Spatial Displacement of a Lure Component Can Reduce Catches of Two Nontarget Species During Spring Monitoring of Southern Pine Beetle

William P. Shepherd¹ and Brian T. Sullivan

USDA Forest Service, Southern Research Station, 2500 Shreveport Highway, Pineville, LA 71360 and ¹Corresponding author, e-mail: williamshepherd@fs.fed.us

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Abstract

Local outbreak risk for the southern pine beetle, Dendroctonus frontalis Zimmermann (Coleoptera: Curculionidae), is forecast with a trapping survey conducted every spring throughout the southeastern United States. Traps baited with pine odors and components of the D. frontalis aggregation pheromone are used to obtain abundance estimates of both this species and its clerid predator Thanasimus dubius (E) (Coleoptera: Cleridae); these data are entered into a predictive model that estimates outbreak risk. An attractant synergist for D. frontalis, endo-brevicomin, has recently been included in the survey lure, but it can have the unintended effect of attracting nontarget species Hylesinus pruinosus Eichhoff (Coleoptera: Curculionidae: Scolytinae) and Enoclerus nigripes (Say) (Coleoptera: Cleridae) which, due to their sometimes large numbers and general similarity in appearance to the target species, could complicate sorting and counting of trap catches. Analysis of bycatch data from a previously-published, 31-mo trapping study in Mississippi indicated that displacement of the endo-brevicomin releaser 6 m from the trap largely eliminated catches of the nontarget species H. pruinosus and E. nigripes while not reducing catches of the target species D. frontalis and T. dubius. Our analysis demonstrates that interspecific differences in spatial responses to attractive semiochemicals can be used to improve insect trap selectivity. Both nontarget beetle species were captured in highest numbers during late winter/early spring, coinciding with the D. frontalis survey.

Key words: Hylesinus pruinosus, Enoclerus nigripes, Dendroctonus frontalis, Thanasimus dubius, bycatch

The southern pine beetle, Dendroctonus frontalis Zimmermann (Coleoptera: Curculionidae) is a native pest species that causes significant economic losses to pine forests in the southeastern United States (Price et al. 1998). Adult D. frontalis use an aggregation pheromone to organize mass attacks that can overwhelm the defenses of healthy host trees (Sullivan 2011). They then feed and reproduce in the phloem of the host which inevitably dies as a result of colonization. Beetles disperse in the spring and, when population densities are sufficient, may initiate localized infestations or ‘spots’ that consist of patches of adjacent, infested trees. Infestations may grow through the spring and summer, but this growth may be suppressed through felling of infested and adjacent trees (Billings 2011). D. frontalis outbreaks occur periodically and may last for several years (Turchin et al. 1991, Birt 2011).

Outbreaks may not be apparent until summer when flagging of foliage of killed trees becomes visible (Billings and Kibbe 1978). Therefore, every spring a network of traps is established throughout the southeastern United States to detect whether outbreak-level populations of D. frontalis exist and to make forecasts regarding the abundance of infestations which may require control during the following summer (Billings and Upton 2010, Billings 2011). Until this year (2017), traps have been baited with an aggregation pheromone component (frontalin) and host volatiles (pine terpentine or a mixture of alpha- and beta-pinene); this combination attracts both D. frontalis and a major predator, Thanasimus dubius (E) (Coleoptera: Cleridae). The numbers of D. frontalis, as well as the proportion of T. dubius trapped, are entered into a model used to predict population levels and infestation trends later in the year (Billings 2011). The ability to predict the severity of an outbreak months in advance allows forest pest managers to more effectively plan for spot detection and suppression activities.

The male-produced pheromone component endo-brevicomin is a potent synergist of the combination of frontalin and host compounds in attracting D. frontalis to traps located outside of beetle infestations (Sullivan et al. 2007). Furthermore, the degree of catch enhancement is similar or increased when an endo-brevicomin lure is displaced a few meters from (as opposed to being placed directly on) a trap baited with the other lure components (Moreno et al. 2008, doi: 10.1093/jisesa/iex106

