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Drone congregation of *Apis cerana japonica* (Radoszkowski, 1877) above large trees

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Summary — In 3 consecutive years (1990–1992) drones of *Apis cerana japonica* were observed pursuing queen dummies in a comet-shaped swarm above prominent trees (*Zelkova serrata*) at a shrine in Morioka, northern Japan. The height of the *Zelkova* tree was between 17.2 and 22.5 m. Thus, drones of *A. c. japonica* aggregate at landmark mating areas like tree tops. Drones were marked at their colonies and some were recaptured at the drone congregation area at a distance of 500 m from their colonies.

***Apis cerana japonica* / drone congregation area / tree topping / *Zelkova serrata* / reproductive behavior**

INTRODUCTION

Drone congregation areas (DCA) of European honeybees, *Apis mellifera* L, have been found at sites above open ground and often in areas of depression into the horizon (Zmarlicki and Morse, 1964; Ruttner and Ruttner, 1963, 1965a, 1965b, 1966). The physical basis for DCAs remains unknown and we have no information how honeybee drones congregate at the same site for many years. Punchedhewa *et al* (1990) found DCAs of *Apis cerana indica* (Fabricius 1798) in Sri Lanka. They reported that this Asian species had different DCA characteristics than the European species; the observation was that the site was in the canopy of trees.

A few years ago we started to breed *Apis cerana japonica* (Radoszkowski, 1877) because of its ability to defend against giant wasps and *Varroa* mites. In this study we

present observations on a DCA of *A. c. japonica* subspecies above trees (tree topping).

MATERIALS AND METHODS

Observations of drones near the hive

We maintain and breed several colonies of *A. c. japonica* in apiaries that originated from the natural population. Observation of the flight direction of drones leaving the hive and attempts to follow them showed that drones seemed to concentrate at groups of trees.

Experimental site

Experiments were carried out at a shrine in Morioka city in northern Japan, which is situated in a compound with several trees. The compound is located at a distance between 435 and 860 m

from the apiaries of *A c japonica*, which were established in 1989 (fig 1).

Observation of drones above trees

A virgin queen was fixed to a balloon filled with helium gas, which was held by a nylon thread (250 m) to a fishing reel (after Gary, 1962) (fig 2). One of us maneuvered the balloon from the ground of the shrine compound. This was difficult because the thread often got entangled in the tree. The observer would watch the flying drones with field binoculars.

Catching drones

To catch drones, flypaper was fixed lengthwise to the nylon thread below the virgin queen (figs 2 and 3). On 5 different days we caught 196 *A c japonica* drones and 1 *A mellifera* drone (table

1). On July 7, outflying drones from hive 1 were painted white, on July 13 drones from hive 4 were painted red. The hives were placed in opposite directions to the DCA, the distances of hives 1 and 4 were 525 and 435 m, respectively.

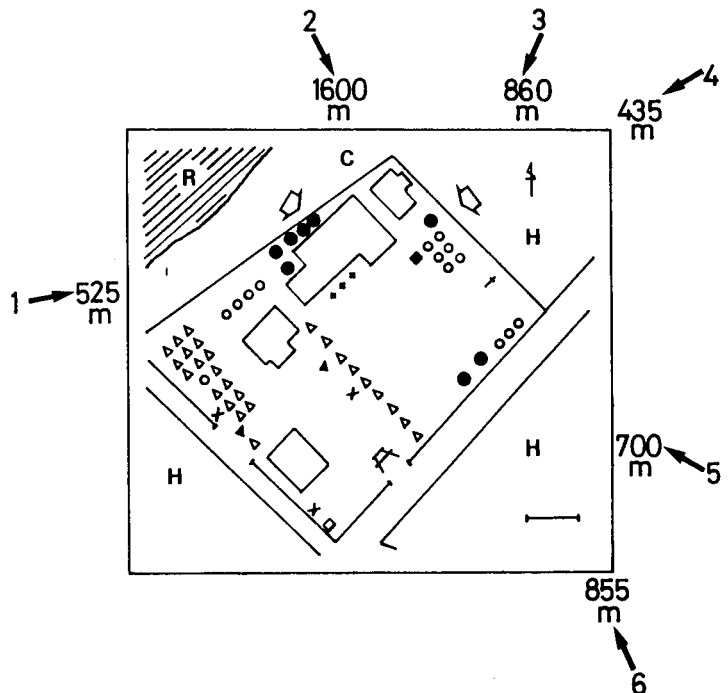
Filming drones

On June 3 1992 a crane machine was set up behind the compound as shown in figure 4. Its height was extended to 24 m. We manipulated the balloon with the virgin queen using a fishing rod (2 m) from the high platform of the crane. A video film and photos (800 mm, telephoto lens) were recorded from this short distance.

