Seasonal abundance and distribution of ambrosia beetles on the North Arm of the Fraser River, British Columbia[1]

DESMOND K.W. LAM AND JOHN A. MCLEAN
DEPARTMENT OF FOREST SCIENCES
THE UNIVERSITY OF BRITISH COLUMBIA
2357 MAIN MALL
VANCOUVER, B.C. V6T 1Z4

ABSTRACT

Pheromone-baited multiple funnel traps were set up on a transect to determine the abundance and occurrence of ambrosia beetles over water and land in the Point Grey log boom storage locations on the North Arm of the Fraser River. Beetle collections made from April to September 1991, showed the proportion of *Trypodendron lineatum*, *Gnathotrichus sulcatus* and *G. retusus* beetles were in ratio of 1,054:24:1, respectively.

Most of the ambrosia beetles were collected in the forested margin close to the shoreline. Although there is no active logging in the adjacent Foreshore and Pacific Spirit Parks, these areas still provide an overwintering refuge to a large number of ambrosia beetles. The transportation of infested log booms to the North Arm of the Fraser and local wind patterns are factors that lead to the build up of beetle numbers in the area.

INTRODUCTION

Sawmill managers detest the presence of ambrosia beetles in their sawlogs because the dark staining galleries show up as "pinhole" defects in lumber. This damage reduces the value of the lumber recovered from infested logs. Most of the lumber with pinholes does not end up in lumber yards, but rather is consigned to the chipper and thence to pulp. Lumber degrade and value losses caused by ambrosia beetles have been documented by McBride and Kinghorn (1960). More recently, McLean (1985) suggested that the damage incurred from ambrosia beetles infestations results in annual losses of $63.7 million in British Columbia (B.C.).

The biology of ambrosia beetles has been described by Nijholt (1978), Shore (1985), Borden (1988) and Lindgren (1990). The three common species of ambrosia beetles found in B.C. are *Trypodendron lineatum* (Olivier), *Gnathotrichus sulcatus* (LeConte) and *G. retusus* (LeConte). All three species make their homes in the fallen branches, boles and stumps of coniferous trees (Dyer 1963; McLean and Borden 1975a). The flight of *T. lineatum* begins in the spring. Overwintering beetles leave the duff when temperatures exceed 16°C (Kinghorn and Chapman 1959). The beetles will hawk through the forest until arrested by suitable host material (Moeck 1970). Although *T. lineatum* adults are able to fly short distances unaided, beetle dispersal by the wind may be as far as 1.9 km from flight origin within 24 h (Salom and McLean 1990). In the forest, the major host is the valuable old-growth sawlog. Once a suitable host is found and the attacks initiated, the pioneering sex releases an aggregation pheromone that attracts other beetles to the site. The first population aggregation pheromone identified was that for *G. sulcatus* and it was given the trivial name, sulcatol (Borden and Stokkink 1973). The aggregation pheromones for the other two ambrosia beetles have also been identified and synthesized: lineatin for *T. lineatum* (MacConnell *et al.* 1977) and retusol for *G. retusus* (Borden *et al.* 1980).

Soon after the beetles enter into a log, eggs are laid in small niches along the galleries. The galleries are also the growing fields for symbiotic fungi which are inoculated on to the wood when the beetles first enter the log. The depth of gallery penetration varies among beetle and host species. Most of the activity is confined to the moist sapwood. The developing larvae feed solely on the fungus and remain in their niche throughout development. The *T. lineatin* larva is walled off behind a frass plug and as the larva grows, the niche is extended. Frass is extruded through a tiny hole in the plug (Borden, 1988). The development from egg to adult is estimated to take 70 days and the population may multiply 8-fold (Shore *et al.* 1987; McIntosh and McLean 1992). *Gnathotrichus sulcatus* and *G.*

retusus differ slightly from *T. lineatum* in that the male is the pioneering sex. The larval niches remain open throughout larval development but the pupa seals the niche before pupating. The overwintering site for *Gnathotrichus spp* is normally within a log but it may also successfully develop in sawn lumber (McLean and Borden 1975b). *T. lineatum* teneral adults leave the log in the summer and are blown to the nearest forest margin where they overwinter in the duff on the forest floor. At this time the teneral adults are unresponsive to pheromones (Borden 1988).

