Enhanced Pheromone Lures to Attract Honey Bee Swarms

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ABSTRACT

We tested the efficacy of various honey bee pheromone combinations in attracting swarms to bait hives. In the first experiment, using paired trap hives, synthetic queen mandibular pheromone plus two components of the worker Nasonov pheromone (citral and geraniol) attracted significantly more swarms than citral/geraniol lures alone. In the second experiment, with a single bait hive at each site, addition of nerolic acid to the citral/geraniol mixture attracted the most swarms (51), followed by the addition of a queen pheromone (43 swarms) or hexanal (38 swarms) lure to the citral/geraniol lure. The lowest trap catch came from hives containing a single lure baited with only citral and geraniol (25 swarms). These results confirm previous studies indicating that the addition of nerolic acid to citral/geraniol lures improves trap catch, and suggest that queen pheromone may further improve the attraction of swarms to bait hives.

INTRODUCTION

The attraction of swarms to bait hives has been a subject of considerable research interest in recent years. The major factor stimulating this work has been the possible use of bait hives to monitor and/or control Africanized bees, although beekeepers also have been interested in using bait hives to attract swarms in order to increase colony numbers. While bait hives have not been successful in stopping or retarding the spread of Africanized bees (Winston 1992), they have been an important tool for monitoring their arrival and density through South and Central America, Mexico, and the southern United States. Also, Canadian regulatory agencies have been using bait hives to monitor the arrival of the *Varroa* and tracheal mites in swarms crossing the border from the northern states.

Bait hive research has concentrated on two aspects of trapping systems, the hives themselves and the use of pheromone lures to increase swarm attraction to the hives. Many types of hives have been investigated, as well as a multitude of questions concerning how to best locate hives to maximize trap catch (Ratnieks 1988; Schmidt and Thoenes 1987a; Schmidt et al. 1989; Seeley and Morse 1978; Vergara 1990; Witherell 1985). The most economic and effective hives are constructed from reinforced wood pulp containing an asphalt reinforcer, and mold, rot, and termite inhibitory agents (Schmidt et al. 1989). These hives are most effective when suspended about 3 m high in trees or similar objects.

However, trap hives are not effective unless attractant baits are hung in or near the entrance holes. The most effective baits to date have been derived from synthetic blends of worker Nasonov pheromone, released by worker bees from abdominal glands. The Nasonov blend functions naturally to attract incoming workers to the nest and to swarm clusters. Although the natural Nasonov blend contains seven components, a blend of three or four of the components (citral, geraniol, nerolic acid, and sometimes geranic acid) has proven equal to the natural blend in swarm attraction experiments. (Burgett 1980; Free et at. 1984; Kigatiira et al. 1986; Schmidt and Thoenes 1987b; Schmidt et al. 1989; Witherell 1985). Nevertheless, some trapping programs have begun to use lures containing only citral and geraniol (for example, see Rubink et al. 1990). A component of the queen mandibular pheromone, 9-keto-decenoic acid, also has been examined alone and in concert with Nasonov-based lures; results have been ambiguous (Free et al. 1984; Kigatiira et al. 1986).

The objectives of the experiments described here were to investigate the 1) use of a more complete, five-component blend of the queen mandibular pheromone, in combination with Nasonov-based lures, 2) importance of including nerolic acid with the citral/geraniol mixture, and 3) efficacy of a hexanal/citral/geraniol lure, in attracting swarms to bait hives. We tested hexanal because it is one of the compounds for which honey bees have the longest memory in learning experiments (Brian Smith, personal communication).

MATERIALS AND METHODS

The first experiment was conducted in central Tamaulipas, Mexico in June-July 1989 and March-April 1990, prior to the arrival of Africanized bees. Sixteen trap sites were used each year, separated by a distance of at least 1.2 km from another trapping site. Each site contained two previously uninhabited, new duplex pulp pot bait hives suspended approximately 50 m apart (see Rubink et al. 1990 for additional details). Each of the two back-to-back cavities of one duplex trap was baited with a sealed 0.4 ml polyethylene Eppendorf micro centrifuge tube containing 0.3 ml of a 50:50 citral:geraniol mixture. In addition, each of the cavities of the second nearby duplex trap received an additional lure containing either a methanol solvent blank or a mixture of 3 Queen equivalents (Qeq) of synthetic honey bee queen mandibular pheromone (Slessor et al. 1988; 1990). In this experiment, one Qeq consisted of 175 μg 9-keto-2(E)-decenoic acid, 58 μg 9-hydroxy-2(E)-decenoic acid (69% R-(-), 31% S-(+)), 13 μg methyl *p*-hydroxbenzoate, and 2 μg 4-hydroxy-3-methoxy phenylethanol. The queen pheromone or solvent blank lures consisted of cotton wicks placed

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in Eppendorf tubes; the cover of each tube was opened after the lures were placed at colony entrances. The queen pheromone lures were color-coded, so that the experiments were conducted blind. Different individuals handled the Nasonov and queen lures to prevent contamination. Results were analyzed by a chi^2 test.

