Journal of Apicultural Research 44(3): 130–132 (2005)

Workers often predominate in dusk 'drone flights' of the giant honey bee *Apis dorsata*

Jerzy Woyke,[1]* Jerzy Wilde,[2] Maria Wilde,[2] C Chandrashekar Reddy[3] and Cleofas Cervancia[4]

[1]Apicultural Division, Agricultural University, Warsaw, Poland

[2]Apicultural Division, Warmia-Mazury University, Olsztyn, Poland

[3]Zoology Department, Bangalore University, Bangalore, India

[4]Institute of Biological Science, University of the Philippines, Los Baños, Philippines

Received 6 October 2004, accepted subject to revision 15 March 2005, accepted for publication 19 May 2005

Keywords: *Apis dorsata*, *Apis dorsata breviligula*, drone flights, dusk flights, India, Philippines

Mating flights of queen and drone honey bees are performed at a particular, species-specific time of day. Mating flights of *Apis dorsata* drones take place in mass flights at dusk (Koeniger & Wijayagunasekara, 1976; Koeniger *et al.*, 1988; Rinderer *et al.*, 1993; Koeniger *et al.*, 1994; Woyke *et al.*, 2001). Queens of *A. dorsata* fly at the same time (Tan *et al.*, 1999). Although only drones and queens have been reported as taking part in these mass flights at dusk, we have observed workers flying together with drones (unpublished observation). The research we report here documents flight activity of worker *A. dorsata* during dusk mass flights (DMFs).

Observations were made in Bangalore, India, from 10–21 March 2002, and in Los Baños and Alfonso (near the city of Tagatay), the Philippines, from 1–6 March 2004. In India, 15 *A. dorsata dorsata* colonies were observed over five days. In the Philippines, two *A. dorsata breviligula* colonies were observed for three days. We observed nests from a distance of < 2 m. After the flights started, flying bees were caught with insect nets during 1- to 2-min periods; the captured drones and workers were counted then released. We repeated this procedure until the end of the DMFs. Bees were caught from individual colonies on all days except on 10 March 2004 in India, when we caught bees together from all 15 colonies within each 2-min period. We describe 65 DMFs based on 6115 bees caught from the 17 colonies.

Large numbers of bees began to leave the nest shortly after sunset. In India, 1858 bees flying in DMFs were caught collectively from 15 colonies on the first day of observation (10 March), and only 1.3% were drones (table 1). Bees were caught separately from each of the 15 colonies on subsequent days. The average participation of drones increased to 16.8% by 20 March. On the last day of observation (21 March), bees were caught during the total flight period exclusively from two colonies that had many drones. Most of the bees in these DMFs were drones (55.7 and 68.6% of the bees; table 1).

In the Philippines, drones predominated in a DMF from a small colony in Los Baños (combs 41 × 35 cm). This apparently was due to production of drones by laying workers. High variation

TABLE 1. Percentages of drone and worker bees participating in 65 dusk flights from 17 different *Apis dorsata* colonies in different days.

Date	No. colonies	No. bees caught	% Workers	% Drones
Bangalore, 2002; *Apis dorsata dorsata*				
10 March	15	1858	98.7	1.3
12 March	14	851	97.6	2.4
18 March	15	780	86.7	13.3
20 March	15	881	83.2	16.8
21 March (col. 5)	1	607	44.3	55.7
21 March (col. 20)	1	261	31.4	68.6
Los Baños, 2004; *Apis dorsata breviligula*				
1 March (LW*)	1	96	42.7	57.3
Alfonso 2004				
4 March	1	146	75.4	24.6
5 March	1	296	98.6	1.4
6 March	1	339	91.2	8.8
Total number	17	6115	5123	992
Percentage**			88.9	11.1

*Colony with laying workers
** % weighted overall mean calculated from % means in particular days

