Circadian activity in a nest of *Bombus terrestris* L. (Hymenoptera: Apidae)

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Nielsen, E. T.: Circadian activity in a nest of *Bombus terrestris* L. (Hymenoptera: Apidae). Ent. Meddr, 46: 73–74. Copenhagen, Denmark. ISSN 0013-8851.

The activity in a subterranean nest of a bumblebee is shown to depend on a circadian rhythm.

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Introduction

The observations and experiments reported below were made in July and August, 1945, close to the biological laboratory Pilehuset in North Zealand, Denmark. The results were presented at a meeting of Entomologisk Forening, Copenhagen in the fall of 1945. The results were at that time so surprising that further publication was postponed until more work could be done, but the opportunity never arose.

Field observations

The nest was situated close to a pine tree in a rather open area with heather and dry grasses; the soil under the tree was sand mixed with pine needles. The nest was probably built in an old mouse nest. The soil was so loose that a bee sometimes came out through it instead of using the entrance hole about 50 cm from the nest. The site of the nest could be located by listening to the ground.

A mercury thermometer placed in the nest showed a temperature of 32–34°C. Outside the nest in the same depth (15–20 cm) it was 13–15°. During the observation period the air temperature 2 m above ground in the open shade of the pine tree ranged from 17 to 30°C.

Just above the nest a number of bees were working in the soil all day, usually 2–12 at a time. Sixteen of these bees were marked, and they were found mostly to stay there. Only rarely was a single one of them seen coming to the entrance with food. In cool weather and towards evening, the workers smoothed the surface; at high temperature they worked down in the soil and the surface looked rough and disturbed. It seemed to be a mechanism for regulation of ventilation or temperature.

When the bees returned to the nest, they were first, from a distance, orientated toward the tree; when they came closer they orientated toward objects around the nest hole; making errors in landing when distinctive straws at the hole were displaced.

The first bees appeared in the morning between 04h30' and 05h00'; sunrise during the observation period was about 04h. The cessation of activity varied from day to day but took place usually between 21h00' and 21h30'. The average hour for sunset was about 20h35' and the twilight lasted about an hour.

Laboratory experiments

During the field observations the question arose: How do these bees in the ground know when it is time to begin the activity?

Between July 18 and August 17, three experiments were performed by means of a very simple actograph. The animal was placed in a cellophane cylinder which in one end was attached to a flat strip of spring steel. By the movements of the animal the cylinder was moving up and down, and the movements were recorded on smoked paper on a kymograph.

The experiments were carried out in a room where illumination and temperature were controlled.

The first experiment showed that by changing the light period from the natural 05h–21h to

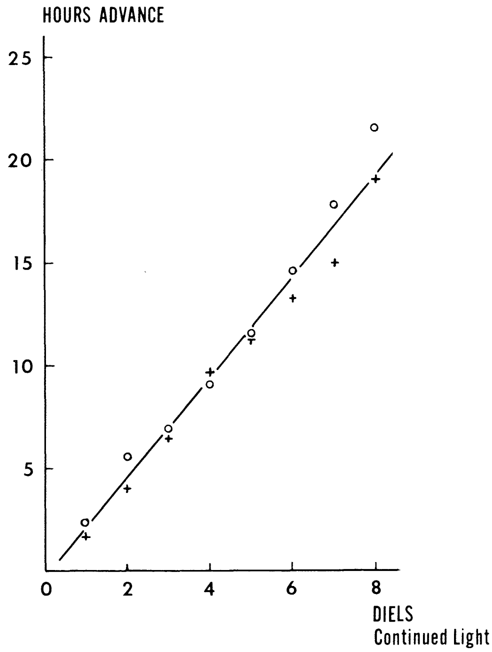

Fig. 1. Advance of the median of locomotory activity of two *Bombus terrestris* during 8 diels in continued light.

21h–13h, the animal became fully adapted after 48 hours to the new light regime. The two other experiments were made in continued light at 24°C, each lasting 8 diels. There was a very distinct advance of the activity from day to day (Fig. 1) averaging for the 16 diels 2h27', S. D. = 40' (there was no significant difference between the two animals).

That "endogenous" activity without cues from the environment deviates from 24 hours was first noticed by Hemmingsen and Krarup (1937); they found that the activity of rats in continued light recurred with about two hours delay. It was, therefore, completely unexpected that bumblebees, also in continued light, advanced the activity. First many years later it became clear that both findings were typical cases of the circadian rules of Aschoff (1965).

A rational explanation of the physiological mechanism of circadian rhythms has been attempted by Nielsen and Dreisig (1970), and Dreisig and Nielsen (1971).

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Sammendrag

Circadian aktivitet i en rede af *Bombus terrestris* L. (Hymenoptera: Apidae).

Ved en undersøgelse af humlers liv i et underjordisk bo kom jeg til at tænke på, hvad der får disse dyr til at flyve ud om morgenen; for nede i boet er der altid mørke og ens temperatur.

Ved hjælp af en ganske enkel teknik var det muligt at vise, at døgnrytmen fortsætter i vedvarende lys og ved konstant temperatur. Perioden var dog ikke på 24 timer, men omtrent to og en halv time kortere.

Det var dengang, i 1948, et så overraskende resultat, at jeg ville vente med at publicere det, til jeg kunne få lavet flere forsøg, men det blev der aldrig lejlighed til.

Imidlertid påviste Aschoff i 1951, at periodicitet, der fortsætter i konstante omgivelser, afviger lovmæssigt fra 24 timer (det circadianske princip). Humlerne opførte sig altså blot i overensstemmelse med denne lovmæssighed. Der foreligger, så vidt mig bekendt, ikke andre undersøgelser af denne side af humlernes levevis.