Bumblebees under the midnight sun

Monitoring circadian rhythms of bumblebees under continuous daylight, using radio frequency identification (RFID)

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1. Why study circadian rhythms in bumblebees?

Most previous studies on circadian rhythms focused on solitary animals [1]. In social insects, the colony as a super-organism has a foraging rhythm aligned to the patterns of resource availability. Within this colony rhythm, the activity patterns of individuals are embedded. In temperate regions bumblebee foragers show strong circadian rhythms.

But what about circadian foraging patterns under continuous daylight?

Will the colony extend its foraging activity over the whole 24h of a day?

2. Methods

Four colonies of *Bombus terrestris* were set up in north-western Finland (Kilpisjärvi Biological Station, 270 km north of the arctic circle).

Bumblebees in that area experience continuous daylight for several weeks during the summer months.

To be able to monitor the foraging patterns of each forager every individual was fitted with a small RFID tag, which was glued to the thorax.

RFID readers placed at the nest entrance automatically recorded every leaving or returning individual.

3. Results: Did the colonies extend their foraging activity over the whole 24h?

Even under continuous daylight the colonies showed strong and consistent circadian rhythms (see below). There was almost no foraging activity between 00:00h and 06:00h.

Light levels and outside temperature never dropped below values that would make it impossible for *Bombus terrestris* workers to forage (right). The picture above was taken at 02:40 a.m. near the field station.

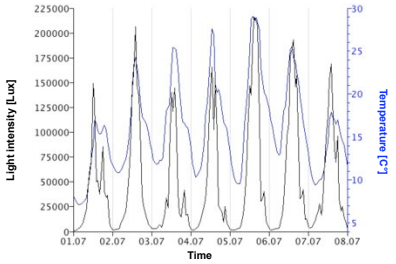

Fig. 2. Light intensity (black) and outside temperature (blue) measured at Kilpisjärvi Biological Field Station between 01/07/07 and 07/07/07. Temperature varied between 4.7 C° and 29.0 C° in this time period, the light intensity varied between 1,051.8 lx and 216,404.4 lx.

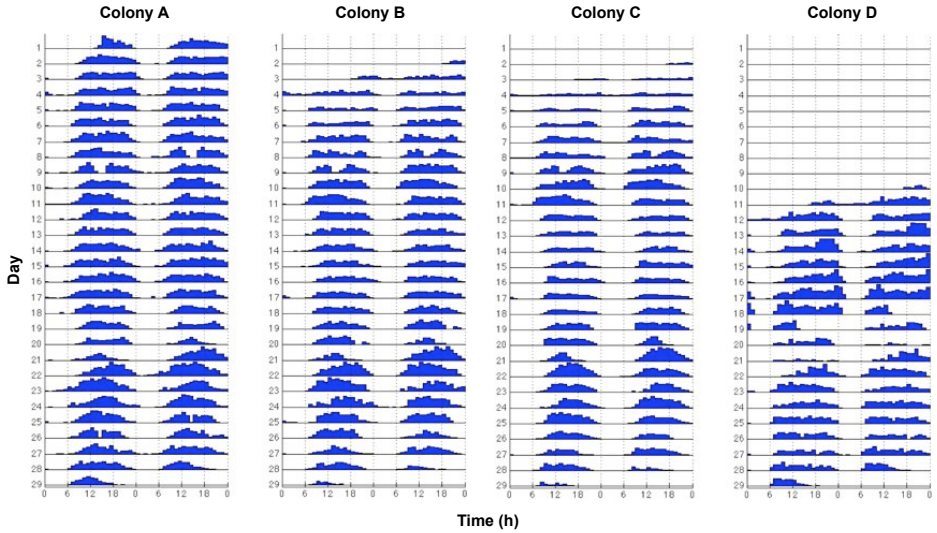

Fig. 1. Double-plotted actograms of the four colonies (A–D) of *Bombus terrestris* tested in the field under continuous daylight between 20/06/07 (day 1) and 18/07/07 (day 29). A given row shows two consecutive days of activity. The second such day is re-plotted in the left half of the next row down. Heights of bars indicate the level of activity per 1h data-collection bin. Colonies A–C were set up at the field station, Colony D was set up about 8 km north of the station. Colonies C and D were interchanged in the early morning of day 20. The colonies were set up on different days.

4. Conclusions

Even without a distinct light:dark cycle the colonies showed a strong and consistent rhythm in their foraging patterns. Thus, the foragers had to be entrained by some cue (*Zeitgeber*).

Temperature could be a possible factor, since it varied greatly over the course of the day (see Fig 2). Previous studies showed that honeybees can be entrained by temperature cycles with a 10°C amplitude [2].

UV radiation, which bumblebees can detect [3], also varies greatly and might therefore be another possible cue.

5. Further work

The next step will be to examine in the laboratory what exactly acts as a *Zeitgeber* on the bumblebees.

6. References

[1] Stanewsky, R. *Cell and Tissue Research* **309**:11-26 (2002)
[2] Fuchikawa, T. & Shimizu, I. *Journal of Insect Physiology* **53**:1179-1187 (2007)
[3] Skorupski, P., Döring, T. and Chittka, L. *J Comp Physiol A* **193**:485-494 (2007)

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