METABOLISM AND EXCRETION OF THE FURANOCOUMARIN XANTHOTOXIN BY PARSNIP WEBWORM, *Depressaria pastinacella*

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Abstract—The parsnip webworm, *Depressaria pastinacella*, feeds on plants containing high concentrations of furanocoumarins, compounds toxic to many organisms. Parsnip webworm larvae were fed radiolabeled xanthotoxin to quantify the detoxification of this furanocoumarin. They metabolized approximately 95% of the ingested xanthotoxin, indicating that metabolic detoxification is important in their tolerance to this allelochemical. Excretion of xanthotoxin and its metabolites was not restricted to the frass but also occurred by means of the silk glands. The silk glands contained half as much of the tritiated compounds as the rest of the body. Because of the feeding habits of this insect, such an excretory pathway may have implications for interactions with predators and pathogens.

Key Words—*Depressaria pastinacella*, parsnip webworm, xanthotoxin, detoxification, furanocoumarins, silk, plant secondary compounds, plant-insect interactions, Oecophoridae, Lepidoptera.

INTRODUCTION

Furanocoumarins are plant secondary compounds most commonly found in the families Rutaceae and Umbelliferae (Murray et al., 1982). Upon exposure to long-wave ultraviolet light, many of these compounds are photoactivated and

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can bind covalently to nucleic acids and generate highly reactive oxygen species (Murray et al., 1982; Knox and Dodge, 1985). Because these processes can damage fundamental biological systems, furanocoumarins are toxic to a broad spectrum of organisms (reviewed in Murray et al., 1982).

A growing body of evidence indicates that furanocoumarins can be significant in herbivore–plant interactions. Not only are several furanocoumarins phototoxic to insect and mammalian herbivores (Berenbaum, 1978; Berenbaum and Neal, 1985; Ashkenazy et al., 1985), some also exhibit acute toxicity independent of photoactivation (Berenbaum, 1978; Berenbaum and Neal, 1985). Chronic toxicity as manifested by reduced fecundity can occur as well (Berenbaum and Feeny, 1981). In addition to postingestive effects, these compounds are frequently phagodeterrent (Yajima et al., 1977; Muckensturm et al., 1981). At a broader level of interaction, patterns of herbivore species distributions are correlated with furanocoumarin content in the Umbelliferae (Berenbaum, 1981). Moreover, the within-plant distribution of furanocoumarins is related to the relative value of the reproductive parts in one umbellifer species, suggesting that these toxins are allocated against herbivores in accordance with optimal defense theory (Nitao and Zangerl, 1987).

A well studied herbivore–plant interaction involving furanocoumarin chemistry involves the parsnip webworm, *Depressaria pastinacella* (Duponchel) (Lepidoptera: Oecophoridae). The larvae feed exclusively on plants in three genera of the Apiaceae, all of which contain furanocoumarins (Murray et al., 1982; Berenbaum, 1983). One of the webworm’s major hosts in North America is the wild parsnip, *Pastinaca sativa* L. (Umbelliferae) (Hodges, 1974). In central Illinois, the wild parsnip generally produces six furanocoumarins, two of which, bergapten and sphonbin, are associated with resistance of this plant against *D. pastinacella* (Berenbaum et al., 1984, 1986). Xanthotoxin, a furanocoumarin highly toxic to polyphagous insect herbivores (Berenbaum, 1978; Berenbaum and Neal, 1985), apparently is not a resistance factor against the parsnip webworm despite its abundance in the plant (Berenbaum et al., 1986). In fact, when bioassayed against the webworm in an artificial diet, xanthotoxin had no detectable effect on larval survivorship or development; in vitro studies suggested that *D. pastinacella* tolerance to xanthotoxin is due at least in part to metabolism by cytochrome P-450 monoxygenases (Nitao, 1989).

In this paper, I present the results of in vivo experiments ascertaining the extent to which the parsnip webworm detoxifies xanthotoxin and the physiological fate of ingested xanthotoxin and its metabolites. Previous studies on taxonomically unrelated insects that regularly feed on furanocoumarin-containing plants have found extensive in vitro and in vivo enzymatic degradation of xanthotoxin (Ivie et al., 1983; Bull et al., 1984, 1986; Ashwood-Smith et al., 1984). The mechanism by which the parsnip webworm tolerates this compound