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Orientation of males of sorghum midge, *Contarinia sorghicola* to sex pheromones from virgin females in the field

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Abstract

The orientation of males of the sorghum midge, *Contarinia sorghicola* Coq. (Diptera: Cecidomyiidae) towards virgin female baited sticky traps was studied in the field. Male response increased linearly with an increase in the number of virgin females in the sticky traps. Five females per vial were optimum for monitoring midge populations in the field. Numbers of males trapped were significantly greater in traps placed at 0.5 and 1.5 m above ground level compared with those placed at 2.5 m. Peak trap catches occurred at 0900 h. The number of males trapped decreased significantly after 1400 h; male catches continued till sunset. Trap catches followed the same pattern as the number of ovipositing females on sorghum panicles at the half-anthesis stage. Midge activity decreased with an increase in temperature and a decrease in relative humidity. Peak midge density was observed during the second fortnight of October in the rainy season and during February–March in the post-rainy season. Sex pheromones can be used to monitor midge population dynamics for integrated pest management and to screen for host plant resistance to this insect.

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is one of the most important cereal crops in Asia, Africa, Australia and the Americas. The sorghum midge, *Contarinia sorghicola* Coq. (Diptera: Cecidomyiidae) is the most destructive pest of grain sorghum on a world-wide basis (Harris, 1976; Sharma, 1985a, b).

Females of *C. sorghicola* produce unisexual progenies (Baxendale & Teetes, 1981). Since more than one female oviposits on one panicle, both males and females emerge from the same panicle. Midge adults begin to emerge from the infested spikelets soon after sunrise, i.e., 0630 to 1030 h. Males emerge about 30 min to 1 h earlier than the females. Males generally sit or hover around the spikelets where the females are about to emerge (Harris, 1976). The adults form small swarms at the crop canopy where mating takes place. This behavior is possibly triggered by sex-related stimuli. The males die soon after mating while the females move in search of sorghum panicles at anthesis for oviposition. Most females lay eggs within 4–6 h after mating, and die within 24 h.

A few species in the Cecidomyiidae including *C. sorghicola* (Moura *et al.*, 1988) have been reported to possess sex pheromones. Research on sex pheromones in *C. sorghicola* was initiated in

1988 at *The International Crops Research Institute for the Semi-Arid Tropics* (ICRISAT, 1988). Sex pheromones have also been reported in the pea midge (*Contarinia pisi* Winn.) (Wall *et al.*, 1985), the Hessian fly (*Mayetiola destructor* (Say)) (McKay & Hatchett, 1984) and the Douglas-fir cone gall midge (*Contarinia oregonensis* Foote) (Miller & Borden, 1981).

Detection of adult emergence from diapausing population, day-to-day variation in midge density, and the knowledge of major population peaks is important for integrated pest management, and to screen for host plant resistance to this insect (Sharma, 1985b). Thus, development of techniques to monitor midge populations is quite important, and sex pheromones could prove to be useful for this purpose. This paper reports the results of studies on orientation, behavior, trapping pattern, and population monitoring of males using virgin female baited sticky traps in the field.

Materials and methods

Experiments were conducted during the rainy and post-rainy seasons at the ICRISAT research farm, Patancheru, India, between 1988 to 1991. Sticky traps baited with different numbers of virgin females were used to investigate the effect of trap height on male catches, relationships between male catches and the female population in the field, and midge population fluctuation during the reproductive phase of sorghum.

Sticky traps. Sticky traps were made of 500 ml (10 cm × 8 cm) capacity plastic jars (Fig. 1). Each jar had a circular grid of 5 mm diameter holes in the center. Virgin females were placed in a 10 ml plastic vial having 1 mm diameter holes all over the surface. The vial containing the virgin females was placed in the plastic jar, which was hung from an iron-pole 1.5 m above ground level with a 15 cm galvanised-iron wire. The traps were placed 20 m apart in a sorghum crop at anthesis to dough stage. The outer surface of the jar was smeared weekly with Tanglefoot (R). The number of males trapped were counted daily and removed.

