EFFECT OF ERGOT ALKALOIDS FROM FUNGAL ENDOPHYTE-INFECTED GRASSES ON FALL ARMYWORM (Spodoptera frugiperda)

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Abstract—Ergot alkaloids produced by endophytic fungi in the tribe Balan-siae (Clavicipitaceae, Ascomycetes), which infect grasses, may provide plant defense against herbivores. This study examined the effects of six ergot alkaloids on survivorship, feeding, and growth of larvae of the fall armyworm (Spodoptera frugiperda, Lepidoptera: Noctuidae), a generalist herbivore of grasses. Corn leaf disks were soaked in solutions of individual ergot alkaloids at different concentrations and presented to neonate larvae. At the highest concentrations (77-100 mg/liter) of ergonovine, ergotamine, ergocryptine, agroclavine, and elymoclavine, larval weights and/or leaf area consumed after eight days were reduced relative to controls. Lysergol had no effect on larval weights and leaf consumption at any concentration. Although active concentrations were higher than those reported from two host grasses, in vivo levels of ergot alkaloids have not been quantified for most endophyte-infected grasses. The detrimental effects on fall armyworm observed in this study suggest that ergot alkaloids could be responsible, at least in part, for the greater insect resistance of endophyte-infected grasses.

Key Words—Balansiae, Clavicipitaceae, ergot alkaloids, fall armyworm, feeding deterrents, acquired chemical defense, fungal endophytes, grasses, Lepidoptera, Noctuidae, Spodoptera frugiperda.

INTRODUCTION

Recently the role of clavicipitaceous fungal endophytes infecting grasses as insect feeding deterrents has been demonstrated (Funk et al., 1983; Clay et al., 1985; Latch et al., 1985). Systemic fungi in the tribe Balansiae, family clavi-
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Cipitaceae (Ascomycetes), and their anamorphs, are known to infect hundreds of species of grasses and sedges (Diehl, 1950; Clay, 1987; White, 1987). Livestock toxicity problems of unknown etiology historically have been associated with certain pasture grasses (e.g., tall fescue, perennial ryegrass). The presence of fungal endophytes in these grasses has been correlated with livestock toxicity (Bacon et al., 1986). Perennial ryegrass pastures in New Zealand toxic to sheep were shown also to be more resistant to damage by the Argentine stem weevil, *Listronotus bonariensis* (Prestidge et al., 1982). The association between fungal endophyte infection and resistance to insect herbivores has now been demonstrated in a number of grasses and sedges (Clay, 1987).

Increased insect resistance of infected grasses may result from the production of alkaloids by the fungi present within the tissues of its host. The Balansiae, like their close relatives in the genus *Claviceps*, produce a variety of ergot alkaloids. However, unlike *Claviceps*, which is a localized ovarian parasite of grass flowers, Balansiae species are systemic, and both the fungi and the alkaloids can be found throughout the above-ground host-plant tissues (Clay, 1986; Siegel et al., 1987). The anamorphic endophytes of tall fescue and ryegrass and several Balansiae species are also known to produce other types of alkaloids (Porter et al., 1977; Bush et al., 1982; Gallagher et al., 1984; Rowan and Gaynor, 1986).

While the association among fungal endophytes, ergot alkaloids, and insect resistance in grasses strongly suggests a functional relationship, to our knowledge there have been no previous published studies of the effect of ergot alkaloids on insect feeding. The purpose of this study is to determine the effect of several ergot alkaloids on feeding by larvae of the fall armyworm (*Spodoptera frugiperda* J.E. Smith, Lepidoptera: Noctuidae), a generalist herbivore of grasses. The fall armyworm has been shown previously to be sensitive to the presence of fungal endophytes in grasses (Clay et al., 1985; Hardy et al., 1985, 1986), and it has been widely utilized as a bioassay for grass feeding studies (Pencoe and Martin, 1981). In particular, we ask whether the alkaloids function as antifeedants and/or antibiotics and whether specific alkaloids representing the major classes of ergot alkaloids differ in their toxicity.

**METHODS AND MATERIALS**

The Alkaloids. A large number of ergot alkaloids have been isolated from Balansiae fungi-infected grasses or extracted from fungal cultures (Bacon et al., 1979; Porter et al., 1979; Lyons et al., 1986). In general, ergot alkaloids are characterized by the ergoline nucleus (Cordell, 1981) (Figure 1) and can be divided into three general groups: clavine alkaloids, lysergic acid alkaloids, and ergopeptide alkaloids (Cordell, 1981). Clavine alkaloids have a \(-\text{CH}_2\text{OH}\) or