Monitoring the Small Hive Beetle Aethina tumida (Coleoptera: Nitidulidae) with Baited Flight Traps: Effect of Distance from Bee Hives and Shade on the Numbers of Beetles Captured

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MONITORING THE SMALL HIVE BEETLE *AETHINA TUMIDA* (COLEOPTERA: NITIDULIDAE) WITH BAITED FLIGHT TRAPS: EFFECT OF DISTANCE FROM BEE HIVES AND SHADE ON THE NUMBERS OF BEETLES CAPTURED

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The small hive beetle, *Aethina tumida* Murray, is an invasive African native that has become established in North America and Australia, where it is now an important pest of European honey bees, *Apis mellifera* L. Its presence in North America was first detected in Florida in 1998 (Division of Plant Industry Entomology Sample 1998: 1555), but subsequent identification of earlier specimens from South Carolina indicates that it became established at least as early as 1996 (Hood 2000). By 2003, the beetle had spread to 29 states, ranging from Florida to Maine and west to Louisiana and North Dakota (Neumann & Elzen 2004).

Field evaluations of a baited flight trap (designed by B. Torto) for detecting and monitoring the beetle showed an unexpected lack of negative correlation between trap catch and distance from bee hives but suggested a strong positive influence of shade (Arbogast et al. 2007). It was hypothesized that the expected correlation was abolished by shade, because the traps were distributed almost equally between sunny locations and locations shaded by small clumps of trees, and the trees were distributed over a wide range of distances from the hives.

The present paper reports the results from a subsequent study (Aug 2006 through Oct 2007) that more closely examined the relationships among trap catch, distance, and shade. The study site located just south of Hatchet Creek and east of County Road 225 in Alachua County, Florida (N 29°44.07', W 82°16.51') consisted of 2 fields bordered by hardwoods and pine, and joined by a short, narrow corridor. The vegetation of the fields consisted of tall grass, blackberry bushes, various wild flowers, and scattered clumps of trees, mostly small pines. There were 15 to 20 bee hives in one of the fields, near the corridor joining the fields.

We laid out an array of 12 traps in the fields and the surrounding woods so that the hives were essentially encircled by traps. The bearing and distance of each trap from the hives was determined by compass and laser rangefinder (Laser 1200, Nikon Inc., Melville, NY). When a direct line of sight between the hives and a trap was obstructed by vegetation, we took a series of readings and calculated the resultant vector. Five traps were placed just inside the woods (10 to 148 m from the hives), where the hardwood canopy provided shade throughout the day. The remaining traps were placed in the fields (66 to 157 m from the hives), either near the edge of the woods or in clusters of trees, where they received partial shade.

Each trap (Arbogast et al. 2007) was baited with 100 g of yeast-inoculated pollen dough tied in a cotton stockinette. The pollen dough was obtained commercially from Global Patties (Airdrie, Alberta, Canada) and inoculated with the yeast *Kodamaea ohmeri* isolated from the beetle (Torto et al. 2007). An insecticidal strip (Vaportape® II, Hercon Environmental, Emigsville, PA) was placed in the bottom of each trap to kill trapped beetles. The traps were suspended about 1 m above the ground on supports made with 2 sections of steel pipe connected at right angles. From Aug through Oct 2006 and from Apr through Oct 2007, the traps were checked weekly and the captured beetles counted. During the cooler months, Nov through Mar, the traps were checked and the beetles counted at monthly intervals. Bait and insecticidal strips were changed every 2 weeks or monthly.

Altogether, 506 small hive beetles were captured during the 63-weeks trapping period, 84% of which were captured in the woods (Fig. 1A). The mean number of beetles per trap in the woods (85.4) was significantly higher than in the field (11.3) (χ^2 one-sample test, $P < 0.01$) (Siegel 1956).