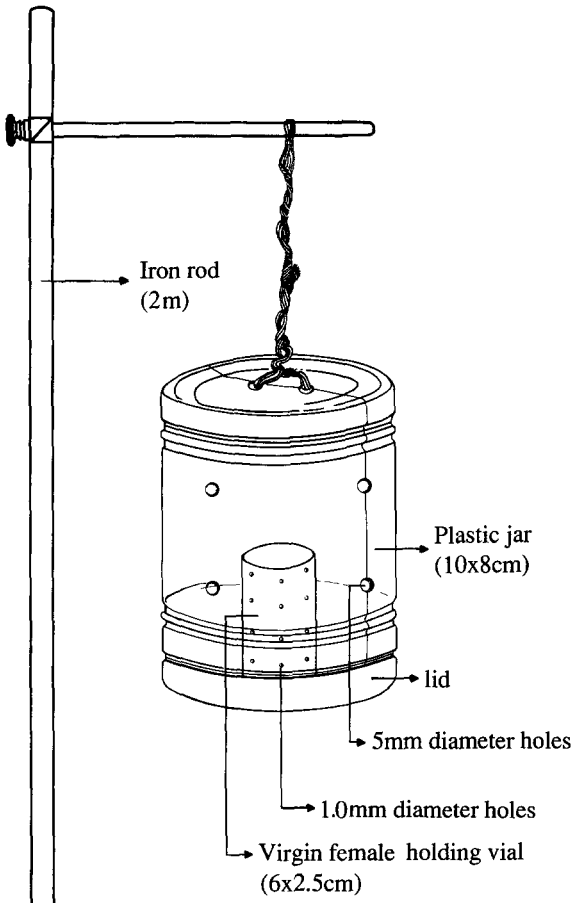

Fig. 1. A diagramatic sketch of the sticky trap used for studying sex pheromones in sorghum midge, *C. sorghicola.*

Insects. Virgin females were aspirated from sorghum panicles just at emergence. Alternatively, the midge-infested panicles were brought to the laboratory, and the primary branches placed individually in 15 ml glass vials plugged with cotton. Females emerging from the infested spikelets in the vials were collected with an aspirator. Between 0700 to 0730 h, virgin females were placed in perforated plastic vials, which were immediately placed in the sticky traps. Fresh females were placed in the traps every day.

Effect of number of females on trap catch. To determine the optimum number of females needed in the sticky traps to monitor male populations, 0, 1, 5, 10, or 20 virgin females were placed in each vial. There were five replications in a randomized block design. The numbers of males

trapped were counted daily. This experiment was conducted for 42 days in the 1989/90 post-rainy season, 26 days in the 1990 rainy season, and for 20 days in the 1990/91 post-rainy season. Virgin females were replaced daily at 0730 h. Trapped males were removed by scraping off a thin layer of Tanglefoot from the surface of sticky traps after each observation.

Effect of trap height. Sticky traps baited with five virgin females/trap were placed at heights of 0.5, 1.5 and 2.0 m above ground. Five traps prepared similarly, but without females served as controls. The traps were placed in a randomized block design, and there were five replications. This experiment was conducted during 10 weeks in the 1989/90 post-rainy season.

Diurnal rhythm. To study the diurnal rhythm of male catches in relation to female activity on sorghum panicles at anthesis, the numbers of males trapped and females ovipositing were counted every hour between 0700 to 1800 h. Catches in ten traps baited with five virgin females were compared with the catches in ten empty control traps. The numbers of ovipositing females were counted on 100 panicles randomly selected at the half-anthesis stage in the same field. Data were recorded on relative humidity (RH) and temperature during the observation period.

Population monitoring. Male midge populations were monitored daily using sticky traps baited with five virgin females over three seasons during the reproductive phase of the crop. There were 10 replications. Females were replaced in the sticky traps daily at 0730 h.