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Materials and Methods

Detailed methods for the trapping experiment are given in Sullivan et al. (2016) and are summarized here. Six 12-unit Lindgren multiple-funnel traps were spaced 450–720 m apart within mixed pine/hardwood forests in the Homochitto National Forest, Mississippi (within 5 km of W91.200, N31.419). Traps were suspended from metal standards with their collection cups approximately 1 m above the ground. Each trap was baited with devices releasing frontalin (>95% purity, racemic; release rate = 1–5 mg/d) and alphapinene (>95% purity, 23% (+)-enantiomer; release rate = 1–5 g/d), both from Synergy Semiochemicals, Vancouver, British Columbia, Canada. A third lure (racemic endo-brevicomin; >95% purity; release rate = 0.25–1.5 mg/d; Synergy Semiochemicals) was either absent, placed directly on the trap, or positioned 6 m east of the trap at 1.5 m height. Release rates of each lure were measured gravimetrically in a fume hood at room temperature (20–24°C) prior to initial deployment and after removal from the trap. We observed a substantial decrease in release over the lifetime of each lure, and this is reflected in the ranges of release rates reported above. Traps were grouped into two lines of three traps, then one of each of the three treatments were assigned randomly to each trap of the group. Treatments were then rotated (by movement of endo-brevicomin lure) continuously through the three positions of each group; treatments were reassigned at the time of catch collection. Collections were made approximately biweekly between 6 February 2009 and 6 September 2011. All D. frontalis, T. dubius, H. pruinosus, and E. nigripes were sorted and counted.

We analyzed these data to determine whether displacement of the endo-brevicomin lure significantly altered the ratios of bycatch species relative to the target species with which they might potentially be confused (i.e., the ratio H. pruinosus to D. frontalis, and E. nigripes to T. dubius). Two data subsets were created for H. pruinosus and E. nigripes, respectively, from the 31 mo of trapping, by including only groups of three consecutive collections (i.e., approx. 6 wk; one complete lure rotation) during which at least one individual was trapped; periods in which no or merely sporadic H. pruinosus or E. nigripes catch occurred were considered irrelevant to our question of interest. Catches were then averaged within treatment and trap to obtain six averages (one per trap) for each treatment. Mean catches per trap per day were cube root transformed to meet assumptions of normality and homoscedasticity prior to analyses. The ratios of E. nigripes to T. dubius and H. pruinosus to D. frontalis were calculated for each trap from the untransformed catches and were log transformed. Transformed mean catches for each species and ratios between species were analyzed for treatment effects with ANOVAs using model factors treatment and trap within group (PROCGLM, SAS 9.4). We calculated all pairwise comparisons of treatment means for each species and nontarget/target species ratios using LSD with Bonferroni correction (α = 0.05).

Results

Both H. pruinosus and E. nigripes were trapped predominantly in the spring with very few caught during the other seasons (Fig. 1). When data were limited to collections from 6-wk intervals in which at least one nontarget beetle was caught, treatment differences were significant for D. frontalis (F = 79.5; df = 2,10; P < 0.0001), H. pruinosus (F = 38.1; df = 2,10; P < 0.0001), and E. nigripes (F = 30.8; df = 2,10; P < 0.0001). For both nontarget species, catches were significantly higher in traps with endo-brevicomin attached directly to them rather than displaced 6 m away, while the reverse was observed for D. frontalis (Table 1). Treatment differences were significant for both the ratios of H. pruinosus to D. frontalis (F = 101.8; df = 2,10; P < 0.0001), and E. nigripes to T. dubius (F = 42.1; df = 2,10; P < 0.0001). Both ratios were significantly higher (P < 0.001) for collections from traps with the endo-brevicomin device attached directly to them compared to those from traps with the endo-brevicomin device positioned 6 m away (Table 1). Highest ratio of H. pruinosus to D. frontalis in any single trap was 57.1:1 (3,633 H. pruinosus and 98 D. frontalis; recorded in late March/early April 2010); the highest recorded ratio of E. nigripes to T. dubius was 1.2:1 (117 E. nigripes and 98 T. dubius; recorded in late February 2011). Both of these extremes were recorded from traps on which the endo-brevicomin lure was attached directly.

