BI-MONTHLY RESEARCH NOTES

A selection of notes on current research conducted by the Canadian Forestry Service, Department of Fisheries and Forestry

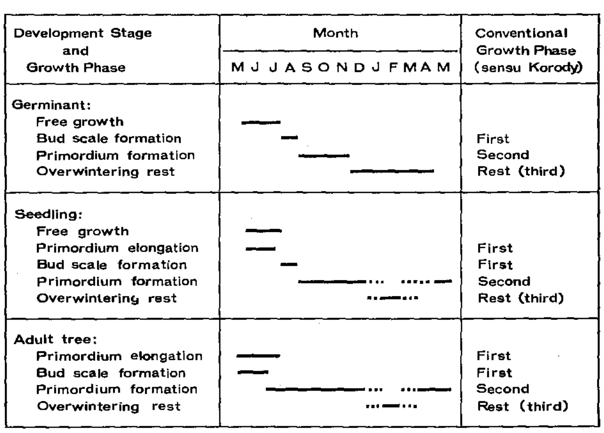
BOTANY

Changes Due to Age in Apical Development in Spruce and Fir.—The literature on morphogenisis of the shoot apex in spruces and firs beyond the seedling stage has been reviewed by Clowes (Apical meristem, Blackwell Sci. Publ., Oxford, 1961). Korody (Beitr. Biol. Pflanz. 25: 23-59, 1937) separated three main phases of growth in the meristematic tissues (Fig. 1): (1) elongation of the shoot primordium after bud-break and simultaneous development of bud scales for the next overwintering bud; (2) formation of primordium for the next year's leader; and (3) a rest period with no significant primordial development, ending with bud-break the next spring.

As delayed bud formation after spring bud-break is commonly observed on juvenile conifers under favorable growth conditions, the pattern for trees is not applicable to seedlings. No comment was found in the literature to explain the difference in developmental pattern in seedlings.

Leaders of spruce and fir seedlings of different stages of life grown under natural or controlled conditions, were collected during the four seasons for 7 years. For comparison, branch or leader tips of mature trees were also sampled. Specimens of *Picea glauca* (Moench) Voss., *P. rubens* Sarg., *P. mariana* (Mill.) BSP., *P. abies* (L.) Karst., and *Abies balsamea* (L.) Mill. growing in the Maritimes Region were obtained.

Gross anatomical and microscopic examinations of the seedling samples grown under natural conditions revealed five growth phases (Fig. 1): **Primordial shoot elongation** (of preformed stem and needles) beginning at the time of bud-burst; **Free growth** of additional non-preformed stem with new needles on it (Fig. 2); **Bud scale formation** for the terminal bud, as during the first phase on old trees; **Primordial shoot formation** starting immediately after formation of bud scales and proceeding intermittently throughout the **Overwintering phase.** The free growth phase is the only evident growth on germinants (first-years seedling), it is typical on young seedlings, and absent on old trees. Development of primordial shoots was obviously slowed during the winter; except for the most severe few weeks of mid-winter, however, dormancy was not evident.



Note: Broken line marks intermittent action.

FIGURE 1. Yearly cycle of growth phases of the shoot apex on germinants, seedlings, and adult trees of spruce and fir in the Maritimes.

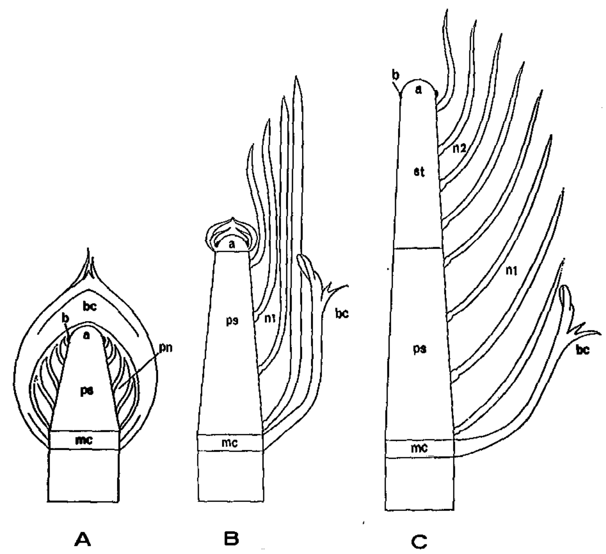


FIGURE 2. Comparison of shoot development from the spring primordium (A), in mature trees (B, after Korody) and young seedlings (C). Legend: bc—bud scale coat, b—buttress, a—apex, pn—primordial needle which extends to form n_1 —primary needle, ps—primordial stem, mc—medullary cavity, st—stem portion formed by free growth, n_2— needles formed *de novo.*

Although the pattern of development of a germinant is sharply distinguished from the pattern of succeeding years, no such definite distinction can be made between a seedling and a tree beyond seedling age. There is a gradual transition during which the free growth phase diminishes in about 5 to 10 years after germination. During these years, while bud formation depends primarily on availability of growth factors (Jablanczy, unpubl. results), the silviculturalist has a challenge to take advantage of the non-proformed free-growth potential.—A Jablanczy, Forest Research Laboratory, Fredericton, N.B.

