Drone congregation areas of red dwarf honeybee, *Apis florea*

The drones of dwarf honeybees assemble at the drone congregation areas close to small trees with dense leafage at the heights between 2 to 4 meters.

Polyandry, mating males with only one female but females mating with several males is rare among insects. Interestingly, queens of honeybee species (*Apis*) mate with several drones possibly from different colonies at the beginning of their lives. Drones of honeybees are known fly to drone congregation areas (DCAs) where they mate with visiting queens[1] However, the time of the day the drones perform mating flights and the places and heights at which they congregate would varies among honeybee species[2,3] . The mating behavior of honeybee species is striking. The drones of western honeybee, *Apis mellifera* congregate in the open air, while its eastern counterpart *Apis cerana* which gathers in close proximity to the trees[4]. Similarly, the drones of red honeybee, *Apis koschevnikovi* assemble under the canopy of lower trees[3]. However, the common giant honeybee, *Apis dorsata* drones[5] seem to fly to large prominent trees as a landmark for orientation and assemble near or under the branches. Presently it is assumed that, the drones and queens of dwarf honeybee species mate at drone congregation areas as it is common to *Apis* species, but attempts to identify these mating places have failed so far[1].

We conducted observations on drone flight activity and drone congregation areas of red dwarf honeybee, *A. florea* in the botanical gardens of the University of Agricultural Sciences, Bangalore, India, during March 2007 and again in April 2009. Prior to the experiments, we

surveyed the number and location of feral *A. florea* colonies, inspected the abundance of drone brood, and recorded drone flight time. The drone flight activity was determined in five different colonies by counting the number of deporting and returning drone bees. The test colonies were observed for 3 hrs from 11.00 to 14.00 hrs. and drone flight activity was recorded for 10 min with 30 min interval. We identified the drone attraction sites by presenting pheromone baits, (2E)-9-oxodecenoic acid (9-ODA) and (2E)-10-hydroxydecenoic acid (10-HDA)[6] purchased from Phero Tech Inc (Delta BC, Canada) either on open meadows or close to vegetation (trees and bushes) in the vicinity of *A. florea* nests.. We used cotton wick as pheromone dispensers, which were impregnated with 1ml of the respective pheromone solution. The drone attraction was tested for different heights ranging from 2 to 6m at several identified locations by lifting the baits into the air with a helium filled balloon. The site at which we attracted a considerable number of drones was used later as drone congregation areas. These areas were reconfirmed visiting *A. florea* drones by repeating the experiments again during April 2009. No drones were observed at the sites without pheromone presentation.

Our observations show that *A. florea* drones performed mating flights from late morning (11.30 hrs) to early afternoon (14.00 hrs), with a peak at noon around 12.30 to 13.00 hrs. of the day (Figure 1). The preferential mating flights of drones during mid day hours of the day, possibly would be owing to no or least occurrence of bee predators in the vicinity. Obviously the bright sunlight is also helpful in detection of the predators if any by the drones and queens in the mating sites. Besides, the presence of drones of other *Apis* species in the vicinity facilitates selection for pre-mating isolation through temporal separation[7]. Whenever honeybee species co-occur, the smaller species mate first[3]. We found that, the mating flights of *A. florea* lasted only for 20-30

minutes which is on par with the flights performed by *A. florea* in Thailand [8]. The short duration of mating flights would be an adaptive strategy against the possible harm by the insect and bird-bee predators.

The results of our study show that, the drones of *A. florea* were attracted to drone congregation areas which was close to small trees with dense leafage while presenting the pheromone lures, 9-ODA and 10-HDA ($p<0.001$) (Figure 2). This drone congregation area was an open space with a diameter of 10-12 meters and has bright sun light. Selection of mating yards with limited open space would be an adaptive strategy to deter insect and bird predators in the vicinity. Irrespective of pheromone baits presented, at different heights, the drones were attracted and assembled at heights ranging from 2 to 4 meters ($p<0.05$). This congregation area was reconfirmed visiting drones of *A. florea* even after 3 years (April 2009). Based on our observations, we report the mating of *A. florea* in the drone congregation areas particularly at the lower heights for the first time.

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References

1. Koeniger, N. Koeniger, G., Gries, M. & Tingek, S. Drone competition and drone congregation areas in four *Apis* species. Apidologie 36: 211-221 (2005)

2. Otis, G. W, Koeniger, N, Rinderer, T. E, Hadisoesilo, S, Yoshida, T, Tingek, S, Wongsiri, S, & Mardan M . Comparative mating flight times of Asian honeybees. Proc. 7 Int. Conf. On tropical bees and 5 AAA, ed. IBRA, pp 137-141(2000).

3. Koeniger, N. & Koeniger, G. Reproductive isolation among species of the genus *Apis.* Apidologie 31:313-339 (2000)

4. Punchihewa, P.W. K, Koeniger, N & Koeniger, G. Congregation of *Apis cerana indica* Fabricius 1798 in the canopy of trees in Sri Lanka. Apidologie 21: 201-208(1990)

5. Koeniger, N, Koeniger, G, Tingek, S, Kelitu, A. & Mardan, M. Drones of *Apis dorsata* (Fabricius 1793) congregate under the canopy of tall emergent trees in Borneo. Apidologie 25:249-264 (1994)

6. Nararaja, N. & Brockmann, A. Drones of the dwarf honeybee *Apis florea* are attracted to (2E)-9-Oxodecenoic acid and (2E)-10-hydroxydecenoic acid. J. Chem. Ecol. 35: 653-655 (2009).

