

**Fraenkel G S.** The raison d'être of secondary plant substances.

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The secondary plant substances (allelochemicals) determine the acceptance of plant food by insects (and other organisms) by acting as repellents or attractants. This at once explains the raison d'être of these myriads of chemically unrelated compounds with no obvious nutritional function, and the specificity of host plants for their insects. [The *SCI*<sup>®</sup> indicates that this paper has been cited in over 200 publications since 1959.]

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"This paper had a long and varied incubation period. A comprehensive study of the basic food requirements of many insects during the war years convinced me that they were essentially identical, and similar to those of 'higher' organisms. At the same time, I became involved in a study of human nutritional needs which also emphasized the importance of green vegetables in a national diet as seen under conditions of food shortages in wartime Britain. Subsequently, at the entomological congress in Amsterdam, 1951, I presented data to the effect that green leaves contained all the nutrients necessary for their insect predators, in excellent quantities and proportions, and there was no *a priori* reason why insects should not develop on any plant provided they ate them.<sup>1</sup>

"By what now seems a coincidence, during the war a then lieutenant of the Canadian Army turned up in my laboratory in England and became engaged in a PhD thesis on the role of the glucosinolates in cruciferous plants as feeding attractants for certain insects,<sup>2</sup> confirming similar earlier results.<sup>3</sup> Thus we had a situation in which all plants were potentially equally nutritious but were

only very selectively eaten, suggesting a role for obviously nonnutritious plant substances in the food selection of certain insects. What could be simpler than putting these two premises together: the enormous variety in the distribution and composition of the secondary plant substances, for which no comprehensive and plausible explanation then existed, accounted for the equally staggering variety of insect/food-plant relationships, by their acting as repellents and attractants for insects (and other organisms). This I first stated in a lecture given at the zoological congress in Copenhagen in 1953.<sup>4</sup> "It took, however, another five years before these ideas found coherent expression in the paper under discussion. The reception of these views, judging by the annual citations (0 in 1959, six in 1960, one in 1961, two in 1962, one in 1963, one in 1964, three in 1965, seven in 1966, ten in 1967, eight in 1968, four in 1969, six in 1970, nine in 1971, six in 1972, seven in 1973, seven in 1974, nine in 1975, 15 in 1976, 24 in 1977, 16 in 1978, 13 in 1979, 14 in 1980, eight in 1981, 13 in 1982, and ten in 1983) now seems surprising —almost icy silence, and what comments there were were mostly negative during the first six years. Then the number of citations increased during the next five years, probably influenced by an important paper by Ehrlich and Raven,<sup>5</sup> but it was not until five years later that the field suddenly broke wide open. Since that time there has been an ever increasing avalanche of papers; almost annually occurring symposia; about 15 full-length books; and the creation of a virtually new discipline (chemical ecology) with its own journal and international society, now forming. Why this long delay in acceptance and prodigious explosion? The delay could not have been caused by a lack of exposure, with the paper in *Science* and a title which should have compelled equally the attention of organic chemists and plant scientists. Perhaps it seemed implausible that such a simple explanation could be virtually new, and at the same time correct."

1. Fraenkel G. The nutritional value of green plants for insects. *Transactions of the IXth International Congress of Entomology. Amsterdam. August 17-24. 1951.* The Hague: W. Junk. 1953. Vol. 2. p. 90-100.

2. Thorsteinson A J. The chemotactic responses that determine host specificity in an oligophagous insect (*Plutella maculipennis* (Curt.) Lepidoptera). *Can. J. Zool* 31:52-72. 1953. (Cited 65 times since 1955.)

3. Verschaeffelt E. The cause determining the selection of food in some herbivorous insects. *Proc. Acad. Sci. Amsterdam* 13:536-42. 1910.

4. Fraenkel G. Insects and plant biochemistry. The specificity of food plants for insects. *Proceedings of the XIV International Congress of Zoology. Copenhagen. 5-12 August 1953.* Copenhagen. Danish Science Press. 1956. p. 383-7.

5. Ehrlich P R & Raven P H. Butterflies and plants: a study in coevolution. *Evolution* 18:586-608. 1964. (Cited 275 times.)