

DEVELOPMENT OF *COPTERA HAYWARDI* (HYMENOPTERA:
DIAPRIIDAE) IN IRRADIATED AND UNIRRADIATED PUPAE
OF THE CARIBBEAN FRUIT FLY AND THE MEDITERRANEAN
FRUIT FLY (DIPTERA: TEPHRITIDAE)

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Augmented releases of tephritid parasitoids have suppressed populations of both the Mediterranean fruit fly (*Ceratitis capitata* [Weidemann]) and the Caribbean Fruit fly, (*Anastrepha suspensa* [Loew]) (Wong et al. 1991, Sivinski et al. 1996). Typically, braconid parasitoids of larvae, such as *Diachasmimorpha longicaudata* (Ashmead), are employed. However, parasitoids that attack fruit fly pupae might be useful additions to such programs since they are able to attack flies that might otherwise escape parasitism. Flies developing within large fruits are less likely to be parasitized by braconids; parasitoids are less able to reach them with their ovipositors (e.g., Sivinski 1991, Sivinski et al. 1997). Since tephritid larvae typically leave fruits to pupate in the soil, fruit size is less important to pupal parasitoids foraging for hosts.

The diapiiid *Coptera haywardi* (Ogloblin) is a widespread native of Latin America, where it has been collected from the pupae of several *Anastrepha* species (Loiacono 1981). It appears to attack only species of Tephritidae (Sivinski et al. 1998). Unlike many common, ectoparasitic, pteromalid pupal parasitoids of cyclorrhaphous Diptera, *C. haywardi* develops as an endoparasitoid (Sivinski et al. 1998). This more intimate relationship with its host may result in greater specialization and a narrower host range (see Godfray 1994). Specialized parasitoids are particularly valuable in augmentative releases since they are less likely to harm beneficial insects and more likely to focus their foraging on declining numbers of target pests.

There is a possibility of adding pupal parasitoids to existing braconid mass-rearing programs. For example, fruit fly larvae could be exposed to a braconid parasitoid, and after host pupation the pupae could then be placed with pupal parasitoids. Unparasitized pupae would typically be available for the second parasitoid since only a few braconid rearing operations consistently reach parasitism levels of 50%, and some, such as early efforts with raising *Diachasmimorpha tryoni* (Cameron), average as low as 20% (pers. observ. of the authors). This scheme would be most effective with a pupal parasitoid that, 1) would not hyperparasitize the primary braconid parasitoid, and 2) was able to develop in flies whose maturation was disrupted by radiation. Irradiation of larvae prior to parasitization is used in mass-rearing programs in Florida, Mexico, and Guatemala to prevent mixed lots of parasitoids and fertile flies (Siv-

inski and Smittle 1990; Sivinski personal observation). Previous studies have found no indication of *C. haywardi* hyperparasitism of *D. longicaudata* developing in *A. suspensa* (Sivinski et al. 1998).

In order to determine if *C. haywardi* would develop in pupae that had been formed by irradiated larvae, we provided the diapiiid with irradiated and unirradiated pupae of *A. suspensa* in the following manner. Mixed lots of unparasitized pupae and pupae parasitized by *D. longicaudata* were obtained from the Florida Division of Plant Industry, Gainesville, Florida (see Sivinski et al. 1996). At the start of the experiment, *A. suspensa* had been in colony for ~ 9 years (150 generations). *D. longicaudata* had been in colony ~ 6 years and *C. haywardi* had been colonized on *A. suspensa* for ~ 1 year. These lots had been previously derived from late 3rd instar larvae that had been either irradiated in a Cesium 137 source (Nordion International Inc., Model M; Kanata, Ontario, Canada) at 6 kR or left unirradiated. Depending on availability, either 10 ml (~400 pupae) or 3 ml (~120 pupae) of 1-day old pupae were placed with 15 unsexed individuals of *C. haywardi* in 250 ml cardboard cups containing moist vermiculite, honey, and water. The cups were covered with a fine-mesh cloth and left at 26 (\pm 1) $^{\circ}$ C and ambient humidity for 1 week. At the end of this period pupae and adult parasitoids were separated and the pupae held at 29 $^{\circ}$ C and 70% humidity for 1 month. At this point the adult insects that had emerged were identified and counted. Unemerged pupae were dissected to determine their contents. There were 8 replicates of 3 ml and 7 replicates of 10 ml cups of pupae. Each replicate consisted of 5 cups of irradiated and 5 cups of unirradiated pupae, so that a total of 470 ml of irradiated and 470 ml of unirradiated pupae were exposed to a total of 1125 diapiiids each. Since the results of the experiment were consistent and unambiguous, the data from cups containing different amounts of pupae were pooled.

