

The importance of olfactory cues in short-range mate finding by the Japanese jewel beetle, *Chrysochroa fulgidissima* (Coleoptera, Buprestidae)

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Abstract

The Japanese jewel beetle, *Chrysochroa fulgidissima* (Buprestidae), is one of the most beautiful Japanese beetles with glossy iridescent colors on the elytra. Although the iridescent colors of jewel beetles have been thought to play a part in mate finding, the use of olfactory senses has also been suggested in the mate-finding behavior of buprestid *Agrilus planipennis*. In this study, the relative importance of olfactory versus visual clues in the mate-finding behavior of *C. fulgidissima* was clarified. A set of three treatments was conducted where beetles were deprived of their olfactory or visual senses by transparent or black polyvinyl chloride (PVC) sheets and black nylon mesh sheet. At short range, olfaction is considered to be more important than vision, because the number of males attracted to females in the olfaction treatment was significantly higher than in the others.

Key words: sexual discrimination, olfaction, vision

Introduction

Buprestid jewel beetles have glossy iridescent colors on their elytra, and the Japanese jewel beetle, *Chrysochroa fulgidissima*, is one of the most beautiful Japanese beetles. The iridescent colors of jewel beetles have been thought to affect mate finding, because buprestid males are usually attracted to purple or green color traps ⁽¹⁾. Males of *Agrilus planipennis* search trees during flight and descend rapidly straight down onto mates from a height of from 30 to 100 cm ⁽²⁾. Males of *C. fulgidissima* also search during flight, and landed on the model with female elytra ⁽³⁾. These observations suggest that the males use visual cues to search for potential mates.

Pureswaran & Poland ⁽⁴⁾ showed the relative importance of olfaction versus vision in the mate-finding behavior of *A. planipennis*. Although males with masked eyes did not differ in their mate-finding capacity compared to untreated males,

males with masked antennae took significantly longer to find females and spent less time in copula compared to untreated males. This indicates that olfactory cues are involved in mate finding by *A. planipennis*.

In this study, we investigate the relative importance of olfactory cues versus visual cues in the mate-finding behavior of *C. fulgidissima*.

Materials & Methods

Collection and Treatment of Beetles

Adults of the Japanese jewel beetle, *Chrysochroa fulgidissima*, were collected in Mt. Kano, Futtsu City, Chiba Prefecture, Japan in late July 2016. All male and all female beetles were kept together in two small containers holding one sex each under natural conditions with leaves of hackberry. In a series of experiments conducted in early August 2016, 20 males and ten females were randomly selected for the following three types of treatments from the general pool of individuals.

Vision and Olfaction Treatments

We conducted three sets of experiments in which male beetles were treated to receive either olfactory or visual cues only by the use of transparent or black polyvinyl chloride (PVC) sheets and black nylon mesh sheet. The basic design consisted of an experimental arena incorporating two concentric rings, with an inner arena (a tube, holding cue-emitting individuals) surrounded by a donut shaped outer arena (holding males responding to cues). When males approached the small inner tube and bent their abdomens as in copulatory behavior, we scored this as “approaching”.

The first (vision-only) experiment was conducted with the following arena; a tube made of a black PVC sheet (diameter, 30 cm; height, 20 cm) had a smaller concentric tube made of transparent PVC sheet (diameter, 12 cm; height, 20 cm),