7. Oldroyd, B. P & Wongsiri, S. Asian Honey bees. Biology, Conservation and Human Interactions. Harvard University Press. Boston Massachusetts, USA (2006).

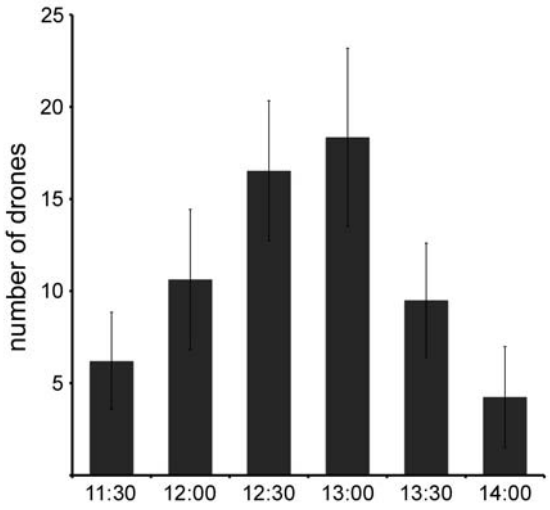
8. Buawangpang, N. Sukumalanand, P. & Burgett, M. *Apis florea* drone flight: longevity and flight performance, Apidologie 40:20-25 (2009)

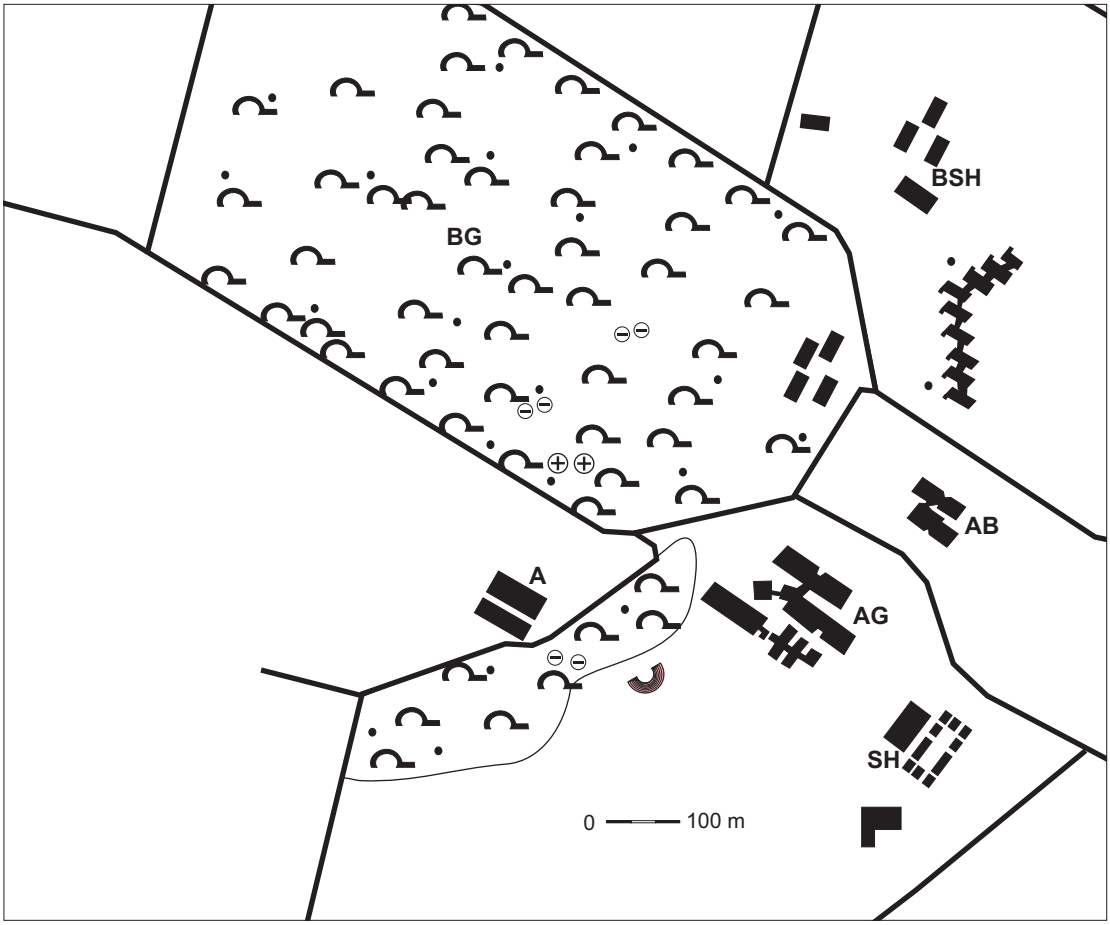
Legends for Figures

Figure 1 Drone flight time. Columns indicate average numbers of drones (±SD) arriving and departing from *A. florea* nests (N=5) within 10 min.

Figure 2 Location of *Apis florea* colonies and site of drone attraction (drone attraction experiments). (A) Map of GKVK Campus and Botanical Garden. (+) sites attracted, (--): sites not attracted by an artificial pheromone lure. BG= Botanical Garden, AC= Agriculture College, BSH: College of Basic Sciences and Humanities, A: Auditorium, SH: Students Hostel.

Figure 1 Drone flight time (the error bars give STdev)

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