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Activity of *Sorex coronatus* (Insectivora, Soricidae) in the field

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Abstract

Studied was the activity pattern of *Sorex coronatus* in the field in order to compare it with that of the sympatric shrew *Crocidura russula*. Eight radioactive tracking experiments, each of 24 hours duration, were performed at Bassins, Switzerland. Like other shrews of the genus *Sorex*, *S. coronatus* exhibits a higher activity rate (about 54 % of the total time) than *Crocidura russula* (about 33 %). This intense activity is mainly achieved by longer activity periods and by a high diurnal activity rate, which almost equals the nocturnal one. It is interpreted as an adaptation to the severe energetical conditions experienced by the wintering shrews in cold climates and/or as a consequence of the maintenance of a large territory.

Introduction

The time budget of the Soricidae in the field only begins to be adequately described. Some observations have been performed by radioactive tracking on *Sorex araneus*, *Sorex minutus* and *Sorex arcticus* in the USSR (KARULIN et al. 1974; KHLIYAP 1980), on *Blarina brevicauda* in North America (PLATT 1976) and on *Crocidura russula* in Europe (GENOUD and VOGEL 1981). The three species of *Sorex* stand out by their high activity rates.

In the framework of a study on the bioenergetics of European shrews, it seemed interesting to describe the activity pattern of *Sorex coronatus* in order to compare it with that of *Crocidura russula*. These two species are sympatric over a large part of Europe but have different ecological distributions (GENOUD 1982). They belong to two different subfamilies (Soricinae and Crocidurinae) which have developed widely different biological strategies (VOGEL 1980).

Material and methods

The observations have been carried out at Bassins (Western Switzerland, 750 m). A small population inhabiting a hedge (320 m long by 3 to 6 m wide) has been followed from November 1981 through November 1982 by regular live-trapping. On eight occasions, resident *Sorex coronatus* were weighed, marked with an auricular ring bearing a filament of radioactive tantalum (^{182}Ta , 400 to 600 microci) and followed continuously during more than 24 h with a portable scintillation counter (GENOUD and HAUSER 1979; GENOUD 1981). The shrews were located every one or two minutes. Resting periods were defined as periods of complete immobility. All observations have been made from a path running along the hedge in an attempt to minimize disturbance. The air temperature in the litter (+2 cm) has been recorded during each experiment.

Results

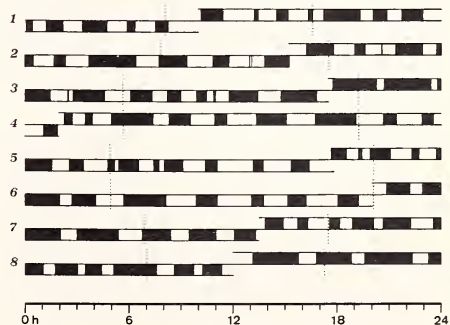
The principal characteristics of the activity of the marked shrews are listed in the table. The total daily activity does not show any clear seasonal trend. It is independent of the thermal conditions (correlation and regression coefficients are not significant; $P > 0.05$). The shrews followed were active for $776 \text{ min} \pm 131 \text{ min}$ each day ($54\% \pm 9\%$ of the time).

Principal characteristics of the activity pattern of *Sorex coronatus*

Experiment	Date	Mean ambient temperature in the litter ($^{\circ}\text{C}$)	Sex	Weight (g)	Age	t.d.a. (min)	d.r.a. (min/h)	n.r.a. (min/h)
1	16. 12. 81	2.9	♀	7.2	sad	632	18.1	30.8
2	03. 02. 82	1.4	♂	8.2	sad	714	32.0	28.3
3	13. 04. 82	1.5	♂	9.0	ad	910	34.4	42.4
4	15. 04. 82	3.0	♀	12.0–9.0 ¹	ad	702	34.7	22.1
5	27. 07. 82	13.3	♀	12.0–10.0 ¹	ad	637	25.4	28.4
6	28. 07. 82	14.5	♂	8.0	sad	757	26.9	39.4
7	20. 10. 82	10.0	♀	9.9	sad	874	34.1	38.3
8	27. 10. 82	8.7	♂	9.3	sad	981	35.3	45.0

