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SUMMARY OF DOCTORAL THESIS

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Title: Studies on the nesting biology of hairy footed flower bee, *Anthophora plumipes* (Hymenoptera: Apidae), with special reference to its utilization as a crop pollinator in protected culture

(ケブカハナバチの営巣生態に関する研究, とくに施設栽培における送粉昆虫としての利用について).....

Anthophora plumipes is univoltine and distributed throughout Western Europe to East Asia including Japan. Flying period is ca. one month from the middle of April to the end of May in south-western Japan. Both males and female bees prefer to visit flowers with a long corolla tube. Nests of the species are often found on the bare clayish slope at the margin of secondary forests. It is gregarious, gentle and tolerant to human activities. Previous studies have suggested that *A. plumipes* can be used as a manageable pollinator of various fruit crops. In order to evaluate their effectiveness as a pollinator of horticultural crops, foraging activity of the species under the closed condition was studied in the greenhouse at the campus of Shimane University, Matsue (lat. 35°22', alt.120m). Also, the life cycle and nesting activity of them was studied at the natural habitat near Hirata (lat. 35°26', atl.30m), Shimane, Japan.

To know the nesting biology of *A. plumipes* under their natural habitat, a study was carried out by examining the nesting and foraging activities in an urban park located at Hirata, Shimane, Japan (lat. 35°26', atl.30m). The bees were found flying for about 32 days. Number of foraging trips per female per hour ranged from 0 to 3, and the highest number of trip was observed from 12:00 to 13:00 (3 trips). Average flight duration for collecting pollen was 29.9 min and for non-pollen flight was 15.6 min. Average number of flights for making one pollen ball was 11. The dense nest aggregation was found in hard clay walls in sloppy land under the root stumps of pine. Single series and multiple series nests were found having linearly arranged cells.

To know the nesting behavior under controlled condition, this bee was reared in a greenhouse located at Shimane University, Matsue, Japan (lat. 35°29', elevation 170 m) for five consecutive

years (2010 to 2014). Several nesting materials of various designs were tested. They accepted different nesting materials (Soil blocks and soil cylinder) made from soils with different colors (red and grey). Nesting female bees preferred well dried nesting materials while building the nest. Four wild flowering plants, phacelia (*Phacelia tanacetifolia*), borage (*Borago officinalis*), centaurea (*Centaurea cyanus*) and red clover (*Trifolium pretense*) and a cultivated flowering plant, strawberry (*Fragaria annanasa*), were used as floral resources. In the greenhouse, bees started digging nests from the next day of liberation, and started collecting pollen after 4 days. Besides visiting flowers, bees collected pollen throughout the day. In addition, the bees actively foraged from a low temperature of 9.5°C to a high of 36.4°C. Foraging activity was commenced at 17–99% relative humidity and light intensity from 1,250–19,810 lux, showing a high stability over a wide range of temperatures and light intensity. Morning activity was observed even in a temperature less than 9.5°C but pollen foraging flight was observed only from 9.5°C to 36.4°C. Stable foraging activities under a wide conditions indicated that this bee is a potential pollinator for greenhouse plants.

Under closed condition (in a greenhouse), bees made an average of 17.3 foraging flights per day per bee. They spent an average of 29.10 min per flight for collecting pollen, which is closer to the field condition for collecting pollen. Bees took 15.6 flights to prepare a pollen ball. A single bee prepared a maximum of 3 nests, having a maximum of 8 cells per nest. The nests were diverse in structure, with single and/or multi-series cells. A nest completed in 3 to 5 days. In this study, most of the brood cells were oriented 30–40° downwards, arranged linearly in both single and multiple series nests. Bees were active for 35 days in the greenhouse, which was almost similar to that under field condition.

Pollination efficiency of this bee for pollinating cultivated flowering plants (i.e., strawberry) was also examined. Bees took handling time of 11.02 sec flower⁻¹ (N = 340), and visited 6.47 flowers min⁻¹ (N = 68) for strawberry flower. Handling time differed by age of the flower and frequency of the visit. Seed fertilization and fruit quality (evaluated based on the shape and deformation) in bee-pollinated fruits was significantly higher than in fruits with no supplementary pollination and almost similar to those in hand-pollinated flowers. The bees visited strawberry flowers mostly for collecting nectar, however collection of pollen was not seen clearly. Frequent visit of bee for nectar seem to favor for the pollination of fruit. This bee can be used as an additional pollinator but cannot be reared for brood provision if strawberry is the only floral resource under the greenhouse conditions.

It is concluded that *A. plumipes* bees can be reared under the closed conditions and can be used as a promising alternative pollinator of different kinds of flowering plants under such conditions.