Evaluation of Multiple-Funnel and Slot Traps for Collection of Southern Pine Bark Beetles and Predators[1]

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Abstract Pheromone-baited traps are frequently used for research or in monitoring populations of bark beetles such as the southern pine beetle, *Dendroctonus frontalis* Zimmermann, and *Ips* spp. which are important pests of southern pines. We compared the effectiveness of two commercially available trap designs, the multiple-funnel trap and the slot trap, for collection of *D. frontalis,* three species of *Ips,* and two of their common predators. Slot traps captured greater numbers of bark beetles while multiple-funnel traps captured more predators. Multiple-funnel traps were judged to be easier to transport and check in the field. This study indicates that slot traps are preferable for monitoring southern bark beetles with the least disruption to natural enemy populations, while multiple-funnel traps are better for monitoring bark beetle/predator ratios. Due to ease of checking and handling, multiple-funnel traps are preferable for uses that involve large numbers of traps, long-distance manual hauling, or frequent relocation of traps.

Key Words Bark beetles, multiple-funnel traps, slot traps, *Dendroctonus frontalis, Ips* spp., bark beetle predators

Bark beetles in the genera *Dendroctonus* and *Ips* (Coleoptera: Scolytidae) are important pests of commercially valuable southern pines. Estimated losses and costs of control from 1972 to 1991 were $150 million in Georgia alone (Douce 1993). In the south, pheromone traps are used to predict population trends of the southern pine beetle, *D. frontalis* Zimmermann (Billings 1988). In other regions, they have been used in mass trapping of bark beetles (Bedard and Wood 1981, König 1992, Raty et al. 1995) and in monitoring of bark beetle predators (Wainhouse et al. 1992). Trap form can have a significant impact on bark beetle trapping efficiency (Borden et al. 1982). Two trap designs that have been used extensively in studies of bark beetles are the multiple-funnel trap (Lindgren 1983) and the slot trap (Neimeyer et al. 1983) (Fig. 1). The multiple-funnel trap consists of a vertical series of black funnels (usually 8 or 12) leading to a collection cup at the bottom of the trap, and offers a vertical, tree-like silhouette to approaching insects. The slot trap is also black, but has a rectangular shape. Each of the two broad surfaces of the slot trap has 18 horizontal slots, and the sides each have six vertical slots. A collection tray is located at the bottom of the trap. The two trap types are similar in surface trapping area. The area of the 12-funnel trap is approximately 5832 cm^2, using the formula for the lateral area

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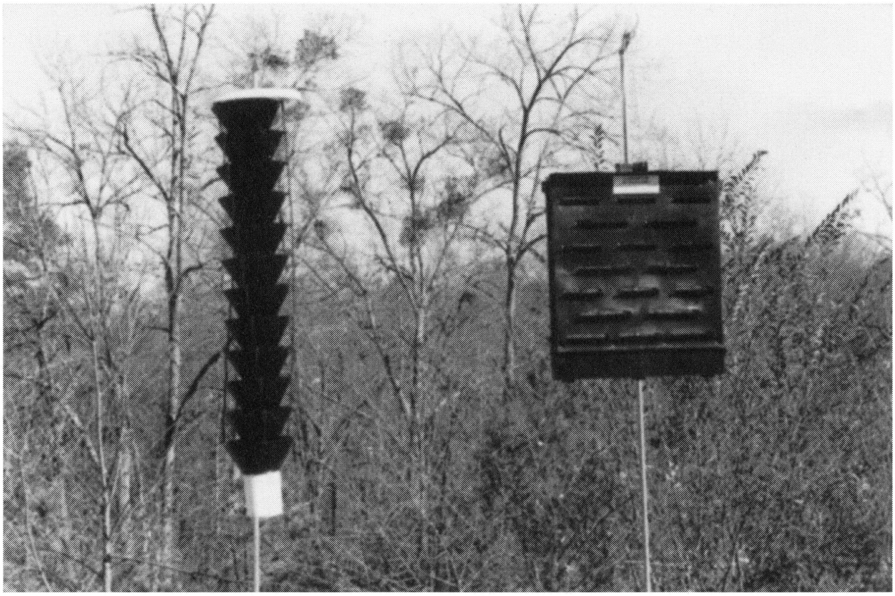

