Elmira Field Establishment, Waterloo County, Ont. and successfully reared on large and small shoot moth larvae throughout the summer. In October 1973, 26 more parasites were received at the Great Lakes Forest Research Centre, Sault Ste. Marie, Ont. These and their progeny were used to determine whether *P. nigrifemur* behaved cleptoparasitically towards *O. obscurator*, although Brewer and Naumann (Acta zool. lilloana 26:129-144, 1970; 26:157-178, 1971) indicated that it showed no such tendencies towards endoparasites in Argentina. Half-grown shoot moth larvae from the Elmira area were reared on artificial medium as described by Syme and Green (Can. Entomol. 104:523-530, 1972) until they reached the fifth or sixth instar. At this stage, *O. obscurator*-infested larvae can be separated from normal larvae by weight (Syme and Green, *loc. cit.*). Thirty-four female *P. nigrifemur* were each confined with one large, healthy, shoot moth larva and one small, presumably *O. obscurator*-infested larva for 2-3 days. Some of these were reconfined with fresh hosts up to five times. In 21 cases, there was attack with oviposition on at least one of the pair. All hosts were dissected to confirm the presence or absence of *O. obscurator* and the results are shown in Table 2.

TABLE 2
Numbers of shoot moth larvae with and without *O. obscurator*, that were attacked, or not attacked by *P. nigrifemur* in the labortary, 1973

	P. nigrifemur		
	Attacked	Not Attacked	Total
Hosts with *O. obscurator*	11	4	15
Hosts without *O. obscurator*	10	17	27
Total	21	21	42

Chi-square is 3.73, $P > 0.05$, indicating that there is no selection by *P. nigrifemur* for or against *O. obscurator*-infested hosts. From these results and those of Brewer and Naumann (*loc. cit.*) we can conclude that if *P. nigrifemur* is introduced into Ontario in an attempt to control shoot moth, it will have no detrimental effects on *O. obscurator*, the most effetcive established parasite of this pest.—Paul D. Syme, Great Lakes Forest Research Centre, Sault Ste. Marie, Ont.

Molecular Vibration and Insect Attraction: *Dendroctonus rufipennis*.—If non-toxic, behavior-controlling chemicals are to become useful supplements to or substitutes for conventional pesticides, the availability, efficacy and cost will be dominant considerations. Two methods have hitherto been used to identify potentially useful substances.

The first and simplest method is to expose a diversified selection of chemicals in traps in the field and to retest those chemicals that show indications of biological activity. Some effective attractants have been found in this way, e.g. for the Mediterranean fruit fly [*Ceratitis capitata*, (Wied.)]. This method was not successful for tests with 100 chemical compounds near Lake Cowichan, B.C., which failed to yield a single one with any sign of attractancy for scolytid or other beetles although there were many in the area (Chapman and Wright, Interim Res. Rep., Forest Entomology and Pathology Laboratory, Victoria, B.C., May, 1964).

The second method is to isolate, identify and then synthesize the natural sex pheromone or host emanation to which a given species responds. This has been spectacularly successful in a few cases, but it is necessarily a lengthy, expensive process and the resulting compounds are usually complex and costly.

Neither method gives any insight into the molecular basis of the biological specificity so that no general, chemical relationships have emerged from a great amount of meticulous analytical and chemical work. There is however, evidence that the olfactory specificity of a chemical compound is related to the low-frequency vibrations of its molecules (R. H. Wright, Proc. N. Y. Acad. Sci., Conference on Odor, Oct. 1, 2, 3, 1973. in press). The frequencies in question are most readily charted by recording the far infrared absorption spectrum of a compound.

When frontalin (1,5-dimethyl-6,8-dioxabicyclo- [3.2.1] octane) was identified as an aggregating pheromone for some species of *Dendroctonus* (Kinzer *et al.*, Nature 221: 477-478, 1969; Dyer and Chapman, Bi-Mon. Res. Notes 27: 10-11, 1971), its far infrared spectrum was recorded in the region 500 to 130 cm^{-1} using a Perkin-Elmer Model 301 Far Infrared Spectrophotometer with the sample dissolved in benzene. Nine well-defined absorption maxima were found at the positions shown in Table 1, and a tenth rather weak one was found near 330 cm^{-1}.