ENTOMOLOGY

Attack by the Spruce Beetle, Induced by Frontalin or Billets with Burrowing females.—Previously we reported (Chapman and Dyer, Bi-Mon. Res. Notes 25:31, 1969) strong cross attraction between the Douglas-fir beetle, [*Dendroctonus pseudotsugae* Hopk.] and the spruce beetle, [*D. rufipennis* (Kirby)]. Pitman and Vité (Ann. Ent. Soc. Amer. 63:661-664, 1970) found that frontalin, the principal pheromine of the southern pine beetle, *D. frontalis* Zimm. (Kinzer *et al.*, Nature 221: 477-478, 1969) was also produced by the female Douglas-fir beetle. In combination with camphene it was attractive to this insect, and it induced attacks in the field. We now report that frontalin induced spruce beetle attacks on *Picea engelmannii* Parry and *P. glauca* (Moench) Voss during tests conducted in British Columbia, near Elko (East-Kootenay mountains) and Naver (Prince George district) in 1970. We also found that frontalin combined with alpha-pinene or spruce billets attracted spruce beetles, although not as effectively as billets with females.

Trees were baited by placing small plastic caps of frontalin (>99.2% purity) at or near breast height. Axe-cuts were made near the caps to supply the host-tree volatiles. Frontalin was tested for attractiveness, using a sleeve olfactometer (Gara, Vité and Cramer, Contrib. Boyce Thompson Inst. 23: 55-66, 1965) and polyethylene covered cages on which barrier traps were mounted, as in our earlier cross-attraction tests. For comparisons of beetle response, spruce billets with attacking females were used as sources of attraction. Many trees were baited by hanging such billets against them 3 to 5 feet above ground.

At Elko, olfactometer tests during early beetle flights showed that frontalin, released from vials in combination with alpha-pinene, beta-pinene or 3 carene, attracted spruce beetles. For example, on June 5 and 6 during 4.6 hours of testing, 61, 40 and 37 beetles per hour were attracted to these combinations, respectively, as compared with 22 per hour responding to an uninfested billet. However, during later flights, June 18 to 21, more beetles responded to a billet with 15 attacking females than to the frontalin and alpha-pinene combination (71 and 18, respectively, during 3.7 hours of testing). The cage-trap units showed that although beetles were attracted to frontalin with alpha-pinene, females in billets were more attractive (Table 1).

TABLE 1
Flight-trap catches at cages in three[1] replications of five different sources of attraction

Attractants	Dates June 1970	*Dendroctonus rufipennis* No. of males	No. of females	Per cent males	Per cent total catch for period
Spruce billet	6-9	169	133	56	66
+ 40 females	20-23	1143	352	76	77
Spruce billet	6-9	25	28	47	12
+ frontalin	20-23	55	90	38	8
Alpha-pinene	6-9	23	38	38	13
+ frontalin	20-23	45	96	32	7
Frontalin	6-9	13	8	62	5
only	20-23	31	24	56	3
Spruce billet	6-9	12	8	60	4
only	20-23	45	54	46	5

[1] Only two functioning June 6-9.

When attacks were noticed on standing trees near sites of frontalin release, four uninfested trees were each baited with two caps of frontalin and axe-cuts. These trees were attacked the same day. The brood survived and eventually killed the trees. Four days later the caps were transferred to four other trees, over 600 feet away. These trees were also attacked, during at later and less intense flight; however, their beetle broods failed and the trees survived that season. After beetle flight had ceased, all trees within 50 feet and several within 300 feet from each frontalin source were exeamined. The results were as follows:

	within 30 ft	30—50 ft	50—300 ft
No. trees examined	48	36	47
No. trees attacked	28	1	0

Baited and surrounding trees ranged from 6.0 to 33.0 inches, with an average of 13.6 inches dbh.