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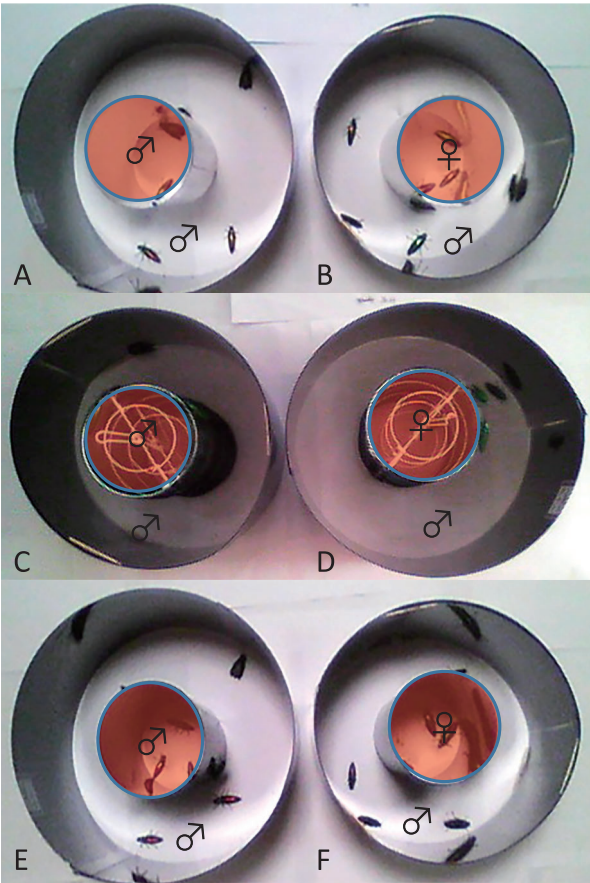


Fig. 1. Arenas for treatments. A and B, the vision cue treatment with transparent PVC sheet; C and D, the olfaction cue treatment with black net; E and F, the control cue treatment with black PVC sheet.

embedded in the round base (Fig. 1A, B). Three females or males (the cue-emitting individuals) were put into the inner arena, and five males (the responding individuals) were put into the outer donut space. Thus, observed males in the outer ring could differentiate whether males or females were in the inner tube by vision but not by olfaction, because the PVC sheet obstructed diffusion of the volatile chemicals emitted. The number of males approaching the inner space was observed every five minutes during an hour, to compare the mean number of beetles approaching for 12 consecutive 5-min observation periods. This experiment, in which two arenas containing either males or females as cue emitting individuals were observed side-by-side (Fig. 1A, B), was repeated three times.

The second (olfaction-only) experiment was conducted with

the following arena: an outer tube made of black PVC, with a smaller concentric tube made of a black nylon net (Fig. 1C, D). Two or three females or males were put into the inner tube, and the same number of males were put into the outer donut space. In this setting, observed males in the outer space might be able to tell whether males or females were in the inner tube by olfaction but not by vision. The number of males approaching the inner tube was recorded for 12 consecutive five minute periods. This olfaction only experiment was repeated three times, each time randomly selecting individuals from the pool of individuals available.

The third (no-cue control) treatment was made with the following arena similar to the previous ones: a tube made of a black PVC sheet with a smaller concentric tube also made of a black PVC sheet (Fig. 1E, F). Two or three females or males were put into the inner small tube, and the same number of males were put into the outer donut space. In this setting, males in the outer space should be able to tell whether males or females were in the inner tube neither by vision nor by olfaction. The number of males approaching the inner space was recorded for 12 consecutive five minute periods. The treatment with males in the outer and inner spaces was repeated three times.

Statistical Analyses

In all treatments, to test whether the number of males approaching the inner tubes differed depending on the sex of the cue emitting individuals and tube type, we used the generalized linear model (GLM) with a Poisson distribution and log-link function. The following factors were included in the model; the number of males introduced in the outer donut area, sex of the individuals in the inner tube, treatment, time, and the interactions among the latter three as explanatory variables, and the replicate as a random variable. All analyses were performed using JMP 12.2 (SAS Institute Japan) statistical software.

Results

Interaction effect between the tube type and the sex of cue-emitting individuals in the inner tube was significant

Table 1 The mean±SE number of observed males of the total number indicated in () that approached the inner tube containing cue emitting individuals (females or males) under the three treatments: vision-cue only treatment with the inner tube made of transparent PVC; olfaction-cue only treatment with the inner tube made of black net; no-cue (control) treatment with the inner tube made of black PVC.