The Point Grey booming ground is located at the mouth of the North Arm of the Fraser River in B.C. It is an important storage area for forest companies which tow their log booms from the northern coast to the mills in the Vancouver area. The booming ground includes two large areas: the North Arm Jetty (NAJ) where groups of booms are tied up after arriving from the north coast, and the Coast Mill Export (CME) ground, that covers 20 km^2 adjacent to the Foreshore Park, where log booms are stored on tidal flats. These two areas, as well as the shores of the Fraser River, are used to store booms of sawlogs in fresh water. Log booms towed to the NAJ are moved up the river for freshwater storage, to the mills located beside the river, or to the CME ground for resale. To the north of the main river channel and the CME ground are the Foreshore and Pacific Spirit Parks. Both parks are mainly second growth forest that followed harvesting in the 1930's. Deciduous trees, shrubs and ferns blanket the understory.

A study in spring of 1991 was conducted across the NAJ, CME grounds and into the Parks to determine: a) the incidence of ambrosia beetles in the boom storage area and adjacent forest foreshore area; and b) the seasonal abundance of *T. lineatum*, *G. sulcatus* and *G. retusus* at the North Arm of the Fraser.

MATERIAL AND METHODS

A trapping transect was set out across the North Arm Jetty, the CME storage area, the forested Foreshore Park area and into the Pacific Spirit Park (Fig. 1). Twenty-four multiple-funnel traps were placed in 8 rows of three traps. The three traps within each row were baited with ethanol and alpha-pinene. The aggregation pheromones lineatin, sulcatol and retusol were assigned randomly to one of the three traps in each row. Traps within each row were at least 50m apart.

The first row of traps was placed on the sandy banks of the North Arm Jetty. The second through fifth rows of traps were placed on dolphins (groups of 4 pilings to which booms are tied) standing between alleys in the CME ground. Access to traps on the NAJ and CME ground was by boat. The sixth row of traps was set out half way up the foreshore cliffs while the seventh row was set out at the top of the cliffs. Traps in row 8 were placed in Pacific Spirit Park on the north side of Marine Drive (Fig. 1).

Traps were checked every week from April through September 1991. Twenty two collections were brought back to the laboratory for counting and identification. The daily maximum temperature, wind direction and wind speed data for the Vancouver Airport were obtained from the Environment Canada office in Vancouver.

RESULTS AND DISCUSSION

Many previous studies have shown that abiotic factors influence the flight of ambrosia beetles during emergence in the spring and selection of overwintering locations in the late summer. Temperature is a major factor that stimulates beetle activity after winter diapause. Results from our study and others (Chapman 1962; Daterman et al. 1965; Shore and McLean 1985) show that significant *T. lineatum* flights occur when temperatures in the spring are above 15.6°C (Chapman and Kinghorn 1958). This initial peak flight is often sudden and correlates with the adult emergence from the forest litter on the first warm days of spring. These adults are sensitive to host odours and pheromones.

In our study, a total of 48,540 *T. lineatum* beetles were collected in the lineatin funnel traps. The major *T. lineatum* flight started in the third week of April (Fig. 2). Very few beetles were caught in the first week of April and the highest catches were recorded in the