The sex ratio of beetle samples at Elko is of interest. The percentage of males was 41.4 in 955 beetles hibernating the previous autumn, 34.3 in 233 beetles taken by sticky wire traps on frontalin-baited trees, and 31.8 in 585 beetles caught by barrier traps on a felled tree, but males predominated in flight trap samples at billets with females and at frontalin only (see Table 1). The sex ratio differences apparently reflect differences in male and female activity or response to different kinds of attraction.

At Naver, olfactometer tests were negative with frontalin combined with various monoterpenes found in spruce, during small early-season beetle flights. However, billet-cage tests, replicated in three locations, indicated that frontalin with alpha-pinene was somewhat attractive. For example, numbers taken June 14 to 21 were: 80—frontalin with alpha-pinene; 417—billet with 40 females; 101—frontalin with billet, and 17—frontalin alone.

A series of trees in 18 locations were baited with billets to which 10 or 15 female beetles were added. The beetles were placed in small holes punched in the bark, and covered with screen wire. Of the 58 baited trees (9 to 23 inches, avg 16.6 inches dbh), 31 were attacked. Most of the billets on these trees had four or more successful attacks by the added females. Most unattacked trees had fewer than four successful attacks by screened females on the bait billet. No trees next to the billet-baited ones were attacked.

On July 17, 10 trees (12—30 inches avg 18.0 inches dbh) in three areas five or more miles apart, were each baited with five caps of frontalin and axe-cuts. Although only a small flying population, mainly reemerged parent adults, was to be expected late in the season, all 10 trees were attacked as well as several others adjacent to the baited trees.

Densities of induced attacks were low at Naver and no attacked trees were killed. Most attacks failed, apparently due to resin flow. Some long egg galleries were noted, but most had no larvae. Attacks were concentrated more at the base of trees baited with billets than when frontalin was used (Table 2). Here, as at Elkio, all attacks seen on standing trees in the test areas were associated with billet- or frontalin-baiting.

TABLE 2
Vertical attack distribution on baited trees—Naver

Height above ground—ft	Billet-female bait[1] No. attacks	Per cent	Frontalin bait[2] No. attacks	Per cent
0 - 1	202	57	56	25
1 - 2	68	19	22	10
2 - 3	38	11	30	13
3 - 4	32	9	33	15
4 - 5	15	4	24	11
5 - 6	1	0.5	21	9
over 6	0	0	37	17
Total	356		223	

[1] 31 trees attacked.
[2] 10 trees attacked.

We conclude that frontalin triggers the process of mass attack by the spruce beetle and that, as with several other *Dendroctonus* species (e.g., McCambridge, Ann. Ent. Soc. Amer. 60: 920-928, 1967), baiting with billets and female beetles acts in a similar way. The low attractiveness of frontalin with alpha-pinene indicates that there are other chemical cues, as yet unknown, involved in secondary attraction of the spruce beetle. However, the consistency with which trees baited with frontalin were attacked, in stands where no attacks on unbaited standing trees were found, suggests that frontalin is a component of spruce beetle secondary attraction. Investigations into the potential uses of frontalin for study, survey and control of the spruce beetle are planned.

The tests were carried out, as part of a cooperative study of secondary attraction in the spruce beetle, with J. P. Vité and G. B. Pitman, Boyce Thomson Institute for Plant Research, Inc. We thank that organization and the Southern Forest Research Institute, Houston, Texas, for supplying the frontalin and D. W. Taylor and T. G. Gray for assistance. E. D. A. Dyer and J. A. Chapman, Forest Research Laboratory, Victoria, B.C.

Field Test of Ethanol as a Scolytid Attractant.—Ethanol, produced in softwood logs, serves as a primary attractant for *Gnathotrichus sulcatus* Lec. (Cade, Hrutfiord and Gara, J. Econ. Entomol. 63: 1014-1015, 1970) and in laboratory tests, for *Trypodendron lineatum* (Olivier) (Moeck, Can. Entomol. 102: 985-995, 1970). A field test with ethanol (Moeck, *loc. cit.*) in 1969 was unsatisfactory due to a small beetle population in the test area, which necessitated repetition in a more highly populated area.

On 29 Apr. 1970, 40 pan-type glass-barrier traps (Dyer and Chapman, Can. Entomol. 97: 42-57, 1965) (Fig. la) were placed on the ground in groups of four at three locations in stands of 60–70-year-old Douglas-fir near Mesachie Lake and Caycuse, B.C. In each group, traps were situated at the corners of a 6-foot square, with the glass panes of adjacent traps oriented at right angles to each other, to reduce directional effects. The test solution (750 ml of 10% ethanol) was placed in each of two adjacent traps of each group, and 750 ml of water (control) was placed in each of the other two traps. The solutions were replaced three times until the conclusion of the test on 19 May.