Replicate	Vision (transparent PVC)		Olfaction (black net)		Control (black PVC)	
	females	males	females	males	females	males
1	0.75±0.00 (5)	1.08±0.08 (5)	0.75±0.13 (2)	1.08±0.08 (2)	0.00±0.00 (3)	0.00±0.00 (3)
2	1.67±0.00 (5)	0.17±0.11 (5)	1.67±0.14 (3)	0.17±0.11 (3)	0.08±0.08 (2)	0.00±0.14 (2)
3	2.08±0.23 (5)	1.58±0.19 (5)	2.08±0.23 (3)	1.58±0.19 (3)	1.42±0.15 (5)	0.75±0.13 (4)

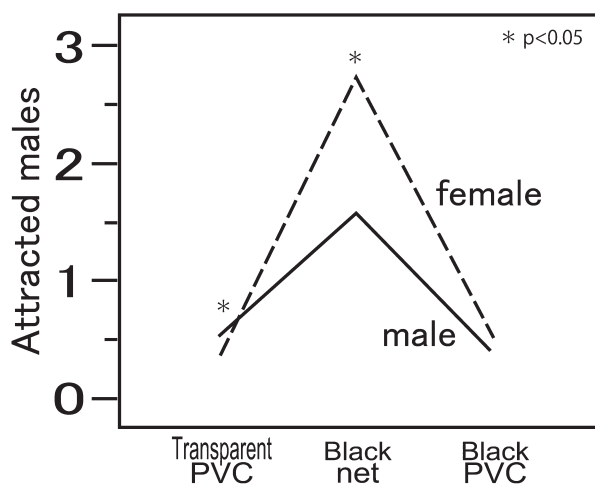


Fig. 2. The number (maximum likelihood estimate) of males attracted to either females or males in the inner tube under the three conditions; vision cue treatment with transparent PVC, olfaction cue treatment with black net, and no cue (control) treatment with black PVC.

(GLM, $df = 2$, $\chi^2 = 9.83$, $p = 0.0073$). There was also a significant effect of the tube type, indicating that more males in the donut area were attracted to the adults in the inner tube made of black net than in the other treatments (i.e., transparent or black PVC) (GLM, $df = 2$, $\chi^2 = 37.9$, $p < 0.0001$) (Table 1, Fig. 2).

Vision cue treatment

Significantly more males in the doughnut area were attracted to males than to females in the inner tube (posthoc GLM, $df = 1$, $\chi^2 = 4.31$, $p = 0.038$).

Olfaction cue treatment

Significantly more (sex, $df = 1$, $\chi^2 = 5.35$, $p = 0.021$) and increasing number over time (sex $\times$ time, $df = 1$, $\chi^2 = 6.86$, $p = 0.009$) of males in the doughnut area were attracted to females than to males in the inner tube.

No cue (control) treatment

There was no significant difference between the numbers of doughnut-area males attracted to females and males in the inner tube ($df = 1$, $\chi^2 = 1.12$, $p = 0.291$).

Discussion

The number of males approaching the cue emitting individuals in the olfaction-only treatment was significantly higher than those in vision-only and no-cue treatments. In the olfaction-only treatment, observed males were more likely to approach females than males. This suggests that olfaction in the short-range mate-finding behavior of *C. fulgidissima* is more important than vision.

Conclusion

The results suggest that olfaction is important in the short-range mate-finding behavior of *C. fulgidissima*.

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ヤマトタマムシ(コウチュウ目, タマムシ科)の短距離での配偶者探索における嗅覚の重要性

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要旨

ヤマトタマムシ(*Chrysochroa fulgidissima*)は鞘翅に美しい金属光沢をもつ昆虫で、その色は短距離における配偶者探索に用いられることが知られていた。しかし、近年タマムシ科の他種では視覚よりも嗅覚が重要であることが示された。そこで、本研究では、大型美麗種であるヤマトタマムシでも同様に嗅覚が配偶者探索において重要であるかを調査した。嗅覚あるいは視覚が遮断される装置において、オスがどのような行動をするかを実験した。その結果、臭いを通すが見ることのできない黒色の網で囲ったメスに対して有意にオスが接近したことから、本種においても配偶者探索に嗅覚が重要であることが示された。

重要語句：雌雄判別, 嗅覚, 視覚

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