. 11-(2): 3-4.

The mortality of beetles caught at the start of spring flight and kept at outdoor temperatures on a variety of woody materials was quite similar. Groups of beetles kept on dry blotting paper had a much higher mortality. Trypodendron lineatum has a survival potential which, even with poor weather conditions, allows time for considerable search.

34. Chapman, J.A. 1955.

Interpretation of adult history in the ambrosia beetle, Trypodendron.
Can. Dep. Agric. For. Biol. Div. Bi-Mon. Prog. Rep. 11(6): 3-4.

Presents a number of criteria, such as color of the oenocytes, presence of corpora lutea and condition of the colleterial glands, by which distinction can be made between young and old female Trypodendron lineatum. By using these criteria, it was found, for instance, that midsummer attacks were made only by old females and that both old and young females entered the duff to overwinter.

35. Chapman, J.A. 1956.

Physiological and biological studies on the ambrosia beetle Trypodendron lineatum (Oliv.).
Can. Dep. Agric., For. Biol. Div. Interim Rep. 1955-2.

Reports and discusses laboratory studies and field observations on T. lineatum in 1955. Covers, among other things, flight studies, internal and external indications to determine adult history and flight muscle changes. Analyzes the adult life in terms of different behavior phases and suggests important aspects that need investigating.

36. Chapman, J.A. 1956.

Flight-muscle changes during adult life in a scolytid beetle.
Nature 177: 1183.

Flight muscles are greatly reduced in Trypodendron lineatum active in gallery and brood establishment and return to normal size and function before emergence from the galleries. Points to the ecological significance of the fact that beetles cannot abandon their galleries by flight during the period of activity in the wood, in which burrowing and brood establishment takes place, and flight is not necessary.

37. Chapman, J.A. 1956.

Studies on the physiology of the ambrosia beetle Trypodendron in relation to its ecology.
Proc. 10th Int. Congr. Entomol. 4: 375-380.

Investigations in the role of physiological factors on the behavior of Trypodendron lineatum disclosed a difference in flight capacity between beetles seeking logs and those flying to overwintering sites. There is a close relationship between the response to a flight stimulus during adult life and the condition of the indirect flight muscles, which change in volume during the brood establishment period. Condition of reproductive organs, oenocyte color, and wear of head setae are used as criteria to distinguish between young and old individuals. Many females overwinter twice and adults are considered to go through a period of adult diapause. Internal changes during the adult's life history are discussed from an ecological standpoint.

38. Chapman, J.A. 1958.

Response of Trypodendron to forest litter.
Can. Dep. Agric., For. Biol. Div. Bi-Mon. Prog. Rep. 14(5): 3-4.

In the field, emerging beetles prefer litter in shaded locations though in laboratory tests, they were often attracted to light. Beetles taken from litter in early spring or caught in spring attack flight often burrow back into litter in the laboratory as well as outdoors.

39. Chapman, J.A. 1959.
Forced attacks by the ambrosia beetle Trypodendron.
Can. Dep. Agric., For. Biol. Div. Bi-Mon. Prog. Rep. 15(5): 3.

Trypodendron beetles were confined singly or in pairs by aluminum rings covered with cloth to logs of winter- and spring-felled Douglas-fir and western hemlock. Females actively constructed galleries in winter-felled logs but not in spring-felled ones. Single females made galleries, but did not lay eggs. Males did not excavate and are not considered necessary for the actual process of gallery excavation, egg laying and brood care.

40. Chapman, J.A. 1960.
The distribution of overwintering Trypodendron (Coleoptera: Scolytidae) around a single tree in relation to forest litter variability.
Proc. Entomol. Soc. B.C. 57: 3-6.

No direct relationship between moss or litter volumes and numbers of overwintering beetles thereon was demonstrated.

41. Chapman, J.A. 1960.
Overwintering mortality in the ambrosia beetle Trypodendron.
Can. Dep. Agric., For. Biol. Div. Bi-Mon. Prog. Rep. 16(4): 3-4.

Adult Trypodendron were confined in litter in cages through the winter period 1959-60. Only 5% mortality occurred.

42. Chapman, J.A. 1961.
A note on felling date in relation to log attack by ambrosia beetle Trypodendron.
Can. Dep. For., For. Entomol. and Pathol. Br. Bi-Mon. Prog. Rep. 17(5): 3-4.

Trees felled during road construction, from February to the middle of May, were examined for attack by Trypodendron lineatum. The heaviest attacks took place on February-March felled-logs. The decrease in attack on April-May-felled logs is seen in reduced frequency of attacked logs rather than lower attack density.

43. Chapman, J.A. 1962.
Field studies on attack flight and log selection by the ambrosia beetle Trypodendron lineatum (Oliv.)(Coleoptera: Scolytidae).
Can. Entomol. 94: 74-92.

T. lineatum are guided to attack by odors from logs, i.e., "primary attraction". After flying upwind toward the odor source, alighting beetles apparently utilize other stimuli to initiate burrowing. Variations between attraction of logs are discussed.

44. Chapman, J.A. 1963.
Field selection of different log odors by scolytid beetles.
Can. Entomol. 95: 673-676.

In a field experiment, air from a common source was blown over logs of different tree species. Trypodendron lineatum responded to Douglas-fir logs and possibly to western hemlock.

45. Chapman, J.A. 1966.
The effect of attack by the ambrosia beetle Trypodendron lineatum (Olivier) on log attractiveness.
Can. Entomol. 98: 50-59.

A detailed field study of the attractiveness of logs placed in "greenhouse" cages. Attack by female T. lineatum was invariably followed by a marked increase in attractiveness of logs. This "secondary" attraction remained when females stayed alone, but disappeared when males were added shortly afterward. Adding males a month later had no reducing effect. Also mentioned are results of experiments on recovery after release of marked beetles and the use of smoke to visualize odor paths through the "greenhouse" cages.

46. Chapman, J.A. 1967.
Response behavior of scolytid beetles and odor meteorology.
Can. Entomol. 99: 1132-1137.

Based on field observations of Trypodendron lineatum over a period of several years, the author considers transport and dispersal of odors by air currents an important factor in scolytid response to attractant sources. Knowledge of rates and types of odor distribution near the ground, in addition to air temperature ("odor meteorology") would provide a basis for most effective use of chemical attractants in natural environments.

47. Chapman, J.A. 1972.
Ommatidia numbers and eyes in scolytid beetles.
Ann. Entomol. Soc. Am. 65(3): 550-553.

The average number of ommatidia of Trypodendron lineatum counted from celloidin replicas of the eye surface was 173. The divided eye surface is clearly illustrated. Suggests that insects with simpler eyes are less dependent on vision.

48. Chapman, J.A. 1974.
Ambrosia beetle, Guidelines to population estimates near dry land log-storage areas and damage hazard assessment.
Can. For. Serv., Pac. For. Res. Cent. Inf. Rep. BC-X-103.

A practical guide in identifying Trypodendron lineatum Ol. and its overwintering sites. Outlines a procedure to sample populations of overwintering beetles, particularly around dry land log-sorting areas, and gives a damage hazard rating guide. A simplified procedure for sampling overwintering population is outlined in an addendum (see No. 157).

49. Chapman, J.A. and E.D.A. Dyer. 1960.
Seasonal flight activity of the ambrosia beetle, Trypodendron lineatum (Oliv.), for 1959, near Parksville, B.C.
Proc. Entomol. Soc. B.C. 57: 30-33.

Mainly presents data on T. lineatum flight activity in relation to weather and season. Many logs not attacked by beetles of the first flight were attacked during later flights. It is assumed that the beetles came from some distance and from scattered sources.

50. Chapman, J.A. and E.D.A. Dyer. 1969.
Characteristics of Douglas-fir logs in relation to ambrosia beetle attack.
For. Sci. 15(1): 95-101.

Growth rate, starch content and cell viability of logs is related to their attractiveness to Trypodendron lineatum. Beetles in the most attractive logs produced more brood per gallery. Outer sapwood moisture was similar in all trees at felling and was unrelated to attack.

51. Chapman, J.A., S.H. Farris and J.M. Kinghorn. 1963.
Douglas-fir sapwood starch in relation to log attack by the ambrosia beetle, Trypodendron.
For. Sci. 9: 430-439.

Trypodendron lineatum does not attack logs with a relatively high starch content, but logs with little or no starch may or may not be attacked. Therefore, there does not appear to be a direct relationship between starch and log attractiveness.

52. Chapman, J.A. and J.M. Kinghorn. 1955.
Window flight traps for insects.
Can. Entomol. 87: 46-47.

Describes construction and use of glass-barrier flight traps for sampling flying populations of ambrosia beetles and other scolytids.

53. Chapman, J.A. and J.M. Kinghorn. 1955.
Flight trap studies of forest coleoptera and other insects with special reference to Trypodendron lineatum (Oliv.).
Can. Dep. Agric., For. Biol. Div. Interim Rep. 1954-4.

Deals with construction and other factors that influence effectiveness of window flight traps. Data on numbers of T. lineatum captured are discussed in considerable detail in relation to the then current knowledge of its biology and to weather.

54. Chapman, J.A. and J.M. Kinghorn. 1958.
Studies of flight and attack activity of the ambrosia beetle Trypodendron lineatum (Oliv.) and other scolytids.
Can. Entomol. 90: 362-372.

Describes and discusses the effect of weather, season and other factors on flights of T. lineatum and to some extent other scolytids.

55. Chapman, J.A. and R. Neitsch. 1959.
Autumn-winter mortality in the ambrosia beetle Trypodendron.
Can. Dep. Agric., For. Biol. Div. Bi-Mon. Prog. Rep. 15(3): 3-4.

Samples of litter containing Trypodendron were collected in April and examined for live beetles; then after drying were examined for evidence of dead beetles. A relatively low mortality occurred in the overwintering population.

56. Chapman, J.A. and W.W. Nijholt. 1965.
Proportion of old and young adults in an overwintering population of the ambrosia beetle Trypodendron lineatum (Oliv.).
Can. Dep. For., For. Entomol. and Pathol. Br., Bi-Mon. Prog. Rep. 21(1): 3-4.