Discussion

Undesired bycatches of two potentially confounding species were reduced to low numbers by removing one lure component a few meters from the trap. Changing the placement of an olfactory lure relative to the trap appears to be a novel method for minimizing bycatches while maintaining levels of target species catches. Other methods have been identified for reducing catches of nontarget species for the purpose of improving sorting efficiency or protecting beneficial insects. These include altering the types or enantiomeric blends of chemicals used (Raffa and Klepzig 1989, Aukema et al. 2000, Panzavolta et al. 2014), and altering the design of traps (e.g., adding a mesh screen to prevent entry) to restrict the size of insects that can enter (Ross and Daterman 1998, Martin et al. 2013). Use of specific trap colors has been shown effective in lowering natural enemy and pollinator trap catches (Weber et al. 2005, Mori and Evenden 2013, Spears et al. 2016).
It is possible that lowering the release rate of the endo-brevicomin device placed directly on the trap would likewise have reduced the proportion of the bycatch species. An endo-brevicomin dose-response study (with endo-brevicomin devices located on the traps and trapping methodology otherwise similar to the present study; Sullivan 2016, authors’ unpublished data) suggested that slightly lowering the release rate of endo-brevicomin from than that used in the present study might significantly increase D. frontalis and decrease H. pruinosus catches. However, in this aforementioned study, at the most attractive release rate of endo-brevicomin for D. frontalis (approximately 0.16 mg/d), the ratio of trapped H. pruinosus to D. frontalis was still nearly 1:1. This suggests that lure rate adjustment could not duplicate the bycatch reduction effects of lure displacement.

Table 1. Mean ± SE catch per day and ratios of catches of target and nontarget species in traps baited with attractive lures for D. frontalis over a 31-mo interval

| Species Category | Absent | On trap | 6 m away |
|------------------|--------|---------|----------|
| E. nigripes      | 0.003 ± 0.002a | 0.462 ± 0.170b | 0.014 ± 0.007a |
| T. dubius        | 2.980 ± 0.340a | 2.971 ± 0.358a | 3.265 ± 0.511a |
| H. pruinosus     | 0.001 ± 0.001a | 0.185 ± 0.082b | 0.004 ± 0.002a |
| D. frontalis     | 0.893 ± 0.141a | 3.257 ± 0.236b | 14.867 ± 2.616c |
| H. pruinosus/D. frontalis | 0.009 ± 0.004a | 2.957 ± 1.157b | 0.022 ± 0.007a |

*Mean catch of each of six traps (n = 6) including averaged catches only from 6-wk intervals in which at least one individual of the nontarget species was trapped (see text).

**Means associated with the same letter were not significantly different within species or species combination (α = 0.05; LSD with Bonferroni correction).**

Fig. 1. Catches of clerid predator Enoclerus nigripes and ash bark beetle Hylesinus pruinosus in multiple funnel traps during 31 mo of trapping in the Homochitto National Forest, Mississippi. Traps were baited with frontalin, alpha-pinene, and a device releasing endo-brevicomin that was located either on the trap or 6 m away. Lure treatments were exchanged among traps so that approximately every 6 wk the treatments were rotated through every trap position. Hence, to balance site effects for trap, mean values shown are the average catches over 6 wk (i.e., a complete rotation). The higher catches of these two species in traps to which the endo-brevicomin device was attached directly contrasts with the response of southern pine beetle, Dendroctonus frontalis and its clerid predator, Thanasimus dubius, caught in the same traps (Sullivan et al. 2016). These latter species either did not discriminate (T. dubius) or showed a preference for traps with displaced endo-brevicomin (D. frontalis), which is a potent attractant synergist for D. frontalis.

For both H. pruinosus and E. nigripes, annual flight peaked in late winter through early spring (February through April) and overlapped with the springtime burst of flight activity of both D. frontalis (February through June) and T. dubius (February through April) (Sullivan et al. 2016). The period of H. pruinosus and E. nigripes peak flight also coincides with the period when traps for the annual D. frontalis forecasting survey are deployed (the 4 wk following bloom of dogwood, Cornus florida L., and, in a recently revised protocol, the bloom of eastern redbud, Cercis canadensis L.; John T. Nowak, personal communication).

endo-Brevicomin is an attractant synergist for D. frontalis that is unusual in its capacity to enhance attraction of this species to sources of attractive lure components (frontalin and host odors) over a radius of at least tens of meters while simultaneously having no
tendency to increase attraction to its own point of release (Sullivan and Mori 2009). Thus, it is not necessary for the compound to be released from an attractant-baited trap for D. frontalis catches to be enhanced. However, removal of the endo-brevicomin device from the trap greatly reduced catches of H. pruinosus and E. nigripes, suggesting that these species orient close to the source of endo-brevicomin which is for them an attractant rather than a synergist (Shepherd et al. 2010). Simultaneously, T. dubius shows behavioral responses to endo-brevicomin (Salom et al. 1992, Sullivan et al. 2016), and therefore its placement is irrelevant to this species. Our study demonstrates that interspecific differences in spatial behavior to attractive semiochemicals among insect species can be exploited in order enhance the targeting of particular species.

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