GRAPHOLITHA TRISTRIGANA (CLEMENS) (LEPIDOPTERA: TORTRICIDAE) ON NATURALIZED HEMP (*CANNABIS SATIVA* L.) IN EAST-CENTRAL ILLINOIS

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ABSTRACT.—*Grapholitha tristrigana* (Clemens) was found to be the most important parasite on naturalized hemp (*Cannabis sativa* L.) in east-central Illinois. Larvae feed in the pith of stems as well as on developing seeds. Data compiled from field and laboratory studies suggest that larvae destroy an average of 7.1 percent of developing seeds in wild populations of hemp, but rarely kill established plants. Although the insect was present in every stand of hemp examined, up to 75 percent of the larvae were parasitized; parasitoids were *Macrocentrus delicatus* Cresson (Hymenoptera: Braconidae), *Tsmelucha* sp. and *Phacogenes walshiae walshiae* Ashmead (Hymenoptera: Ichneumonidae), and *Lixophaga variabilis* (Coquillett) (Diptera: Tachinidae) *P. walshiae walshiae* has not been reported previously from *G. tristrigana.* Observations on the life cycle of *G. tristrigana* are reported. Evidence suggests that this insect has become an important pest on hemp in this country only within the last 20 years.

During intensive studies of the ecology and drug production of naturalized hemp *(Cannabis sativa L.)* in east-central Illinois, it became apparent that larvae of *Grapholitha tristrigana* (Clemens) (Lepidoptera: Tortricidae) (hereafter referred to, tentatively, as the hemp borer) were the most important parasites of this annual forb. The hemp borer was described first by Clemens (1865) who named it *Stigmonota tristrigana* Clemens. Subsequently, the species was reported by Kearfott (1907) who misidentified it as *Enarmonia saundersana* Kearfott. Heinrich (1926) transferred the hemp borer to the genus *Grapholitha* where it has since remained. He reported the food species to be *Baptisia* spp. and *Lupinus* spp. and cited collections from Ontario, Massachusetts, New York, New Jersey, North Carolina, Florida, Alabama, Illinois, Texas, Kansas and Oklahoma. Additional description of the insect was provided by MacKay (1959) who included hemp as a food species, citing four larval specimens from stems of hemp collected in New York in 1944.

Cannabis, generally considered to be a monotypic genus, is one of the most widely distributed plants. Literature on origin, nomenclature and uses of this dioecious species was summarized most recently by Schultes (1970). Hemp may have been introduced into United States as early as 1629 (Boyce 1900). Brendel (1887) noted that *Cannabis sativa* was "perfectly naturalized and common around Peoria (Illinois) in the year 1852." Haney and Bazzaz (1970) discussed the current distribution of naturalized hemp in Illinois.

METHODS

Intensive field studies were made, primarily in Champaign County, during 1969 and 1970 to elucidate the ecology of naturalized hemp. Observations were focused on 101 strands representing a broad range of site conditions. In autumn 1969, when collected plants were examined in detail in the laboratory, the importance of the hemp borer was realized. During 1970, borers were collected

and reared in the greenhouse and in rearing chambers to determine more of their life cycle and fecundity. Populations in the field were assayed by tallying the number of exit holes in hemp stems of randomly selected stands.

Results and Discussion

From late May until the middle of August, larvae were found in the pith of basal stems of hemp plants. Galleries usually were marked by distinct fusiform swellings of the stems. Exit holes were first observed in the last week of June and increased in number through early August. Sudden increases in numbers of exit holes, indicating maturation of a generation, were not noted. From middle August until frost, larvae were found principally in loose webs around seed clusters and in pith of terminal branches of female hemp plants. During this period, larvae became increasingly active and were frequently found crawling over plants. This was in sharp contrast to the more sedentary behavior of larvae earlier in the growing season.

Based on data from 101 isolated hemp stands, larvae destroyed an average of 7.1 percent of all seed developed. Within these stands, seed destruction by the borer ranged from 0 to 25 percent although no stand was found without the insect. No significant correlation was found between seed destruction by the borer and plant characteristics such as height, stem diameter or seed production. Significant correlations were found between average number of exit holes in stems of female plants and plant height ($r = +0.47$, $P<0.05$) as well as with stem diameter ($r = +0.66$, $P<0.01$). These data support our field observations that more larvae develop in larger plants. Larvae seldom, if ever, resulted in death of plants and they never completely utilized available pith or seeds. Larvae rarely were found on plants less than 25 cm. tall, even when numerous developing seeds were present.