Samples of beetles were collected from duff and bark at several sample spots in a forest margin. The ratios of old to young adult T. lineatum were determined. Statistical tests revealed that the samples were not homogeneous.

57. Chararas, C. 1961.
Recherches sur la spécificité de Xyloterus lineatus Ol. (Coléoptère: Scolytidae)
(Studies on the specificity of Xyloterus lineatus Ol. (Coleoptera: Scolytidae))
G.R. Seances Acad. Sci. 252: 602-604.

The host preference of Trypodendron lineatum depends on the condition of the host plant and on the odors it produces. Attraction occurred to very dilute alpha- and beta-pinene and D-3-carene. A correlation was shown between amounts of host nitrogen and attack density. Larval development seems to take place in areas richest in nitrogen and carbohydrates. Concludes that the ambrosia fungus modifies the biochemical constituents of the attacked tree and thus creates a complex of factors that further link insect to the host plant.

58. Christiansen, E. 1967.
Stripet vedborer. Vinterhogd tømmer angripes sterkest.
(Striped woodborer. Winter logged timber is attacked the heaviest.)
Skogeieren 11: 21 and 45.

Demonstrates that winter logged timber is attacked the heaviest and suggests preventative measures for Trypodendron lineatum.

59. Christiansen, E. and T. Saether. 1968.
Infestation density of Trypodendron lineatum (Olivier)(Coleoptera: Scolytidae) in relation to felling date of logs.
Nor. Entomol. Tidsskr. 15: 28-30.

Trypodendron lineatum attacked Norway spruce logs cut in October 1966 through March 1967, with the heaviest infestation in the logs felled in the first part of the period. Logs cut in April, May, and June remained undamaged. Under the climatic conditions existing in this part of Norway, logs felled as late as the middle of March may be infested.

60. Daterman, G.E., J.A. Rudinsky and W.P. Nagel. 1965.
Flight patterns of bark and timber beetles associated with coniferous forests of western Oregon.
Oreg. Agric. Exp. Stn. Tech. Bull. 87.

Summarizes the diurnal and seasonal flight patterns of scolytid beetles, as influenced by various environmental factors, particularly temperature, light intensity and wind velocity, and by the life histories of the species involved. Temperature, and to a lesser extent, light intensity, were the primary factors governing flight activity. For Trypodendron lineatum, olfactory response highly affected the flight activity.

61. Dobie, J. 1978.
Ambrosia beetles have expensive tastes.
Can. For. Serv., Pac. For. Res. Cent. Inf. Rep. BC-P-24.

Updates information on lumber degrade caused by ambrosia beetles of a previous study, No. 137, to current market conditions.

62. Dominik, J. 1956.
Spostrzezenia nad mozliwõscia chemicznego zwalzania w drewnie drwalnika paskowanego (Trypodendron lineatum Ol.)
(Observations on the feasibility of chemical control of Trypodendron lineatum within the wood.)
Sylwan 100: 40-42.

A mixture of DDT and BHC in heavy oil is reported effective in controlling T. lineatum in unbarked Scots pine logs.

63. Dominik, J. 1959.

Z dóswiadczén nad chemicznym zwalczaniem w drewnie drwalnika (Trypodendron lineatum Ol.) nieparka pospolitego (Xyleborus dispar F.), drwalniezka Saxesena (Xyleborus saxeseni Ratz.) i rytla pospolitego (Hylocetus dermestoides L.).
(The chemical control of Trypodendron lineatum, Xyleborus dispar, Xyleborus saxeseni and Hylocetus dermestoides in wood.)
Sylwan 103: 1-9.

Reports on details of the effect of chemical preparations used as thick coatings against Trypodendron lineatum and other species, with generally good results.

64. Dyer, E.D.A. 1960.

The use of marked ambrosia beetles (Trypodendron) in studies of spring attack flight.
Can. Dep. Agric., For. Biol. Div. Bi-Mon. For. Rep. 16(6): 3-4.

During preliminary tests to determine whether marked beetles released at various distances from attractive logs could be recovered, it was shown that a small amount of attractive log material can attract large numbers of beetles. A combination of large numbers of marked beetles, material known to be highly attractive and efficient recovery techniques are necessary to obtain a clear indication of insect movement.

65. Dyer. E.D.A. 1961.

Flight capability of ambrosia beetle (Trypodendron).
Can. Dep. Agric., For. Biol. Div. Bi-Mon. Prog. Rep. 17(1): 4.

A marked Trypodendron lineatum released the previous year was found at a distance of 2½ miles and at a 1200-foot lower elevation from the point of release, indicating that the species has considerable flight potential.

66. Dyer, E.D.A. 1962.

The effect of exposure of hibernation sites on the time of Trypodendron spring flight.
Can. Entomol. 94(9): 910-915.

There was 6 weeks difference between flight activity of Trypodendron lineatum at exposed and sheltered hibernating sites. Points out that winter logging operations frequently expose large numbers of hibernating beetles and that the resulting logs and logging debris are likely to sustain early season attack before the main swarming flight by insects hibernating in sheltered sites.

67. Dyer, E.D.A. 1963.

Attack and brood production of ambrosia beetles in logging debris.
Can. Entomol. 95: 624-631.

Where autumn and winter felling is in progress very large populations of Trypodendron lineatum can develop. In study areas, the population increase was estimated to be four-fold, amounting to a quarter of a million beetles produced per acre.

68. Dyer, E.D.A. 1963.

Distribution of Trypodendron attacks around the circumference of logs.
Can. Dep. For., Bi-Mon. Prog. Rep. 19(2): 3-4.

Reports on field tests with logs placed in sunshine and in shade. The upper part exposed directly to sunshine was scarcely attacked. Logs in the shade were uniformly attacked around the circumference.

69. Dyer, E.D.A. 1967.

Relation of attack by ambrosia beetle (Trypodendron lineatum)(Oliv.)) to felling date of spruce in central British Columbia.
Can. Dep. For., Bi-Mon. Res. Notes 23(2): 11.

Indicates differences in relationship of attack density of Trypodendron to felling date of spruce logs in the interior of British Columbia compared to those on Douglas-fir and western hemlock in coastal forests. Only spruce trees felled well before the onset of winter were attractive to Trypodendron the following spring.

70. Dyer, E.D.A. and J.A. Chapman. 1962.

Brood productivity of ambrosia beetles in water-soaked logs.
Can. Dep. For., For. Entomol. and Pathol. Br. Bi-Mon. Prog. Rep. 18(5): 3.

Two investigations with water-soaked logs suggest that, although they are readily attacked, they produce little or no brood.

71. Dyer, E.D.A. and J.A. Chapman. 1963.
Flight and attack of the ambrosia beetle Trypodendron lineatum (Oliv.) and other scolytids in relation to felling date of logs.
Can. Dep. For., For. Entomol. and Pathol. Br. Interim Res. Rep. Sept. 1963.

A detailed study that showed that logs from trees felled in August through January were well attacked by T. lineatum while whole logs cut in February did not attract beetles, although short pieces of them did. Material from March through May fellings received negligible attack. Logs protected from attack until mid-summer were readily attacked when exposed. The physiological condition of the tree when felled rather than the subsequent post-felling changes of aging is apparently the most important factor affecting log attractiveness. Beetles confined on logs responded in the same way as beetles from natural populations.

72. Dyer, E.D.A. and J.A. Chapman. 1964.
Ambrosia beetle brood production in relation to tree growth and sapwood depth.
Can. Dep. For., For. Entomol. and Pathol. Br. Bi-Mon. Prog. Rep. 20(3): 3-4.

The fastest growing Douglas-fir trees produced the largest Trypodendron lineatum broods. The physiological and physical conditions of logs from fast-growing trees are thought to contribute to the beetles boring longer galleries and laying more eggs.

73. Dyer, E.D.A. and J.A. Chapman. 1965.
Flight and attack of the ambrosia beetle, Trypodendron lineatum (Oliv.) in relation to felling date of logs.
Can. Entomol. 97(1): 42-57.

The importance of felling date in relation to subsequent attack by T. lineatum was firmly established. The critical period of felling was between January and February. Considerable variability in attractiveness exists between trees of the same felling date. The cutting of logs in short pieces increased their attractiveness, indicating that attractiveness is not dependent on felling date alone. Attacked logs tend to have reduced attractiveness to later flying beetles.

74. Dyer, E.D.A. and J.M. Kinghorn. 1961.
Factors influencing the distribution of overwintering ambrosia beetles, Trypodendron lineatum (Oliv.).
Can. Entomol. 93(9): 746-759.

The large variations in numbers of T. lineatum in overwintering habitats with similar characteristics were studied in relation to the amount of shelter and incident light penetrating to the ground. The nature of duff and bark was not a factor in determining relative population density. The amount of light reaching the forest floor is governed by the density of the forest canopy and added shelter by the various growths within the stand. The optimum hibernating sites are positions of lowest incident light near the end of the light gradient from the open forest edge to the more uniform within stand conditions.

75. Dyer, E.D.A. and W.W. Nijholt. 1965.
Observations of overwintering Pseudohylesinus and Trypodendron.
Can. Dep. For. For. Entomol. and Pathol. Br. Bi-Mon. Prog. Rep. 21(4): 3.

Pseudohylesinus granulatus (Le Conte) and P. grandis Swaine were found hibernating in the bark of green Abies fir trees, together with Trypodendron lineatum often occupying the same hole. On Douglas-fir and western hemlock in the same area, only T. lineatum were found.

76. Enzinger, F. 1949.
Bekämpfung des Xyloterus lineatus mit DDT.
(Controlling Xyloterus lineatus with DDT.)
Forst Holzwiss. Ztg. Wien 60: 194.

Reports on a small experiment on application of DDT to kill and postpone further attack by Trypodendron lineatum. The experiments were conducted after heavy attacks were observed in late August and early September (sic).

77. Farký, O. 1931.
Ochrana před dřevokazem čarkovaným (Xyloterus lineatus, Oliv.).
(Control of X. lineatus, a beetle injurious to trees.)
Drev. Listy 1-15.