*Corresponding author: woyke@alpha.sggw.waw.pl

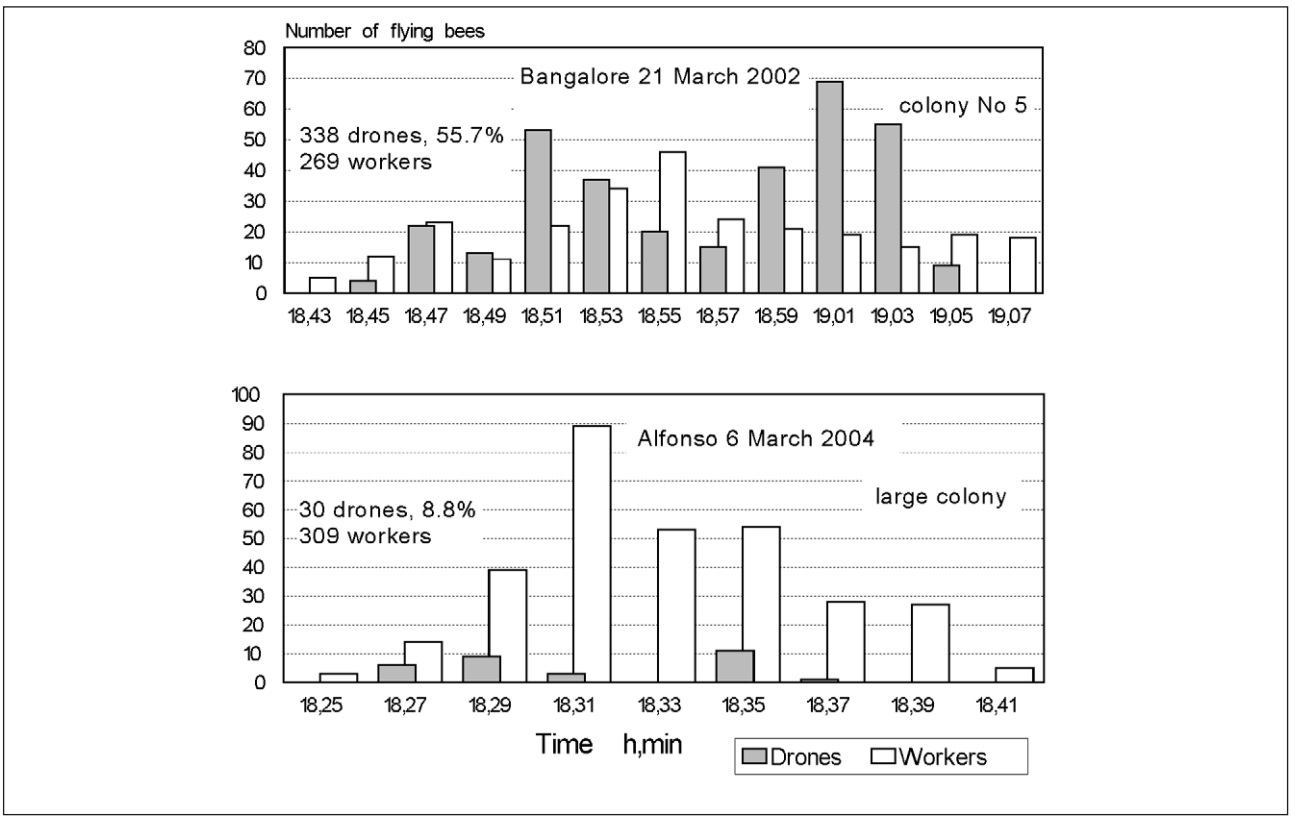

FIG. 1. Examples of frequency distribution of drones and workers of *Apis dorsata* participating in dusk mass flights.

(1.4–24.6%) was found in the percentage of drones flying on three consecutive days from the large colony in Alfonso (combs 173 × 84 cm) (table 1).

In summary, a mean of only 11.1% of bees in the 65 DMFs were drones. Of the 47 DMFs recorded from individual, normal, queenright colonies, 14.9% of DMFs had no drones, 22% had >10% drones and 10.6% had >50% drones. Thus, workers predominated in 89.4% of DMFs.