Measurement of the height of the trees

A 'Baumhöhenmesser' (Blume–Leiss) was used in addition to the crane.

Fig 1. Map of trees in the experimental site and nests of *A c japonica*. Tree species identified by Dr Tozawa and height of trees in the shrine compound determined according to the method of Baumhöhenmesser (Blume–Leiss): ●, *Zelkova serrata* (17.2–22.5 m); ○, *Pru-nus yedoensis* (6.9–16.4 m); △, *Cryptomerria japonica* (15.3–21.2 m); ▲, *Abies firma* (17.5–18.9 m); †, *Castanea crenata* (17 m); □, *Ostrya japonica* (20.2 m); ■, *Chamaecyparis pisifera* (5.1 m); x, *Ginkgo biloba* (16.5–20.1 m); +, *Acer palmatum* (3.7 m). Numbers and arrows indicate the distances between the experimental site and each nest: 1, 3, 4, 5, and 6, apiary; 2, natural nest. ⇨, Balloon flying over *Zelkova* trees; C, Crane machine (see fig 3); H, Houses; R, River. Bar = 10 m.



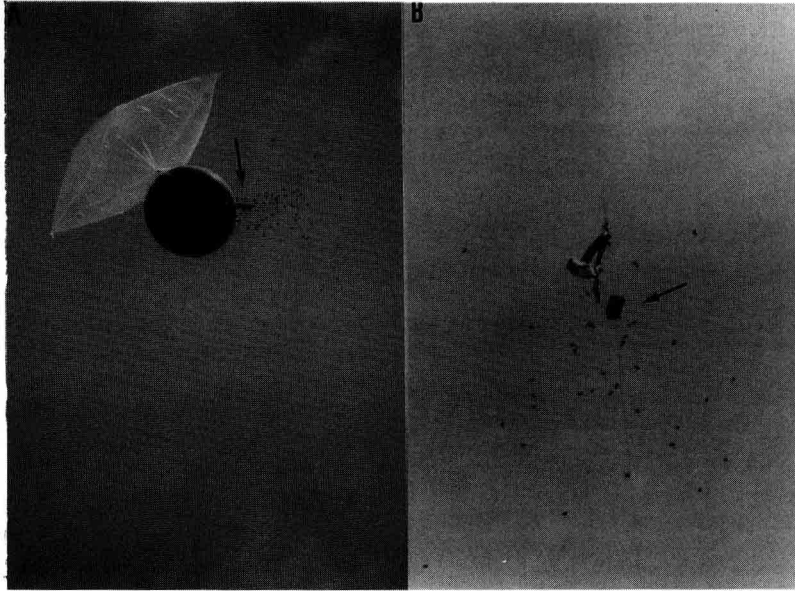


Fig 2. Drones pursuing a queen prepared with balloon. A: drone flight on July 3, 1991. B: Expanded comet-shaped pattern photographed from the top of the crane on the June 3, 1992. Stars indicate the queen.

RESULTS

Behavior of drones

In all 3 years of experiments drones left the hives when the weather conditions were suitable. The temperature was above 18.0°C and relative humidity was high (for exam-

ple, 21°C maximum and 18°C minimum, relative humidity 89%). They had short flights around the nest during the morning. Around 13:00 h the number of flights increased. Drones stopped flying between 16:30 h and 17:30 h. These results are the same as those observed by Ohtani (personal communication). From around 13:00 h the flight duration increased to about 10–20 min,

Table 1. Identification and counting of bees caught on the flypaper in June and July 1991.

<i>Date</i>	<i>Investigated time</i>	<i>No of drones in A c japonica</i>	<i>No of drones with a spot of colored paint in A c japonica *</i>	<i>No of drones in A mellifera</i>
June 5	15:00–16:10 h	54	–	1
June 11	14:45–16:20 h	56	–	0
July 3	14:56–? h **	56	–	0
July 14	14:10–14:20 h	14	2 (red), 2 (white)	0
July 15	15:30–16:15 h	16	1 (red), 2 (white)	0

* Drones flying out the first nest (see figure 1) were painted red and are discriminated from drones painted white in the 4th nest. We painted drones only earlier morning on July 7 (white) and July 13 (red) 1991. ** We had no record.