Four compounds with some degree of spectral similarity to frontalin, as shown in Table 1, were selected for field testing near Hixon, B.C., during the summer of 1973. All were dispensed in 1 ml polyethylene vial caps. Three different testing methods were used to have a variety of environmental sites and beetle populations. Although all tests were made in the vicinity of mature *Picea - Abies* forests, no host trees (*Picea*) were closer than 20 m from any position of chemical testing. The object of the experiment was to demonstrate the practical usefulness of far infrared spectra in selecting candidate attractants.

Table 2 shows the total catch over a period of 6 weeks, using 12 x 12 inch (30.5 x 30.5 cm) glass barrier traps mounted at breast height, 66 feet (20.1 m) apart, on four sides of nonhost trees (*Abies*) and with the chemicals exposed in polyethylene caps. This method was used to avoid any secondary attraction that might arise if host trees were attacked by the beetles. Three replicates of each chemical were used.

Also shown are the results of a second experiment, lasting 4 weeks, with glass barrier traps placed 50 feet (15.2 m) apart on top of convection boxes with black polyethylene sides and screened tops so that air convected upward into and through the traps. The chemicals were moved each week to a new random distribution of the boxes.

Finally, Table 2 shows the results of a test in which the *Dendroctonus* were handpicked from six vertical canvas sleeves about 10 feet (3 m) high, through which air was driven upward by fans. Four tests, lasting 1 hr each, were made when the temperature exceeded about 21 C. As these were done where beetle flight was relatively weak, the results may be less significant than the others.

Ortho-phenyl anisole, or methyl diphenyl ether as it is commonly known in the perfumery trade, appears to be approximately comparable to the pheromone itself under the conditions of the test; that is, in the absence of any secondary attraction from infested host trees. Figure 1 shows its chemical and stereochemical configuration with that of frontalin. Clearly, none of the usual criteria of molecular similarity would have led to it being selected for test, which emphasizes the special value of the far infrared spectroscopic properties.

The other three candidates show some biological activity when air is circulated through the traps. This emphasizes an important distinction between intrinsic attraction and the strength of the attractant effect, which will normally depend upon volatility and chemical stability of the substance and which is not related to attractiveness *per se*. The success achieved with only four candidates is in striking contrast to the total failure of the 1963 experiments in which the 100 chemicals of unknown molecular-vibrational characteristics were used. Furthermore, the simplicity and commercial availability of methyl diphenyl ether in drum lots at a cost of about $1.50 per pound show that complexity and cost are not necessary attributes of insect pheromone-mimics.

TABLE 1
Far Infrared Resemblance of Selected Compounds to Frontalin

	cm⁻¹									
Frontalin	176	242	284	296	330	358	396	439	474	493
Methyl diphenyl ether	—	246	—	295	322	350	—	444	—	491
Methyl 2-naphthyl ketone	170	236	—	—	321	360	404	—	473	—
Menthyl acetate	—	—	287	299	330	360	396	442	475	—
Thujamber (8, 14 Cedran oxide)	177	246	285	—	323	—	—	—	—	—

TABLE 2
Results of Field Bioassays

		Glass Barrier Traps	Traps with Convection Boxes	Traps with Forced Circulation
Frontalin	male	9	42	14
	female	10	50	21
	total	19	92	35
Methyl diphenyl ether	male	82	9	27
	female	33	17	4
	total	115	26	31
Methyl 2-naphthyl ketone	male	0	3	11
	female	1	2	4
	total	1	5	15
Menthyl acetate	male	1	1	10
	female	0	4	0
	total	1	5	10
Thujamber	male	0	7	16
	female	0	5	7
	total	0	12	23
No chemical	male			1
	female	—	—	0
	total			1

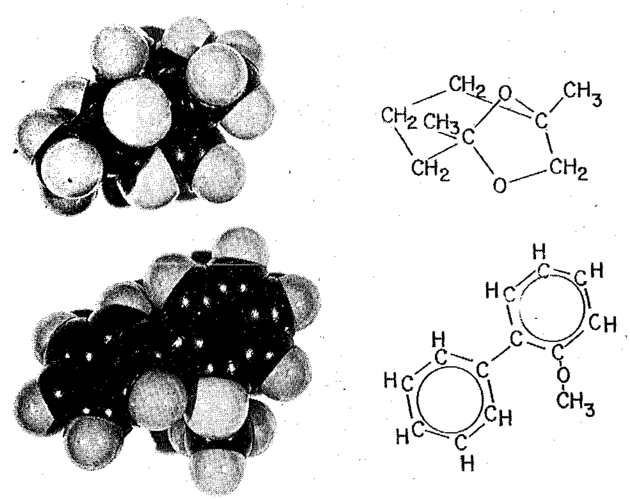

Figure 1. Frontain (upper) and methyl diphenyl ether (lower) have little if any structural or steric resemblance likely to suggest a similarity in their ability to attract *Dendroctonus rufipennis.*

