EFFECTS OF Solanum GLYCOALKALOIDS ON CHEMOSENSILLA IN THE COLORADO POTATO BEETLE
A Mechanism of Feeding Deterrence?

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Abstract—Steroidal glycoalkaloids, found in species of the Solanaceae, elicit bursting activity in galeal and tarsal chemosensilla of adult Colorado potato beetles. The effect has an average latency of 6–12 sec, depending on the sensillum/alkaloid combination. A 20-sec alkaloid treatment is often sufficient to render galeal sensilla unresponsive to gamma-aminobutyric acid, normally an effective stimulant. The alkaloids have similar effects on galeal sensilla of larval Colorado potato beetles and on labellar chemosensilla of the blowfly. It is concluded that these compounds act independently of any specialized chemoreceptor in the Colorado potato beetle, and that association of the Colorado potato beetle with solanaceous plants has not led to evolution of a specific receptor for Solanum glycoalkaloids.

Key Words—Colorado potato beetle, Leptinotarsa decemlineata, Coleoptera, Chrysomelidae, feeding deterrents, Solanaceae, Solanum alkaloids, chemoreceptors, mouthpart sensilla, tomatine, solanine, chaconine, demissine, leptine III.

INTRODUCTION

The Colorado potato beetle, Leptinotarsa decemlineata (Say), is an oligophagous phytophagous insect which naturally feeds on several members of the family Solanaceae (Tower, 1918) and which can be reared experimentally on some nonsolanaceous plants (Hsiao and Fraenkel, 1968). Among species of Leptinotarsa studied to date, it appears that L. decemlineata is one of the least specific in its host plant selection, and it has been suggested that this relative lack of specificity may have contributed to its status as a widespread pest (Hsiao, 1974).

The solanaceous host plants of L. decemlineata contain a number of related steroidal glycoalkaloids, with the genera Solanum and Lycopersicon being par-
ticularly rich sources of these compounds (Schreiber, 1979). Since the mid-40s *Solanum* glycoalkaloids have been implicated as feeding deterrents for *L. decemlineata* (see Bongers, 1970, for an extensive list of references to early papers). Although many of the steroidal alkaloids from *Solanum* and *Lycopersicon* are chemically quite similar (Schreiber, 1979), there is evidence that they differ in their effect on the Colorado potato beetle. Stürckow and Löw (1961) compared potencies of a number of *Solanum* glycoalkaloids by infusing them into leaves of *Solanum tuberosum* and determining reduction in feeding on treated leaves by adult beetles. The leptins, which are acetylated glycoalkaloids (Sinden et al., 1980), were clearly the most potent. Among the nonacetylated glycoalkaloids, tomatine, a compound characteristic of species of *Lycopersicon* including tomato, and also present in some species of *Solanum*, was slightly more potent as a feeding deterrent than solanine or chaconine. The latter two compounds both occur commonly in species of *Solanum*, including *Solanum tuberosum* (Schreiber, 1979; Gregory et al., 1981).

Since these early studies, the relationship between species of *Solanum* and *L. decemlineata* has been explained largely on the basis of assumed differences in sensitivity of the beetles (larvae and adults) to the varied alkaloids in potential host plants. In this context the *Solanum* alkaloids have been variously referred to as phagorepellents (Levinson, 1976), repellents (Robinson, 1974; Levin, 1976), and deterrents (Hsiao, 1974, Sinden et al., 1978) for the Colorado potato beetle. Hsiao (1974) extended studies to include several species of *Leptinotarsa*, demonstrating that these species differed in their sensitivities to various commercially available solanaceous alkaloids, including steroidal glycoalkaloids.

In many of the above papers it is implied, although not often explicitly stated, that the alkaloids exert their effect directly via the chemosensory system of the beetle. Bongers (1970) was most explicit, stating that "while some of these alkaloids may be toxic, the effect of several others (e.g., tomatine) is a sensory inhibition of feeding activity."

Only one previous study has attempted to address this possibility directly. Stürckow (1959) investigated tarsal sensilla in adult beetles and described bursting activity from the cells when tomatine and solanine were applied. The delayed bursting activity in Stürckow’s electrophysiological recordings could be interpreted as due to injury of the sensory cells (Stärdler, 1984; see Discussion). Also, it is difficult to see how these tarsal sensilla would normally come in contact with alkaloids, or that they would be the only means of detecting alkaloids.

In this study, we reinvestigate the hypotheses that chemosensory cells are responsible for detecting *Solanum* alkaloids that are potential feeding deterrents and for providing differential sensitivity to these chemically similar compounds. Sensilla on the maxillary galeae of adult beetles are accessible to electrophysiological recording (Mitchell and Harrison, 1984) and presumably are well situated for detecting chemical compounds inside the leaf as it is macerated by the mandibles. They also contain cells sensitive to amino acids and sucrose (Mitchell...