Suggests chemical treatments with carbolinium 5-10% as the most practical control for beetles affecting saw logs, stove wood and old stumps. Warns against spread of insect population due to material left in the woods.

78. Farris, S.H. and J.A. Chapman. 1957.
A preliminary study of the deposition and early growth of fungus within the galleries of the ambrosia beetle Trypodendron lineatum (Oliv.).
Can. Dep. Agric., For. Biol. Div. Bi-Mon. Prog. Rep. 13(6): 3.

Examination of histological sections of galleries made by T. lineatum suggests that the ambrosia fungus is deposited at a number of scattered points within the galleries during their construction. The deposition process may be under control of the beetles rather than merely due to the physical exertion of burrowing.

79. Finegan, R.P. 1967.
Environmental contamination by benzene hexachloride used for control of ambrosia beetles.
B.C. Fish Wildl. Rep.

Reports results of a pilot study which disclosed BHC residues in oysters, fish and birds.

80. Fisher, R.C. and G.H. Thompson. 1952.
Recent developments in the prevention of attack by ambrosia (pinhole) borer) beetles in standing trees and logs.
Commonw. For. Conf., 6th, Canada, 1952.

Recent developments in assessment of losses, and treatment in the prevention of beetle attack by BHC and DDT are described, with reference to results of experimental work in the Gold Coast and Malaya. A summary of the proposed investigation of these insects in West Africa is given.

81. Fisher, R.C., G.H. Thompson and W.E. Webb. 1953, 1954.
Ambrosia beetles in forest and sawmill. Their biology, economic importance and control.
Part I - Biology and economic importance.
For. Abstr. 14(4): 381-389.
Part II - Prevention and control.
For. Abstr. 15(1): 3-15.

A summary of existing knowledge on the habits, economic importance and the control of ambrosia beetles, including Trypodendron lineatum. Indicates gaps in the knowledge of the biology and conditions essential for their attraction to and development in trees and logs. Suggestions are presented as to the direction future research should take.

82. Fockler, C.E. and J.H. Borden. 1972.
Sexual behavior and seasonal mating activity of Trypodendron lineatum (Coleoptera: Scolytidae).
Can. Entomol. 104: 1841-1853.

Newly emerged brood adults mated with low frequency. Mating activity of revived overwintering T. lineatum slowly increased with time until, in February, a sudden rise of activity was noticed suggesting that overwintering populations undergo only a reproductive diapause. Mating activity was primarily dependent on the condition of the males.

83. Fockler, C.E. and J.H. Borden. 1973.
Mating activity and ovariole development of Trypodendron lineatum: effect of a juvenile hormone.
Ann. Entomol. Soc. Am. 66(3): 509-512.

Topical application of a juvenile hormone analogue (EFA) caused repression of mating activity, primarily in the male T. lineatum. A lower dose (0.05ug) of EFA accelerated mating activity after 1 hour and a higher dose (50ug) induced growth and maturation of ovaries.

84, Francia, F.C. and K. Graham. 1966.
Aspects of orientation behavior in the ambrosia beetle Trypodendron lineatum (Olivier).
Can. J. Zool. 45: 985-1002.

A detailed laboratory study of the orientation behavior of T. lineatum to light, temperature, odor, air flow and gravity, and the influence of recent flight history. Discusses photic stimuli in relation to olfactory responses. Felled, dying trees have a primary attractant that is absent from the living, healthy tree. Describes two basically new techniques using beetles as bioassay instruments in evaluating their response to odors.

85. Francke, W. and V. Heemann. 1974.
Lockversuche bei Xyloterus domesticus L. und X. lineatus Oliv. (Coleoptera: Scolytidae) mit 3-hydroxy-3-methylbutan-2-on.
(Experiments on attraction of Xyloterus domesticus L. and X. lineatus Oliv. (Coleop-

tera: Scolytidae) to 3-hydroxy-3-methylbutan-2-on.)
Z.ang.Ent. 75: 67-72.

In laboratory assays, 3-hydroxy-3-methylbutan-2-one, isolated from extractions from Xyloterus domesticus and Trypodendron lineatum (X. lineatus) attracted both species, but T. lineatum responded to a lesser degree. In the field, the attack response proved greatest to combinations of the aggregation substance and the odors from susceptible logs.

86. Francke, W., V. Heemann and K. Heyns. 1974.
Flüchtige Inhaltsstoffe von Ambrosiakäfern (Coleoptera: Scolytidae), I.
Z. Naturforschungen 29c: 243-245.

Deals with isolation and identification of 3-hydroxy-3-methylbutan-2-one found in equal amounts in extracts of males and females of Xyloterus (Trypodendron) domesticus L., Xyloterus signatus F. and Xyloterus lineatus Oliv.

87. Francke-Grosmann, H. 1956.
Zur Ubertragung der Nährpilze bei Ambrosiakäfern.
(The fungus transfer by ambrosia beetles)
Naturwissenschaften 43: 286-287.

Describes the location of the glands containing spores of the ambrosia fungus associated with Trypodendron lineatum.

88. Francke-Grosmann, H. 1956.
Hautdrüsen als Träger der Pilzsymbiose bei Ambrosiakäfern.
(Integumental glands as carriers of symbiotic fungi of ambrosia beetles.)
Z. Morphol. Oekol. Tiere, 45: 275-308.

A comprehensive study on the methods of transfer of symbiotic fungi by ambrosia beetles. Includes a detailed morphological description of the mycangia of Trypodendron sp. and discusses various aspects of the relationship between the insects and their symbiotic fungi.

89. Francke-Grosmann, H. 1957.
Über die Ambrosiazucht holzbrütender Ipiden im Hinblick auf das System.
(The propagation of wood inhabiting Ipidae in regard to the system.)
Verhandlungsber, Deut. Ges. ang. Entomol. 14: 139-144.

Describes the prothoracic glands and their fungus content in female Trypodendron lineatum. Other ambrosia beetles and their fungi are also discussed.

90. Francke-Grosmann, H. 1957.
Beiträge zur Kenntnis der Übertragungsweise von Pflanzenkrankheiten durch Käfer.
(Contributions to the knowledge of the transfer methods of plantpathogens by beetles.)
Verhandl. Intern. Congr. Pflanzenschutz, 4th, Hamburg, 805-9 (1959).

Mentions in part the fungus transport mechanism of Trypodendron lineatum. The phytopathological relationship is not clear. A technique of sterilizing fungus-carrying beetles is described.

91. Francke-Grosmann, H. 1963.
Some new aspects in forest entomology.
Ann. Rev. Entomol. 8: 415-438.

A comprehensive review with emphasis on symbiotic relationships between fungi and forest insects, including T. lineatum. Recent studies on attraction are also discussed at length.

92. Fröhlich, J. 1933.
Zur Frage der Wertverminderung von Fichtenstammholz durch Lagerung.
(On the question of value loss of spruce logs through storage.)
Centralbl. Gesamte Forstwes. 59: 143-147.

Points to relationship between attacks by Trypodendron lineatum and length of storage of the logs in the woods, size of storage piles and percentage of bark remaining on the logs.

93. Fry, R.H. and N.D. Wygant. 1971.
Spruce beetle mortality in cacodylic acid-treated Engelmann spruce trap trees.
J. Econ. Entomol. 64(4): 911-916.

Treatment of Engelmann spruce trees with cacodylic acid proved fatal to Dendroctonus rufipennis (Kirby) and prevented brood development. The development of Trypodendron lineatum attracted to the trees was not affected.

94. Funk, A.
The symbiotic fungi of certain ambrosia beetles in British Columbia.
Can. J. Bot. 43: 929-932.

Describes and identifies the symbiotic fungus of Trypodendron lineatum found in British Columbia as Monilia ferruginea Mathiesen-Käärik.

95. Gaumann, E. 1930.
Untersuchungen über den Einfluss der Fallungszeit auf die Eigenschaften des Fichten- und Tannenholzes.
II Teil. Einfluss der Fallungszeit auf die Dauerhaftigkeit des Fichten und Tannenholzes.
(Investigations on the effect of time of felling on the qualities of spruce and fir wood. Part II: Effect of time of felling on the durability (?) of spruce and fir wood.)
Beih. Z. Schweiz. Forstvereins. 6: 26-32.

In Europe, Trypodendron lineatum did not attack spruce and fir cut from March to August. Attacks were heaviest on trees cut in October, November and December, although January felled spruce was also heavily attacked.

96. Gibson, C., J.M. Kinghorn and J.A. Chapman. 1958.
Ambrosia beetle prood productivity.
Can. Dep. Agric., For. Biol. Div. Bi-Mon. Prog. Rep. 14(5): 2-3.

A discussion comparing brood productivity of Trypodendron lineatum in different parts of various logs in older Douglas-fir. Some data are also given on young Douglas-fir.

97. Graham, K. 1953.
Report on ambrosia beetle control in the Nimpkish Valley, B.C.
Can. Dep. Agric., For. Biol. Div. Bi-Mon. Prog. Rep. 9(5): 3-4.

Although some untreated logs did not receive any attacks by Trypodendron lineatum, others treated with BHC were unaccountably heavily damaged.

98. Graham, K. 1954.
Chemical control of ambrosia beetles (1952).
Can. Dep. Agric., For. Biol. Div. Interim Tech. Rep. For. Zool. Lab.

Deals with some aspects of experiments on insecticidal control of Trypodendron lineatum, and discusses exploratory work on chemical attraction by logs of ambrosia and bark beetles.

99. Graham, K. 1959.
Release by flight exercise of the chemotropic response from photopositive domination in a scolytid beetle.
Nature, 184: 283-284.

Reports that flight exercise results in the diminuation of photopositive response of Trypodendron lineatum, and allows the beetles to react to chemical and contact stimuli.

100. Graham, K. 1960.
Photic behavior in the ecology of the ambrosia beetle Trypodendron lineatum.
Proc. Int. Congr. Entomol., 11th, Vienna, 1960.

