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INSECT ATTRACTION (WASPS)

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Introduction

A statistical analysis of U. S. D. A, studies of insect attractancy pro- vides evidence for the real existence of discrete primary odor stimuli, of which a given molecule may carry several without mutual interference. Furthermore there is evidence that these primary odor qualities are related to the basic, low- frequency vibrational movements of the molecules, and a preliminary survey of the far infrared spectra from 340 to 100 $cm^{-1}$of 25 compounds rated as attractive to the Oriental fruit fly (Dacus dorsalis Hendel) indicated a probable corre- lation between attractancy and a peak frequency between 190 and 220 cm^{-1} (Wright, 1966). It was already suspected that attractiveness to this insect would correlate with a single frequency band because 25% of the more than 3000 compounds evaluated by the U. S. D. A. gave a positive response, suggesting that the relevant molecular quality was by no means uncommon.

This work has now been extended by an examination of the far infrared spectra fropi 500 to 100 cm^{-1} of 43 substances rated as attractive to the Oriental fruit fly. The results were analyzed by counting the number of peaks falling within a band 7 cm^{-1} wide, and running progressively from 105 to 495 cm^{-1}, with the results shown in Figure 1. This indicates possible correlations near 200, 300, 350, 400 and 460 cm^{-1}, but comparison with the spectra of 120
substances rated as non-attractants to this insect gave the results in Table I
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showing that only the correlation near 200 cm is significant, and is, indeed, very strongly so.

Experimental

This method of correlating insect attraction with molecular vibration requires: (1) *A* substantial number of substances known to be attractive to a particular insect; (2) Vibrational spectra in the general range 500 to 100 cm^{-1}, of both attractant and non-attractant substances, and also of substances of unknown attractance; (3) Access to appropriate insects in order that predictions of attrac- tancy based on spectroscopic data may be tested.

For the writer, yellow jacket wasps (Vespula SAP.) meet these con- siderations. Davis et al (1969) tested 340 miscellaneous compounds and found 15 of them, or *4%,* to be distinctly attractive, which would suggest that this insect responds to the simultaneous presence of two vibrational frequencies in the molecule (Wright, 1966). Spectra were run on 13 of these attractants and 19 non- attractants, These numbers are scarcely adequate, but the results showed pos- sible correlations with bands near 250, 340 and 400 cm^{-1}, Comparison with the

non-attractants indicated that the 250 cm^{-1} band is probably not significant and that the 340 and 400 cm^{-1} bands taken singly are also not significant, but when taken together they are strongly so. for not only is there a strong correlation of attractancy with the simultaneous presence of these two bands, but there is also a strong inverse correlation between the absence of attraction and the simultaneous absence of both frequencies. Table 2.

Accordingly, available spectra were searched for substances with the appropriate spectroscopic character combined with satisfactory stability on exposure to air and sunlight and suitable volatility characteristics. Dimethyl benzyl carbinyl acetate and n-Butyl benzoate met these requirements very closely, and these together with a few others that met part of the specification (e.g., the 250 and 340 cm^{-1} bands but not the band at 400 cm^{-1}) were tested in a field in the vicinity of a large wasps' nest. n-Butyl benzoate proved to be distinctly attractive whereas none of the others, except possibly Dimethyl benzyl carbinyl acetate showed any attractancy. The samples were tested in traps made from 250 ml straight-sided glass jars fitted with inverted screen cones with entrance holes about 1 cm in diameter. In some cases the traps were exposed at or near ground level in rows with trap separations of about 35 cm. In other experiments the traps were suspended from a bar about 2.5 meters above the ground (slightly lower than the nest) and about 5 meters from it.

Traps baited with n-butyl benzoate were consistently attractive, whereas none of the others caught any wasps, except Dimethyl benzyl carbinyl acetate which caught one.

Discussion

These results are important for two reasons.

First, as soon as a substantial number of compounds have been found to attract a certain insect, the search for additional attractants can be based on a specific property or combination of properties rather than on a general chemical similarity which may not be nearly as relevant. Thus the point of departure for Davis' work was the unexpected observation that 2, 4-Hexadienyl butyrate was highly attractive to Vespula spp. Working from this hint and synthesizing variations on this structure, several other strongly attracting substances were produced, in many of which the unsaturation was located in the acid moiety, and especially in the alpha-beta position, as, for example, in Hexyl 2-pentenoate or Ethyl 2-heptynoate (Davis et al, 1967, 1968). While this approach to the problem can undoubtedly lead to useful formulations, the synthetic work and the cost of the best materials are likely to be substantial. Butyl benzoate is in a very different category both structurally and economically from 2, 4-Hexadienyl butyrate (with its four geometrically isomeric forms), and would be most unlikely to emerge from the usual method of experimentation.

