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Original paper

An extra entrance hole practical on bait hives to lure Japanese honeybee (*Apis cerana japonica*) swarms

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Abstract: This study probed into the effectiveness of bait hives with an extra entrance hole ("EE hole," mostly a natural knot hole; some circular and others oblong) in luring Japanese honeybee (*Apis cerana japonica*) swarms in comparison to those without. The experiment was done from April to June in 2013 in Okayama City, southwestern Honshu, Japan. Used were 22 bait hives (7 with EE holes varying in size, and 15 with an ordinary entrance only). By the end of May, bees inhabited 3 hives, all with an EE hole up to 12mm. Their choice of hives with an EE hole in preference to those without was statistically significant ($P < 0.05$). Additional observations indicated an EE hole as large or larger than 11-12mm diameter would not hinder hornets from entering or inhabiting the hive; an EE hole smaller than around 10mm seemed better.

I. Introduction

Many hobby beekeepers in Japan prefer to capture wild swarms of the native Japanese honeybee, *Apis cerana japonica*, rather than purchase a colony of the Western honeybee, *A. mellifera* (Fujiwara and Murakami 2000, Hisashi 2010a, b, 2011, Yoshida 2000). For that purpose, they have designed various hives from simple to sophisticated. The simplest is a traditional log hive made of an appropriate sized cross-section piece of a hollowed-out log, placed upright with a top lid and bottom (e.g., Takuno 1994). Today, however, materials for this type of hive are short in supply and planks are often used to make box hives instead. In particular, fixed comb "*jubako*" hives have become popular (Fujiwara and Murakami 2000, Hisashi 2010a, b, 2011, Yoshida 2000).

"Japanese honeybee" keepers employ various techniques, some of which are also likely practiced overseas in the natural distribution range of this species, *A. cerana*, to obtain a starter colony. Besides direct capture of a swarm ball, bait hives are set in appropriate places to attract swarms. The top three tips to enhance the probability of wild bees' spontaneous habitation in bait hives are as follows (Fujiwara and Murakami 2000, Hisashi 2010a, b, 2011, Yoshida 2000). (1) Compressed comb after honey extraction or beeswax of *A. cerana* is rubbed onto the hive, in particular on its wall (both inside and outside) and ceiling as well as around the entrance. (2) *Cymbidium floribundum* (Orchidae) in flower is placed beside the bait hive. This Asian orchid, occurring from the Himalayas to Taiwan or in the center of *A. cerana*'s distribution range, flowers in *A. cerana*'s swarming season. Its flower, before getting pollinated, attracts *A. cerana* in swarming phase with a scent mimicking the aggregation pheromone of this particular honeybee species. Placement of *C. floribundum* flowers beside the hive is, therefore, an effective means of luring *A. cerana* swarms (Sugahara et al. 2013). (3) An extra entrance hole ("EE hole") on the wall, in addition to the ordinary horizontal or vertical entrance slit (6-9mm in height or width) close to the bottom, has been traditionally said to be effective (Fujiwara and Murakami 2000).

The first and second tips are understandable given the search behavior of *A. cerana* based on their sense of smell. However, the significance of the third remains dubious without any

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scientific support. The present study is a preliminary attempt probing into the effectiveness of an EE hole on the wall in luring wild Japanese honeybee swarms into bait hives through an experimental comparison between hives with an EE hole and those without.

II. Materials and Methods

We did the experiment in the 2013 undergraduate fieldwork class at the Department of Zoology, Okayama University of Science (OUS). In the swarming season of the Japanese honeybee, from April to June, 22 "*jubako*" bait hives were placed on the OUS campus, Okayama City, southwestern Honshu, Japan. The "*jubako*" hives used (similar to Warré's [1948] hive except for the absence of top bars and the presence of skewers supporting combs instead; Hisashi 2010a) measured 27cm × 27cm outer dimension and about 30-40cm in height. They were hand-made by the students who participated in the class. Of those hives, 7 had an EE hole on the wall, varying in size (mostly natural knot holes [some circular and others oblong] and the rest bored artificially), and the remaining 15 without. A *C. floribundum* flower spike, enclosed in a net cover to avoid pollination, was placed beside each bait hive to attract bees (Fig. 1).