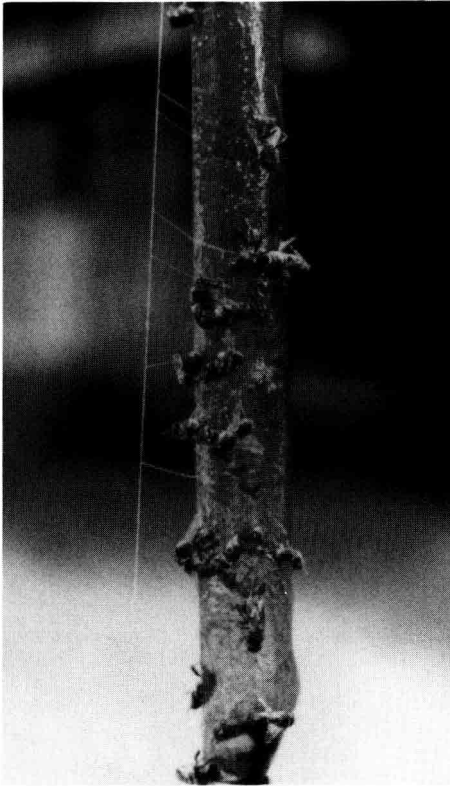


Fig 3. Drones caught on flypaper on July 3, 1991.

which was also observed by Ohtani. The flight peak was between 13:20 h and 16:00 h. These times, however, varied slightly according to weather conditions such as cloud cover and temperature.

At the DCA, we watched the drones with field binoculars and a video camera from the ground. Drones followed the queen in a comet-shaped pattern (fig 2A) above the *Zelkova* trees. We could observe the behavior only during the peak of drone flight activity. During this time in 1992, we were able to hear the humming noise of the drones while standing on top of the crane.

Drone catches

On July 14 and 15 we captured 30 drones, 3 red and 4 white. Thus drones of *A c japonica* fly distances of more than 500 m to the DCA from different directions.

Height of flight

Drones formed the comet-shaped pattern above the *Zelkova* trees at different heights. Although we were not able to determine the vertical distribution exactly, we estimated that the drones congregate in a space between 30 and 70 m (between 5 and 50 m above the trees). We did not find drones above lower trees. The *Zelkova* trees were about 5 m higher than the surrounding ones (figs 1 and 5).

DISCUSSION

We observed drones of *A c japonica* aggregating in the open air above *Zelkova* trees where they pursued virgin queens fixed on a balloon. Pursuing drones formed a comet-shaped swarm behind the female as described for *A mellifera* in Europe and the United States. This behavior could be observed only when many drones started from the colonies (mainly between 15:00 h and 16:00 h). The space over *Zelkova* trees was an important site to which the drones were attracted. We did not observe drones over other trees besides *Zelkova serrata*. These trees were prominent compared to the others within the shrine (fig 1). Although our results are still limited they suggest that prominent trees are important landmarks for DCA of *A c japonica* drones.

The results from this observation were confirmed by using a crane for close observation and by catching drones with flypaper. The importance of outstanding trees seem to be supported by the fact that drones from