Fig. 1. Multiple-funnel (left) and slot trap.

of a cylinder; whereas, the area of the slot trap is approximately 5519 cm^2. Top surfaces and collection containers were excluded from measurements. Both types can be considered as silhouette interception traps (Chénier and Philogène 1989), onto which the beetles land and then are captured as they fall passively (Niemeyer 1985). Our objective was to compare the effectiveness of the 12-unit multiple-funnel trap and the slot trap in collection of *D. frontalis,* southern *Ips* spp., and their common natural enemies.

Materials and Methods

***Ips* trapping.** Trapping for *Ips* spp. was done from 9 September to 17 November 1995 at three sites in the Oconee National Forest in Putnam Co., GA. Sites were located in loblolly pine (*Pinus taeda* L.) stands that had recently received cut-and-leave treatments (felling of trees that contain southern pine beetle brooks, plus a buffer zone of uninfested trees) (Billings 1981) for southern pine beetle control. At each site, four traps were set up in two pairs, with each pair consisting of one multiple-funnel trap (Phero Tech, Delta, BC, Canada) and one slot trap (Theysohn, Salzgitter, Germany). Pairs were located at least 15 m apart, and traps within pairs were located 1.5 m apart and oriented in the same direction, which was randomly determined. Traps were set up so that the midpoint of each trap was approximately 1.9 m high. At two of the sites traps were baited with 2 ml elution vials containing ipsdienol, a lure which is attractive to *I. avulsus* Eichhoff and *I. calligraphus* (Germar) (Renwick and Vité 1972). At the third site traps were baited with ipsenol, an attractant for *I. grandicollis* Eichhoff (Vité et al. 1976). Elution vials included a wick inserted through a hole drilled in the vial cap. Elution vials were attached at the midpoint of the traps. Pieces of insecticidal strips (Ectrin® insecticidal cattle ear tags, Fermenta Animal Health, Kansas City, MO) were placed in the collection containers to quickly kill collected insects. Traps and baits were checked at approximately 5-d intervals, and insects were collected when at least 20 *I. avulsus* (for ipsdienol sites) or 10 *I. grandicollis* (for ipsenol sites) were contained in a single trap. Trap location within each pair was switched at each collection. Four collections were made. Collected insects were returned to the laboratory and *Ips* beetles and the predators *Temnochila virescens* (F.) (Coleoptera: Trogossitidae) were identified and tallied.

Southern pine beetle trapping. *Dendroctonus frontalis* and their predators were collected in an active beetle infestation, in a *P. taeda* stand at Oconee National Forest in Putnam Co., GA. Trapping was done from 12 August to 30 August 1997. Four pairs of traps were set up, with each pair consisting of one of each trap type. Distances between traps and height of traps were the same as for *Ips* trapping. Traps were baited with the southern pine beetle attractant frontalure, a 2:1 mixture of turpentine and frontalin (Kinzer et al. 1969). Baits were contained in 4-ml elution vials with holes drilled in the top. Portions of insecticidal cattle ear tags were placed in collection containers as in the *Ips* trials. Traps and baits were checked, and insects collected, every other day, at which time trap locations were switched within each pair. Eight collections were made. Collected insects were returned to the laboratory where *D. frontalis* and the predator *Thanasimus dubius* (F.) (Coleoptera: Cleridae) were identified and tallied.

