The structure of locomotor activity in bilobectomized cockroaches *(Blaberus fuscus)*

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Summary. The aperiodic activity patterns of bilobectomized cockroaches can largely be described by simple stochastic regularities: a) there are no correlations between the lengths of successive activity bursts and rest pauses, b) the probabilities for the transition from activity to rest and from rest to activity are time-independent. The activity sequence is strongly influenced by singular temperature steps or temperature cycles.

In Orthoptera and Blattoidea, the circadian locomotion rhythm ceases after bilateral interruption of the nervous tracts between the optic lobes and the protocerebrum[1-3]. Possibly, in the lobes, a circadian pacemaker is localized modulating the excitation of other nervous centres which inhibit respectively activate locomotion[4,5]. Our investigations are aimed to verify the loss of any rhythms by means of a mathematical periodogram analysis, and to describe the activity sequences by means of simple stochastic regularities[6,7].

Method. The cockroaches were individually tested in running wheels whose rotations were counted in 10-min intervals by an IR beam. The experiments lasted 18-21 days. The periodogram-analysis searches for those actograms in which the arrangement of phase-identical values in horizontal lines is optimalized[8]. The analysis for simple stochastic regularities distinguishes only between activity and rest. Because small intervals without recordings may not represent actual rest pauses but special activities like eating or drinking, we defined: a burst of activity is only finished by more than 2 consecutive 10-min intervals without wheel movements. The analysis includes a) the computing of the serial correlations between 'the length of the activity bursts' (=A) and 'the length of succeeding respectively preceding rest pauses' (=R) and b) the description of the A- and R-frequency histograms by fitted exponential functions of the type $y = a \cdot e^{-f \cdot x}$ (conformity rejected at $a_{\chi^2} = 0.25$).

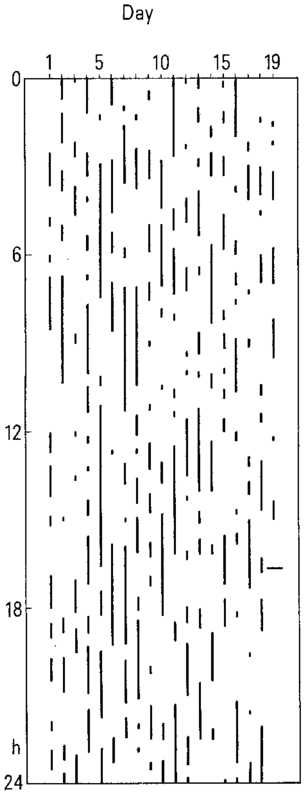

Fig. 1. The aperiodic actogram of a cockroach with bilateral interruption of the optic tracts. LL (0.07 lux). Dark lines: activity bursts.

Results. 34 actograms of 12 operated animals were recorded in the range of 1-240 days after the bilateral interruption of the optic tracts (in constant darkness, constant light (0.07 lux) and 12/12 h light/dark cycles (0/4 lux)). Neither circadian nor infradian or ultradian periodical components could be detected by periodogram-analysis (figure 1). Correlations between A and R do not exist in the aperiodic

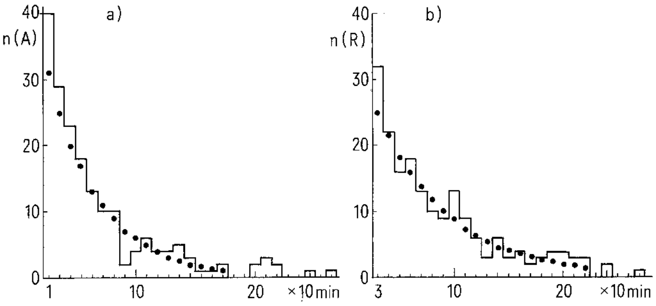

Fig. 2. The frequency histograms of the lengths of activity bursts (a) und rest pauses (b) of the actogram in figure 1. Ordinates: frequencies of the classes. Abscissa: length-classes. Course of points: the fitted exponential functions in the range of conformity with the observed distributions (in both cases $a\chi^2 = 0.75$). The range of conformity includes 97 and 88% of the values.

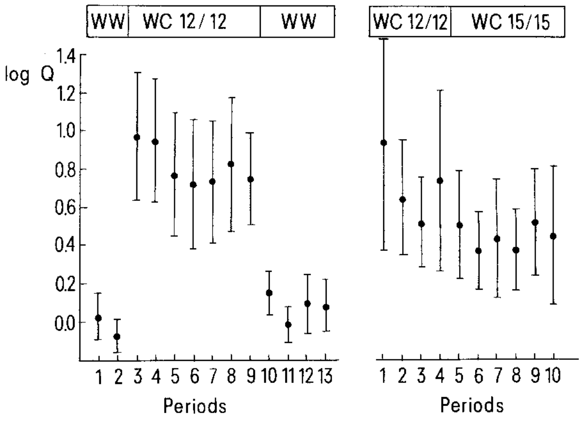

Fig. 3. The behaviour of bilobectomized cockroaches in temperature cycles. Experimental programs: left: constant temperature (30 °C, WW) → 12/12 h temperature cycles (30/25 °C, WC) → WW (30 °C); right: 12/12 h WC (30/25 °C) → 15/15 h WC (30/25 °C).

$$Q = \frac{[\text{duration of activity in 1 warm phase}] \times 2}{[\text{duration of activity in the previous and following cold phase}]}$$

or

$$Q = \frac{[\text{duration of activity in 2 successive warm phases}]}{[\text{duration of activity in the intercalary cold phase}] \times 2}$$