¹ pregnant at the beginning, lactating at the end (parturition occurred during the experiment).
t.d.a. = total daily activity; d.r.a. = mean diurnal hourly rate of activity; n.r.a. = mean nocturnal hourly rate of activity; sad = subadult; ad = adult

The daily activity shows a polyphasic pattern (Fig.). 10.6 ± 1.7 activity periods occur every 24 h. They last on an average 75 min (1 min to 183 min) and are separated by resting periods of 61 min average duration (7 min to 125 min). There is a slight tendency ($P = 0.15$) for the activity rate to be higher at night ($34.3 \pm 8.0 \text{ min/h}$) than during the day ($30.1 \pm 11.5 \text{ min/h}$). On the average, the activity periods are also slightly longer during the night (79 min against 67 min).



Activity pattern of *Sorex coronatus*. The activity periods are represented in black. Dotted lines: sunset and sunrise. No. of the experiment in italics. For details see table

Discussion

Since several authors have reported strong seasonal variations in the activity rate of other species of the genus *Sorex* (BUCHALCZYK 1972; NEWMAN 1976; VLASAK 1980; CHURCHFIELD 1982), it seems at first surprising that the activity of *Sorex coronatus* is more or less evenly distributed through the annual cycle. This contradiction needs three remarks: firstly, those studies that were performed in the field (NEWMAN 1976; VLASAK 1980) were based on indirect methods (live-trapping) which only give little information on the real activity of the shrews. Secondly, the activity pattern observed in captivity may be very different from that of free-living shrews, especially during the winter (GENOUD and VOGEL 1981). In fact, GENOUD and VOGEL (1981) have shown that these differences are essentially due to differences in food availability: it is quite clear that the abundance, distribution and accessibility of prey in nature can hardly be simulated artificially. Thirdly, the previous observations based on radioactive tracking, particularly those on *Crocidura russula* (GENOUD and VOGEL 1981), also lack any clear seasonal trend in the activity rate. However, it must be stressed that for each species studied by radioactive tracking, only few experiments were performed. Obviously, such a small number of observations cannot show in a precise way all the variations in the activity pattern as a function of the physiological state or of the environmental conditions. Nevertheless, it can be assumed that they show the major traits of the activity pattern of a given species, provided that they are representative of all the situations usually encountered by that species.

The activity pattern of *Sorex coronatus* is similar to that of *Sorex araneus*, *Sorex minutus* and *Sorex arcticus*. In particular, its total daily activity does not differ significantly from that of these species ($P > 0.05$) (*Sorex araneus*: 876 min \pm 81 min, KARULIN et al. 1974; *Sorex minutus*: 752 min \pm 124 min and *Sorex arcticus*: 905 min \pm 157 min, KHLIAP 1980). On the contrary, it is significantly higher ($P < 0.01$) than that of the sympatric shrew *Crocidura russula* (478 min \pm 92 min, GENOUD and VOGEL 1981). This difference is partly due to the longer activity periods and the shorter resting periods of *Sorex coronatus*. But the higher activity rate of *Sorex coronatus*, compared to that of *Crocidura russula*, is mainly achieved by an intense diurnal activity. *Sorex coronatus* only exhibits weakly differing rates during the day and the night, whereas in *Crocidura russula* the mean diurnal rate is approximately half as high as the nocturnal rate.

Whether the differences in the activity patterns of *Crocidura russula* and *Sorex coronatus* represent behavioural adaptations, secondary consequences of some other traits (e.g. metabolism or territoriality), or simply adjustments to particular environmental conditions remains open to question. Up to a given threshold, the shrews certainly do adjust their activity pattern to the environment (PERNETTA 1973; GENOUD and VOGEL 1981). However, this seems far from being a sufficient explanation for the differences between the two species since 1. these differences are large, 2. the activity pattern of *Sorex coronatus* is similar to that of other species of *Sorex* which were studied in other regions and other habitats and 3. even in captivity, the shrews belonging to the genus *Sorex* maintain a higher diurnal activity rate than those of the genus *Crocidura* (VOGEL et al. 1981).