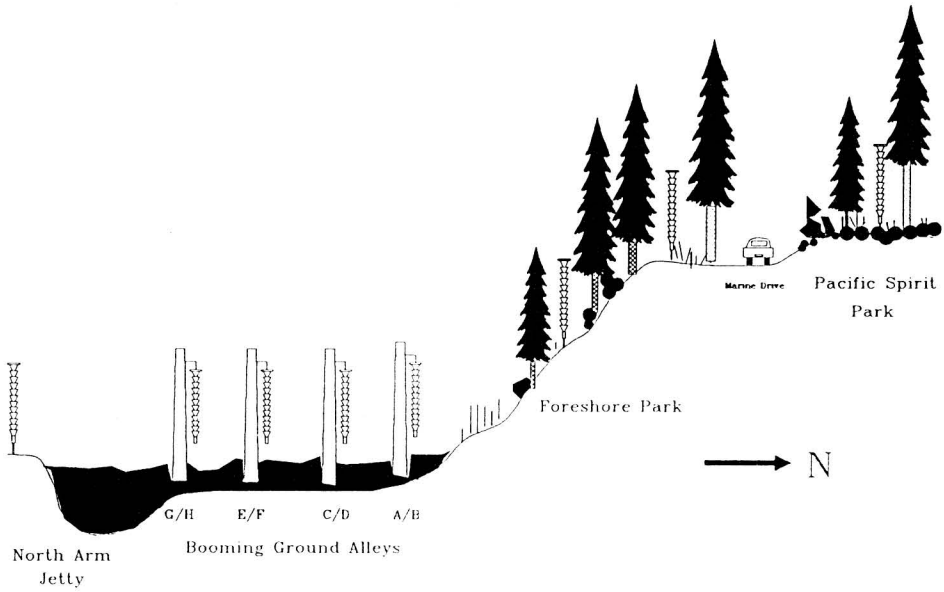

Figure 1. Diagrammatic cross-section of the Point Grey log boom storage area showing the relative positions of the 8 trap lines. Each trap line consisted of three traps set out 50 m apart in an east-west direction. See text for baiting regimes.

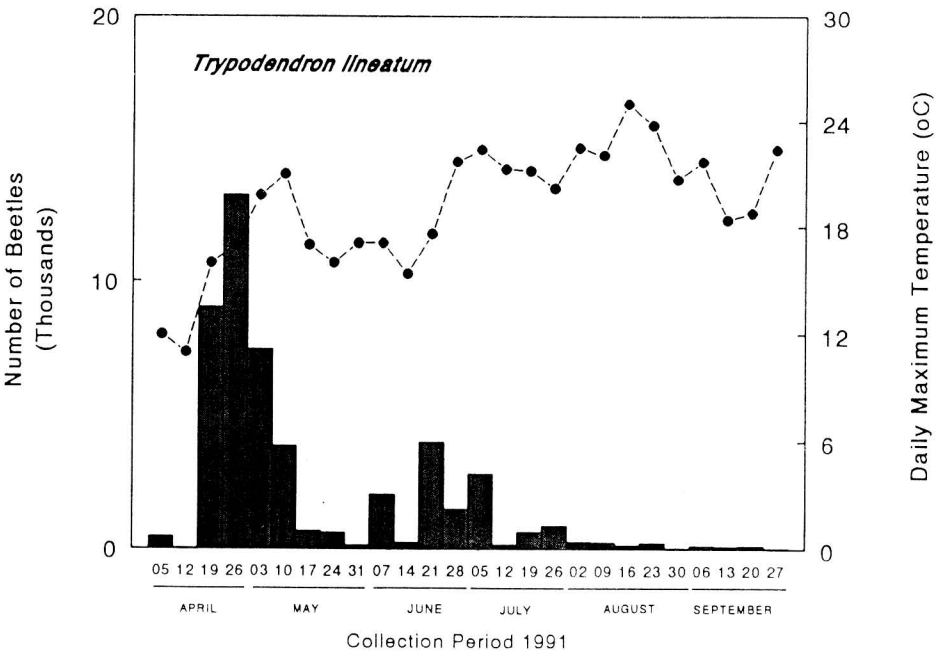

Figure 2. Weekly total catches of *Trypodendron lineatum* in the Point Grey log boom storage area.

last week of April. In the third week of collection, the daily maximum temperature during April 12 to 18, exceeded the required temperature for flight on 2 of the 7 days. The beetle catch increased from 20 to 9,016 *T. lineatum* beetles in two weeks. Beetle emergence from the forest litter continued into the second week of May and finally ended in the same month. A second, but smaller *T. lineatum* peak ("sister flight") was observed in June and July; these beetles represented 21% of the total beetle catch from April to September 1991. This second peak of beetles is thought to be mainly pheromone-sensitive parent beetles that leave infested logs at the same time as their offspring (McIntosh and McLean 1992). A few teneral adults, which are considered to be pheromone insensitive until they have overwintered (Borden 1988), were also caught. A proportion of the parental adults collected in the traps could possibly establish a second brood that would emerge before year's end. We observed some mid-summer attack of logs by *T. lineatum* but have no data on the success of these galleries. Vigorous parents may reattack and raise a second late summer brood (Nijholt 1978).

