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Development of semiochemical-based strategies for old-house borer, *Hylotrupes bajulus* (Coleoptera: Cerambycidae)

Abstract - Earlier studies have demonstrated that among the eight differently colored ground traps tested in the greenhouse, black colored traps were the most effective compared with the performances of brown, yellow, red, grey, blue, white, and green traps. In the present study, efficiency of ground traps with different shades of black (black thick, pure black, mix black and black medium) were evaluated in the greenhouse for the capture of *Hylotrupes bajulus*. Black thick colored traps caught significantly higher *H. bajulus* than traps with other shades of black. Therefore, black thick colored ground traps are recommended to use for monitoring and mass trapping *H. bajulus* in museums and human dwellings.

Key words: color cues, semiochemicals, *Hylotrupes bajulus*, traps, Cerambycidae.

INTRODUCTION

The old-house borer beetle (*Hylotrupes bajulus*) is a major cause of damage to softwood timbers including in the buildings with cultural heritage importance (Becker, 1979). This borer is a native of northern Africa, but is now widespread, with a range which includes Europe, North and South America, South Africa, Asia Minor, China and Russia (Durr, 1954; Duffy, 1963).

Insecticides must have good penetration characteristics to control this wood borer because larvae of *H. bajulus* feed below the surface of wood. However, the application of insecticides is detrimental and frequently undesirable, particularly in the human dwellings and cultural properties. In this context, the development semiochemical-based trapping method could provide an alternative control measure, as well as providing a mechanism for monitoring populations of this insect (Reddy & Guerrero, 2004; 2010). To improve the surveillance capability, much research has been done to test the attractiveness of sex pheromones and monoterpenoids within the laboratory or similar enclosed conditions. Our previous studies indicated that a 'ground trap' baited with synthetic sex pheromone (3R)-ketol + 1-butanol was the most efficient trap in capturing *H. bajulus* in both greenhouse and field tests (Reddy *et al*., 2005a; 2005b).

Additionally, our previous studies indicate a ground trap baited with a pheromone+ethyl acetate blend can efficiently trap adult *H. bajulus* (Reddy, 2007).

Importantly, trap color was a significant factor in trap efficacy. Moreover, *H. bajulus* preferred black color over other colors. In this current study, the response *H. bajulus* to different shades of black colors was investigated in the greenhouse.

MATERIALS AND METHODS

Hylotrupes bajulus larvae are reared in darkness at 25ºC and 75% R.H. at the Institute of Wood Biology and Wood Protection, Hamburg, Germany as described previously (Fettköther *et al.*, 2000). Pheromone dispensers and ground trap used in this study were the same as in our previous study (Reddy *et al.*, 2005a; 2005b; Reddy, 2007). Experiments were conducted between 1200 and 1730 h, a period in which most beetles produce and respond to pheromones (Fettköther *et al.*, 2000). All experiments were conducted in a greenhouse using a screen cage (450 cm long x 230 cm wide x 100 cm high) with six openings to insert or remove both traps and beetles.

Trap-color characteristics were determined using a Konica Minolta CR-410 Chromometer (Minolta Instrument Systems, Ramsey, NJ). L* which indicates a measure of ‘lightness’ that runs through the median of the color-scale chart, where 100 (at the top) represents white, and zero (at the bottom) represents black. The a* axis, which runs from left to right on the color chart, indicates a red shade when greater than zero (positive) and a green shade when lower than zero (negative). Similarly, the b* axis which runs vertically through the color chart indicates a yellow shade when positive and a blue shade when negative. The hue angle is expressed on a 360º grid on which 0º = red, 90º = yellow, 180º = green, and 270º = blue (Wrolstad *et al.*, 2005). Trap color measurement values are given in Tab. 1.

