NATURALLY OCCURRING INSECTICIDES

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Edited by

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In honor of Professor Ryo Yamamoto
and the late Dr. F. B. LaForge—pioneers in the chemistry of
naturally occurring insecticides

PREFACE

During the centuries of warfare between mankind and his insect enemies, chance observation and desperate experiment revealed that certain plants and minerals provided useful products which could ward off or even control the invading pests. The eventual realization that these ordinary chemical substances, some of them quite simple, indeed could serve broadly as ecological weapons led directly to the development of the numerous synthetic insecticides we know today.

Yet the romantic history, fascinating chemistry, and real utility of the natural insect-control agents have persisted. With the advent of modern instrumental techniques of analysis, scientists probably have learned more in the past decade about the chemical structures and properties of this group of natural products than had accumulated throughout all the rest of history. Holman's 1940 classic, *A Survey of Insecticidal Materials of Vegetable Origin*, could describe only a few pure substances, and even the most recent review—that of Feinstein and Jacobson in 1953—could cover little more.

A purpose of the present book, then, is to provide a modern and rather detailed general account of the chemistry, toxicology, and uses of insecticides of natural origin. The authorities who have provided these essays generally have not aimed at exhaustive treatment but rather at a readable and informative introduction to each subject. Supplementing the well-recognized botanical insecticides, microbial insecticides have been discovered and developed in recent years, and these new additions also have been reviewed here.

Despite their value to man, most of the known plant-derived insecticides probably have little ecological significance; we remain remarkably

ignorant of the natural compounds with which plants actually defend *themselves* against insect attack. However, we are coming to recognize the chemical defenses of insects. In addition, insect hormones present models for future insect-control chemicals and are discussed here in some detail with an eye for what could come. The reader may note several apparent omissions from the accepted list of natural insecticides—the minerals and the petroleum oils. In actual fact, very few inorganic insecticides are "natural," and even such a common substance as cryolite is primarily of synthetic origin. The complex mixtures represented by oils have not yielded biochemically active constituents, and the insecticidal properties appear to be physical rather than chemical.

Contrary to some popular accounts, natural insecticides are far from a panacea. Many actually are quite toxic to mammals, most have inadequate persistence, and all are expensive in comparison with synthetics. It is intended that this monograph should serve as a source book on such properties, stimulate interest in the search for new insecticidal natural products, and suggest more satisfactory synthetic compounds modeled upon natural agents. Many years' intense search for synthetic insecticides has resulted in only three major structural types; even a partially equivalent effort in the field of chemical ecology might do as well.

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PART I

Botanical Insecticides

CHAPTER 1

PYRETHROIDS

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I. Introduction

Pyrethrum represents the dried flowers of *Chrysanthemum cinerariaefolium* Vis. (*Pyrethrum cinerariaefolium* Trev.), a member of the Compositae. The powder has been used as an insecticide from ancient times; the original home of the pyrethrum flower (Figs. 1, 2) is said to have been the Middle and Near East. In the nineteenth century, it was introduced into Europe (1828), the United States (1876), and then Japan, Africa, and South

Fig. 1. Pyrethrum flower (*Chrysanthemum cinerariaefolium*) (courtesy of Dainihon Jochyugiku Co., Ltd.).

America. At the beginning of the twentieth century, Dalmatia (Yugoslavia) and Japan became the principal producing countries; by 1941, Japan was the major producer, but after World War II her pyrethrum output declined sharply and, at present, Kenya stands first, followed by Tanzania, Uganda, Congo, Ecuador and then Japan.

Precise production statistics are not available from some countries, but deducing from exports and other data, the world's production in 1966–1967 was approximately 20,000 tons: 10,000 tons in Kenya, 4000

tons in Tanzania, 2000 tons in Uganda, and 1000 tons in Japan. More than 80 % of the total output is extracted with solvent and comes into the market as "pyrethrum concentrate" which contains 20–25 % active ingredients.

The discovery of pyrethrum as an insecticide, its production, and the history of its use are discussed thoroughly by Gnadinger (*1*, *2*), Shepard (*2a*), and McDonnell et al. (*2b*).

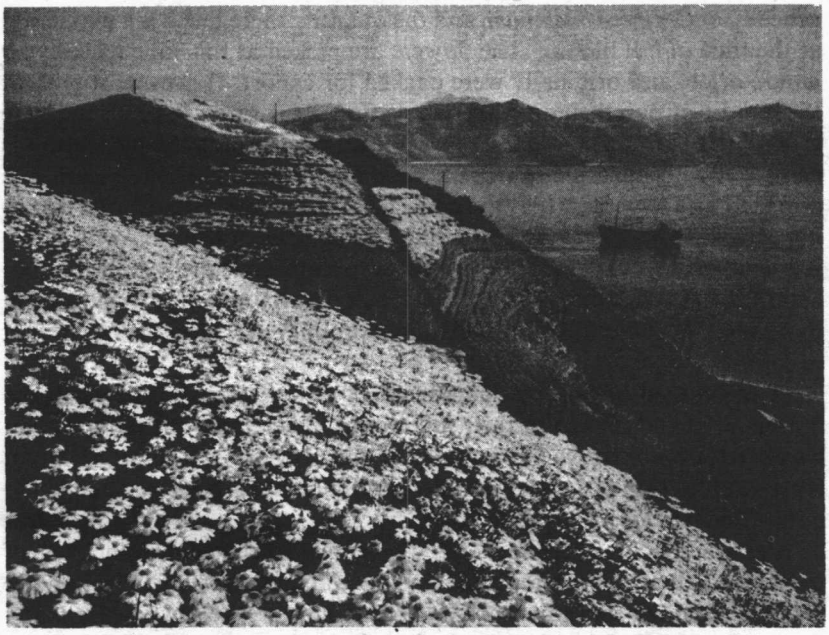

Fig. 2. Field of pyrethrum (courtesy of Dainihon Jochyugiku Co., Ltd.).

The flower now sold in commerce is chiefly the above-mentioned *Chrysanthemum cinerariaefolium*, although the "painted daisy," *Chrysanthemum coccineum* Willd. (*C. carneum* Steud or *C. roseum* Adam), also is planted in some regions. Some flowers of other plant species belonging to the Compositae also may contain the characteristic insecticidal principles, although not all the plants within the family contain active compounds. Although the petals of *Paeonia albiflora* (Pall.), of the family *Ranunculaceae*, were reported (*2c*) to contain considerable quantities of pyrethroids, this was later shown to be incorrect (*2d*).