Deals with the transition from photoresponse during early flight to host selection and brood establishment. Ties the transitional period, in particular, the sustained period of searching on log surfaces to length of the period in which a beetle could contact applied residual pesticides and the variation in effectiveness of these chemicals.

101. Graham, K. 1961.
Air-swallowing: a mechanism in photic reversal of the beetle Trypodendron.
Nature 191: 519-520.

Laboratory experiments show that unflown Trypodendron lineatum are strongly photopositive, that accumulation of gas in the ventriculus always accompanies the photic reversal in a flown beetle and that deflation restores the photopositive response. Artificial inflation is effective in abolishing the photopositive response. Concludes that release of other than photic responses is brought about by detection by pressure sensors sensitive to the ventricular air bubble.

102. Graham, K. 1968.
Anaerobic induction of primary chemical attractancy for ambrosia beetles.
Can. J. Zool. 46: 905-908.

The formation of olfactory attractants for Trypodendron lineatum is accelerated by

induced anaerobic conditions (submersion in water) in green sapwood of western hemlock and Douglas-fir. The attraction is detectable after 4 hr and peaks at 20 to 24 hr of treatment. Supports the hypotheses that oxygen deficiency is a causal factor in the formation of chemical attractants, and that in a log or dying tree, stagnation of the translocative and pneumatic systems leads to deficiency of oxygen at the active metabolic centers. Consequently, the change from oxidative to fermentative metabolism induces attractant formation.

103. Graham, K. and E.C. Boyes. 1950.
Pinworms in lumber (historical and economic aspects).
B.C. Lumberman 34: 42 and 106.

Outlines the problems caused by evidence of ambrosia beetle damage, in lumber on the international market since 1928. Discusses the costs of inspection and fumigation and the implications of the damage as they affect lumber manufacturing.

104. Graham, K., J.M. Kinghorn and W.E. Webb. 1950.
Measurement of a damage index in logs infested by ambrosia beetle.
B.C. Lumberman 34(8): 43f.

Describes the degree of infestation and damage by ambrosia beetles in logs before milling, and concludes that the number of holes per square foot of log provides a direct damage index. Correlation of these counts with values obtained in mill studies shows just how much loss can be expected. Further mill studies are required to include log diameter in the damage index.

105. Graham, K. and I.A. Moeck. 1968.
The aligning effect of light flicker on phototaxis of the ambrosia beetle Trypodendron lineatum (Olivier).
Can. J. Zool. 46: 602-603.

Light flicker at 5 cycles per second provoked a more direct guided response in Trypodendron lineatum than a steady source of the same intensity. This observation may be of importance in bioassay of chemical attractants where light is used as an opposing stimulus.

106. Graham, K. and H.A. Richmond. 1950.
Ambrosia beetles.
Can. Dep. Agric., For. Biol. Div. Bi-Mon. Prog. Rep. 6(2): 2-4.

Discussion, in part, of economic aspects of logging practices and the need for a damage index. States that for Trypodendron lineatum attacks, the total number of holes appearing on an edge-grain surface is directly proportionate to the number of beetle entrance holes on the log surface. This number will suffice as a damage index.

107. Graham, K. and W.E. Webb. 1952.
Chemical control of ambrosia beetles.
Can. Dep. Agric., For. Biol. Div. Bi-Mon. Prog. Rep. 8(4): 3-4.

Preliminary report on the use of BHC applied as a spray to water stored booms of Douglas-fir, plywood peeler logs. Two applications during the beetle flight season proved successful in preventing attack.

108. Graham, K. and A.E. Werner. 1956.
Chemical aspects of log selection by ambrosia beetle.
Can. Dep. Agric., For. Biol. Div. Bi-Mon. Prog. Rep. 12(1): 3-4.

Describes a method of cold-trapping volatiles from wood attractive to Trypodendron lineatum and some preliminary bioassay trials which indicate that beetles are attracted to otherwise unattractive wood treated with these extracts.

109. Gurchiani, R.R. 1968.
Study of the distribution and the threat of the striped ambrosia beetle (Trypodendron lineatum Ol.) in Upper Svanetia.
Bull. Acad. Sci. of the Georgian SSR 49: 683-688.

(This report is printed in Armenian and summarized in Russian.) From 1964-1966, logs felled in March, April and August were not attacked by T. lineatum. Attacked logs were in shady and moist conditions. In some cases standing big trees that seemed healthy were attacked. Attacks were also observed on broadleaf trees such as linden and birch, larger than 30 cm diam. Fresh stumps of 25-30 cm were also attacked.

110. Gurchiani, R.R. 1968.

Data from a study of the biology and factors causing the large population increase of Trypodendron lineatum under conditions prevailing in Upper Svanetia.
Bull. Acad. Sci. of the Georgian SSR 50: 207-210.

(The report is printed in Armenian and summarized in Russian.) Reports on a large population increase of T. lineatum (Oliv.) that occurred between 1964-1966, caused by severe windfall and logging debris left in the woods. The beetles overwintered 2-3 cm deep in the forest litter and also in sawdust and between boards. Only one generation per year was observed. A 4% BHC solution produced good control.

111. Hadorn, C. 1933.

Recherches sur la morphologie, les stades évolutifs et l'hivernage du Bostryche Liseré (Xyloterus lineatus Oliv.).
(Studies on the morphology, developmental stages and hibernation of Bostriches lineatus (Xyloterus lineatus Oliv.).)
Suppl. aux org. de la Soc. forest. Suisse, Bern 11: 1-120.

Extensive coverage of the morphology, anatomy and biology of Trypodendron lineatum. The beetles overwinter at the most 30 m from the breeding place with the majority between 6-16 m. Flight depends on the stand location. During the brood rearing time, the male cleans the gallery, while the female lengthens its, prepares the egg niches and cultivates the fungus. Following oviposition, the female also keeps the gallery clean. Cleanliness and ventilation are prerequisites for a good brood development. Under adverse circumstances the females may leave the gallery and start another brood. although only one generation is produced each year. Egg laying starts when the brood gallery has reached a length of 4-5 mm, the ambrosia fungus culture starting at the same time. Before that, neither the male nor the female eat. The gallery entrance is kept free from fungus. Development occurs in 6-10 weeks. Larvae hatch 5-10 days after oviposition and enlarge the niche to 4-4.8 mm. The larval and pupal stages last 3-6 weeks, and 8-10 days, respectively, much depending on temperature. The young beetles enter the brood gallery, after enlarging the hole and consuming the fungus on the wall of the pupal niche. If too little fungus is present in the gallery, cannabalism can occur. After 2-3 weeks, the young beetles void their guts and emerge to migrate to their overwintering site. A method of extracting overwintering beetles from forest litter and bark, using a heated pan, is described. To prevent beetle attack suggests that trees be debarked immediately after felling, but that those trees felled between November and February should be treated with carboleum.

112. Hadorn, C. 1934.

Schützet die Nadelnutzholzsortimente gegen den linierten Nadelholzbohrer, einen gefährlichen Holzzerstörer.
(Protect the conifer log sorting areas against the striped ambrosia beetle, a dangerous pest.)
Schweiz. Z. Forstwes. 85: 64-65.

Debarking of trees, felled from March to the end of October provides complete protection against Trypodendron lineatum attack. For trees felled during the other months, suggests spraying log piles with carboleum before beetle flight to prevent attack, and to kill beetles inside the brood galleries. Also proposes burning or spraying the top layer of the debris (litter) at log storage sites.

113. Hartig, T. 1872.

Der Fichten-Splintkäfer Bostrichus (Xyloterus) lineatus.
(The spruce beetle Bostr. (Xyloterus) lineatus.)
Allg. Forst. Jagd-Ztg 48: 181-182.

A detailed description of gallery construction, larval growth and fungus development of Trypodendron lineatum. Initially the larvae consume wood fibers and excrement is used to strengthen the walls between the larval niches and the main galleries where the first fungal growth takes place. Concludes that a second generation must occur. Clerus formicarius larvae in the main galleries may be responsible for the large egg mortality. Suggests that girdling of trees prior to felling may prevent beetle attack through drying out of the stems.

114. Hedlin, A.F. and T.A.D. Woods. 1970.

Experiments in preventive treatment of Douglas fir against attack by the ambrosia

beetle Trypodendron lineatum (Oliv.) using benzene hexachloride, methyltrithion and other insecticides.
Can. Dep. Fish. and For. Int. Rep. BC-18.

BHC was more effective than methyl-Trithion in protecting Douglas-fir logs against attack by T. lineatum.

115. Heeman, V. and W. Francke. 1976.
1,3-Dimethyl-2,9-dioxabicyclo(3.3.1) nonane; a host-specific substance in Norway spruce under attack by Trypodendron lineatum Oliv.
Naturwissenschaften 63: 344.

The authors report on techniques used to isolate the title compound and claim its permanent and exclusive presence in Norway spruce attacked by Trypodendron lineatum.

116. Hopping, G.R. and J.H. Jenkins. 1933.
The effect of kiln temperatures and air-seasoning on ambrosia insects (pinworms).
Can. Dep. Inter. For. Serv. Circ. 38.

Trypodendron lineatum in western hemlock kiln dried at temperatures ranging from 120°-160°F and at a constant humidity of 80% died after periods of time, ranging from 9 to 1½ hr, respectively. Suggests kiln drying as a practical method for killing ambrosia beetles in green lumber. Air seasoning eventually kills the beetles but is too time-consuming.

117. Johnson, N.E. 1958.
Ambrosia beetle infestation of coniferous logs on clearcuttings in Northwestern Oregon.
J. For. 56: 508-511.

Trypodendron lineatum, Gnanthotrichus sulcatus and Platypus wilsoni commonly attack Douglas-fir, western hemlock, grand fir and western red cedar in northwestern Oregon. Host preference and seasonal variation of attack are discussed.

118. Johnson, N.E. 1958.
Field identification of ambrosia beetles attacking coniferous timber in the Douglas-fir region.
Can. Entomol. 90: 236-240.

Provides information for field identification of Platypus wilsoni, Trypodendron lineatum, Gnathotrichus sulcatus, G. retusus and Xyleborus saxeseni by body shape, gallery diameter and characteristics of the wood borings.