Distribution of larvae within stands was highly irregular and, in early summer, was without apparent regard for the sex of the plant. However, after the middle of August, when seeds were developing, most larvae were found on female plants.

From greenhouse and rearing cage observations, the generation time of the hemp borer is five to seven weeks. Three generations probably are completed each year in this area. The insect apparently overwinters in the soil as a pupa or last instar larva; an intensive search for overwintering insects in stalks and litter revealed none.

Attempt was made to determine the oviposition and number of eggs laid by females mated and maintained in rearing cages. At no time were we able to locate eggs or observe oviposition on the hemp plants in the cage. Adults may be nocturnal. Fecundity estimates, based on the number of resulting first instar larvae, averaged about 17 per female. Data from field stands showed that during a growing season, slightly over four exit holes per hemp plant were cut. This suggests the actual population level of borers in these stands.

The principal population control of the hemp borer was parasitization. Larvae were parasitized up to 75 percent during 1970. Four parasitoid species were identified from our material: *Macrocentrus delicatus* Cresson (Hymenoptera: Braconidae), *Tsmelucha* sp, and *Phacogenes walshiae walshiae* Ashmead (Hymenoptera: Ichneumonidae), and *Lixophaga variablis* (Coquillett) (Diptera: Tachinidae). The braconid, which previously had been reported from *G. tristrigana*, has a known range from Manitoba and Quebec south to Flor-

ida and west to Texas and Iowa. *P. walshiae walshiae* is known only from New Jersey, Delaware, Maryland, Virginia, Pennsylvania, Ohio and Illinois. It apparently was not reported previously from *G. tristrigana* although it is known from *G. molesta* (Busch). The tachinid has been reported from Manitoba to Maine and south to Florida and Texas. It also is known from British Columbia and California (personal communication from Reece I. Sailer).

There was indication in the field that the population of *L. variabilis* tended to increase later in the summer with a corresponding decrease in the population of the Hymenoptera parasitoids. More research is needed to elucidate the relationships between these species.

The biological control of wild hemp rendered by the hemp borer is slight in spite of considerable potential. Extrapolated over three generations, a female could give rise to 1200 larvae, assuming no parasitization or predation, in a single growing season. Larvae collected in the field and reared in the greenhouse on hemp plants destroyed an average of four seeds each during a four week period from early instar to pupation. With this level of seed destruction, one mating pair of borers in the spring potentially could bring about the destruction of 4900 hemp seeds by late summer. This becomes meaningful when we consider that, on the average, each female hemp plant produces about 95 seeds. Seed production is based on seed tallies from 101 wild stands.

Two outbreaks of *Grapholitha* on hemp have been reported from Europe. Nagy (1967) described a rapid increase in the population of *G. sinana* Felder, especially in southeastern Hungary. This insect, according to the author, was autochthonous in Hungary and had been known previously only from wild hops (*Humulus lupulus* L.). Hops belong to the hemp family, Cannabaceae. *G. sinana* also developed in the hemp stem, producing fusiform swellings similar to those we describe, and fed on seeds during late summer. The species was heavily parasitized, up to 20 percent of the eggs and 70 percent of the larvae, but parasitoids were not identified in the publication. Manoliache et al. (1966) reported a similar outbreak in Rumania during 1966 but the insect was identified as *G. delineana* Walker. Again, this insect previously had not been reported in hemp.

It is apparent in the European reports that *Grapholitha* spp. have recently become pests of hemp there. The same is true in this country. It is significant that with intensive research on cultivation of hemp in United States, until about 1945, there is no mention of *G. tristrigana* in the research reports, yet the species now would offer a serious problem to attempts to raise hemp for fiber or seed. The potential of *Grapholitha* spp., as well as their parasitoids, for biological control would justify further research. Additionally, information pertaining to the causes of recent outbreaks of populations in at least two widely separated areas may be important to the understanding of plant-herbivorous parasite relations.

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