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Elliott M & Janes N F. Synthetic pyrethroids—a new class of insecticide. *Chem. Soc. Rev.* 7:473-505, 1978.
[Department of Insecticides and Fungicides, Rothamsted Experimental Station, Harpenden, Hertfordshire, England]

The review deals with the structures and biological activities of synthetic pyrethroid insecticides, which, as a group, are now comparable in importance for controlling domestic, agricultural, horticultural, and veterinary pests with the longer established organochlorine, organophosphate, and carbamate compounds. Pyrethroids in general are at least one order of magnitude more active against insects than the other major insecticide classes, yet they have low toxicity to mammals. Some pyrethroids can therefore protect important crops (e.g., cotton) at previously impractical levels (10-50 g ha^{-1}); residues of pyrethroids are rapidly degraded to harmless products and so do not persist to contaminate the environment. [The *SCI®* indicates that this paper has been cited in over 180 publications.]

Safer Crop Protection

Michael Elliott
Department of Insecticides and Fungicides
Rothamsted Experimental Station
Harpenden, Hertfordshire AL5 2JQ
England

March 5, 1990

About a quarter of insecticides used worldwide today are synthetic pyrethroids, which have a more benevolent spectrum of properties than other types of insecticides. The origin of a large proportion of these can be traced to the foresight and initiative of two outstanding British scientists, Stanley H. Harper (1913-1987), an organic chemist, and Charles Potter (1907-1989), an entomologist. Both men owed much to the Department of Insecticides and Fungicides at Rothamsted Experimental Station founded in 1925 by Frederick Tattersfield, a distinguished pioneer of the study of natural and synthetic insecticides.

I joined Rothamsted in 1948 following a recommendation by Harper, who had supervised my PhD work on pyrethrum at (the then) University College, Southampton, and at King's College, London. Harper had worked during the war on the synthesis of constituents of the natural pyrethrins, supported by the Agricultural Research Council, which feared restriction of supplies of this valuable insecticide to the armed forces.[1] (As well as a survey of the chemistry, L. Crombie[1] gives many relevant historical and personal details. Both in collaboration with Harper and independently, he greatly advanced knowledge of the chemistry and synthesis of the pyrethrins.)

Potter succeeded Tattersfield as head of the department in 1947 and, from much practical experience, decided that I should collaborate with an entomologist, Paul H. Needham, on a study of the relationship between chemical structure and insecticidal activity of pyrethroids, despite more fashionable interests at the time in organochlorine (e.g., DDT) and organophosphate insecticides. There were no marked advances initially, and Potter had to defend the programme against authorities who recommended termination. However, in 1961 a report by the Beltsville (US) group (from whom Potter in 1948 had obtained samples of the first commercial synthetic pyrethroid, allethrin) of the efficacy of some simple benzyl chrysanthemates, combined with our own concepts, stimulated examination of allylbenzyl esters, whose simple structure and impressive insecticidal activity led the National Research Development Corporation ([NRDC] to whom we were required to report such results) to support the work. Norman F. Janes, an organic chemist (and ex-student of Harper at King's College) was appointed, and we started a productive association that was to span more than two decades.

With creative help from a succession of organic chemists (especially David A. Pulman) and entomologists (Needham, Roman Sawicki, and Andrew W. Farnham) and with the benefit of interactions with colleagues in the Medical Research Council Laboratories at Carshalton and in the research group of John E. Casida in the University of California at Berkeley, a succession of compounds[2,3] (resmethrin, bioresmethrin, permethrin, cypermethrin, and deltamethrin[4]) was developed. These products, licensed worldwide by the British Technology Group (succeeding and incorporating the NRDC), proved to have a favourable combination of properties not possessed by previous classes of insecticides and have now attained an annual market value (sales) approaching £1,000 million.

The review describes in structural terms how insecticidal activity was gradually increased in new compounds whilst other desirable properties were retained or introduced; however, it hardly conveys the excitement and stimulation of a period during which colleagues reported successive increments in activity to unprecedented levels for compounds sometimes synthesised only days earlier.

The work has been recognised by Queen's Awards for Technological Achievement (1976 and 1980), by the Unesco Science Prize (1978), by the Mullard Medal of the Royal Society (1982), and by other individual, national and international honours including, most recently, the Wolf Foundation Prize in Agriculture (1989).

1. **Crombie L.** The natural pyrethrins: a chemist's view. (Lunt G G, ed.) *Neurotox '88: molecular basis of drug & pesticide action.* Amsterdam, The Netherlands: Excerpta Medica, 1988. p. 3-25.
2. **Elliott M, Janes N F & Potter C.** The future of pyrethroids in insect control. *Annu. Rev. Entomol.* 23:443-69, 1978. (Cited 170 times.)
3. **Leakey J P, ed.** *The pyrethroid insecticides.* London: Taylor and Francis, 1985. 440 p.
4. **Elliott M, Farnham A W, Janes N F, Needham P H & Pulman D A.** Synthetic insecticide with a new order of activity. *Nature* 248:710-1, 1974. (Cited 170 times.)

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