

# Effects of trap shape, size, and color variations on capture rates of *Chrysobothris* (Coleoptera: Buprestidae) and related buprestids

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Trap design and capture rates for crop pests are pivotal factors in pest management strategies for tree nurseries (LeBude et al. 2012; Frank et al. 2013). Often, traps need to be designed uniquely for the targeted pest (Vinatier et al. 2012; Cavaletto et al. 2020). Trapping methods have been evaluated for some important metallic wood-boring beetle pests (Coleoptera: Buprestidae) such as emerald ash borer, *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae) (Oliver et al. 2003; LeBude & Adkins 2014; Haack & Petrice 2019), but the genus *Chrysobothris* Eschscholtz (Coleoptera: Buprestidae) is less well studied. *Chrysobothris* are problematic in ornamental tree nurseries on genera such as *Acer* (Sapindaceae), *Cornus* (Cornaceae), and *Malus* (Rosaceae), thus requiring more focused management research (Oliver et al. 2010; Dawadi et al. 2019; Addesso et al. 2020). The objective of this study was to develop suitable traps for buprestid borers commonly found in ornamental tree nurseries. *Chrysobothris* and related buprestids are attracted to purple-colored traps that have a peak reflectance near infrared (~740 nm) (Imrei et al. 2020; Perkovich et al. 2022). To optimize the trap style, the first experiment analyzed trap material, shape, and size. A second experiment further optimized trap design. These trap trials were conducted in 2004 and 2005 with emerald ash borer as the original target for monitoring. Growing concerns about *Chrysobothris* damage in nurseries led to a revisit of these data collections to assess the trap preference of the *Chrysobothris* genus.

A CM2600d spectrophotometer (Konica Minolta Sensing Americas, Inc., Ramsey, New Jersey, USA) was used to determine reflectance characteristics (i.e., lightness [ $L^*$ ], red to green [ $a^*$ ], blue to yellow [ $b^*$ ], and peak reflectance [ $PR$ ]) of traps and trapping materials. Settings for the spectrophotometer were as follows: observer illuminant Daylight 65, observer angle at 10° (CIE 1964 color space), and included specular component SCI and UV at 100% (see Werle et al. 2014 and Perkovich et al. 2022 for further details). Using traps with similar reflectance values and previously demonstrated efficacy for buprestid traps (Perkovich et al. 2022), 12 trap designs were field evaluated for efficiency at capturing *Chrysobothris* and related buprestid species beginning in Apr 2004. Trap designs were made from panels of corrugated plastic (Coroplast, LLC, Vanceburg, Kentucky, USA) or wood and were covered with colored insect glues (Brooks 1919) created by mixing Folkart® 654 (amethyst) or 411 (purple) acrylic violet-like paints (Plaid Enterprises, Inc., Peach Tree Corners, Georgia, USA) into clear Pestick™ glue (Hummert International, Earth City, Missouri, USA) (mix rate: 1 kg glue per 34 g paint). Glitter glue was made by mixing Poly\*Flake

purple glitter (Glitterex Corp., Cranford, New Jersey, USA) into clear Pestick™ glue (mix rate: 1 kg glue per 21 g glitter). All traps were placed at ground level. Corrugated plastic panel traps included purple traps 3.8, 15.2, or 30.5 cm wide × 1 m tall (covered with clear unmodified glue), or white traps 3.8 cm wide (covered with clear unmodified, purple glitter, amethyst, or purple glues). The corrugated box trap treatment had four 3.8 cm wide purple panels covered with clear unmodified glue. Tan-colored wooden traps consisted of 1.9 × 3.8 cm posts that were 1 m in height covered with clear unmodified, purple glitter, amethyst, or purple glues (see Table 1 for details of trap design combinations and materials used). Traps were placed in a randomized complete block design using 4 replicates along the edge of a mixed deciduous forest on the Tennessee State University Otis L. Floyd Nursery Research Center in McMinnville, Tennessee, USA. There were 5 m between each block, and each trap treatment was placed 2 m apart. Beetles were collected from traps weekly, cleaned in Histo-Clear™ II (National Diagnostics, Atlanta, Georgia, USA) and 70% ethanol (diluted from 200 proof ethanol, Fisher product #BP2818-4; Fisher Scientific, Pittsburgh, Pennsylvania, USA), then frozen until identification to species using Downie and Arnette (1995). Species in the *Chrysobothris femorata* (Olivier) (Coleoptera: Buprestidae) complex were identified with revised keys (Wellso & Manley 2007).