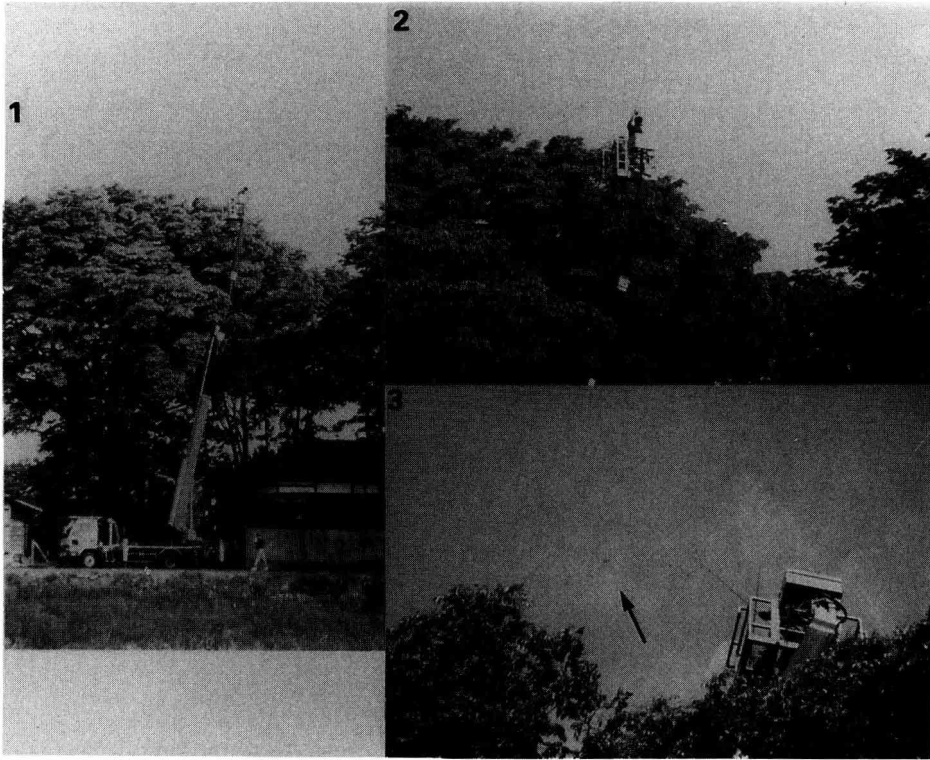


Fig 4. Series of experiments using crane. Fujiwara manipulating a short trap at the top of the crane. Star indicates a queen.

colonies in opposite directions were caught at the DCA.

These observations represent the first report of a drone congregation area of *A c japonica* and the second of *A cerana* in Asia. The DCA in Japan has different features compared with *A mellifera*, *A c indica* and *A c cerana* in Europe. Punchihewa *et al* (1990) described the DCA of *A c indica* in Sri Lanka, which is restricted to a space within the canopy of trees in coconut and rubber plantations or other areas with larger trees. Ruttner (1973) caught imported *A c cerana* drones at the same DCA as *A mellifera* in Germany. On one hand, *A c japonica* drones aggregate in the open like *A mellifera*, while, on the other hand, the most

important landmarks seem to be outstanding trees.

In addition, the *A c japonica* drones differ in their flight time and duration, their vertical distribution in the DCA and their flight range compared with *A c indica* drones. The flight time at the colony begins around 13.00 h and ends between 16:30 h and 17:30 h. The individual drone flight time is between 10 and 20 min. Flight times are different compared with those in Sri Lanka and Borneo (Koeniger *et al*, 1988; Punchihewa *et al*, 1990). A distance of 500 m between the DCA and the hive seems to be normal in *A c japonica*, while it is less in *A c indica*. These differences between the 2 subspecies may depend on the natural habitat.

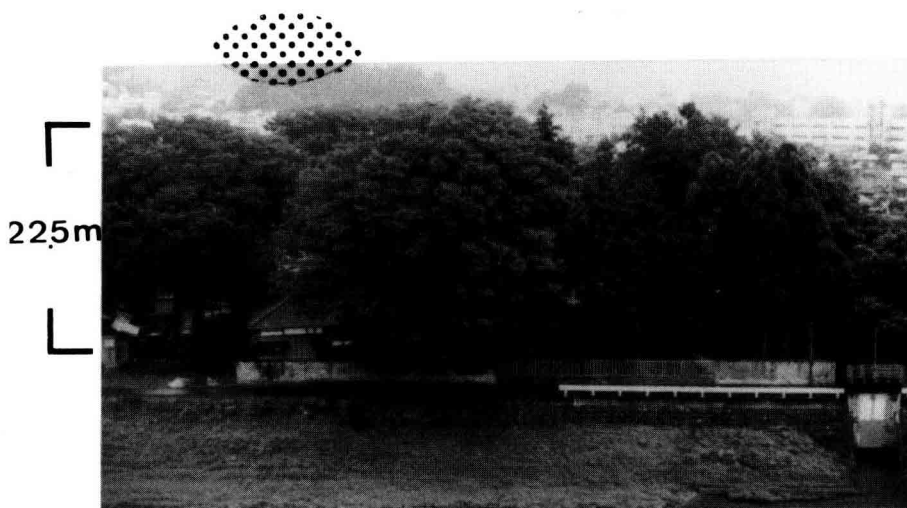


Fig 5. Scheme of drone congregation area in *A c japonica*. Photograph indicates trees along with the river (see fig 1). Dotted area indicates an assumptive vertical distribution of congregation area.