119. Johnson, N.E. 1961.
Ambrosia beetle attacks in young-growth western hemlock.
Can. Dep. For., For. Entomol. and Pathol. Br. Bi-Mon. Prog. Rep. 17(5): 3.

Fall-felled western hemlock were heavily attacked by Trypodendron lineatum except where the limbs were left on the logs.

120. Johnson, N.E. 1964.
Effects of different drying rates and two insecticides on beetle attacks in felled Douglas-fir and western hemlock.
Weyerhaeuser For. Res. Note 58.

Trypodendron lineatum completely avoided felled trees with crowns left attached. Douglas-fir and hemlock logs dried out faster with crowns left intact.

121. Kinghorn, J.M. 1955.
Post-attack chemical treatment for ambrosia beetles.
Can. Dep. Agric., For. Biol. Div. Bi-Mon. Prog. Rep. 11(5): 3.

A post-attack treatment to prevent ambrosia beetle damage with an emulsion of fumigant poison, ethylene dibromide and lindane (gamma-BHC) arrested development of the beetles in the wood and successfully prevented subsequent attacks.

122. Kinghorn, J.M. 1956.
Preventive treatment of Douglas-fir and western hemlock logs against attack by the lined ambrosia beetle, Trypodendron lineatum (Oliv.).
Can. Dep. Agric., For. Biol. Div. Interim Rep. 1954-5.

Log protection resulting from treatments with lindane applied in different formulations apparently depended on the toxicity of the deposit, adequate bark coverage and weathering.

123. Kinghorn, J.M. 1956.

Sapwood moisture in relation to Trypodendron attacks.
Can. Dep. Agric., For. Biol. Div. Bi-Mon. Prog. Rep. 12(5): 3-4.

States that lack of wood moisture may limit Trypodendron lineatum attack, but the presence of moisture does not attract attacks. After the beetles have entered the wood, inadequate moisture doubtlessly influences parent adult abandonment and poor survival of the broods.

124. Kinghorn, J.M. 1957.

Two practical methods of identifying types of ambrosia beetle damage.
J. Econ. Entomol. 50: 213.

Difference in diameter of gallery entrance holes is used to distinguish between damage by Trypodendron lineatum and Gnathotrichus sulcatus. The test is made with a No. 53 wire gauge drill (diam. 0.0595 inch). Another way of differentiation is by differences in the shape of the boring dust.

125. Kinghorn, J.M. 1957.

An induced differential bark-beetle attack.
Can. Dep. Agric., For. Biol. Div. Bi-Mon. Prog. Rep. 13(2): 3-4.

Trypodendron attacked small bolts of wood (16 inches long) cut from western hemlock and Douglas-fir trees felled in early April. Immersion in water and storage at room temperature until the time of attack reduced the attack density. The remaining long logs were only lightly infested except for areas adjacent to the cuts. No clear differences were seen in the sapwood moisture content.

126. Kinghorn, J.M. 1960.

Chemicals for preventing ambrosia beetle attacks.
Can. Dep. Agric., For. Biol. Div. Bi-Mon. Prog. Rep. 16(5): 3.

Damage by Trypodendron lineatum was reduced during tests using Lindane and Thiodan, with the latter proving more effective. Thiodan is slightly more toxic to warm blooded animals and fish and should be tested before use on water-stored logs.

127. Kinghorn, J.M. 1960.

Scolytid notes.
Proc. Entomol. Soc. B.C. 57: 50-51.

In part, discusses incidence of Trypodendron lineatum attack on living trees. The attacks were abortive and most likely prevented by resin flow.

128. Kinghorn, J.M. 1961.

Ambrosia beetle preventives.
Can. Dep. For., For. Entomol. and Pathol. Br. Bi-Mon. Prog. Rep. 17(6): 3-4.

Partial repeat of previous year's experiments with Lindane and Thiodan, with the latter again giving the better results.

129. Kinghorn, J.M. and J.A. Chapman. 1954.

Observations on the flight of Trypodendron sp.
Can. Dep. Agric., For. Biol. Div. Bi-Mon. Prog. Rep. 10(3): 3.

Some behavioral characteristics of T. lineatum were observed during days of heavy flight.

130. Kinghorn, J.M. and J.A. Chapman. 1957.

The effect of Douglas-fir log age on attack by the ambrosia beetle, Trypodendron lineatum (Oliv.).
Proc. Entomol. Soc. B.C. 54: 46-49.

Reports that artificially aged blocks of wood declined in attractiveness with time, while autoclaved wood received little damage by T. lineatum. Points to the need for more information on the occurrence and seasonal fluctuations of various sapwood constituents in relation to ambrosia beetle selectivity.

131. Kinghorn, J.M. and J.A. Chapman. 1959.

The overwintering of the ambrosia beetle Trypodendron lineatum (Oliv.).
For. Sci. 5(1): 81-92.

Based on data from field collections of overwintering T. lineatum gives information about the distribution of the beetles in relation to standing trees, forest margins and logs in clearings. Overwintering mortality and length of dormancy are also discussed.

132. Kinghorn, J.M. and E.D.A. Dyer. 1960.
Overwintering of ambrosia beetles.
Can. Dep. Agric., For. Biol. Div. Bi-Mon. Prog. Rep. 16(1): 4.

In addition to overwintering in the upper layer of forest litter, Trypodendron beetles were also found hibernating in the outer bark of standing living and dead trees.

133. Kleine, R. 1944.
Die europäischen Borkenkäfer und die bei Ihnen lebenden Räuber, Parasiten und Commensalen (Ipidae).
(The predators, parasites and commensals found with the European bark beetles.)
Entomol. Bl. 40: 68-83.

Mentions names and references for predators and parasites of the families Staphylinidae, Nitidulidae, Histeridae, Cleridae and Tenebrionidae found with Trypodendron lineatum.

134. König, E. and W. Berwig. 1971.
Der Einfluss des Wassergehaltes im Fichtenholz auf die Befallsdisposition für den gestreiften Nutzholzborkenkäfer Trypodendron lineatum (Oliv.) (Coleoptera: Scolytidae).
(Influence of water content of spruce wood on the attack by Trypodendron lineatum (Oliv.) (Coleoptera: Scolytidae)).
Z. Angew. Entomol. 68: 258-263.

Experiment with spruce trees infested with bark beetles that were attacked by T. lineatum the following spring. Six weeks later, the water contents of wood samples were determined. The water content of the attacked wood was significantly higher than that of the unattacked. There is a close relationship between the number of holes and the water content of the wood.

135. Löyttyniemi, K. 1967.
Tikaskuoriaisesta Trypodendron lineatum Oliv. (Col. Scolytidae) kuorellisen havupuutavaran pilaajana.
(Damage to unbarked softwood by Trypodendron lineatum (Oliv.)(Coleoptera: Scolytidae).
Silva Fenn. 1(2): 49-57.

Trypodendron lineatum, a widely distributed and serious pest in Finland, where it particularly attacks winter- and autumn-felled wood stored in shade. Spruce and pine are about equally attacked. Attacks on larch have been observed. Freshly cut stumps in the forest, but not on clear fellings, are important breeding sites.

136. McBride, C.F. 1950.
The effect of ambrosia beetle damage upon lumber value.
B.C. Lumberman, 34(9): 46-8, 122-8.

A light attack by ambrosia beetles, including Trypodendron lineatum, will cause considerable loss in lumber values for the better grades of wood. Recommends more comprehensive sampling of loss in lumber grade and a study of a further number of aspects of mill operations.

137. McBride, C.F. and J.M. Kinghorn. 1960.
Lumber degrade caused by ambrosia beetles.
B.C. Lumberman, July 1960, 44: 40f.

Reports detailed data on which to base estimates of losses through damage to lumber caused by Trypodendron lineatum. Details of grading rules and lumber prices used to determine value losses are given. With information on beetle attack, these data can be adapted to current market conditions to arrive at a reasonable loss estimate.

138. MacConnell, J.G., J.H. Borden, R.M. Silverstein and E. Stokkink. 1977.
Isolation and tentative identification of lineatin, a pheromone from the frass of Trypodendron lineatum (Coleoptera: Scolytidae).
J. Chem. Ecol. 3(5): 549-561.

The proposed structure of an attractant compound isolated from frass produced by Trypodendron lineatum female beetles boring in Douglas-fir is one of two isomeric tricyclic acetals to which the trivial name lineatin is assigned.

139. McLean, J.A. and J.H. Borden. 1977.
Suppression of Gnathotrichus sulcatus with sulcatol-baited traps in a commercial sawmill and notes on the occurrence of G. retusus and Trypodendron lineatum.
Can. J. For. Res.: 348-356.

During trials with the population aggregation pheromone, sulcatol, for Gnathotrichus sulcatus, the first verified attacks of freshly sawn lumber by Trypodendron lineatum and Gnathotrichus retusus were recorded. Adults, callow adults and Trypodendron pupae were found, which demonstrates that T. lineatum could be introduced to other countries in imported lumber.

140. McMullan, D.L. 1956.
Ambrosia beetles and their control in British Columbia.
For. Chron. 32: 31-43.

A review of the ambrosia beetle problem situation and the attempts to control the damage from the industrial foresters's viewpoint. Information is presented on costs of protection and difficulties are indicated relative to reducing of log inventories during spring and summer months.

141. Mathers, W.G. 1935.
Time of felling in relation to injury from ambrosia beetles, or pinworms.
B.C. Lumberman 19(8): 14.

This early study on ambrosia beetle attack on western hemlock clearly demonstrates that Trypodendron lineatum attacks fall- but not spring-felled trees. Time of felling had no bearing on the attacks by Platypus or Gnathotrichus spp.

142. Mathiesen-Käärik, A. 1953.
Eine Übersicht uber die gewöhnlichsten mit Borkenkäfern assoziierten Bläuepilze in Schweden und einige für Schweden neue Bläuepilze.
(A review of the blue-stain fungi commonly associated with bark beetles in Sweden and some blue-stain fungi newly found in Sweden.)
Medd. Statens Skogsforskningsinst. 43(4): 1-74.