In Apr 2005, 7 new trap design treatments were tested based on the 2004 test results. Treatments included: (1) triangular prism traps with 15.2 cm wide panel sides (created by folding a plastic panel to create three 15.2 cm wide sides) with clear glue; (2) 30.5 cm purple plastic panel with clear glue; (3) 15.2 cm purple plastic panel with clear glue; (4) 30.5 cm white plastic panel with purple glue; (5) 3.8 cm wooden stake with clear glue; (6) 3.8 cm wooden stake with purple glue; and (7) a purple plastic box with 3.8 cm wide sides with clear glue. All traps were 1 m tall and placed at ground level. Specimen collection, handling, and identification were conducted as previously described.

The effect of trap design in both the 2004 and 2005 studies were analyzed using generalized linear mixed models. The model included number of individuals (buprestids, *Chrysobothris*, *Chrysobothris* females, and *Chrysobothris* males) collected (as dependent variables) and trap designs (as independent variable) throughout the trapping season (negative binomial distribution). Models were fitted using the “glmer.nb” function in the lme4 (Bates et al. 2017) package in R (R Core Team 2021). Simultaneous pairwise comparisons of trap designs were made using Tukey’s HSD tests. Mean female and male *Chrysobothris*

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**Table 1.** Mean (± SE) total buprestids, *Chrysobothris*, *Chrysobothris* females, or *Chrysobothris* males captured on different trap designs in 2004.

Trap features					Mean (± SE) total trap captures								
Material	Width (cm)	Shape	Base color	Glue color <sup>1</sup>	L*	a*	b*	PR (nm)	Buprestids	Female			Male
										Chrysobothris <sup>2</sup>	Chrysobothris <sup>3</sup>	Chrysobothris	
Plastic	3.8	Box	Purple	Clear	3.09	2.42	-5.76	740	157 ± 3.2 a	142 ± 2.4 a	83 ± 1.9 a*	59 ± 2.4 a	
Plastic	15.2	Panel	Purple	Clear	3.09	2.42	-5.76	740	113 ± 3.0 b	82 ± 1.9 b	49 ± 2.1 b*	33 ± 2.0 b	
Plastic	3.8	Panel	White	Ameth	16.76	1.02	-1.13	740	113 ± 1.2 b	50 ± 0.7 c	34 ± 0.6 c*	16 ± 1.1 c	
Plastic	3.8	Panel	White	Purple	14.03	4.11	-6.14	740	107 ± 2.3 b	67 ± 0.9 c	52 ± 0.7 b*	15 ± 0.5 c	
Wood	1.9 × 3.8	Box	Tan	Ameth	7.72	3.68	5.8	740	70 ± 0.8 c	52 ± 0.7 c	39 ± 1.1 c*	13 ± 1.0 c	
Wood	1.9 × 3.8	Box	Tan	Purple	12.03	3.32	1.04	740	59 ± 0.7 cd	24 ± 1.4 d	17 ± 1.2 e*	7 ± 1.2 cd	
Plastic	3.8	Panel	White	Clear	20.25	0.15	0.09	720	57 ± 0.6 cd	28 ± 0.8 d	17 ± 0.8 e*	11 ± 0.9 c	
Plastic	3.8	Panel	White	Glitter	14.62	1.27	-2.43	720	52 ± 1.1 cd	38 ± 1.0 cd	29 ± 1.1 d*	9 ± 1.3 cd	
Plastic	3.8	Panel	Purple	Clear	3.09	2.42	-5.76	740	45 ± 1.0 d	31 ± 1.0 cd	20 ± 1.0 d*	11 ± 1.2 c	
Wood	1.9 × 3.8	Box	Tan	Glitter	10.45	3.36	-1.03	740	43 ± 1.2 d	52 ± 1.0 c	34 ± 0.8 c*	18 ± 0.9 c	
Plastic	30.5	Panel	Purple	Clear	3.09	2.42	-5.76	740	40 ± 0.8 d	17 ± 0.9 e	14 ± 0.9 e*	3 ± 1.1 d	
Wood	1.9 × 3.8	Box	Tan	Clear	11.49	3.43	10.19	740	10 ± 1.0 e	9 ± 0.8 e	8 ± 0.5 f*	1 ± 0.0 d	

<sup>1</sup>Glue colors: "Clear" = unmodified Pestic<sup>®</sup> glue, acrylic violet-reflecting colored paints that were mixed into the clear glue included "Ameth" = Folkart 654, "Purple" = Folkart 411, "Glitter" = PolyFlake purple glitter flakes of violet-like glitter mixed into the clear glue.

<sup>2</sup>*Chrysobothris* species included *C. adelpha* (n = 142), *C. azurea* (n = 20), *C. cribraria* (n = 4), *C. femorata* (n = 28), *C. harrisi* (n = 1), *C. quadrimpressa* (n = 179), *C. rugosiceps* (n = 110), *C. sexsignata* (n = 56), *C. shawnee* (n = 17), and *C. viridiceps* (n = 35).