At least two factors can explain to some extent the intense activity of the representatives of the genus *Sorex*:

1. In captivity (CROWCROFT 1954; BUCHALCZYK 1972) as well as in the field (GENOUD and VOGEL 1981) the wintering shrews devote a major part of their activity to foraging. Since for a small searching predator, the net rate of energy gain is directly related to the search rate, a high activity rate certainly favours the balancing of the energy budget in winter. The intense activity of the *Sorex* may then have evolved either in response to high energy expenses or to a low resource availability, or to both. On one hand, the *Sorex* do in fact have higher metabolic rates than the *Crocidura* (VOGEL 1976; NAGEL

1980), but a comparison of the absolute energy requirements of individual species of these two genus in the field is still not available. On the other hand, the *Sorex* are able to balance their energy budget even in cold habitats, where prey are rare and scattered in winter, whereas the European *Crocidura* are restricted to mild climates or depend on man-made energetically favourable sites (RICHTER 1963; GENOUD and HAUSSER 1979; GENOUD 1982).

2. Contrary to *Crocidura russula*, the *Sorex* defend large exclusive territories in winter (CROIN MICHELSEN 1966; GENOUD 1978). The maintenance of a territory may take up a certain amount of time (e.g. border patrol, marking, PLATT 1976; ELLENBROEK 1980). It should be kept in mind that in *Sorex*, territoriality has itself been interpreted as an adaptation to harsh climatic conditions during the winter season (CROIN MICHELSEN 1966).

These two hypotheses should be examined carefully. Firstly, *Blarina brevicauda* exhibits an activity rate similar to that of *Crocidura russula* although it is widely distributed in the cold regions of North America and has a winter social organization similar to that of the European *Sorex* (PLATT 1976). It should be remembered that the activity pattern is just one of the numerous traits which constitute an energy strategy. Even under grossly similar energetical conditions, different taxa may adopt quite different strategies. Secondly, these two hypotheses exclusively involve behavioural traits or environmental conditions dealing with wintering populations. One could argue that other factors may also have influenced the evolution of the activity pattern in *Crocidura* and *Sorex* (especially that exhibited during the breeding season), such as the mating system, the exploratory behaviour or the pattern of dispersal. However, it should be remembered that resource acquisition and allocation evidently has set strong constraints on the evolution of shrews in the colder regions (CROIN MICHELSEN 1966; PUCEK 1970; VOGEL 1980). Most probably, the activity patterns of the European *Sorex* and *Crocidura* primarily reflect the widely different energy strategies which these shrews have adopted.

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Zusammenfassung

Die Aktivität von Sorex coronatus (Insectivora, Soricidae) im Freiland

Aktivitätsdauer und -rhythmus von *Sorex coronatus* wurden im Freiland (Bassins, Westschweiz, 750 m) mittels radioaktiv markierter Tiere untersucht und mit Resultaten der sympatrischen Spitzmaus *Crocidura russula* verglichen. Die acht Experimente von je 24 Stunden Dauer zeigten 1. keine klare saisonale Veränderung der Tagesaktivität, die im Durchschnitt 776 min \pm 131 min (ungefähr 54 % der Zeit) beträgt, 2. ein polyphasisches Aktivitätsmuster mit 10.6 \pm 1.7 Aktivitätsphasen pro Tag und 3. keinen klaren Tagesrhythmus, denn *Sorex coronatus* ist tagsüber fast ebenso aktiv wie nachts. Im Vergleich zu *Crocidura russula* zeigt *Sorex coronatus* – genau wie andere Vertreter der Gattung *Sorex* – ein höheres Tagestotal der Aktivität, eine Folge der längeren Aktivitätsphasen und einer tagsüber höheren Aktivität. Diese intensivere Aktivität bei *Sorex* wird als Anpassung an die sehr strengen energetischen Bedingungen interpretiert, denen die Spitzmäuse im Winter ausgesetzt sind, und/oder aus der Konsequenz, welche aus der Erhaltung eines großen Territoriums resultiert.

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Chromosomal evolution in Holarctic ground squirrels (*Spermophilus*)

II. Giemsa-band homologies of chromosomes and the tempo of evolution

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Abstract

Chromosomal morphology within the Holarctic ground squirrels (subgenus *Spermophilus*) was studied by means of Giemsa-banding. Diploid numbers within the subgenus range from $2n = 30-46$ in 23 species, with 11 species displaying a modal $2n = 36$. Chromosome pairs comprising the $2n = 38$

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