Gnathotrichus sulcatus catches were consistently lower than *T. lineatum* catches (Fig. 3). Again most of the beetles were caught in the first two months of collection. There was one major flight of *G. sulcatus* beetles that occurred in early May. This peak emergence was 2 or more weeks after the peak *T. lineatum* flight. A major second *G. sulcatus* flight was expected in late August (McLean and Borden 1975b), however this did not occur. One reason for the low number of *Gnathotrichus* beetles in the area may have been the lack of infested logs. No suitable host or infested material was seen within the parks. A total of 1,121 *G. sulcatus* and 47 *G. retusus* beetles were collected in the sulcatol and retusol traps, respectively.

Significantly greater numbers of *T. lineatum* and *G. sulcatus* beetles were caught in the two trap rows in Foreshore Park, than in Pacific Spirit Park ($X^2 < 0.001$ in both cases). Very few beetles were caught on the NAJ and CME dolphins (Fig. 4). Only 300 *T. lineatum* beetles, half of which came from one collection on July 7th, were caught in the lineatin traps on the row 5 dolphins of alley A/B. Total *T. lineatum* and *G. sulcatus* catches on the NAJ and CME ground were 1% and 4%, respectively of the total catch.

It is likely that the beetles caught in the parks originated from infested logs in storage during June and July of the previous summer at the NAJ and in the CME booming ground. The parental and brood adults that emerged in June, July and August were displaced by the prevailing winds to the forested Foreshore Park area. Daterman *et al.* (1965) have shown that *T. lineatum* and *Gnathotrichus* beetles are in flight between 1100 to 1700 hours. Wind direction analysis for this time in April/May and July through September showed that for 89% of the time, the wind blew from the NAJ and CME ground towards the land. Furthermore, wind tunnel studies have shown that ambrosia beetles are unable to maintain directional flight at winds speeds over 1.8 km/hour (Salom and McLean 1991). Average wind speed recorded at the airport weather station between July through September, during the time that the beetles are thought to be in flight was 12 km/hour. The station is less than 10 km distant.

Wind speeds of this magnitude during the dispersal flight periods support the hypothesis that the number of beetles caught in the traps in the forested margin in 1991 are a direct result of previous summer's wind patterns which displaced a number of the beetles emerging from infested log booms over the water and into the forest margins. Beetles then emerged in the subsequent spring and flew in search of suitable new host material within the forested area where they were captured in traps. Wind patterns were suitable for flight towards the log booms for only 10% of the time.

There is a nine month delay between the flight of brood beetles to overwintering sites in forested areas and their reemergence the following spring to attack any suitable host material in the area. Loggers who fall trees in the fall one year will not see signs of beetle attack on the logs until the following spring. Managers of coastal tie-up areas must recognize that booms stored against a forested foreshore are in a high ambrosia beetle hazard zone (Fig. 4). High value booms would be best stored in areas that are as far as possible from forested foreshores to prevent ambrosia beetles from attacking the floating sawlogs. The Ambrosia Beetle Task Force that conducted a year long study on MacMillan Bloedel's inventory in 1990/1991 found