Reviews the blue-stain fungi associated with bark beetles in Sweden. Isolates and gives morphological description of the ambrosia fungus of Trypodendron lineatum as Monilia ferruginae.

143. Moeck, H.A. 1967.
Electron microscopic studies of antennal sensilla in the ambrosia beetle Trypodendron lineatum (Olivier)(Scolytidae)
Can. J. Zool. 46(3): 521-556.

Extensive and detailed description of the types, distribution and structure of T. lineatum antennal sense organs.

144. Moeck, H.A. 1970.
An olfactometer for the bioassay of attractants for scolytids.
Can. Entomol. 102: 792-796.

Describes an olfactometer for determining the responses of pedestrian beetles, including Trypodendron lineatum to attractants.

145. Moeck, H.A. 1970.
Ethanol as the primary attractant for the ambrosia beetle Trypodendron lineatum (Coleoptera: Scolytidae).
Can. Entomol. 102(8): 985-995.

Using gas-liquid chromatography identifies ethanol as a major component in extracts of attractive wood and bark and demonstrates in bioassays that it is attractive in low concentrations to both sexes of T. lineatum. Ethanol is also found as the most prevalent component when attraction is induced by anaerobic treatment of both sapwood and phloem of conifers.

146. Moeck, H.A. 1971.
Field test of ethanol as a scolytid attractant.
Dep. Fish. For. Bi-Mon. Res. Notes 27(2): 11-12.

In field tests with ethanol in pan-type-glass-barrier traps and non-directional traps in the field Trypodendron lineatum and other ambrosia beetles were clearly attracted by ethanol. Several explanations are given for the relatively low numbers of T. lineatum caught within a large flying population.

147. Morley, P.M. 1939.
Time of cut as a factor influencing infestation of coniferous logs.
Can. Entomol. 71: 243-248.

Presents information relating time of felling to infestation of pine, spruce and balsam logs in Eastern Canada by insects. Only few observations on Trypodendron lineatum are reported.

148. Neger, F.W. 1909.

Ambrosiapilze.
II Die Ambrosia der Holzbohrkäfer.
(Ambrosia fungi. II The Ambrosia of the woodborers.)
Ber. Dtsch. Bot. Ges. 27: 372-389.

Isolates the symbiotic fungi of Xyloterus dispar and Xyloterus (Trypodendron) lineatum, notes similarities but does not describe them systematically. Observes the development of the fungi in the galleries.

149. Neger, F.W. 1911.

Zur Übertragung des Ambrosiapilzes von Xyleborus dispar.
(On the transport of ambrosia fungi by Xyleborus dispar.)
Naturwiss. Z. Forst- u. Landw. 9: 223-225.

Deals mainly with the fungus transport of Trypodendron lineatum before the mycangia were discovered. Speculates that transport of the fungus spores is oral or through the digestive tract.

150. Nigam, P.C. 1969.

Laboratory evaluation of twelve insecticides against adult ambrosia beetles.
Can. Dep. Fish. and For. Bi-Mon. Res. Notes 25(2): 11-12.

Contact toxicity under laboratory conditions is used as a criterion to identify promising compounds for field tests. Twelve insecticides are listed in order of toxicity to Trypodendron lineatum. Most were more toxic than BHC, with Sumithion (Fenitrothion) the most effective.

151. Nijholt, W.W. 1965.

Moisture and fat content in the ambrosia beetle Trypodendron lineatum (Oliv.).
Proc. Entomol. Soc. B.C. 62: 16-18.

Describes a method to determine moisture, fat and dry matter in groups and individual small beetles using standard laboratory equipment. Female T. lineatum showed a greater variability in weight and a larger percentage of fat based on dry weight.

152. Nijholt, W.W. 1967.

Moisture and fat content during the adult life of the ambrosia beetle Trypodendron lineatum (Oliv.).
J. Entomol. Soc. B.C. 64: 51-55.

Depletion of fat deposits of T. lineatum during hibernation amounts to about one quarter of the amount at the start of hibernation. During flight, another quarter of the original amount is used up. Fat loss increases during a long, cool spring; this suggests that the vigor of the population may be affected.

153. Nijholt, W.W. 1969.

Fat content of the ambrosia beetle, Trypodendron lineatum (Oliv.) during attack and brood production.
J. Entomol. Soc. B.C. 66: 29-31.

In male T. lineatum the fat content increased steadily after 5 days in the galleries. Fat content in the female decreased during the first 5 days, then maintained the same level for about 1 week, after which it rapidly increased. Data from this and earlier studies give a general understanding of lipid changes during the adult life of this beetle.

154. Nijholt, W.W. 1970.

The effect of mating and the presence of the male ambrosia beetle Trypodendron lineatum, on "secondary" attraction.
Can. Entomol. 102: 894-897.

As virgin and mated females both produce secondary attraction, mating does not seem to affect the reduction in attractiveness that occurs when males were added to a log that has been infested by females only. The reduction seems to be associated with the males' presence only, suggesting that they produce a masking substance. Points to data (see no. 114) suggesting that insecticide application may prolong secondary attraction by killing the males on the bark surface.

155. Nijholt, W.W. 1973.

The effect of male Trypodendron lineatum (Coleoptera: Scolytidae) on the response of field populations to secondary attraction.
Can. Entomol. 105: 583-590.

Addition of male T. lineatum to logs infested with females reduced the strong attractiveness. Findings with field response to mixtures of odors in "duplex" greenhouse cages suggest that females continue production of attractive pheromone in the presence of the males and that males appear to produce a volatile repellent or anti-attractive substance.

156. Nijholt, W.W. 1973.
Ambrosia beetle attacks delayed by turpentine oil.
Can. Dep. Fish. and For. Bi-Mon. Res. Notes 29(6): 36.

Logs treated with turpentine oil were protected for about 5 days from attack by Trypodendron lineatum, while untreated logs were heavily infested. Points to possible use of naturally occurring terpenes in combination with other methods as an effective means of log protection.

157. Nijholt, W.W. 1976.
A simplified procedure for sampling overwintering populations of the ambrosia beetle Trypodendron lineatum (Oliv.).
Can. For. Serv., Pac. For. Res. Cen. Add. to BC-X-103.

Suggests use of plastic bags instead of the double-pan method as a simpler and more convenient procedure to collect overwintering populations of Trypodendron lineatum from duff samples (See No. 48).

158. Nijholt, W.W. 1978.
Ambrosia beetle: A menace to the Forest Industry.
Can. For. Serv., Pac. For. Res. Cen. Rep. BC-P-25.

Expresses concern about population buildup due to trend toward more dry-land operations. Discusses problem detection, life history and identification of Trypodendron lineatum and Gnathotrichus spp. Recommends measures emphasizing avoidance and prevention of the problems.

159. Nijholt, W.W. 1978.
Evaluation of operational watermisting for log protection from ambrosia beetle damage.
Can. For. Serv., Pac. For. Res. Cen. Rep. BC-P-22.

Relates to No. 181 and reports that the benefits of a watermisting system outweighed the costs by a factor varying from 4-6 with an estimated saving over a 5-year period of about $250,000.

160. Nijholt, W.W. and J.A. Chapman. 1964.
Uptake of water by the ambrosia beetle Trypodendron following desiccation.
Can. Dep. For., For. Entomol. and Pathol. Br. Bi-Mon. Prog. Rep. 20(6): 3-4.

Describes a method to make small insects such as Trypodendron lineatum ingest water, making it possible to introduce dyes and other tracers via the alimentary tract. Adults survived a weight loss of 10-25% without apparent damage.

161. Nijholt, W.W. and J.A. Chapman. 1968.
A flight trap for collecting living insects.
Can. Entomol. 100: 1151-1153.

Describes construction of window flight traps and presents data illustrating the usefulness of the traps for collecting living insects, such as the ambrosia beetle T. lineatum.

162. Nijholt, W.W. and J. Schönherr. 1976.
Chemical response behavior of Scolytids in West Germany and Western Canada.
Can. For. Serv., Bi-Mon. Res. Notes 32(6): 31-32.

A cooperative study on the chemical response behavior of Trypodendron lineatum showed no apparent differences between the European and North American populations based on response to ethanol-α-pinene combination.

163. Novak, V. 1960.
Přirození nepřátelé a nemoci dřevokaza čárkového Trypodendron lineatum Oliv. (Natural enemies and diseases of the striped beetle Trypodendron lineatum Oliv.)
Zool. Listy 9(4): 309-322.

Among the main natural enemies of T. lineatum are the predators Pterostichus oblongpunctatus and P. burmeisteri (Carabidae) and the parasite Perniphora robusta (Hymenoptera). These were reared in the laboratory and their impact studied. The bacterium Pseudomonas septica, is considered a major contributor to disease of the beetle. Suggests that chemical treatment to reduce the damage by ambrosia beetles should be possible without undue damage to useful insects.

164. Novák, V. 1960.

Dřevokaz čárkovaný a boj proti němu. (The wood-boring beetle and the fight against it)
Lesnické Aktuality 1. 132 pp. Praha.

A detailed report on Trypodendron lineatum in Czechoslovakia and an outline of experiments to find control measures, curb development and reduce wood damage. Includes studies on systematic biology, a comprehensive study of the developmental stages, hibernation, factors influencing reproduction, natural enemies and diseases, host conditions, time of felling and the economic significance of the damage. Protective and defensive measures suggested include keeping forests and stockyards clean. Results are given of experiments using BHC and other chemicals for log and soil treatment.

165. Novák, V. 1962.

Einige neue Erkenntnisse über die bionomie des gemeinen Nutzholzborkenkäfers Trypodendron lineatum Oliv. und ihre Anwendung in der Forst- und Holzwirtschaft.
(Some new knowledge on the biology of the ambrosia beetle Trypodendron lineatum Oliv. and its application in forest and lumber management.)
Proc. Int. Congr. Entomol., 11th Vienna V.2 1960 266-269.

Identifies differences between observations by the author on the biology of T. lineatum and those reported in the literature, particularly those pertaining to the number of generations and to the movement and location of the overwintering beetles. Recommends procedure for treatment of soil under storage areas and spraying of logs with insecticides in combination with clean woods management to curb the spread of this insect.