Fig. 1. One of the trap hives, with an extra entrance hole ("EE hole", arrowed →) in addition to the ordinary horizontal slit entrance at the bottom, visited by scout bees in search of a nesting site; this with a 25mm diameter EE hole, largest in the experiment, not inhabited in the end. (Photo by H. Takasaki)

III. Results

While the orchid flowers were fresh, all hives were visited by scout bees in search of nesting sites. However, the scouts did not enter most of the 15 hives with no EE hole, although they, being lured by the flowers, flew around them. By contrast, they entered and re-entered all the 7 hives with an EE hole, to repeat inspection of the inside. They also guarded the entrances against non-nestmates. In the end, bees inhabited only 3 hives, all with an EE hole up to 12mm in maximum aperture (Fig. 1). The hives with a larger EE hole were not chosen for habitation. Their choice of hives with an EE hole in preference to those without was statistically significant as summarized in Table 1 (Fisher's exact test, P = 0.04545 < 0.05).

Table 1. Statistically significant habitation by *Apis cerana japonica* in bait hives with an extra entrance (EE) hole in preference to those without (Fisher's exact test, P = 0.045 < 0.05).

		Habitation		
		+	−	Total
EE	+	3	4	7
hole	−	0	15	15
Total		3	19	22

During the experiment an interesting observation was made by Yoda, who happened on 22 May to wear a brown shirt with black buttons 10mm in diameter (Fig. 2). When he neared one of the bait hives attracting many scout bees, some bees were lured to the buttons. Their small circular form and dark color in contrast to the brown background, resembling those of natural knot holes, likely triggered the bees to inspect them

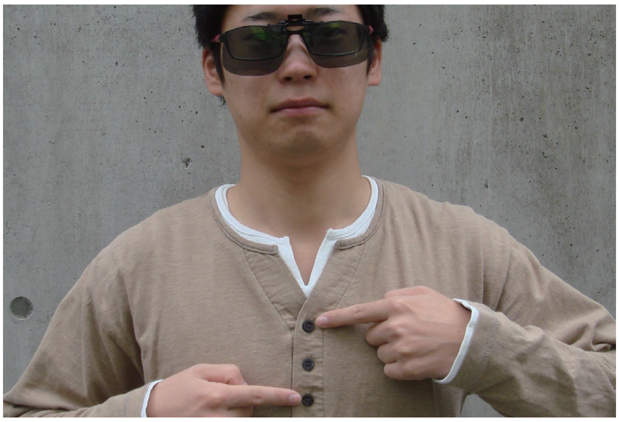

Fig. 2. Black buttons, 10mm in diameter, of a brown shirt lure scout bees. (Photo by H. Takasaki)

Fig. 3a. A *Vespa simillima xanthoptera* queen enters a bait hive, inhabited by two queens to make a nest together, through its extra entrance (EE) oblong knot hole, greater than 11mm in minimum aperture, beside a 2cm-diameter coin. (Photo by H. Takasaki)

Fig. 3c. Two queens (Queens I and II) and 6 workers dead in the hive on 22 June; the right wings of Queen I bitten off and left wings damaged badly, suggesting a "duel" between the queens on emergence of workers. (Photo by H. Takasaki)

Fig. 3b. Hornet nest in the bait hive on 22 June 2013, 11 days after closure of all entrances to prevent hornet-sting accidents on the campus. (Photo by H. Takasaki)

further as entrances of a prospective nesting site.

In the experiment, the bait hives were placed in locations varying in conditions, some favorable but some poor for bees. This was due mainly to the lack of experience of the participant students. Possibly it may have debased the statistical test. Nevertheless, along with Yoda's observation above, the results of the experiment seem likely to have reflected the general tendency correctly. A veteran beekeeper's practice of adding an EE hole on the bait hive would indeed result in higher success rates in luring swarms.

Notably, one of the hives, with an oblong EE hole greater than 11mm in minimum aperture, was inhabited by two queens of the medium-sized hornet *Vespa simillima xanthoptera* to make a single nest together (Figs. 3a-c; two-queened nests in early founding phase before emergence of workers, though rare, have been reported for this species [Nakamura 1996, Takamizawa 2005]). In late May, Tada observed that scout bees visited and entered it before their habitation, but never after. To prevent hornet-sting accidents on the campus, Takasaki closed this hive on the evening of 11 June 2013, 3 weeks after their nesting was first noticed, but before the first emergence of worker hornets. We found the 2 queens (Queens I and II) and 6 workers dead in the hive on 22 June, 11 days after closure of all entrances (Fig. 3c). In close examination, Queen I's right wings were bitten off, and her left wings were damaged badly. Probably the queens fought with each other on the emergence of workers, as Nakamura (1996) reported, resulting in the mutilation and killing of Queen I by Queen II.