The duration of the DMFs at Bangalore was 29 min 30 s ± 58 s (mean ± s.d.; n = 30). This was significantly greater (t = 23.0, df = 34, $P < 0.01$) than the duration of flights at the Philippine sites (19 min 0 s ± 42 s; n = 5). Perhaps the dusk flight activity of *A. d. breviligula* is shorter than that of *A. d. dorsata*. The difference between the observed maximum and minimum duration of flight activity was only 3 min (within each country), and the coefficient of variation was only 3.3%. The low variation occurred despite the absence of drones in flights from some colonies and variable participation of drones in flights from other colonies. The duration of DMFs clearly does not depend upon the presence of drones. The durations of DMFs we observed are within the range reported previously (maximum 45 min, Koeniger & Wijayagunasekera, 1976; minimum 15 min, Rinderer *et al.*, 1993).

Drones were leaving the nest within 5–10 min after the beginning of DMF activity and they flew for about 10–12 min. Thus, there was a period of no or low drone flight about mid-way through the DMF and little or no interference between drones leaving and returning. This resulted in two peaks of flight activity, one 4–8 min after the start of flights, and the other 2–6 min before the end (fig. 1). Conversely, individual workers were leaving the nest within a slightly longer period (about 10–15 min after beginning of DMF activity) and they flew for only about 5 min. Thus, only one peak of flight occurred near the nest about midway through the DMF. There was noticeable interference between leaving and returning workers near the nest. Perhaps the peaks for drones represent a period of departure and a period of return of most drones on relatively long flights, whereas workers have only one peak because they make relatively short flights near the nest. We suggest that previously published graphs that present one peak for drones flying near the nests during DMFs (Koeniger & Wijayagunasekara, 1976; Koeniger *et al.*, 1988; Rinderer *et al.*, 1993) depict activities of workers.

Bees participating in the dusk flights defecated during DMFs. In India on 15 March, we placed sheets of paper (total 3.08 m^2) on the ground during DMFs near the Polytechnic building and also near a tree with about 100 nests at the campus of the Agricultural University. After flight ended, we found an average of 124 and 80 faecal spots per square metre at these respective sites. The large number of faecal spots suggests that not only drones but also workers defecated during DMFs and that defecation is one of the important purposes for workers making these flights. This also may explain why some colonies of *A. dorsata* do not perform daytime periodic mass flights (during which they release faeces) for several days (Woyke *et al.*, 2004).

The participation of drones only in the DMFs of *A. dorsata* was described previously based largely on sound and on the blunt conformation of the abdomen. The presence of workers in such flights has not been reported. We were surprised to observe DMFs that involved none or very few drones, and to find that workers predominated in about 90% of flights. Greater participation of drones occurred in stronger colonies (unpublished observation) during March when conditions were favourable for swarming. It is not known, however, how the makeup of DMFs may vary during the season. We suggest that dusk flights without workers do not occur. Workers may play some role in drone and queen flights, for example, by facilitating orientation by drones and queens, or by diminishing the risk of drones and especially of queens being caught by predators such as bats.

Worker flight activities at dusk differ considerably from activities during periodic mass flights (PMFs) at daytime. DMFs always start very closely following sunset, they last at least 20–30 min, and one flight always occurs in each colony daily. In contrast, the start of PMFs in different colonies occurs over a period of up to 10 hours. Workers of some colonies do not perform PMFs for several days, while bees from others perform up to six flights

daily. The duration of PMFs is only about 5 min, but the number of bees flying per time unit is higher than in DMFs (Woyke *et al.*, 2004). Mass flights at dusk and those during the day apparently represent two very different activities by workers of *A. dorsata*.

Acknowledgements

We thank Dr N Nagaraja from Agricultural University in Bangalore, India, and Dr A Fajardo from the University of the Philippines in Los Baños for their help during the investigation.

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Journal of Apicultural Research 44(3): 132 (2005)

Erratum

TANANAKI, C; THRASYVOULOU, A; MENEXES, G (2005) Absorption of volatile compounds in honey from stored spices. *Journal of Apicultural Research* 44(2): 71–77.

Correction to SUMMARY

Replace 'cinnamon' with 'cumin' on line 5 of the SUMMARY. The line should read:

'…honey, whereas coffee resulted in one volatile compound in honey, peppermint two, sage three, cumin four,'.