On the ordinate, the decadic logarithm of the mean values of Q is plotted (together with the SD; left program: 10, right program: 8 animals were tested). In constant temperature formally the same time screen as in the temperature cycles is used. In WW, respectively in non-inducing environmental cycles, log Q should be 0 on the average.

actograms (level of significance 1%). That means: the events determining the transition from activity to rest and from rest to activity have no influence on one another. The frequency histograms of A and R could be fitted in 66% and 90% of all actograms to exponential functions. Therefore the conclusion is permitted that in these cases the transition probabilities from activity to rest and vice versa are independent of the duration of activity respectively rest. The transition probabilities $p_{A \to R}$ and $p_{R \to A}$ are negatively correlated with each other ($r = -0.75$, $\alpha < 0.1\%$). - The transition probabilities are not temperature-compensated. An increase of temperature reduces the probability for the transition from activity to rest and enlarges the probability for the transition from rest to activity (2 experiments, each with 10 animals; 1st experiment: 11 days 23.5 °C → 11 days 28 °C; 2nd experiment: 7 days 28.2 °C → 7 days 33 °C → 7 days 28.5 °C). Whereas the endogenous circadian periodicity of intact cockroaches is hardly influenced by temperature cycles, in operated animals 12/12 h as well as 15/15 or 24/24 h cycles induce corresponding locomotion rhythms (12/12 h cycles: 23/29 °C, 19/29 °C, 25/30 °C; 15/15 h cycles: 25/30 °C; 24/24 h cycles: 25/30 °C; each experiment with at least 7 bilobectomized animals, figure 3) (see the partly contrary results in Gryllus[9]). In constant conditions, the induced rhythms seem to cease immediately (figure 3).

Discussion. The activity patterns of bilobectomized cockroaches can largely be described by the assumption of simple stochastic regularities. Possibly other higher animals also are endowed with at least 2 nervous mechanisms by which spontaneous activity and rest can be controlled. 1 mechanism is the circadian pacemaker, the other probably consists of 2 random generators which produce endogenous signals starting and closing activity bursts and rest pauses. Normally the random mechanism seems to be superimposed by the circadian clock. The importance of the random mechanism in intact animals is unknown. Perhaps it controls the subtle distribution of activity in rhythmically structured locomotion patterns. In animals with degenerated circadian clock (for instance *Uca* species[6,7] or cavernicolous animals[10,11]) the activity sequence is predominantly or exclusively structured by an endogenous random mechanism.

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Effects of an insect growth regulator, ZR-2646 on egg fertility in the fleshfly, *Sarcophaga bullata*[1]

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Summary. Topical application of an insect growth regulator, ZR-2646 on adult females of *Sarcophaga bullata* affects the viability of the eggs. The compound is most effective if applied at the time of ovulation.

Though the presence of optimal titers of juvenile hormone (JH) is essential for the normal reproductive performance of insects, the same hormone or compound with JH activity can act as an ovicide if applied at a certain time during the ovarian cycle[3-5]. Usually this is the period of ovulation when the endogenous JH titer is at its low. On these grounds several insect growth regulators (IGR) with JH activity have been synthesized and their potential use against insect pests tested[6]. I report here the ovicidal effects of one such IGR, ZR-2646 on the fleshfly, *Sarcophaga bullata*.

Material and methods. The fleshfly, *Sarcophaga bullata* was reared in the laboratory under constant conditions of photoperiod (16 h light/8 h dark) and temperature (25 °C)[7]. Under these conditions yolk deposition starts on the 4th day of eclosion and mature eggs are ovulated on the 7th day after eclosion. After 4 days of embryonic development 1st instar larvae are laid on the 11th day after eclosion.

The IGR ZR-2646[8] was dissolved in 99.9% pure acetone and 5 µl of the solution containing known amounts of IGR was applied topically onto mid dorsal abdominal cuticle of each female fly. Since this compound was reported to act as a juvenile hormone mimic as well as a juvenile hormone antagonist in *Manduca sexta* with high and low doses respectively[9] the effect of 20 µg or 5 µg per fly was tested. Control flies received 5 µl of acetone only.

Results and discussion. The table shows the effect of ZR-2646 on egg fecundity. Neither of the doses used caused any reduction in the total number of matured eggs produced per fly. However, fertility was affected by 20 µg of IGR. The effect was dependent on the day of treatment.

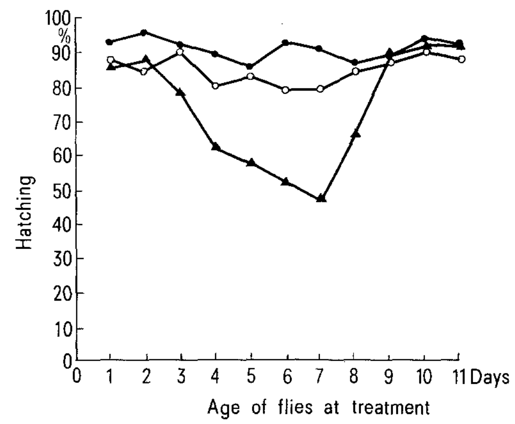

Fig. 1. Effect of ZR-2646 on the percentage of eggs that hatch into 1st instar larvae. ●, Control; ○, 5 µg of ZR-2646; ▲, 20 µg of ZR-2646.