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ANNUAL AND DAILY LOCOMOTOR ACTIVITY OF THE FROGS *RANA ARVALIS* AND *R. TEMPORARIA*

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SUMMARY

The locomotor activity of moorfrogs and common frogs was studied by means of pitfall trapping and with laboratory tests in an actograph. Juveniles of both species were active in day-time, whereas older ones were active at night-time. Older frogs had two activity peaks, one before and one after midnight. During those parts of nights when rain fell, activity increased. Also juveniles were active on these occasions. Common frogs were more active than moorfrogs during late autumn and winter.

INTRODUCTION

This paper reports on field and laboratory studies of the locomotor activity of the moorfrog *Rana arvalis* and the common frog *R. temporaria*. Both species live very similar lives; studies that could reveal any resource partitioning should be of interest as they might suggest resources that are in short supply and thus limit them. The locomotor activity is probably related to weather conditions, activity of prey species, or activity of predators or, more probably, a combination of them. A study of only locomotor activity must thus be extended with further aspects. The present study is intended as a base for future investigations.

STUDY AREA AND METHODS

The study was conducted at the Stensoffa Field Station of the University of Lund in South Sweden (55°40′N, 13°30′E). To study the activity in the field, pitfalls were dug in the ground. They measured 25 × 60 cm with a depth of 45 cm. To prevent the frogs from climbing out, the upper 10 cm of the walls were covered with plastic. The pitfalls were dug at 10 m distance. Two grids with 12 pitfalls in each were situated in a moist meadow and a moist birch forest, respectively. They were operated continuously from September 1972 to August 1974. The pit-falls were checked about twice a week in summer and at least once every two weeks in winter. During a total of nine 24-hour periods in June through September 1972, the pitfalls were checked every second hour.

To test whether adult frogs are repelled by pitfalls, the following experiment was performed. Two pitfalls, 0.25 × 3.0 meters and 45 cm deep, were dug on the opposing sides of a hexagon in a lawn. Frogs were released in the centre and had thus a 33% chance of being caught. The experiment was performed at night and in the day.

The activity during the daily cycle was also studied in a laboratory test. Frogs were put in plastic boxes (30 × 20 × 15 cm high) that were suspended and connected to a pen which registered all movements on a time-chart. A description and figure of the apparatus has been published (Loman, 1974). For the evaluation, every hour was given a score of zero to four, depending on the number of 15-min periods during which the frog exhibited any movement. Sixteen common frogs and 17 moorfrogs were used in these experiments, each for 24 hours.

Juveniles refers to frogs aged no more than one year after metamorphosis.

RESULTS

Daily activity

The experiments on day-time and night-time trapability did not suggest that the frogs were easier to trap during the day than during the night. Eight of 29 frogs were captured during the day (expected number 9.7) but only eight of 48 during the night (expected number 16). This could suggest that the frogs were more difficult to trap during the night, but this seems very implausible. I suggest that this is a random deviation. Any preference for night-time activity found with pit-fall trapping is certainly real.

Juvenile frogs were more active during the day than during the night. This was specially pronounced just after metamorphosis, in June and July. (Table I). Older frogs were more active during night than during day (Table I). A comparison of the species showed that adult common frogs were relatively more night-active than adult moorfrogs ($\chi^2 = 12.7$, $P < 0.001$). Moorfrogs had more tendency for most activity in the hours around dawn and dusk (Table II).

In the laboratory experiments that only included adult frogs, almost all activity took place during the night (Fig. 1). There was a tendency that more activity took place between 2000 h and 2200 h and between 0200 h and 0400 h than between 2200 h and 0200 h. This was significant for moorfrogs ($\chi^2 = 3.84$, $P < 0.05$) (as in the field tests), but not for common frogs ($\chi^2 = 3.47$, $0.10 > 0.05$).

TABLE I. Number of frogs trapped in pitfalls during the hours of light and darkness. Frogs were captured during nine 24-h periods, four in June and July (16 L:8 D) and five in late August and September (12 L:12 D). Juvenile frogs were not separated on the two species in June and July. Those two-hour periods during which rain fell are omitted from the computations. Figures given are number of frogs trapped, and in parentheses, the total number of capture hours. The probability values (computed with χ^2-tests) refer to the probability that locomotor activity was the same during light and dark capture hours

	Light hours	Dark hours	χ^2	P
Juveniles				
Rana sp (June, July)	41 (78)	3 (40)	14.4	<0.001
Rana arvalis (Aug., Sep.)	31 (48)	10 (38)	6.49	<0.05
Rana temporaria (Aug., Sep.)	41 (48)	10 (38)	12.4	<0.001
Older				
Rana arvalis (June, Sep.)	11 (126)	16 (78)	4.20	<0.05
Rana temporaria (June, Sep.)	9 (126)	27 (78)	20.5	<0.001

TABLE II. Activity during midnight hours (2200 h–0200 h in June and July, 2000 h–0400 h in August and September) compared with activity during the two preceding dusk hours and two following dawn hours. Two-hour periods when rain fell are omitted. Trappings considered comprised 44 midnight hours and 34 dawn and dusk hours. Figures given are number of frogs trapped. Juvenile frogs are not considered

	Midnight	Dawn and dusk	χ^2	P
Rana arvalis	8	16	5.12	<0.05
Rana temporaria	15	12	0.075	>0.10

The influence of rain

Rain fell on six 2-h periods during the periods when the traps were emptied every second hour. As five of them were at night-time in August and September, only this period is considered in the test of the influence of rain. Both juveniles and older individuals of both species were significantly more active during those periods when rain fell than at other times (Table III).