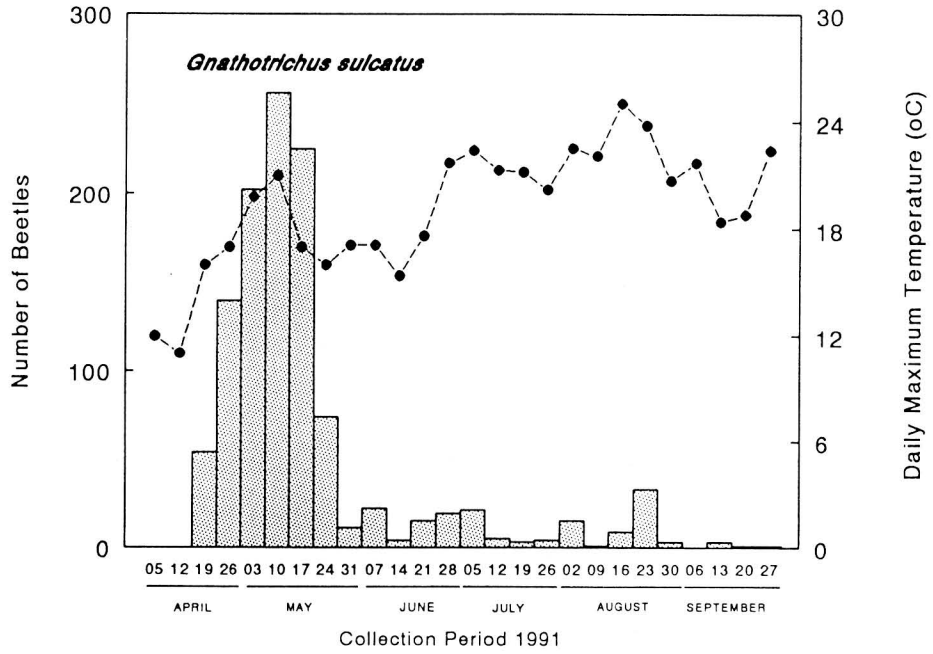

Figure 3. Weekly total catches of *Gnathotrichus sulcatus* in the Point Grey log boom storage area.

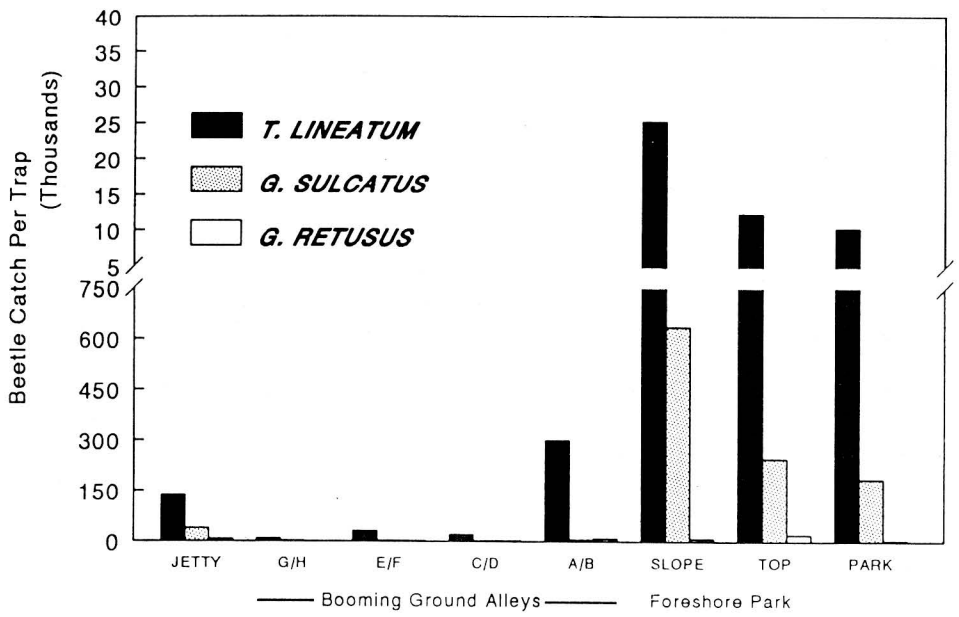

Figure 4. Total seasonal catch of three species of ambrosia beetles across the Point Grey log boom storage area and the forested foreshore area (see Fig. 1).

some degree of attack on log booms stored against forested foreshore areas while more remote locations such as the Nanaimo River flats and the outer alleys of the Point Grey booming ground had few fresh attacks. In this study on the North Arm of the Fraser, it is possible that ambrosia beetles blown into the forested margin may be able to disperse out to the beach tie up areas when the onshore winds abate. Hence, valuable sawlog booms should be stored away from the forested margin and alley A/B during the April and May beetle flight period.