Statistical analysis. Differences in captures between trap types were analyzed using paired *t*-tests for *D. frontalis, I. avulsus,* and *T. dubius.* Transformations of data for *D. frontalis* (natural logarithm) and *T. dubius* (square root [x] + 0.5) were done to satisfy assumptions of normality and homogeneity of variances. Because of relatively low numbers of trap captures (*I. calligraphus* and *T. virescens*) and paired comparisons (*I. grandicollis*) capture data for these species were analyzed using the nonparametric Wilcoxon's signed ranks test (Sokal and Rohlf 1995). Collections in which no beetles of a given species were collected in either trap type were omitted from the analyses. All analyses were done using SigmaStat for Windows, Version 2.0 (Jandel Scientific 1994).

Results and Discussion

Mean numbers of captures per trapping period for each bark beetle species and predator are shown in Figs. 2 and 3. Slot traps captured significantly greater numbers of *I. avulsus* (t = 2.291; df = 15; P = 0.037) and *I. grandicollis* (W = 23.0; n = 8; P = 0.047) than multiple-funnel traps. Captures of *D. frontalis* and *I. calligraphus* by the two trap types were approximately equal. Niemeyer (1985) found that slot traps caught significantly greater numbers of *I. typographus* (L.) than did multiple-funnel traps (eight-funnel type) in a study of bark beetle trap designs in Germany; whereas, McLean et al. (1987) found no consistent differences in catches of the ambrosia beetle, *Trypodendron lineatum* (Oliver) (Coleoptera: Scolytidae), between the two trap types. It has been suggested that *D. frontalis* host location and selection is done by random landing, guided by its strong preference for vertical objects (Gara et al. 1965). If so, this might explain why the multiple-funnel traps, with an obvious vertical silhouette, were relatively more efficient in capturing *D. frontalis* than *Ips* spp. The

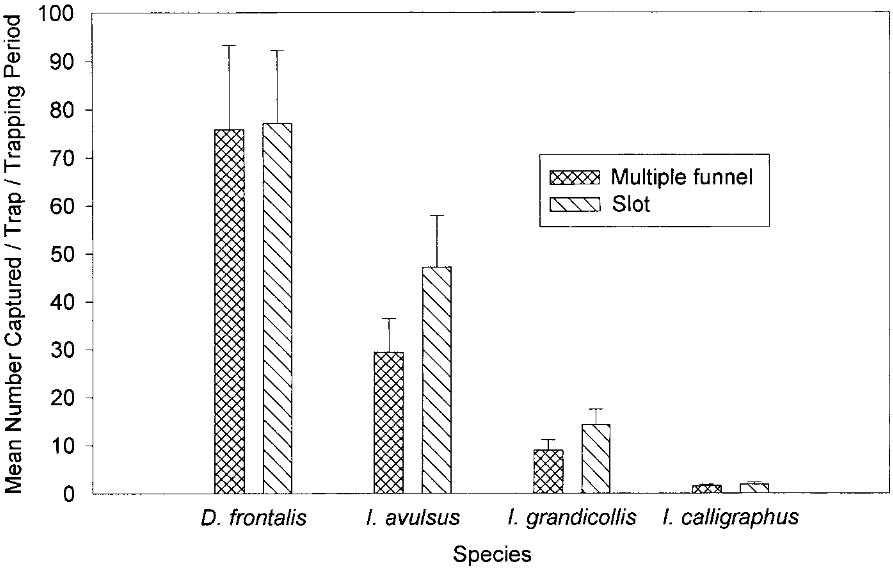

Fig. 2. Mean (+ one SEM) numbers of bark beetles captured/trap/trapping period in multiple-funnel and slot traps.

ratio of *D. frontalis* to *Ips* captured was 1.90 for the multiple-funnel traps and 1.22 for the slot traps.

