BIOLOGICAL AND HOST RELATIONSHIPS OF MICROPLITIS CROCEIPES[1/][2/]

Janine E. Powell and Gary W. Elzen

U.S. Department of Agriculture, Agricultural Research Service,
Southern Field Crop Insect Management Laboratory
Stoneville, Mississippi 38776

ABSTRACT

The biology of Microplitis croceipes (Cresson) is described, and the parasitoid's host-plant interactions and ecology are discussed. Results of the many studies of M. croceipes indicate that the wasp has potential for use in Heliothis spp. management programs. The ability to induce and break diapause in M. croceipes could be important in mass-rearing for augmentation. In the field, this parasitoid can be found associated with Heliothis spp. in many cultivated and wild host plants. Where resistant soybean varieties are used, M. croceipes can be used favorably to enhance host mortality. Strong preferences for instars of H. zea and H. virescens were shown on cotton, and wasp developmental time was inversely correlated with preference for an instar. Search rate was 0.2 m^2/day in spring and 0.6-0.9 m^2/day in summer. Parasitized larvae moved less and damaged fewer fruits on cotton than unparasitized larvae.

INTRODUCTION

The biology of the braconid Microplitis croceipes (Cresson) is reviewed. In addition, recent studies are discussed involving the parasitoid's host-plant interactions and ecology, including host instar preference, search rate, and feeding and movement on cotton. Other names previously used for this species were Microgaster croceipes Cresson and Microplitis nigripennis Ashmead (Muesebeck et al. 1951).

DISCUSSION

Biology. Microplitis croceipes is distributed widely throughout the U.S., from New Jersey south to Georgia, west to Texas, New Mexico, Arizona, Utah, and Oregon (Krombein et al. 1979, Krombein and Burks 1967, Muesebeck et al. 1951). This species apparently has become increasingly important as a biocontrol agent in the South in recent years. Its potential for suppressing Heliothis spp. populations was discussed by King and Powell (this supplement). Although the host range of M. croceipes is generally considered to be limited to larvae of H. zea (Boddie) and H. virescens (F.) (Danks et al. 1979), it is capable of parasitizing H. subflexa (Guenee) (Krombein et al. 1979, Lewis 1970b) and H. phloxiphaga Grote and Robinson (Bryan et al. 1969). Other host species exposed to the wasp were the almond moth, Cadra cautella (Walker), the Indianmeal moth, Plodia interpunctella (Hübner), and the lesser cornstalk borer, Elasmopalpus lignosellus (Zeller), but these were

1/ Hymenoptera: Braconidae.
2/ Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products.

rejected for oviposition. When the fall armyworm, Spodoptera frugiperda (J. E. Smith), beet armyworm, S. exigua (Hubner), and the cabbage looper, Trichoplusia ni (Hubner) were offered, M. croceipes accepted them; but no progeny developed (Lewis 1970b).

The life cycle is approximately 14.5 days at 30°C (Bryan et al. 1969), and the female oviposits an estimated 300 eggs, with a range of 30 to 600 reported (Lewis and Snow 1971). The three instars obtain their nutrition from the host's hemolymph, but they do not immediately kill the host (Lewis 1970a). A parasitoid larva develops within the host, then the mature larva bores its way out and spins a cocoon. The adults are 3.5-4.5 mm long. Usually, only one parasitoid develops per host, but sometimes two parasitoids emerge from a single host and develop successfully (Bryan et al. 1969). Unmated females exhibit arrhenotokous parthenogenicity, producing only male progeny. Longevity ranges from 5 to 15 days (Lewis and Snow 1971). Heliothis virescens larvae parasitized as early instars molt more times than those parasitized as late instars (Powell 1988). Furthermore, as the number of molts increased, the average time spent per instar decreased.

Prepupae of M. croceipes are induced into diapause by low temperatures. At 15°C, 100% diapause occurred; while at 20°C, 60% occurred, and at 30°C, no diapause occurred (Bryan et al. 1969). Brown and Phillips (In Press) found that short day lengths in M. croceipes favored a high rate of diapause induction when temperatures were appropriate. Critical day length to night length ratios (50% diapause induction) for 18°C and 21°C were 11:00::13:00 and 10:30::13:30, respectively, under laboratory conditions. At a photoperiod of LD 14:10, the temperature 15°C induced 100% diapause. High variability in intensity of diapause was indicated by the range in developmental time from wasp pupation to adult emergence.

The ability to induce and break diapause in M. croceipes could be useful in an augmentation program. Massive numbers of insects could be reared and stored throughout the year, rather than reared just prior to field release. Presently, large numbers can be reared and accumulated in cold storage for two weeks (Powell and Hartley 1987). However, automated techniques for rearing massive numbers of M. croceipes are being developed at the USDA Gast Insect Rearing Laboratory in Mississippi. When the potential for mass-rearing these parasitoids is realized, large-scale field testing could be accomplished.

Heliothis spp. larvae parasitized by M. croceipes grew more slowly and had a lower respiration rate than larvae that were not parasitized (Jones and Lewis 1971). The earlier the host was parasitized, the further the reduction in weight gain; feeding by the host virtually stopped soon after oviposition. The parasitoid apparently controls development of the host, stopping it before the pupal stage is reached. Maintaining control of host development is important for protection against physiological defense reactions of the host (Jones and Lewis 1971).

Heliothis virescens larvae that were parasitized by M. croceipes consumed significantly less artificial diet than unparasitized larvae (Powell, In Press). The greater proportion of feeding by unparasitized larvae occurred after they reached the 4th stadium, whereas, feeding by parasitized larvae remained at a low level. Therefore, larvae parasitized before reaching the 5th stadium may cause considerably less damage to the host plant than unparasitized larvae.

