A PRELIMINARY REPORT ON THE DIURNAL RHYTHM IN THE LOCOMOTOR ACTIVITY OF PILL-MILLIPEDE, ARTHROSPHAERA DALYI (POCOCK)

BY AL. PAULPANDIAN*

(University of Madras, Madurai Centre, Madurai-2, S. India)

Received May 10, 1965

(Communicated by Dr. S. Krishnaswamy, F.A.Sc.)

The phenomenon of 24-hour periodicity in animals and plants is well known. Reviews by Welsh (1938), Park (1940) and Calhoun (1944), Harker (1958) and Cloudsley-Thompson (1961) give detailed information about physiological and behavioural rhythmicity in the animal kingdom.

Park, Lockett and Myers (1931) have studied the activity of the millipede, Polydesmus serratus and found the endogenous nature of locomotor activity which showed the peak of activity at night and inactiveness during the day. They showed that activity increases with increasing relative humidity and decreasing temperature; and decreases with decreasing relative humidity and increasing temperature. Park (1935) has shown in Spirobolus marginatus a persistent locomotor rhythm lasting for periods up to 18 days which is not associated with feeding or hunger periods. Cloudsley-Thompson (1951) has reported an exogenous rhythm primarily responding to light and darkness in the British millipedes, Blaniulus and Paradesmus. He has also shown in his aktograph studies on Ophistreptus and Oxydesmus an endogenous diurnal rhythm independent of fluctuating light and temperature and persisting up to 19 days.

The present paper is a preliminary report on the persistent endogenous diurnal rhythm in the locomotor activity of pill-millipede, Arthrosphaera dalyi (Pocock).

MATERIAL AND METHODS

The pill-millipedes, Arthrosphaera dalyi (Pocock), were collected from Pazhamudir Solai area of Alagarcoil hills which is about 12 miles from Madurai. They were reared in a glass terrarium, the base of which was

* Present Address: Marine Biological Station, Porto Novo, S. India.
filled with damp humus. Once in three days spraying water on the surface of the humus helped it to regain the loss of dampness. The temperature inside the terrarium was 27° C. ± 1° C. throughout the period of investigation.

The locomotor activity was recorded with an aktograph consisting of an animal chamber and a mechanical recording system. The animal chamber was a rectangular plastic box with perforations to allow free passage of air. One end of the chamber was suspended in a rigid support and the other end was connected to a palmer lever. Suitable weight was added in the recording arm to counterbalance the weight of activity chamber. When the animal moved from one end to the other, the chamber tipped on one side which actuated the lever which in turn recorded the movement on a smoked kymograph drum. To keep the animal chamber moist throughout the experimental period a wet filter-paper was placed at the bottom of the chamber. A cord piercing through the filter-paper and the bottom of the chamber irrigated the filter-paper from the water kept in a finger bowl placed 5 cm. below the activity chamber. This ensured not only a constant moist surface but a constant relative humidity. The activity chamber and the water container were placed in an outer chamber where the temperature was maintained at 27° ± 0.1° C. with a thermostat.

A 60-Watts incandescent lamp placed 50 cm. above the terrarium served as a light source for treating the animals to constant light condition. A similar lamp was placed 50 cm. above the experimental chamber to record the activity in continuous light condition. For treating the animals to constant darkness the terrarium was made light-tight by covering it with black paper. In the same way the experimental chamber was also made light-tight. The terrarium and experimental chamber were exposed to the normal light condition for natural light experiments.

A quantitative picture of the activity was obtained by measuring the number of tilts recorded in the paper.

RESULTS

Figure 1 shows the Kymograph tracing of the locomotor activity of pill-millipede A. dalyi kept in constant darkness.

Pill-millipedes conditioned to natural light in the laboratory show the diurnal rhythm of activity which is persistent beyond ten days. The activity phase sets in between 4 and 5 p.m. in the evening (Fig. 2). Two peaks of
activity could be noted during the night; one occurring between 6 and 8 p.m. and the second between 12 midnight and 2 a.m. A stepwise decrease in activity was evident after the second peak of activity. The activity is continuous during night and this phase of activity was found to end always between 7 and 8 a.m. Intermittent outbursts of activity occur during the daytime.

The pattern of activity exhibited by animals adapted to constant darkness is illustrated in Fig. 3. As in the case of natural light adapted animals the activity phase sets in between 4 and 5 p.m. and the animal was continuously active throughout the night. This active period ends abruptly at 6 a.m. During the day the animal was totally inactive. This pattern was found to be repeated in tracings made on consecutive days.

The activity pattern is, however, altered when the animal was conditioned to constant light (Fig. 4). A shift is evident in the activity pattern. The activity phase sets in only after 6 p.m., showing nearly 2 hours shift and
Fig. 3. Activity of *A. dalyi*, kept in constant darkness. (Total period: 48 hours. M is midnight, N is noon.)