There was not a single successful development of *C. haywardi* in pupae formed by irradiated *A. suspensa* larvae. In the unirradiated lots, a total of 9772 *A. suspensa* eclosed. In the irradiated lots, 1 *A. suspensa* and 0 *C. haywardi* eclosed. Parasitism by *D. longicaudata* was 31% (SE = 7%) in unirradiated lots and 29% (SE = 7%) in irradiated lots. Parasitism by *C. haywardi* of unirradiated pupae averaged 12% (SE = 0.3%).

A similar experiment, examining the development of *C. haywardi* in irradiated pupae of *C. capitata* was conducted in the "Aurora" USDA-APHIS/MOSCAMED facility in Guatemala City, Guatemala. At the time of the experiment, *C. haywardi* had been reared for ~5 generations on *C. capitata* pupae. *Coptera haywardi* was presented with pupae of *C. capitata* formed from larvae either irradiated at 14.5 kR with a Cobalt 60 source at the MOSCAMED rearing facility at El Pino, Guatemala or left unirradiated. Lots of 1180 pupae, either irradiated or unirradiated, were exposed for a period of three days to ~ 800 unsexed individuals of *C. haywardi* housed in a 1 m by 1 m plexiglass cage. Pupae then were removed and held at 26 $^{\circ}$ C and 60-70% humidity for one month. There were six replicates, so that a total of 7080 irradiated and 7080 unirradiated pupae were exposed to parasitism.

As in the case of irradiated *A. suspensa*, there was no emergence of adult *C. haywardi* from irradiated *C. capitata*. Unirradiated pupae yielded 231 *C. haywardi* (~ 4% parasitism).

Thus, *C. haywardi* lacks the useful attribute of being able to exploit irradiated fruit flies in those mass-rearing programs which expose larvae to high levels of radiation. This does not preclude its use in other types of mass-rearing programs. For example, in a parasitoid mass-rearing system previously used in Hawaii there was a sufficient difference in the developmental periods of the braconid *Diachasmimorpha tryoni* (Cameron) and its host *C. capitata* to allow separation of the adults of the two species without the use of radiation. (Wong and Ramadan 1992). In this instance, the

adult fruit flies emerged first and were allowed to die off before the braconid was "harvested". Assuming that *C. haywardi* would not hyperparasitize *D. tryoni*, this lack of irradiation permits the exposure of pupae to *C. haywardi*. Genetic "sexing-strains" of host flies sometimes generate sexually dimorphic pupal colors that allow the mechanical separation of male and female pupae in mass-rearing programs (Willhoeft et al. 1996). Since female pupae are considered detrimental in sterile releases, they are discarded after sorting. These might be more profitably employed to provide hosts for pupal parasitoids (Jorge Hendrichs, pers. comm.). In the Aurora Facility in Guatemala, *C. haywardi* has been successfully reared on the female pupae of *C. capitata* generated by the "Temperature Sensitive Lethal" sorting strain (see Franz et al. 1996).

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SUMMARY

Coptera haywardi, a diapriid parasitoid of tephritid pupae, failed to develop in pupae formed by *Anastrepha suspensa* larvae that had been previously irradiated at 6 kR. Irradiation is typically used in the mass-rearing of braconid larval parasitoids such as *Diachasmimorpha longicaudata*. Neither was *C. haywardi* able to develop in *Ceratitidis capitata* pupae formed by larvae irradiated at 14.5 kR. A scheme that sequentially exposes irradiated fruit fly hosts to first a braconid, such as *D. longicaudata*, and then to *C. haywardi* is impracticable. However, mass rearing programs of other pest fruit flies and natural enemies that do not require irradiation to separate braconid parasitoids from adult hosts, such as the production of *Diachasmimorpha tryoni* on *C. capitata*, may allow for the integration of *C. haywardi*.

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