At the same time, it is important to recognize that intrinsic attractancy and cost are not the only criteria of really useful compounds. It depends upon the conditions of use. A compound that caught 25 or more insects in the first week and none thereafter might be rated "stronger" or "weaker" than one that caught 5 per week for five or more weeks.

Taken in conjunction with other predictive successes of the theory (Wright, Israel J. Entomol. 4:83, 1969; Can. Entomol. 103:284, 1971; Wright, Chambers, and Keiser, Can. Entomol., 103:627, 1971; Wright, and Brand, Nature, 239:225, 1972), far infrared (vibrational) spectra can be usefully employed in the development of selective insect attractants.—R. H. Wright, 6822 Blenheim St., Vancouver, B.C., John A. Chapman and E. D. A. Dyer, Pacific Forest Research Centre, Environment Canada, Victoria, B.C.

FIRE

Effect of Duff Weight on Drying Rate.—The Duff Moisture Code (DMC) of the Fire Weather Index (FWI) (Can. For. Serv. 1970) was designed to follow the day-to-day moisture changes in a pine forest duff layer of 1 lb./ft^2 dry weight (about 5 kg/m^2). During work on the DMC (Van Wagner, Can. For. Serv. Publ. 1288, 1970), trays of duff layers of many different weights were exposed for study, and the results had to be normalized to match the 1 lb./ft^2 standards. It was discovered that this could be neatly and adequately done by simply correlating daily log drying rate with the inverse of duff weight. (The log drying rate is the slope of the semilog graph of free moisture content against time, a fairly straight line for most forest fuels, including duff). The range of weights covered during this work was 2 to 6 kg/m^2; since then data have been collected for both heavier and lighter layers, and it appears that the principle can be extended.

Figure 1 shows the earlier data from a red pine plantation (Van Wagner, Can. J. For. Res. 34-39, 1972) with the addition of results from tray exposures in two forest stands with heavy duff layers weighing up to 20.7 kg/m^2: a balsam fir stand at Petawawa, Ont. (46°N); and a black spruce stand at Nicauba, Quebec (50°N). The latter was obtained through the cooperation of J. T. Arnott. In Fig. 1, log drying rate k has been plotted against the inverse of duff weight w. For practical purposes, the simple relation $wk = 0.12$ fits fairly well. Each point represents an average of several drying runs during a whole season, each adjusted to normal noon weather of 70 F and 45% RH by the techniques used to construct the DMC. They refer to upland stands only, with duff layers well above the soil water table. Furthermore, the log drying rates apply to rainless periods of 3-10 days broken by significant amounts of rain. Very long dry spells, especially with very heavy duff layers, may result in somewhat lower log drying rates.

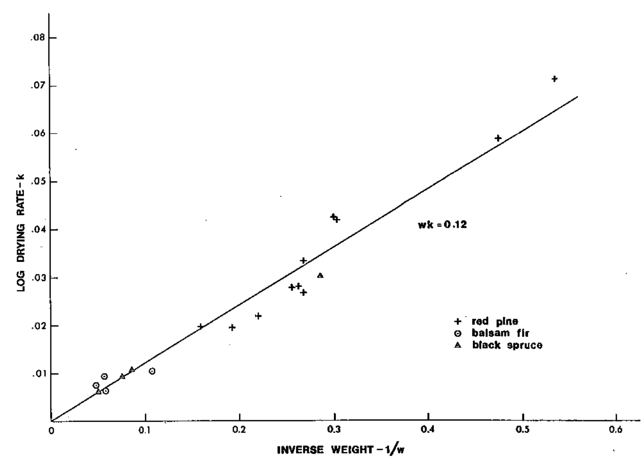

Figure 1. Relationship between log drying rate k and dry weight w of the duff layer.

At the light end of the weight scale, litter layers are very responsive to the daily cycle of temperature and humidity.