Multiple-funnel traps captured significantly greater numbers of *T. dubius* ($t = 5.721$; df = 30; $P < 0.001$) and *T. virescens* ($W = 132.0$; $n = 19$; $P = 0.002$) than slot traps (Fig. 3). Both species were three to four times more prevalent in multiple-funnel traps than slot traps. The ratio of *Ips* to predators was 14.94 for slot traps, but only 3.23 for multiple-funnel traps. Likewise, slot traps caught 18.20 times as many *D. frontalis* as predators; whereas, multiple-funnel traps caught only 6.14 times as many. These results could be due to the difference in sizes of the collection container openings of the two traps. The diameter of the circular opening in the multiple-funnel trap measures 68 mm; whereas, the opening in the slot trap is only 5.5 mm wide. The predators trapped in this study range in length from about 8 mm for *T. dubius* to 20 mm for *T. virescens,* and some may be excluded by the narrow opening of the slot trap. However, Ross and Daterman (1998) found no difference between unmodified multiple-funnel (16-unit) and slot traps in selectivity for Douglas-fir beetles, *Dendroctonus pseudotsugae* Hopkins (Coleoptera: Scolytidae), relative to *Thanasimus undatulus* (Say) (Coleoptera: Cleridae). They also found that placing metal screens above the collection cup or providing a strip of metal screen to serve as an escape route reduced the number of predators captured in multiple-funnel traps.

In terms of storage, transport, and ease of use, slot traps are somewhat bulkier and heavier than multiple-funnel traps. Slot traps weigh 2.4 kg vs. 1.06 kg for the multiple-funnel trap, which can be collapsed to approximately 0.06 m^3. The opening of the collection container top of the slot trap is a narrow slit, and insects cannot be viewed through it, making it impossible to spot-check without removing the collection

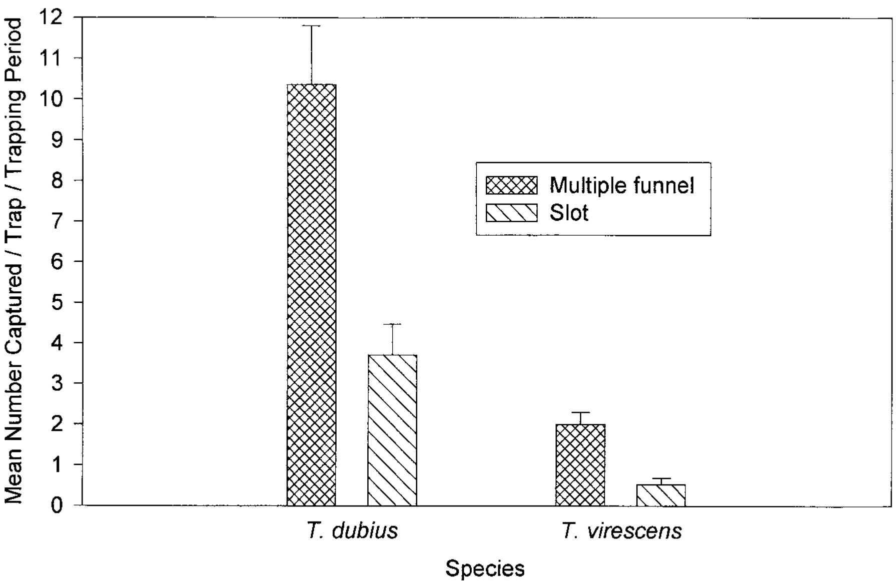

Fig. 3. Mean (+ one SEM) numbers of bark beetle predators captured/trap/trapping period in multiple-funnel and slot traps.

container. The collection container is black on slot traps, making it more difficult to see and count bark beetles. The beetles are more easily seen and counted in the white container of the multiple-funnel trap. Finally, the multiple-funnel trap allows insects to be collected either dry or in a liquid preservative, whereas the slot trap, unless modified, can only be used for dry trapping. The multiple-funnel trap (12 funnels) costs (1999 prices in U.S. dollars) $36.51 per trap vs. $30.00 for the slot trap. An eight-unit multiple-funnel trap costs $29.24.

Both trap types are capable of effectively capturing large numbers of these four major species of southern pine bark beetles. The slot trap was generally more effective at capturing *Ips* beetles, but the two trap types collected *D. frontalis* equally well. The fact that two such radically different trap designs work equally well for *D. frontalis* suggests that researchers should look to factors other than trap design in attempts to improve monitoring systems for this species.

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