Second, they provide an insight into the basic mechanism of olfaction at least insofar as it relates to insects. What is increasingly clear is that molecular vibrations are in some way related to insect attraction, even though much

remains to be found out. The difference between the wasps' response to Dimethyl benzyl carbinyl acetate and n-Butyl benzoate which appeared to be equally promising spectroscopically is challenging. It may be due to steric factors or to differences in volatility but the fact that 2,4-Hexadienyl butyrate which was used by Davis et al as their standard caught relatively few in these experiments may indicate that the wasp population was insufficient to ensure a significant comparison of the effectiveness of different attractants. In this circumstance, a positive response is much more significant than a negative one.

With the increasing and universal concern over environmental pollution by insecticides, insect attractants are likely to become ever more important as a means of bringing the insects to the poison instead of attempting to send the poison to the insect by distributing it broadcast.

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REFERENCES

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Table 1

Oriental Fruit Fly

Comparison of 43 Attractants with 120 Non-Attractants

Peak Frequency	Correlation coefficient	Chi-square
250 ± 5 cm^{-1}	0.66	14.2
300 ± 5	0.18	0.6
351 ± 5	0.29	1.8
403 ± 5	0.18	0.6
458 ± 5	0.30	2.2

Note, For p = 0.05, Chi-square = 3.8

For p = 0.001, Chi-square = 10.8

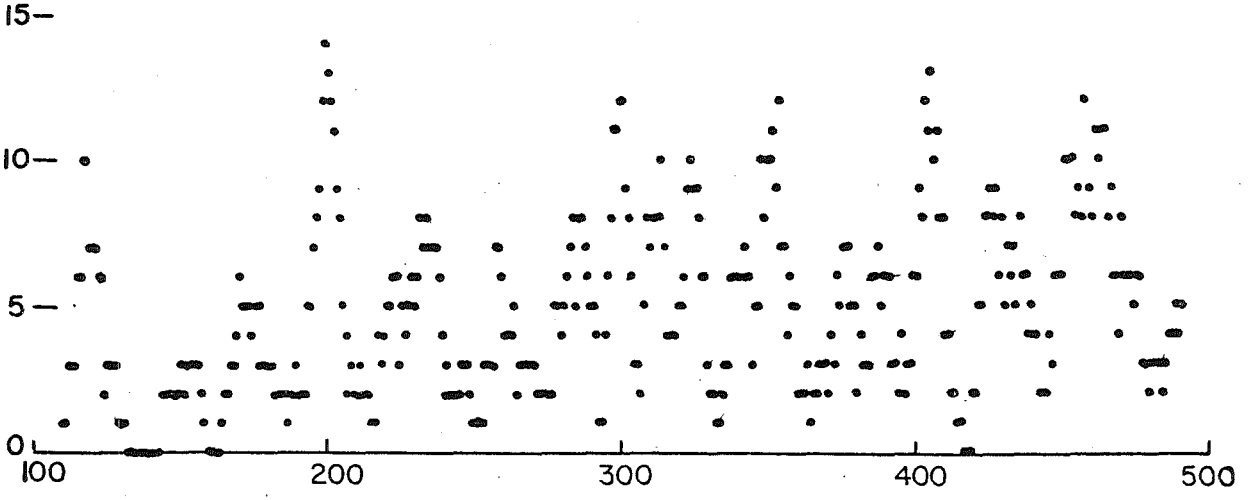
Table 2

Yellow-Jackets

Comparison of 13 Attractants with 19 Non-Attractans

Frequency Specification		Correlation coefficient	Chi-square
331-350	390-410		
yes	no	+ 0.53	0.12
no	yes	- 0.08	0.04
yes	yes	+ 0.82	9.17
no	no	- 1.00	7.94

Note, For p = 0.01, Chi-square = 6.6



Frequency of occurrence of peaks
in bands 7 cm^{-1} wide
in 43 Oriental fruit fly attractants.

Figure 1.