The second experiment was conducted in southern Louisiana in March-June 1991. Bait hives were set up in four sites: along the Mississippi River west and southeast of New Orleans, n=52; along the river south of Baton Rouge, n=52; along the Calcasieu and Sabine Rivers south and southwest of Lake Charles, n=40; and on docking facilities along the Intracoastal Waterway between Morgan City and New Iberia, n=16. Single, previously unoccupied pulp pots were placed individually at sites separated by at least 1 km from each other. Assignment of equal numbers of the four treatments within each area were done at random. Traps originally were deployed and baited between mid-October and mid-November 1990, and all pheromones were replaced between 15–30 March 1991. Bait hives were monitored at least every three weeks, and occupied hives were replaced with either a new bait hive or a depopulated, ether-cleaned hive; fresh pheromone baits also were added to replaced hives. All of the pheromone baits included a mixture of 30 μl citral and 30 μl geraniol, in Eppendorf tubes as described previously. The treatments tested included an additional tube with 1) 30 μl nerolic acid, 2) 30 μl hexanal, 3) 3 Qeq of queen mandibular pheromone as previously described, or 4) a second blank lure. The latter two treatments again were color-coded so that the queen pheromone portion of the experiment was conducted blind. Results were analyzed by a Wilcoxon Scores (Rank Sums) test, with each site considered to be one replicate; thus, df=3.

RESULTS

For experiment 1, using the paired bait hive design, traps baited with citral/geraniol alone attracted 2 swarms, while traps baited with citral/geraniol plus a queen pheromone lure caught 11 swarms (chi^2 0.005(1) = 7.88, $P<0.005$). The citral/geraniol plus queen pheromone treatment caught 8 swarms in 1989 and 3 in 1990, compared to 0 and 2 swarms, respectively, in the treatment with only citral/geraniol.

For experiment 2, the citral/geraniol/nerolic acid treatment caught the most swarms (51), followed by citral/geraniol/queen pheromone (43), citral/geraniol/hexanal (38), and citral/geraniol alone (25) (Table 1). The citral/geraniol/nerolic acid and the citral/geraniol plus queen pheromone treatments were not statistically different from each other ($P>0.1$), but citral/geraniol/nerolic acid caught significantly more swarms than either citral/geraniol or citral/geraniol/hexanal ($P<0.03$).

Table 1: Number of swarms captured. Treatments followed by the same letter were not significantly different.

Pheromone Blend	Site: New Orleans	Baton Rouge	Lake Charles	New Iberia	Total
citral/geraniol	10	7	6	2	25b
citral/geraniol/hexanal	16	12	9	1	38b
citral/geraniol/queen pheromone	17	13	11	2	43ab
citral/geraniol/nerolic acid	18	14	14	5	51a

DISCUSSION

The results of these studies confirm previous reports indicating that lures baited with citral, geraniol, and nerolic acid attract more swarms than those baited with citral and geraniol alone (Free et al. 1984; Schmidt and Thoenes 1992). Since nerolic acid is inexpensive, its use in combination with citral and geraniol is recommended. Based on our results, the use of hexanal to enhance swarm attraction to bait hives does not appear justified, although further work with this compound may be warranted.

The use of a second lure containing synthetic queen mandibular pheromone can improve bait hive functioning, as indicated by the higher trap catches reported in both our paired and single trap design experiments. These results were particularly evident in the Mexican experiment, where swarms were presented with choices of any existing natural cavity, traps baited with citral/geraniol, and traps baited with citral/geraniol plus queen pheromone. The high occupancy rate of the citral/geraniol plus queen pheromone traps in this experiment emphasizes that honey bee swarms are capable of sophisticated choices in nest sites when presented with options. In the Louisiana experiment, it would have been unlikely that an individual swarm would have discovered and had to choose between any two bait hives. In that experiment, the addition of queen pheromone marginally improved attraction over citral/geraniol alone, but the citral/geraniol/nerolic acid combination proved the most effective.

Previous reports with one queen pheromone component, 9-keto-2(E)-decenoic acid, used in combination with Nasonov pheromone blends, were ambiguous (Free et al. 1984; Kigatiira et al. 1986), possibly because they did not use the complete, five-component pheromone. Indeed, other queen pheromone functions such as formation of a worker retinue around the queen, inhibition of queen rearing, and attraction of workers to the queen during swarming also required the full blend to duplicate the queen's mandibular gland effects (Winston and Slessor 1992).

Queen pheromone used alone is not attractive to swarms (Denby and Scott-Dupree in prep.; unpublished observations), so the use of queen pheromone lures should be in combination with Nasonov-based lures. We currently are conducting tests of queen pheromone deployed in conjunction with a citral/geraniol/nerolic acid lure, which may provide the best attraction. Further work with pheromone blends, including different proportions of components as well as brood and other queen pheromones, might increase swarm attraction even further.

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