Another hive, of which the oblong EE hole was 12mm in maximum aperture, once inhabited by bees, was deserted in mid July, probably because of the unusual summer heat in 2013. Soon *V. simillima xanthoptera* and *V. analis* came to the hive and scavenged it for the abandoned honey. These observations evidenced the two species of hornets pass through a knot hole 11-12mm in aperture. Thus, the maximum aperture of an EE hole would be better kept less than around 10mm to avoid entry and habitation by hornets.

IV. Discussion

In some part of Asia, apiculture with the Western honeybee (*A. mellifera*) is impractical, as the species suffers from indigenous natural enemies and pests. In Japan they cannot survive unless protected by humans against predatory hornets and ectoparasitic mites. Most feral colonies die out in the autumn due to raids by the world's largest Asian giant hornet (*V. mandarina*). Even if they survive the autumn, they hardly remain intact until the next swarming season due to an infestation by *Varroa* mites. In such regions, there are non-*mellifera* wild honeybee species and their subspecies, including *A. cerana* in several regional forms (Radloff et al. 2010). They likely share with *A. c. japonica* some resistant behaviors against the natural enemies and pests—heat and asphyxiation balling to kill the *Vespa* hornets (Ono et al. 1987, 1995, Sugahara and Sakamoto 2009), and mutual grooming between nestmates to remove the *Varroa* mites (Peng et al. 1987). *A. cerana* is widespread in Asia, from Afghanistan in the west to Japan in the east, and from China and Russian Far East in the north to Indonesia in the south; and it has been introduced to Papua New Guinea (Bradbear 2009, Radloff et al. 2010). Therefore, this species has great potential to provide pleasure and honey through apiculture to many people living in its distribution range with a low cost initial investment (Bradbear 2009, Hisashi 2010a).

In this study we have confirmed the significance of one of the common tips practiced with bait hives. A knot hole on the hive wall likely functions as a visual cue inducing scout bees in search of nesting sites further to inspect the inside of a prospective site. Also we have obtained the practical measurement of an extra entrance hole's maximum size, around 10mm, to avoid entry or habitation by *Vespa simillima xanthoptera* and *V. analis*—the smallest two of the hornet species preying on honeybees in Japan. The same approach would be applicable to luring some other honeybee species nesting in cavities (*A. mellifera*, *A. koschevnikovi* [Sabah in northern Borneo], *A. nigrocincta* [Sulawesi in Indonesia], and *A. nuluensis* [Borneo]) into bait hives.

The traditional beekeepers' role is not insignificant in the conservation of the native honeybee species as well as many flowering plants (Bradbear 2009). Some native plants can be pollinated only by native bees, because they have co-evolved together over a long period of time. The indirect contribution by "native bee" keepers to the conservation of local ecosystem and biodiversity, therefore, must be considerable through the number of native plant flowers successfully pollinated. Many traditional beekeepers long for bees' spontaneous habitation in their bait hives. Our findings in this study would be of some use for them.

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高崎浩幸・多田正和・平位祐人・角　貴哉・依田健・小林秀司：**ニホンミツバチ（*Apis cerana japonica*）分蜂群用の待ち巣箱側面「寄せ孔」の効果**

要約

ニホンミツバチ（*Apis cerana japonica*）の分蜂群を待ち巣箱に誘い込むにあたって，巣箱の側面に設けた「寄せ孔」の効果を，寄せ孔付きの巣箱とそれがない巣箱で比較検討した．実験は，22個の待ち巣箱（寄せ孔付き７個，底部に設けた通常の出入り口以外なし15個）を2013年４月から６月まで野外（岡山理科大学構内）に設置して行なった．営巣場所を探索中の働き蜂が，各巣箱の傍らに置いたキンリョウヘン（*Cymbidium floribundum*）の花に誘引されて，全22個の巣箱の周りを飛んだり，壁面にとまったが，寄せ孔のない大多数の巣箱の中には入らなかった．他方，寄せ孔のある全７個の巣箱には寄せ孔と底部に設けた通常の出入り口の両方から出入りし，他の群れの蜂に対して出入り口を防御した．最終的に，３個の巣箱（すべて最大開口幅が12mm以下の寄せ孔のもの）に入居があった．寄せ孔付きの待ち巣箱の入居率は，寄せ孔のない巣箱に比べて統計的に有意（$P < 0.05$）に高かった．大小の寄せ孔の比較観察の結果，スズメバチ類の侵入と居住を回避するには，寄せ孔の最大開口幅は10mm程度を限度とすべきことが推察された．

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