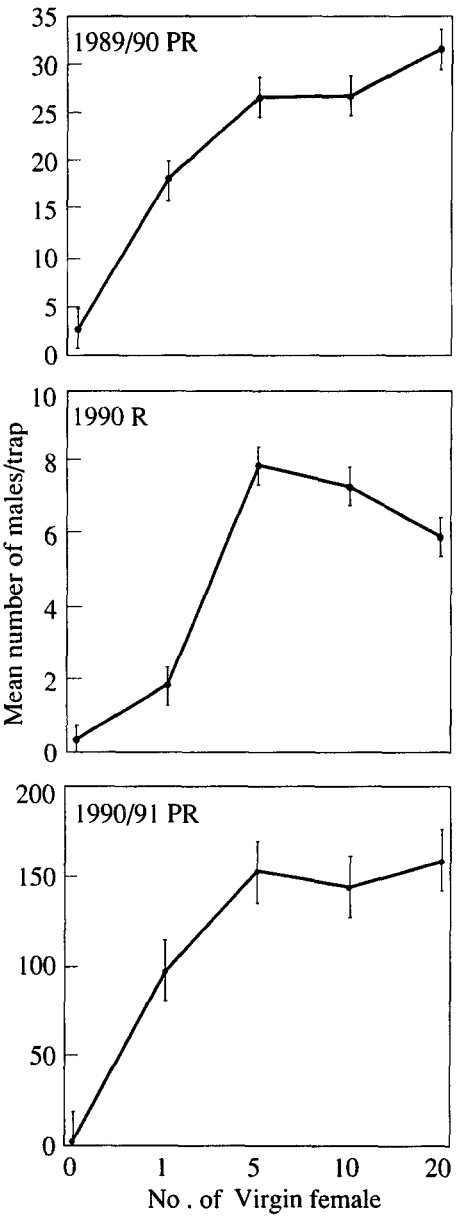

Fig. 2. Number of sorghum midge males trapped in sticky traps baited with different numbers of virgin females (1989/90 post-rainy season for 42 days, 1990 rainy season for 26 days, and in 1990/91 post-rainy season for 20 days). R = Rainy season, and PR = Post-rainy season.

Results

Effect of midge numbers on trap catch. The numbers of males trapped in the sticky traps increased linearly with an increase in the number of virgin females up to 5 midges/trap (Fig. 2). Thereafter, the increase in trap catches was either marginal (1989/90 and 1990/91 post-rainy season) or the numbers of males trapped decreased slightly in traps baited with 10 or 20 virgin females/trap (1990 rainy season).

Effect of trap height. The largest numbers of males were caught in traps placed at heights of 0.5 to

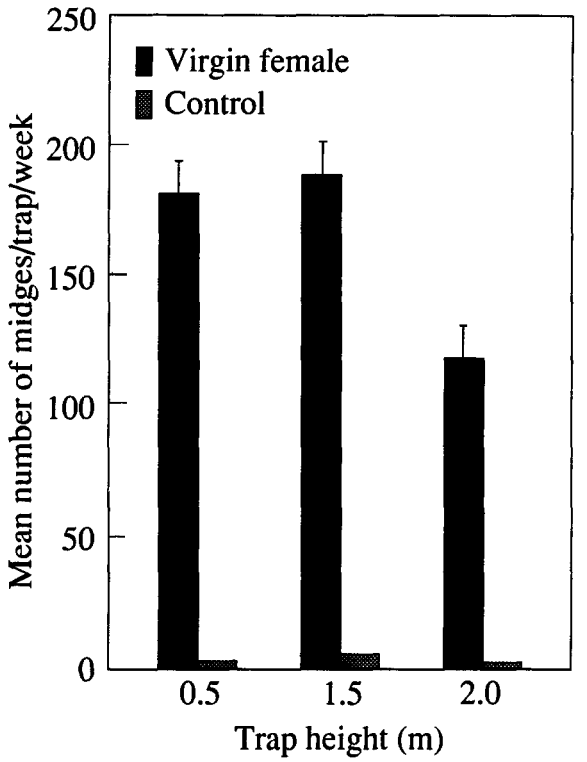

Fig. 3. Number of males trapped in sticky traps (baited with five females) placed at different heights during 10 weeks in the 1988/89 post-rainy season.