Further experiments are necessary to analyze whether drones of *A c japonica* visit prominent trees other than *Zelkova*. In addition to a better understanding of drone behavior of the native Japanese honeybee we could demonstrate the importance of a shrine in the city to supply a valuable environment for this rare subspecies.

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Résumé — Rassemblement de mâles d'*Apis cerana japonica* (Radoszkowski, 1877) au-dessus de grands arbres. Nous avons observé des mâles d'*A c japonica* 3 années de suite. L'activité de vol a eu lieu principalement entre 13 h 20 et 16 h. Durant cette période les mâles poursuivaient une reine vierge fixée à un ballon qui flottait au-dessus des arbres (*Zelkova serrata*) à Morioka, dans le nord du Japon. Le comportement des mâles a été observé à l'aide de jumelles depuis le sol ou du sommet d'une grue de 25 m. Les mâles poursuivaient la reine en formant derrière elle une figure en forme de comète (fig 2A), comme cela a été décrit pour les mâles d'*A mellifera*. Les zelkovas dépassaient les autres arbres et les mâles se rassemblaient (figs 1 et 5) dans l'espace (5 à 50 m) situé au-dessus de leur cime. Ces résultats, quoique limités, suggèrent que des arbres proéminents constituent des points de repère importants pour la for-

mation d'un lieu de rassemblement de mâles (DCA) chez *A c japonica*. Ceci a été confirmé par la capture de 196 mâles d'*A c japonica* à l'aide de papier tue-mouches fixé sur le fil du ballon sous la reine (fig 2). Les mâles ont été marqués à leurs colonies situées à 525 et 435 m du DCA dans des directions opposées. Certains d'entre eux ont été repris sur le DCA, ce qui prouve que les mâles d'*A c japonica* volent sur des distances > 500 m dans diverses directions pour atteindre un DCA. D'autres expériences sont nécessaires pour savoir si les mâles d'*A c japonica* visitent des arbres proéminents autres que *Zelkova serrata* et si le rassemblement au-dessus de la cime des arbres est un comportement qui leur est habituel.

***Apis cerana japonica* / lieu rassemblement mâles / cime / *Zelkova serrata* / comportement reproducteur**

Zusammenfassung — Drohnensammelplätze von *Apis cerana japonica* (Radoszkowski, 1877) über großen Bäumen. Drohnen von *Apis cerana japonica* wurden in drei aufeinanderfolgenden Jahren (1990–1992) beobachtet. Die Flugaktivität fand hauptsächlich zwischen 13.20 und 16.00 statt. Während dieser Zeit verfolgten die Drohnen unbegattete Königinnen, die an einem Ballon befestigt oberhalb einer Gedenkstätte in Morioka/Nordjapan schwebt. Das Verhalten der Drohnen wurde mit Feldstechern vom Boden aus oder von der Spitze eines 25 m hohen Krans beobachtet. Die verfolgenden Drohnen bildeten einen kometenähnlichen Schweif hinter der Königin (Abb 2), wie er bereits für *A mellifera* Drohnen beschrieben wurde. Hierbei waren die Stellen oberhalb von *Zelkova* Bäumen bevorzugt (Abb 1, 5), wo sich die Drohnen in einer Höhe von 5 bis 50 m über den Bäumen sammelten. Als Nachweis wurden 196 *A c japonica* Drohnen mit Fliegenpapier gefangen, das längs an der Ballonschnur unterhalb der Königin befestigt war (Abb 3). Diese Beobachtun-

gen weisen darauf hin, daß herausragende Bäume wichtige Landmarken für die Bildung von Drohnensammelplätzen (DCA's) bei *Apis cerana japonica* darstellen. Drohnen wurden in ihren 525 m und 435 m entfernt vom DCA in entgegengesetzter Richtung stehenden Völkern markiert. Von diesen wurden einige auf dem DCA wiedergefangen. Drohnen von *A c japonica* fliegen daher aus unterschiedlichen Richtungen aus Entfernungen über 500 m Drohnensammelplätze an. Weitere Experimente müssen klären, ob ausser *Zelkova serrata* auch andere herausragende Bäume angefliegen werden, und ob das Sammeln über Baumwipfeln ein generelles Verhalten von *A c japonica* darstellt.

***Apis cerana japonica* / Drohnensammelplatz / Fortpflanzungsverhalten / *Zelkova serrata* / Baumwipfel**

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