166. Novák, V. 1963.

Studie vývojových stupňů dřevokaza čárkovaného Trypodendron lineatum Ol. (Coleoptera: Scolytidae).
(A study on the developmental stages of the striped timber beetle, Trypodendron lineatum Ol. (Coleoptera: Scolytidae))
Zool. Listy 12: 135-138.

Ascertains that there are only two larval instars in T. lineatum. Explains the low number of instars as due to the consumption of the high quality ambrosia fungus food.

167. Novak, V. 1963.

Population density of the overwintering Trypodendron lineatum (Oliv.) in cold decks and forest stands.
Pr. Vyzk. Ustavu Lesn. Hospod Mysirosti (Strnady)

Based on many observations claims that T. lineatum tends to overwinter where possible in the soil immediately below the attacked timber, in contrast to earlier reports of post attack flight into nearby stands and return flight in the spring. Describes methods of sampling overwintering populations.

168. Novak, V. 1963.

Investigation of diapause in the ambrosia beetles Trypodendron lineatum Ol.
Commun. Inst. For. Cech. 3: 23-43.

From experiments and histological studies concludes that the phenomenon of overwintering by adult T. lineatum, which partly takes place at relatively high temperatures, is related to the larval diapause. Through development of negative phototaxis, decrease in flight activity and, in the males, cessation of spermatogenesis and spermateliosis (pubescence) before entering the hibernation site, the beetles become incapable of reproduction. They overwinter in a lethargic state in so-called dormancy or quiesence and are positively phototactic. Based on the information on overwintering habits of T. lineatum regular chemical treatments are carried out in storage areas in Czechoslovakia.

169. Nunberg, M. 1951.

Nieco o gruczolach znajdujacych sie w przedtulowiu korników (Scolytidae) i wyrynników (Platypodidae)(Coleoptera).
(Contribution to the knowledge of prothoracic glands of Scolytidae and Platypodidae (Coleoptera).
Ann. Mus. Zool. Pol 14: 261-265.

This is the earliest report on the presence and the location of the prothoracic glands in Trypodendron lineatum. The author, who claims to have noticed these glands as early as 1927, suggests that they may serve as storage depots for the spores of the fungus grown in the galleries.

170. Ostaff, D. 1974.
Ambrosia beetles (pinhole borers).
Can. For. Serv., East. For. Prod. Lab. Rep. OPX99E.

Describes life stages, habits and seasonal development of Trypodendron lineatum and Gnathotrichus sulcatus and discusses aspects of lumber degrade and prevention and control measures.

171. Payne, T.L., H.A. Moeck, C.D. Willson, R.N. Coulson and W.J. Humphreys. 1973.
Bark beetle olfaction-II. Antennal morphology of sixteen species of Scolytidae (Coleoptera).
Int. J. Insect Morphol. Embryol. 2(3): 177-192.

Deals with a scanning electron microscopy study of the antennae of several scolytid species in the genera Dendroctonus, Ips, Pseudohylesinus, Scolytus and Trypodendron. The shape of the antennal club is distinct for each genus. The arrangement of the sensilla on the clubs is discussed and speculation is offered on the possible function of some of the sensilla.

172. Popo von, A. and W. Thalenhorst. 1974.
Untersuchungen über den Anflug und die Brutentwicklung des gestreiften Nutzholzborkenkäfers, Trypodendron lineatum (Oliv.)
(Studies on the flight and breeding of the ambrosia beetle, Trypodendron lineatum (Oliv.))
I Phenology and relations to the host tree.
Z. Angew Entomol. 76: 251-277.

An extensive report on observations under nearly natural conditions of the attack of T. lineatum in which late attack flights could not be attributed to the local populations. Attractiveness and breeding suitability of the stem were not necessarily linked to each other. Attractiveness depends on the degree of seasoning but can be modified by other physiological factors and amplified by the emmision of pheromones. Breeding suitability depends largely upon the "history" of the tree and the degree of seasoning relative to the time of attack.

173. Popo von, A. and W. Thalenhorst. 1974.
Untersuchungen über den Anflug und die Brutentwicklung des gestreiften Nutzholzborkenkäfers, Trypodendron lineatum (Oliv.).
(Studies on the flight and breeding of the ambrosia beetle, Trypodendron lineatum (Oliv.))
II Density of attacks, number of eggs, mortality and progeny.
Z. Angew. Entomol. 77: 31-72.

A detailed study of T. lineatum indicating that host breeding suitability influences the premature "exodus" of parent beetles, the number of eggs deposited and the progeny mortality. These factors are to some extent considered density dependent. The fact that attractancy and breeding suitability are not necessarily linked leads to diversity in attack density, development of progeny and multiplication index even within a single infestation and affect analysis and interpretation of the results.

174. Prebble, M.L. and K. Graham. 1957.
Studies of attack by ambrosia beetles in softwood logs on Vancouver Island, British Columbia.
For. Sci. 3: 90-112.

Derives quantitative estimates of intensity of attack by different ambrosia beetles in relation to time of felling and period of exposure as a measure of the resultant damage in the logs. T. lineatum was consistently present in the study material. Discusses gallery construction and comments on the variability in attack density with the time of felling, period of exposure, timber and beetle species and intra- and inter-log variability. Depth of penetration as well as number of holes should be considered when measuring damage. Attack patterns in relation to felling date are noted and can be used to alter the risk of damage.

175. Pulliainen, E. 1965.
Studies on the light and humidity reactions of Trypodendron lineatum (Oliv.)(Coleop-

tera: Scolytidae).
Ann. Entomol. Fenn. 31(3): 197-208.

Suggests that during spring swarming flights of T. lineatum, a photopositive reaction reverses to photonegative and when the beetles leave their breeding places the opposite change takes place. Humidity influences the phototactic response. Beetles excavated from galleries during brood development were hygropositive and photonegative in moist conditions.

176. Reisch, J. 1967.
Barked softwood suffers less damage from Trypodendron lineatum.
Holsforsch. Zentralbl. 93(143): 2221.

Barked logs on dry sites were only superficially attacked by T. lineatum, which did not produce brood galleries, leading to overrating the damage. Spraying with BHC and DDT in combination with Synergid 3 gave several months' protection.

177. Richmond, H.A. 1961.
Helicopters protect log booms in B.C.
Can. Lumberman Dec. 1961.

Describes the use of helicopters for the spraying of BHC on log booms. Gives information on dosage, log protection, effects on fish and spraying costs.

178. Richmond, H.A. 1962.
Ambrosia beetle control. Experimental spraying of bundled logs on flat cars, Crown Zellerbach operations, Nanaimo Lakes.
B.C. Loggers' Assoc. Rept. 1962.

Bundled logs on flat cars were sprayed with BHC, giving moderately good protection. Disadvantages of this method are the high cost and time-consuming application, which must take place at the moment the train is loaded regardless of the hour or the weather.

179. Richmond, H.A. 1969.
Appetite for wood. Chemicals help but good woods management remains best way to control destructive ambrosia beetle.
B.C. Lumberman 53(8): 34-36.

Reviews aspects of the habits of Trypodendron and Gnathotrichus, the problem of measuring actual losses and the treatment with insecticides. Suggests that good woods management is the method of choice to reduce losses caused by ambrosia beetles.

180. Richmond H.A. 1966.
The ambrosia beetle on the British Columbia Coast.
B.C. Loggers' Assoc. Publ. Feb. 1966.

A review of some of the more important information as developed from Governmental and Industrial Research from 1933-1963, with a summary of chemical tests for prevention of ambrosia beetle damage in B.C. undertaken by the Federal Government and Forest Industry during that period.

181. Richmond, H.A. and W.W. Nijholt. 1972.
Water misting for log protection from ambrosia beetles in B.C.
Can. For. Serv., Pac. For. Res. Cent. Inf. Rep. BC-P-4-72.

Outlines the test design and operation and reports on the biological assessment of a water misting system to protect dry-land sorted logs from attack by ambrosia beetles, mainly Trypodendron lineatum. The system on the whole proved totally effective and a practical means of protection. (See also No. 159).

182. Richmond, H.A. and D.N. Radcliffe. 1961.
Ambrosia beetle attack on sawlogs in water storage.
B.C. Lumberman, 45(10) Oct. 1961.

Covers winter cut logs, susceptible to beetle attack, stored prior to spring flight, and a mill study. Degrade losses to lumber were determined and are compared with those for logs attacked by ambrosia beetles while in the woods.

183. Richter, H. 1918.
Über die Lebensweise und Bekämpfung des Nutzholzborkenkäfers (Xyloterus lineatus Ol.)
(The living habits and control of the ambrosia beetle (Xyloterus lineatus Ol.)
Forstwiss. Zentralbl. 40: 241-244.

An early report on heavy damage to windfall spruce and fir timber in Germany by Trypodendron lineatum. Recognizes preferred breeding places of the beetles in remaining stumps. As preventive measures, recommends the removal of stumps, debarking of logs and general clean wood management.

184. Roff, J.W. and H.W. Eades. 1959.
Deterioration of logging residue on the British Columbia Coast.
Can. For. Br., For. Prod. Lab. Tech. Note 11, 32 pp.

Deterioration in wood attacked by ambrosia beetles (e.g. Trypodendron lineatum) was more rapid than that which had not been attacked, particularly in western hemlock and Sitka spruce.

185. Rudinsky, J.A. 1966.
Scolytid beetles associated with Douglas-fir: response to terpenes.
Science 152: 218-219.

Reports results of field studies on host or primary attraction to bark and ambrosia beetles in a forest stand of primarily Douglas-fir trees. Dendroctonus pseudotsugae and Gnathotricus sulcatus were attracted by some single terpene hydrocarbons diluted with ethanol. Even though Trypodendron lineatum abounded, only a few responded. No beetles were attracted to the 95% ethanol controls.

186. Rudinsky, J.A. 1966.
Observations on olfactory behavior of scolytid beetles (Coleoptera: Scolytidae) associated with Douglas-fir forests.
Z. angew. Entomol. 58: 356-361.