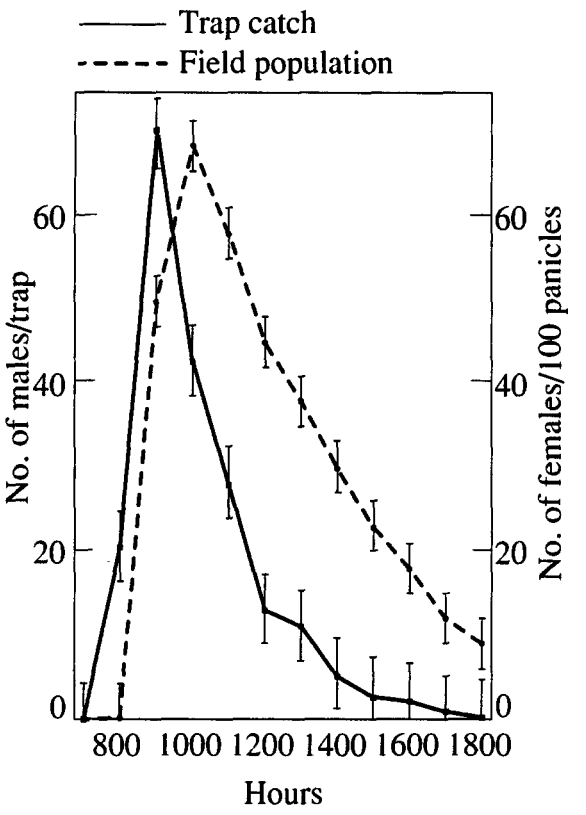

Fig. 4. Diurnal pattern of male catches in pheromone traps (baited with five females/trap) and the number of ovipositing females on sorghum panicles at anthesis (0700 to 1800 h) (mean of ten traps over 10 days) (1990/91 post-rainy season).

1.5 m above the ground (Fig. 3). Catches were reduced by 37% from the maximum in traps placed at 2 m above ground.

Diurnal rhythm. The largest numbers of males were trapped at 0900 h (Fig. 4). Males were trapped throughout the day between 0700 and 1800 h, but the numbers decreased over time after 0900 h, and less than 5 males/trap were trapped between 1400 to 1800 h. The initiation of oviposition by females and peak activity in the field occurred about one hour later than that of male trap catches. Male trap catches in the traps and the female numbers on sorghum panicles at anthesis were highly correlated ($r = 0.37$; $df = 117$). Over a period of 8 days, the peak in trap catches of males was observed between 0900 and 1000 h on 7.2.91, 10.2.91 and 11.2.91 (Fig. 5). On 4.2.91 and 6.2.91, most of the males were trapped between 0800 and 1200 h, while greatest numbers of ovipositing females were recorded between 0900 and 1200 h. There was a 1 to 3 h difference in peak density of males and females on some days. Trap catches of males and the female activity on sorghum panicles at anthesis decreased with a decrease in RH and an increase in temperature during the day.

Population monitoring. Using virgin female baited sticky traps, the midge population was monitored during the 1989/90 post-rainy season, 1990 rainy season and 1990/91 post-rainy season (Fig. 6). During the 1989/90 post-rainy season, two major peaks were recorded during the first and fourth weeks of March. During the 1990 rainy season, the trap catches were low till the first fortnight of October. Two population peaks were recorded, one on 15.10.1990 and another on 19.10.1990. In