Fig. 4. Activity of *A. dalyi* kept in constant light. (Total period: 48 hours. M is midnight, N is noon.)

thus it differs from dark and normal adapted animals. The end of the activity phase also shows a shift of two hours from the natural light adapted animals by prolonging the activity up to 10 a.m. Even though no clear peaks of activity could be noted, the maximum activity was found in the early hours of the activity phase. A stepwise decrease in the activity beyond 2 a.m. could be noted as in the case of natural light adapted animals. But constant light adapted animals show no outbursts of activity during daytime. Table I shows the total number of tilts of the activity chamber in a period lasting for 48 hours for five sets of animals adapted to natural light,
Diurnal Rhythm in Locomotor Activity of Pill-Millipede, A. dalyi

constant light and constant dark conditions. The activity was very high in natural light condition which was followed by the constant light adapted animals. The least number of tilts was found in the dark adapted animals.

TABLE I

Total number of tilts of the activity chamber for a period of 48 hours

<table>
<thead>
<tr>
<th>Total number of tilts in 48 hours</th>
<th>In natural light</th>
<th>In constant light</th>
<th>In constant darkness</th>
</tr>
</thead>
<tbody>
<tr>
<td>SET 1</td>
<td>989</td>
<td>774</td>
<td>632</td>
</tr>
<tr>
<td>SET 2</td>
<td>642</td>
<td>728</td>
<td>597</td>
</tr>
<tr>
<td>SET 3</td>
<td>732</td>
<td>640</td>
<td>615</td>
</tr>
<tr>
<td>SET 4</td>
<td>806</td>
<td>673</td>
<td>622</td>
</tr>
<tr>
<td>SET 5</td>
<td>827</td>
<td>692</td>
<td>640</td>
</tr>
<tr>
<td>Grand Total</td>
<td>3996</td>
<td>3507</td>
<td>3106</td>
</tr>
</tbody>
</table>

DISCUSSION

The observations on the locomotor activity of the pill-millipede, A. dalyi, show a definite diurnal rhythm in constant temperature and humidity. The setting of the activity phase between 4 and 5 p.m. in laboratory conditions and in dark adapted animals could be ascribed to the fall in temperature and increase in the relative humidity in the natural environment (Park, 1931). However, this was noted even under constant temperature and relative humidity in the present investigation. In the constant light condition, a delay of nearly two hours is found in the setting of activity which is similar to the observations reported in cockroach (Harker, 1960). The two peaks of activity found in natural light condition are similar to the flight activity of Trichopterans (Corbet and Tjønneland, 1956) and that of the heart beat of the brackish water prawn Metapenaeus monoceros (Paulpandian, 1964). This may be attributed to an active feeding followed by a brief period of less activity and their repeated feeding activity. Constant light and darkness appears to have an inhibitory effect on the peaks of activity, the latter having a more pronounced effect,
Activity is high and continuous at nights and spasmodic outbursts are found during day in natural light adapted animals. Further, it is continuous and high in constant light and continuous and low in constant darkness. This is contrary to the reported findings in cockroach where the activity is low and fairly continuous in light and spasmodic and high in darkness (Harker, 1956).

The total activity for five sets of animals for a period of 48 hours in all three conditions shows a higher rate in the natural light condition and is mainly due to the occasional outbursts of activity during the daytime. In the field it may be advantageous to the animal to lie buried at various depths in the soil according to the variations of temperature and light during the day and this may cause the intermittent, brief bursts of activity noticed in the day. Constant darkness and light completely inhibit such occasional outbursts of activity. The higher activity found in constant light may be due to avoidance reaction of the animals. Constant darkness brings down the total activity thus showing an inhibitory mechanism.

Though it was reported that the tropical millipedes, *Ophistreptus* and *Oxydesmus*, were not affected by light and darkness (Cloudsley-Thompson, 1951), the tropical pill-millipede studied here behaves differently. In *A. dalyi* the locomotor activity is inhibited by constant darkness and a shift in the phase of activity is evident in constant light condition.

**SUMMARY**

The investigation on the locomotor activity of the pill-millipede, *Arthrosphaera dalyi*, kept under constant temperature and humidity, shows a persistent diurnal rhythm. The activity phase was found to occur mainly during night. In natural light condition, the activity pattern is characterised by two peaks followed by a stepwise decrease in activity during night and occasional outbursts of activity during day. The inhibitory influence of constant darkness on the activity is evident from the absence of peaks and the occasional outbursts of activity. Constant light causes a shift of nearly two hours in the setting in of the activity phase with a corresponding shift of two hours in the termination of the activity phase.

**ACKNOWLEDGEMENTS**

The author is deeply indebted to Professor S. Krishnaswamy for his guidance and keen interest in the subject. Thanks are due to the Government of India, for the award of a Research Scholarship.
REFERENCES