<sup>3</sup>The asterisk (\*) in the total female *Chrysobothris* captured column indicates statistically greater captures of females than males on those traps. "L\*" = lightness, "a\*" = red to green, "b\*" = blue to yellow, "PR" = peak reflectance (nm, see text for description). Different letters within columns indicate significant differences between means in a Tukey's HSD test.

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**Table 2.** Mean ( $\pm$  SE) total buprestids, *Chrysobothris* females, or *Chrysobothris* males captured on different trap designs in 2005.

Material	Trap features				PR (nm)	Mean ( $\pm$ SE) total trap captures						
	Size (cm)	Shape	Base color	Glue color <sup>a</sup>		L*	a*	b*	Buprestids	<i>Chrysobothris</i> <sup>2</sup>	Female <i>Chrysobothris</i> <sup>3</sup>	Male <i>Chrysobothris</i>
Plastic	15.2	Triangle	Purple	Clear	3.09	2.42	-5.76	740	62 $\pm$ 1.3 a	37 $\pm$ 1.4 a	33 $\pm$ 0.9 a*	4 $\pm$ 0.2 b
Plastic	3.8	Box	Purple	Clear	3.09	2.42	-5.76	740	61 $\pm$ 1.7 a	43 $\pm$ 1.4 a	29 $\pm$ 1.3 a*	14 $\pm$ 0.9 a
Plastic	30.5	Panel	White	Purple	14.03	4.11	-6.14	740	59 $\pm$ 2.2 a	25 $\pm$ 1.3 b	18 $\pm$ 1.3 b*	7 $\pm$ 0.2 b
Plastic	30.5	Panel	Purple	Clear	3.09	2.42	-5.76	740	51 $\pm$ 1.2 a	22 $\pm$ 1.2 b	9 $\pm$ 0.8 c*	13 $\pm$ 0.6 a
Plastic	15.2	Panel	Purple	Clear	3.09	2.42	-5.76	740	37 $\pm$ 1.4 b	23 $\pm$ 1.0 b	16 $\pm$ 1.1 b*	7 $\pm$ 1.2 b
Wood	3.8	Box	Tan	Purple	12.03	3.32	1.04	740	28 $\pm$ 0.9 c	16 $\pm$ 0.5 b	11 $\pm$ 0.8 bc*	5 $\pm$ 0.3 b
Wood	3.8	Box	Tan	Clear	11.49	3.43	10.19	740	3 $\pm$ 0.1 d	0 $\pm$ 0.0 c	0 $\pm$ 0.0 d	0 $\pm$ 0.0 b

The asterisk (\*) in the total female *Chrysobothris* captured column indicates statistically greater captures of females than males on those traps. "L" = lightness, "a<sup>ab</sup>" = red to green, "b<sup>ab</sup>" = blue to yellow, "pp<sup>ab</sup>" = peak reflectance (nm, see text for description). Different letters within columns indicate significant differences between means in a Tukey's HSD test.

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## Summary

Using an appropriate trap design can significantly increase trap capture rates for specific insect pests. *Chrysobothris* are common buprestid pests in nursery production. Using traps that are shaped to mimic preferred tree hosts captured higher numbers of *Chrysobothris* than other trap designs. Based on these tests, the best trap design (shape and materials) for *Chrysobothris* monitoring was clear glue on a purple plastic trap folded into a triangular prism shape with panel widths (i.e., 3.8 cm) and trap height (i.e., 1 m) similar to a young sapling tree trunk. Our trap design will help in *Chrysobothris* pest management strategies for tree nurseries by increasing capture success rates and leading to overall better monitoring of *Chrysobothris* populations in nursery production.

Key Words: beetles; flatheaded borers; jewel beetles; pest monitoring; visual cues

## Sumario

El uso de un diseño de trampa apropiado puede aumentar significativamente la tasa de captura de las trampas para plagas de insectos específicos. *Chrysobothris* son plagas buprestidas comunes en viveros en producción. El uso de trampas que imitan la forma de los árboles hospederos preferidos capturó un mayor número de *Chrysobothris* que otros diseños de trampas. Con base en estas pruebas, el mejor diseño de trampa (forma y materiales) para el monitoreo de *Chrysobothris* fue pegamento transparente en una trampa de plástico púrpura doblada en forma de prisma triangular con el ancho de los paneles (3,8 cm) y su altura (1 m) similares a un tronco de árbol joven. Nuestro diseño de trampa ayudará en las estrategias de manejo de plagas de *Chrysobothris* en los viveros de árboles al aumentar la tasa de éxito de captura y llegar a un mejor monitoreo general de las poblaciones de *Chrysobothris* en la producción en viveros.

Palabras Clave: escarabajos; barrenadores de cabeza plana; escarabajos joya; monitoreo de plagas; señales visuales

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