Host Plant Interactions. In the field, M. croceipes can be found associated with Heliothis spp. in many cultivated and wild host plants. Briefly, M. croceipes was reported in cotton, Gossypium hirsutum L., as well as other crops in 1958 (Butler 1958) and in 1968 (Bottrell et al., 1968). Later, the wasp was reported in Mississippi in soybean, sorghum, alfalfa, and corn (Smith et al. 1976). In a study conducted from 1971-74 (Pair et al. 1982), many species of parasitoids, including M. croceipes, were collected from sesame interplanted in cotton. Microplitis croceipes also attacked H. zea on potatoes in North Texas (Puterka et al. 1985).

Wild host plants are believed to be important for survival of Heliothis spp., both early-season hosts in the spring and late-season hosts after cultivated crops have matured. Studies in Geranium carolinianum L. in Georgia, Mississippi, and South Carolina (Snow et al. 1966) indicated that this plant supports large populations of both H. zea and H. virescens necessary for the buildup of parasitoid populations that attack later generations of Heliothis spp. in crops. According to Lewis and Brazzell (1968), parasitoids, including M. croceipes, provided a high degree of control in G. carolinianum, as well as in tomato, Lycopersicon esculentum Mill., and spider flower, Cleome spinosa Jacq. Stadelbacher et al. (1984) in Mississippi studied five early-season wild host plants of Heliothis spp., and they showed that Geranium dissectum L. and crimson clover, Trifolium incarnatum L.), were important for propagation of parasitoid populations. They also found that M. croceipes parasitized larger numbers of Heliothis spp. larvae in more species of host plants and was active over a longer period than any other parasitoid. The relationships between Heliothis spp. and their wild host plants was examined, and the possible role of wild hosts as trap crops for biocontrol or cultural control was described (Stadelbacher et al. 1986).

Host Plant Resistance. In laboratory studies, the effect of host plant resistance to Heliothis spp. in soybean on biological control of Heliothis spp. by M. croceipes was investigated by Powell and Lambert (1984). Heliothis spp. larvae were reared on soybean foliage of susceptible 'Davis' and on the resistant plant introductions, PI-171451, PI-227687, and PI-229358. Since PI's are being used as sources of resistance in many soybean breeding programs, the influence of resistant plants on survival of M. croceipes was investigated.

The percentage of parasitized larvae that successfully produced a parasitoid declined from susceptible to more resistant soybean varieties. Percentage survival was not significantly different for parasitized larvae reared on Davis and PI-171451 foliage, or from unparasitized hosts reared on the same genotypes. This suggests that the use of genotypes with PI-171451 as a donor parent may be compatible with the use of M. croceipes in a biocontrol program. In fact, the mean weights of parasitoid pupae and associated cocoons were similar for Davis and PI-171451 soybean. Weights were significantly lower ($P<0.01$) for PI-227687 and PI-229358, indicating that resistance factors in these PI's may reduce the quality of developing parasitoids. This information, along with data on parasitoid development and leaf area consumption by parasitized larvae, indicated that biological control by M. croceipes may be desirable along with use of Heliothis spp. resistant cultivars developed by using genotype PI-171451. Use of PI-227687 and PI-229358 may have adverse effects on the parasitoid population, precluding any additional crop protection from parasitization of Heliothis spp. by M. croceipes (Powell and Lambert 1984).

Ecology. Microplitis croceipes showed strong preferences for instars of H. zea and H. virescens when measured on cotton in field cages (Hopper and King 1984b). As measured by parasitoid emergence, wasps preferred 3rd instars most, 2nd and 4th instars next, and 1st and 5th instars least. Preference was independent of total host density or density of the most preferred instar, and wasps did not prefer one Heliothis sp. over the other. Subsequent laboratory studies showed that preference for certain instars of H. virescens may be due, in part, to variation in the probability of parasitization upon parasitoid host encounter (Hopper 1986). The sex ratio of M. croceipes was not significantly affected by host instar parasitized, however, wasp developmental time was inversely correlated with preference for an instar (Hopper and King 1984b). Host acceptance was higher and handling time shorter for preferred host instars, and adult head width was larger for wasps from hosts parasitized in preferred instars (Hopper 1986). The number of oocytes was smallest in wasps from hosts parasitized in the most preferred instar (the 3rd).

The relationship between search rate (m^2/day) of M. croceipes and variation in 3rd instar H. virescens and H. zea density was determined in field cages containing G. dissectum during the spring and cotton during the summer (Hopper and King 1986). The number of larvae parasitized increased linearly over the range of host densities tested (3-24 larvae/m^2); M. croceipes exhibited a linear functional response. The search rate was about 0.2 m^2/day in spring and 0.6-0.9 m^2/day in summer.

Feeding and movement on cotton of H. zea and H. virescens that were parasitized and unparasitized by M. croceipes were compared in greenhouse studies (Hopper and King 1984a). First instars placed on cotton plants in the greenhouse were parasitized at instars 2-5 with corresponding instars left unparasitized. The location and activity (feeding, resting, crawling, hanging from a plant, or pupating) of each larva were recorded daily, and displacement per day was used to measure larval movement. Parasitized larvae moved less and damaged fewer squares, blooms, and bolls than unparasitized larvae (Hopper and King 1984a). Larvae damaged fewer squares and bolls over their lifetime when parasitized as 2nd, 3rd, and 4th instars than when unparasitized. Larvae parasitized as 5th instars damaged as many fruit as unparasitized larvae. Parasitized larvae moved less and fed less often than unparasitized larvae. Parasitized larvae damaged fewer fruit because they attacked less fruit per day, not because they spent less time on the plant. The results suggest that M. croceipes may decrease the abundance of Heliothis spp. in later generations in the field and cause immediate reduction in plant damage by present generations of larvae.

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