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REFERENCES

Borden, J.H. 1988. The striped ambrosia beetle, Trypodendron lineatum (Olivier). In A.A. Berryman (Ed.). Dynamics of Forest Insect Populations. Plenum Publ. New York. pp. 579-596.

Borden, J.H. and E. Stokkink. 1973. Laboratory investigation of secondary attraction in *Gnathotrichus sulcatus* (Coleoptera: Scolytidae). Can. J. Zool. 51:469-473.

Borden, J.H., J.R. Handley, J.A. McLean, R.M. Silverstein, L. Chong, K.N. Slessor, B.C. Johnston and H.R. Schuler. 1980. Enantiomer-based specificity by two sympatric *Gnathotrichus* species (Coleoptera:Scolytidae). J. Chem. Ecol. 6:445-456.

Chapman, J.A. 1962. Field studies on attack flight and log selection by the ambrosia beetle *Trypodendron lineatum* (Oliv.) (Coleoptera: Scolytidae). Can. Ent. 94:74-91.

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. Ent. 90:362-372.

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. State Univ. Tech. Bull. 87:46 pp.

Dyer, E.D.A. 1963. Attack and brood production of ambrosia beetles in logging debris. Can. Ent. 95:624-631.

Kinghorn, J.M. and J.A. Chapman. 1959. The Overwintering of the Ambrosia Beetle *Trypodendron lineatum* (Oliv.). Forest Sci. 5:81-92.

Lindgren, B.S. 1990. Ambrosia Beetles. J. For. 88:8-11.

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. 5:549-561.

McBride, C.F. and J.M. Kinghorn. 1960. Lumber degrade caused by ambrosia beetles. B.C. Lumberman. 44:40-50.

McIntosh, R. and J.A. McLean. 1992. A life stage development index for *Trypodendron lineatum* (Oliv.) in the Port Alberni region of Vancouver Island. J. Ent. Soc. B.C. 89:43-47.

McLean, J.A. 1985. Ambrosia beetles: a multimillion dollar degrade problem of sawlogs in coastal British Columbia. For. Chron. 61:295-298.

McLean, J.A. and J.H. Borden. 1975a. *Gnathotrichus sulcatus* attack and breeding in freshly sawn lumber. J. Econ. Entomol. 68:605-606.

———. 1975b. Attack by *Gnathotrichus sulcatus* on stumps and felled trees baited with sulcatol and ethanol. Can. Ent. 109:675-686.

Moeck, H.A. 1970. Ethanol as the primary attractant of the ambrosia beetle *Trypodendron lineatum*. Can. Ent. 102:985-995.

Nijholt, W.W. 1978. Ambrosia beetle: a menace to the forest industry. Can. For. Serv. Pac. For. Res. Cen. Rep. BC-P-25.

Salom, S.M. and J.A. McLean. 1990. Dispersal of *Trypodendron lineatum* (Olivier) within a valley setting. Can. Ent. 122:43-58.

Salom, S.M. and J.A. McLean. 1991. Flight behavior of scolytid beetle in response to semiochemicals at different wind speeds. J. Chem. Ecol. 17:647-661.

Shore, T.L. 1985. Ambrosia Beetles. Can. For. Serv. Pac. For. Res. Cen. Rep. FPL-72. 4 pp.

Shore, T.L. and J.A. McLean. 1985. A survey for the ambrosia beetles *Trypodendron lineatum* and *Gnathotrichus retusus* (Coleoptera:Scolytidae) in a sawmill using pheromone-baited traps. Can. Ent. 117:49-55.

Shore, T.L., J.A. McLean and J.C. Zanuncio. 1987. Reproduction and survival of the ambrosia beetle *Trypodendron lineatum* (Oliv.)(Coleoptera:Scolytidae) in Douglas-fir and western hemlock logs. Can. Ent. 119:131-139.