Trap Color	**L***	**a***	**b***	**Chroma**	**Hue angle (h°)**
Pure black	32.75 ± 0.24	-0.18 ± 0.03	0.72 ± 0.03	0.74 ± 0.02	---
Mix black	31.89 ± 0.03	-0.12 ± 0.02	0.95 ± 0.02	0.96 ± 0.02	---
Black medium	30.44 ± 0.06	0.42 ± 0.03	-1.08 ± 0.04	1.16 ± 0.05	---
Black thick	33.8 ± 0.1	7.6 ± 0.2	-5.4 ± 0.1	9.28 ± 0.1	---

Tab. 1 - Colour measurements of the different shades of black. Means (± SD) were generated from three observations.
L* indicates a measure of ‘lightness’ that runs through the centre of the colour chart, where 100 at the top represents white and zero at the bottom represents black. The a* axis, which runs left to right on the colour chart, indicates a red shade when greater than zero (positive) and a green shade when lower than zero (negative). Similarly, the b* axis which runs vertically through the colour chart indicates a yellow shade when positive and a blue shade when negative.

The ground trap with different shades of black (pure black, mix black, black medium and black thick) colors were tested individually (eight replicates, 40 insects per color). The trap tested was placed on the floor of the screen cage 2 h before the release of the adults, so that pheromone vapors could spread throughout the laboratory. Forty adults were then released into the laboratory, about 3 m from the trap. The number of adults trapped during the succeeding 3 h was recorded. Trapped beetles were removed after capture and discarded. Uncaptured insects were removed before the next trial, and we used fresh adults for each replicate to avoid pseudoreplication.

The data was analyzed with the generalized linear mixed model procedure of SAS Version 9.13 (SAS Institute 2009). Because all the response variables used in the experiments were counts, a one-way Poisson ANOVA model was fitted by The GLIMMIX Procedure to analyze the data from the experiments. For the comparisons of the means, the least square means test was used to make multiple comparisons for significant differences between treatments at $P = 0.05$.

RESULTS

The shade of black significantly affected adult catches in ground traps ($F = 8.2$; $df = 3,22$; $P < 0.05$; Fig. 1). Black thick colored traps caught significantly more adult weevils (20.0 ± 0.8 adults/trap) than did other shades. Pure black, mix black and black medium colored traps did not differ significantly in the numbers caught, as they caught 8.0 ± 1.2, 7.0 ± 0.9, 8.0 ± 06 adults/trap, respectively).

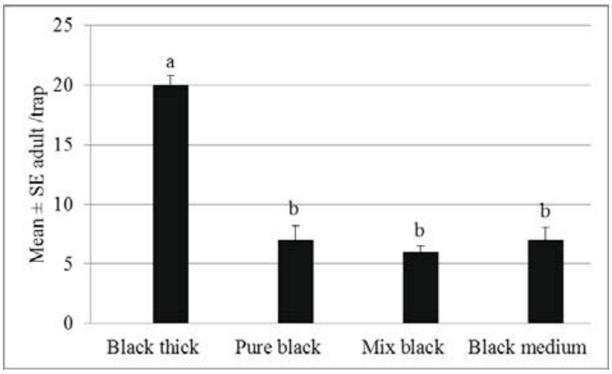

Fig. 1 - Mean (± SE) numbers of adult *H. bajulus* caught in semiochemical-baited ground traps of different shades of black in a greenhouse. Different lower-case letters indicate significant differences between treatments (one-way ANOVA using Poisson model, least square means, $P < 0.01$). Adding black to the other colors did not improve their performance. Bars represent means of four replicates.

DISCUSSION AND CONCLUSIONS

Our previous studies have confirmed that among the eight differently colored traps tested in the greenhouse, black traps were the most effective compared with the performances of yellow, red, grey, blue, brown, white, and green traps (Reddy, 2007). In the present color-choice tests study, effectiveness of ground trap with the different shades of black was evaluated in the greenhouse for the capture of *H. bajulus*. The results indicated, *H. bajulus* preferred black thick over other color traps, with no specific preferences for different other shades of black. Although previous studies by Reddy & Raman (2011) and Reddy *et al*. (2011) reported that the black colored traps were preferred by *Cosmopolites sordidus* (Germar) (Coleoptera: Curculionidae) and *Rhabdoscelus obscurus* (Boisduval) (Coleoptera: Curculionidae) indoor conditions, no significant difference occurred in trials made comparing between the different shades of black traps in capturing the adults. By exploiting these results, it may be possible to produce efficacious trapping systems that could be used in a behavioral approach to old-house borer control. Black thick colored traps used in this study could be effectively installed for the monitoring and mass trapping of *H. bajulus* particularly in museums and human dwellings.

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