For each trap, the number of observations with at least 1 small hive beetle was divided by the total number of observations (41) and multiplied by 100 to determine percentage frequency of capture. The relationship between this frequency and distance from the hives (Fig. 1B) was analyzed by linear regression (Systat Software 2006). Slopes and elevations of the regression lines were compared by methods outlined by Zar (1999). When all 12 traps were included together, regression analysis showed no significant relationship between frequency of capture and distance ($F_{(1, 10)} = 2.174$, $P = 0.171$). However, when the traps in shade and those in partial shade were analyzed separately, frequency of capture declined with distance in both instances (Fig. 1B), and the rates of decline were

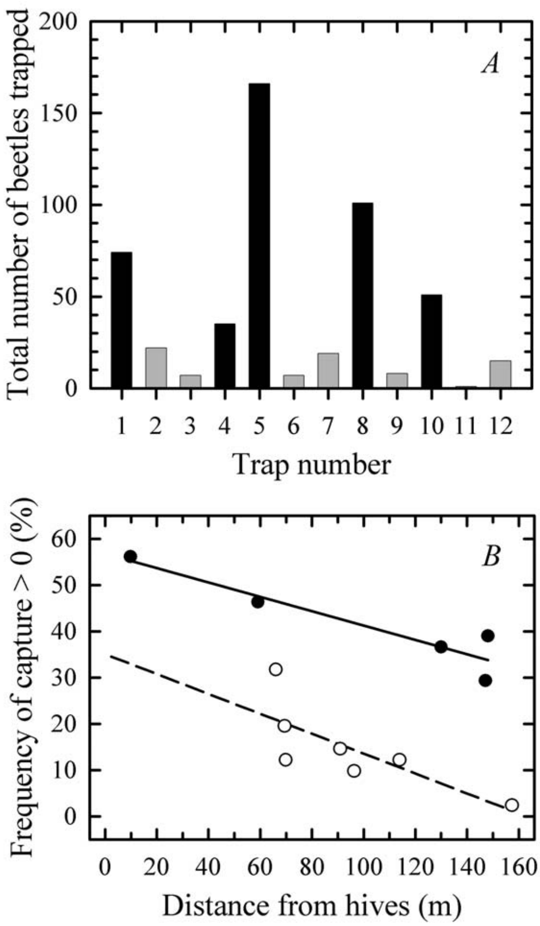

Fig. 1. Capture of *A. tumida* by baited flight traps in the vicinity of an apiary near Gainesville, FL. (A) Total number captured by each of 12 traps during the period 11 Aug 2006 - 19 Oct 2007. Black bars represent traps shaded by forest canopy, and gray bars represent traps in partial shade. (B) Relationship between frequency of trap captures greater than zero and distance of the traps from bee hives. Traps shaded by forest canopy (solid circles): $y = 56.74\ (\pm\ 3.78) - 0.155\ (\pm\ 0.03)\ x$. ($R^2 = 0.877$ and $F_{(1, 3)} = 21.39$, $P = 0.019$). Traps in partial shade (open circles): $y = 35.00\ (\pm\ 7.96) - 0.215\ (\pm\ 0.08)\ x$. ($R^2 = 0.591$ and $F_{(1, 5)} = 7.215$, $P = 0.044$). Numbers in parentheses indicate standard errors.

not significantly different ($t = 0.756$, 8 DF, $P > 0.05$). Thus the two regression lines can be considered parallel with a common slope of -0.172 percentage points of frequency/m from the hives. The regression line for shade was significantly higher than that for partial shade (Fig. 1B) ($t = 6.365$, 5 DF, $P < 0.01$), indicating a consistently higher frequency of capture in the shade.

These findings confirm the strong positive influence of shade suggested by Arbogast et al. (2007) and show the expected negative correlation with distance. We conclude that the probability of detecting small hive beetles with baited flight traps is highest when the traps are located in full shade and that the probability of detection declines with distance from bee colonies.

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Summary

In the vicinity of bee hives, flight traps baited with yeast-inoculated pollen dough captured more small hive beetles in shade than in partial shade, and the frequency of capture declined with distance from the hives. Thus, the probability of detecting the beetles in apiaries can be maximized by placing the traps in full shade and as near as possible to the hives.

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