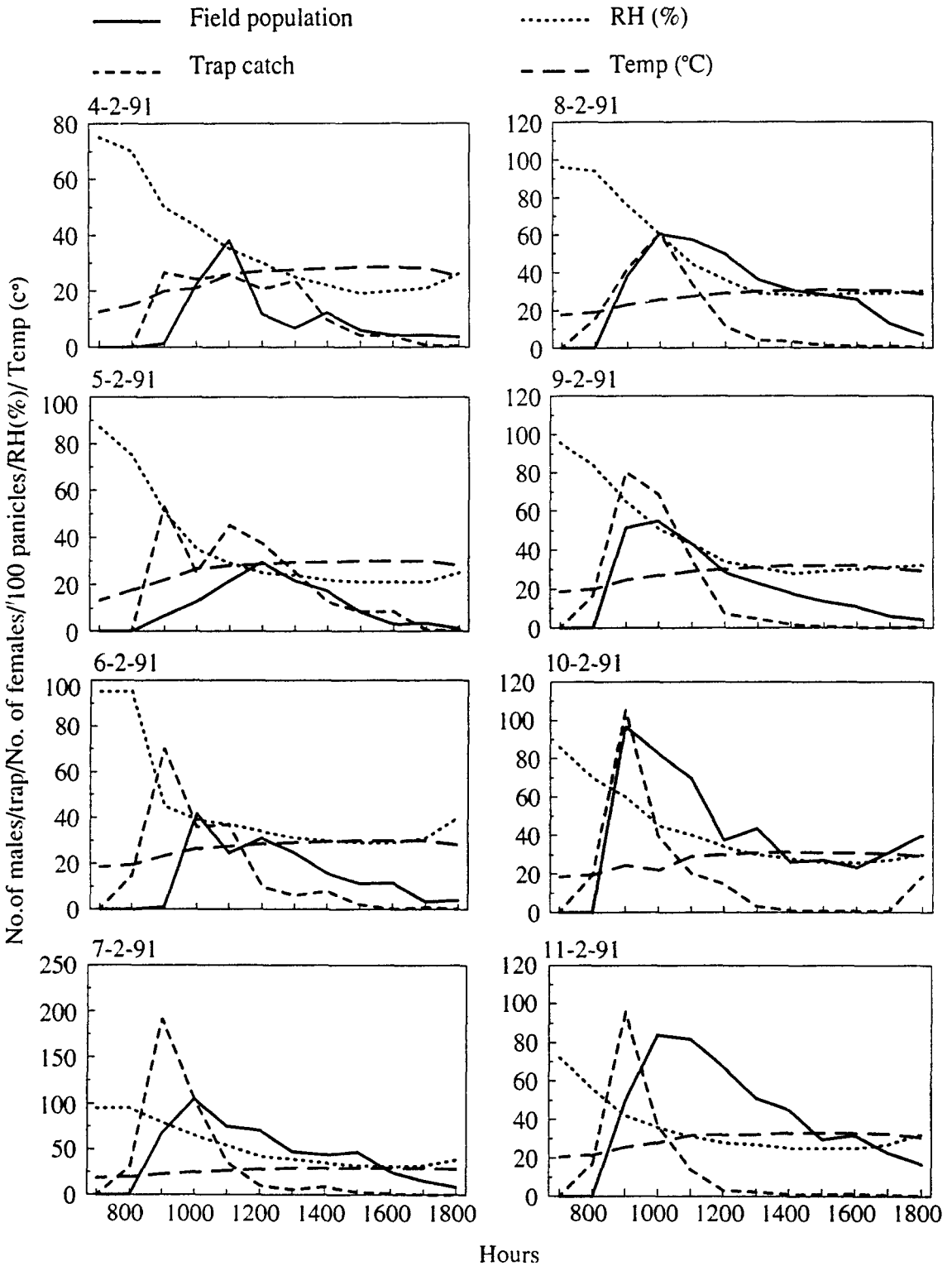

Fig. 5. Diurnal pattern of male catches in pheromone traps in relation to female population, R.H. and temperature over a period of 8 days between 0700 to 1800 h (1990/91 post-rainy season).