Deals with investigations on the way in which Scolytidae are attracted to and attack Douglas-fir trees. Where others were affected by volatile resinous components, Trypodendron lineatum appeared far less attracted to these terpenes.

187. Rudinsky, J.A. and G.E. Daterman. 1964.
Field studies on flight patterns and olfactory responses of ambrosia beetles in Douglas-fir forests of Western Oregon.
Can. Entomol. 96: 1339-1352.

Demonstrates diurnal and seasonal patterns in the flight of Trypodendron lineatum, Gnathotrichus sulcatus and G. retusus as influenced by temperature, wind and daylight. Reports an emergence threshold of 50-52°F and a flight threshold of about 60°F. A species-specific sex pheromone produced by sexually mature females entering the host is considered responsible for mass attraction of T. lineatum.

188. Rudinsky, J.A. and G.E. Daterman. 1964.
Response of the ambrosia beetle Trypodendron lineatum (Oliv.) to a female-produced pheromone.
Z. angew. Entomol. 54(3): 300-303.

Field experiments revealed that the substance that induces mass attraction of T. lineatum is a species-specific, sex-dependent pheromone produced by the female shortly after entering the xylem of a suitable host. Beetles of both sexes released in the field responded equally well to an ethanolic extract of pheromone-laden boring dust.

189. Rudinsky, J.A. and I. Schneider. 1968.
On the olfactory behavior of Trypodendron lineatum (Oliv.).
Proc. Int. Congr. Entomol. 13th., Moscow, 1968 Vol II: 35.

Summary of studies in olfactory behavior of T. lineatum. Observes that host substances and/or their metabolites play a role in host location. Discusses findings that suggest a relationship between feeding and pheromone production. Also refers to histolotical studies that were reported elsewhere.

190. Rummukainen, U. 1964.
Hyonteisten aiheuttamasta tuoreen kuorellisen havupuutavaran pilaantumisesta ja sen kemiallisesta estämisestä.
(On the deterioration of green softwood caused by insects and its chemical control.)
Commun. Inst. For. Fenn. 28(5): 1-67.

Details results of experiments with DDT-spray treatments of Scots pine and Norway spruce to prevent attack by scolytid beetles, including Trypodendron lineatum.

191. Schindler, U. 1967.

Borkenkäferbekämpfung unter besonderer Berücksichtigung der Rindenbrüter an Fichte und Kiefer sowie des gestreiften Nutzholzborkenkäfers.
(Bark beetle control with special reference to pine and spruce bark beetles as well as the striped ambrosia beetle)
Forsttech Inform. 3: 15-23.

In part, discusses and makes recommendations as to preventive measures against Trypodendron lineatum, such as immediate removal of logs from the woods and spraying with HCH(BHC)-fuel oil, although use of the latter is limited by regulations.

192. Schindler, U. 1968.

Nutzholzborkenkäfer-Bekämpfung mit chemischen Mitteln in Abhängigkeit von den biologischen Grundlagen.
(Ambrosia beetle control with chemical means subject to biological fundamentals).
Forst. Holzwirt. 23(13): 1-3.

Discusses reasons for the increase of Trypodendron lineatum population in W. Germany up to 1967, and recommends "clean" wood management in addition to chemical treatments to reduce the population and protect the lumber.

193. Schindler, U. 1968.

Die Forstschutzlage in Nordwestdeutschland.
(The forest protection situation in northwest Germany.)
Allg. Forstz. 23: 187-192.

Reviews various aspects of forest protection in N-W. Germany. Trypodendron lineatum is of particular interest because of its tremendous increase in the last 20 years, especially after the heavy windfall in Feb. 1962. Discusses uses and effectiveness of HCH(BHC)-fuel oil and DDT mixtures.

194. Schindler U. 1969.

Experience from last year's control operations against Trypodendron lineatum.
Allg. Forstz. 24(11): 205-206.

Deals with recommendations on preventive spray treatment of spruce logs and spraying of attacked logs against T. lineatum.

195. Schindler, U. 1970.

Further experience in the control of Trypodendron lineatum.
Holz. Zentralbl. 96: 505-506.

Reports on spray trials with combinations of lindane and carbamate in water, killing T. lineatum even 4-5 cm inside the wood.

196. Schneider, I. and J.A. Rudinsky. 1969.

The site of pheromone production in Trypodendron lineatum (Coleoptera: Scolytidae): bioassay and histological studies of the hindgut.
Can. Entomol. 101: 1181-1186.

Through bioassay and histological studies, the site of pheromone production was found to be in a layer of secretory cells in the posterior ileum and the anterior rectum, which only occurs in feeding adults. The attractive material is produced only in the presence of digested bark and wood particles. The hypothesis is proposed that the attractive material acts under influence of a substance or a process activating or activated by the maturation of the fertilized egg.

197. Schneider, I. and J.A. Rudinsky. 1969.

Anatomical and histological changes in internal organs of adult Trypodendron lineatum, Gnathotrichus retusus and G. sulcatus (Coleoptera: Scolytidae).
Ann. Entomol. Soc. Am. 62: 995-1003.

Anatomical and histological changes are described and correlated with the metabolism of maturing or breeding ambrosia beetles. During the dispersal flight, the mycetangia completed their secretion cycle, the salivary glands grew and the fat body depleted. With the start of the flight, the glands of the reproductive organs were activated and, after mating, the eggs developed.

198. Schönherr, J. 1958.

Die Dämpfung, ein Weg zur Entseuchung des von Nutzholzborkenkäfer (Xyloterus lineatus) befallennen Holzes.
(Steaming, a way to sterilize wood attacked by the beetle Xyloterus lineatus)
Forst Jagd. 8(5): 227-228.

Describes experimental steam treatment of logs at 1.3 atm. After 15 min, only pupae of Trypodendron lineatum lying deeper than 25 mm survived. Suggests that increased pressure might achieve total kill.

199. Schwerdtfeger, F. 1963.
Zur Generationsfrage beim gestreiften Nutzholzborkenkäfer Xyloterus lineatus Ol. (On the question of the number of generations of the striped ambrosia beetle Xyloterus lineatus Ol.)
Forst Holzwirt. 18: 449-451.

Concludes from observations in 1963 on windthrown spruce in Germany that there was only one generation of Trypodendron lineatum.

200. Schwerdtfeger, F. 1964.
Wie kann der gestreifte Nutzholzborkenkäfer bekämpft werden?
(How can the striped ambrosia beetle be controlled?)
Holzzentralbl. 90: 331-332.

Discusses dosages, concentrations and costs of preventive spraying and treatments of logs infested by Trypodendron lineatum with various insecticides. Also suggests removal of infested logs and trap trees before July.

201. Trågårdh, I. 1925.
On some methods of research in forest entomology.
Proc. Int. Congr. Entomol. 3rd Zurich 2: 577-592.

Beetles are divided into groups according to the attack in relation to the time of felling. The author considers Trypodendron lineatum as a secondary species, as it attacks pine and spruce trees felled 6-12 months previously. Reports on observations on host selection and succession of attack.

202. Uusvaara, O. and K. Loyttyniemi. 1975.
Effect of injury caused by the ambrosia beetle (Trypodendron lineatum Oliv., Col., Scolytidae) on sawn timber quality and value.
Folia Forestalia 231: 1-14.

Trypodendron lineatum is considered the most harmful injurious insect to softwood logs in Finland. Gives some figures on losses and concludes that susceptible saw logs cannot be stored during the swarming period for longer than about two weeks without significant losses in quality and value of the sawn timber.

203. Vasechko, G.I. 1971.
The biology of the bark beetle (Coleoptera, Ipidae) pests of spruce and fir in the Carpathians.
Entomol. Rev. 50(4): 427-430.

Deals in part with some biological aspects of Trypodendron lineatum. Discusses, as a main and a sister generation, the activities following two observed flight maxima. Observes longer entrance galleries in timber lying in sunny locations than within the forest and subscribes this to difference in moisture content of the wood.

204. Vité, J.P. 1965.
Ist die vorbeugende Begiftung von Fangbäumen zwechmässig?
(Is preventive poisoning of trap trees practical?)
Allg. Forst. 20: 438-439.

Brief discussion of recent research on attractants. Deals in part with Trypodendron lineatum being far more attracted to infested logs and to air blown over their bark than to uninfested trees or air blown over their bark. Concludes that by reducing primary infestation, preventative poisoning of trap trees may make them ineffective.

205. Werner, A.E. and K. Graham 1957.
Volatile wood constituents in relation to ambrosia beetles.
Can. Dept. Agric., For. Biol. Div., Bi-Mon. Prog. Rep. 13(4):

This is the first report on the use of gas chromatography in this field. Alpha- and beta-pinene are found as major constituents of gas-distilled extracts of Douglas-fir sapwood. Wood treated with these compounds failed to induce attack by Trypodendron. Some evidence that these materials act as a deterrent to boring by these insects was found.

206. Wichmann, H. 1925.

Die Ökologie des Xyloterus lineatus Ol. The ecology of Xyloterus lineatus Ol. Anz. Oesterr. Akad. Wiss. 1925: 52.

Describes in some detail the activities of female Trypodendron lineatum in the brood galleries. As the ambrosia fungus is aerobic, the galleries have to be cleaned out so that air can circulate. Also describes the mechanism for elimination of larval waste.

207. Wood, S.L. 1957.

Ambrosia beetles of the tribe Xyloterini (Coleoptera: Scolytidae) in North America. Can. Entomol. 89: 337-354.

In part, the most recent and comprehensive systematic description of Trypodendron lineatum (Olivier).

208. Wright, R.H. 1965.

Attenuating the sex attractant of the ambrosia beetle Trypodendron lineatum (Oliver). B.C. Research Counc. Ann. Rep. E.M.R. F11.

Gives data collected when testing an apparatus designed to measure the strength of an attractive odor in terms of the number of insects responding to it. Male T. lineatum were tested and the effect of various chemicals on the attraction to the odors produced by gallery excavating females assessed. The results reported are preliminary and not conclusive.

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