D-(+)-Pinitol, an Oviposition Stimulant for the Pipevine Swallowtail Butterfly, Battus philenor

DANIEL R. PAPAJ,* PAUL FEENY, KUSUM SACHDEV-GUPTA, and LORRAINE ROSENBERRY

Section of Ecology and Systematics
Corson Hall, Cornell University
Ithaca, New York 14853

(Received June 24, 1991; accepted January 17, 1992)

Abstract—Oviposition by females of the pipevine swallowtail butterfly, Battus philenor, was stimulated by contact with alcoholic extracts of host foliage. D-(+)-Pinitol was isolated and identified from leaf material of one host species, Aristolochia macrophylla (Aristolochiaceae). In combination with chloroform-soluble components of host leaf material, this compound was comparable to the parent extract in stimulating oviposition.

Key Words—Battus philenor, Papilionidae, Lepidoptera, Aristolochia macrophylla, Aristolochiaceae, learning, D-pinitol, sequoyitol, myo-inositol, cyclitols, oviposition stimulant.

INTRODUCTION

Plant secondary chemicals are thought to pose both toxicological and behavioral barriers to evolutionary changes in host use by phytophagous insects (Fraenkel, 1959; Ehrlich and Raven, 1964; Feeny, 1987). Arguing that secondary chemicals represent principally behavioral barriers, Dethier (1941) and Jermy (1976,
1984) proposed that colonization of a novel plant by an insect species will be more probable if that plant contains compounds similar to those that the insects already use as cues in host recognition.

Dethier (1941) suggested that evolutionary shifts across plant families by swallowtail butterflies (family Papilionidae) were facilitated by essential oils shared by these families, compounds to which he found that the larvae were attracted (see also Takaishi et al., 1969; Saxena and Prabha, 1975; Khattar and Saxena, 1978). While the significance of essential oils as host-selection cues by papilionid larvae remains somewhat unclear (D.R. Papaj, K. Hale, D. Miller, and P. Feeny, unpublished), Feeny (1987) suggested that evolutionary host shifts were as likely to be regulated by the behavior of the adult female as by that of the larvae. Adult females choose the plant on which eggs will hatch and are known to oviposit "mistakenly" on nonhost plants from time to time. Plants on which mistakes are made may occasionally be incorporated into the host range of an insect population, perhaps leading eventually to the formation of new insect species (cf. Bush, 1975).

If inclusion of a given novel plant into a species’ host range depends on how often eggs are mistakenly laid on the plant and if mistakes occur more frequently on plants containing chemicals similar to those that females use to select hosts than on chemically dissimilar plants, we might anticipate that related insect species will tend to exploit host species that are phytochemically, although not necessarily taxonomically, related. Exactly this pattern is observed in some taxa of butterflies (Ehrlich and Raven, 1964; Feeny et al., 1983), although little is yet known about which particular compounds are important in mediating host recognition.

Our paper is part of a broader effort by this and other laboratories to characterize the oviposition stimulants of the Papilionidae (Ichinos6 and Honda, 1978; Saxena and Goyal, 1978; Feeny et al., 1983, 1988; Nishida, 1977; Oh sugi et al., 1985; Nishida et al., 1987; Nishida and Fukami, 1989; Honda, 1986, 1990). Comparative studies of different species in a family for which both larval food plants (Scriber, 1984) and systematics (Miller, 1987) are particularly well known should permit clarification of the roles played by plant chemistry in the evolution of phytophagous insects (Feeny, 1987, 1991). Here we report the isolation and identification of an oviposition stimulant for the pipevine swallowtail butterfly, Battus philenor, from the foliage of one of its host species, Aristolochia macrophylla. The pipevine swallowtail is found across much of the continental United States and Mexico (Tyler, 1975). Over its entire range, adults oviposit and larvae feed exclusively on plants in the genus Aristolochia in the family Aristolochiaceae (Opler and Krizek, 1984). A previous study (Papaj, 1986a) indicated that methanolic extracts of A. macrophylla leaves elicited oviposition by pipevine swallowtail females on artificial substrates treated with those extracts.