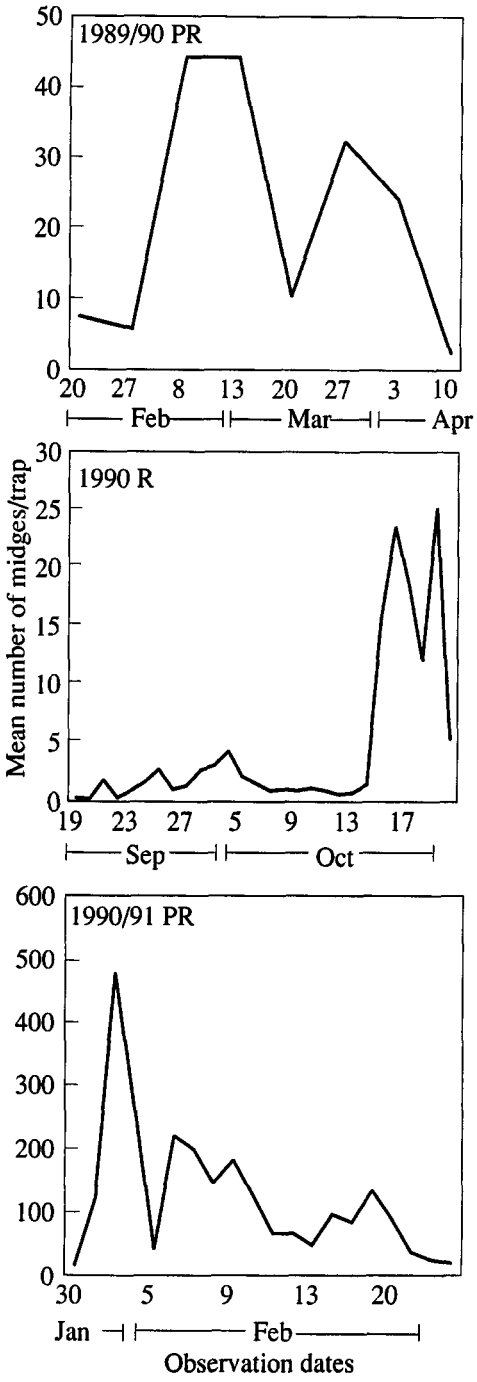

Fig. 6. Midge population monitoring with virgin female baited sticky traps (five females/trap) in the 1989/90 and 1990/91 post-rainy seasons and the 1990 rainy season during the reproductive phase of the sorghum crop at ICRISAT Center. R = Rainy season, and PR = Post-rainy season.

1990/91 post-rainy season, the greatest midge density was observed during the first week of February followed by two smaller peaks between the second and third week of February.

Discussion

The sorghum midge completes its biological functions of mating and oviposition in less than 24 h (Sharma *et al.*, 1990). During the cropping season, mating is assured by the fact that males and females emerge from the same panicle. The location of females is crucial for adults emerging from diapausing larvae, and during periods of very low midge density. Also, because of the 1–2 h life span of males (Harris, 1976), and the limited period during which oviposition takes place, the role of sex pheromones is very important in the biology of this insect.

An increase in the number of virgin females in the holding vials (> 10 females/vial) possibly leads to crowding and disrupts the normal calling activity of the females, and this may account for no further increases in male catches (Fig. 2). Peak trap catches at 0.5 to 1.5 m above the ground (Fig. 3) correspond to the height of the crop canopy. We have observed that most midges occur on medium-tall (1.5–2.0 m) genotypes and least on tall genotypes (> 3 m) (unpublished data).

Female attractiveness and the mating activity of *C. sorghicola* is very similar to that of *M. destructor* with a peak during the morning hours and then a steady decline between 1400 to 1800 h (McKay & Hatchett, 1984). Virgin females and hexane extracts of *C. pisi* (Wall *et al.*, 1985) and *C. oregonensis* (Miller & Borden, 1981) have also been shown to be attractive to males.

Our data shows that trap catches of males in pheromone traps can be used to obtain an idea of ovipositing female population in a field, activity pattern, and population dynamics over a period of time. This information can be used for detecting adult emergence from diapausing larvae and periods of greatest midge density for use in integrated pest management (IPM) and screening for host plant resistance to this insect.

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