Yearly activity cycle

The main activity period for both species fell in the period of July to October (Table IV). Among adults, moorfrogs were significantly more active than common frogs in May and September, whereas the opposite applied from October through December. It should be noted that some activity persisted throughout the winter. As the size of the juvenile population changed much during the first year, and distances to breeding places of the two species might influence the result, a species comparison for juveniles cannot be made with much confidence. It seems clear that during winter juvenile common frogs were much more active than were juvenile moorfrogs (Table IV). The high activity for older frogs in March and April coincides with, and is probably due to, the breeding migrations. No information is available about the duration of the breeding migrations, but if the frogs return to their summer home-ranges immediately after breeding, all should be present in the trapping area by May.

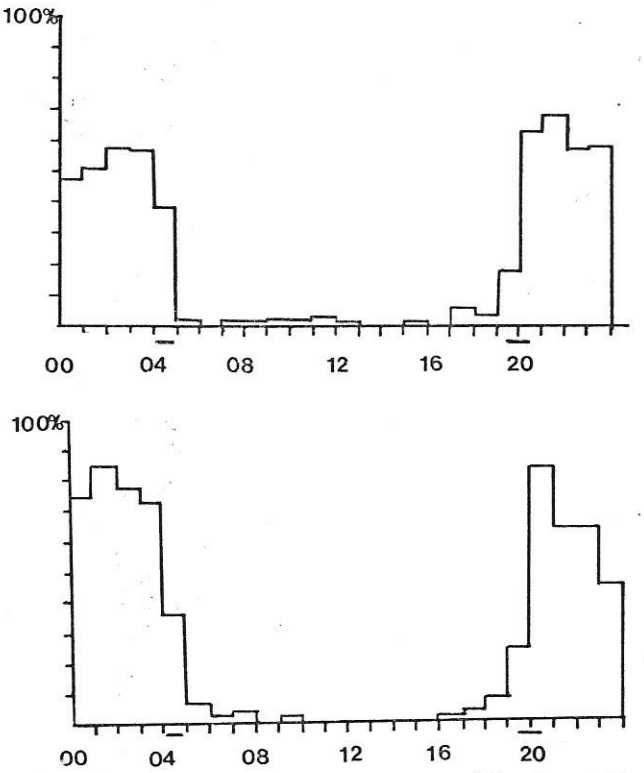

FIG. 1. Relative activity of *R. temporaria* (above) and *R. arvalis* (below) according to the laboratory tests. For each hour, the activity score in relation to the total score possible is given. The score is given according to the number of 15-m periods during which any activity was exhibited. The tests were run under a natural light and temperature cycle during the period 28 July to 15 August 1974. Time of sunset and sunrise is indicated below the time-axis.

DISCUSSION

Day-time activity for juvenile frogs and night-time for adults has been reported for several other species, including *Rana clamitans* (Martof, 1953), *Bufo viridis*, *B. calamita* (Hemmer & Kadel, 1971), and *B. boreas* (Mullaly, 1968). One possible explanation is that adult frogs are predators on juveniles (Loman in press). The

TABLE III. Activity during periods with and those without rain. Periods with rain are those two-hour periods when at least ½ mm of rain fell. Only activity during night hours in August and September is included. There were altogether 10 hours with rain and 38 without. The figures refer to number of frogs trapped

	Rain hours	Non-rain hours	P (binomial test)
Juveniles			
Rana arvalis	10	10	<0.01
Rana temporaria	19	7	<0.01
Older			
Rana arvalis	6	2	<0.01
Rana temporaria	5	3	<0.05

TABLE IV. Total number of frogs trapped during different months. The χ^2-tests refer to the samples of older frogs and give the probability of a species difference

	Juveniles		Older			
	R. arvalis	*R. temporaria*	*R. arvalis*	*R. temporaria*	χ^2	*P*
September	148	105	30	8	11.4	<0.001
October	102	282	16	35	4.69	<0.05
Nov.–Dec.	27	180	5	26	10.9	<0.001
Jan.–Feb.	1	50	3	6		
Mar.–Apr.	24	26	30	21	1.47	n.s.
May	22	6	17	4	7.05	<0.01
June	30	34	10	7	0.33	n.s.
July	19	186	47	65	1.28	n.s.
August	70	102	20	10	2.92	n.s.
	443	971	178	182		

increased activity of adult frogs, at least moorfrogs, during early and late night compared to the hours around midnight (Table II, Fig. 1), also reported by Inozemtsev (1969), might be related to decreased visibility of prey animals when it is very dark. I do not know, however, whether frogs really have difficulties in seeing their prey. This is also related to the question of whether locomotor activity is related to feeding activity. Dole (1965) reports that leopard frogs *Rana pipiens* adopt a sit-and-wait strategy for the capture of prey, which suggests that there is not necessarily a correlation. However, stomach analyses of newly captured and killed frogs did not show a particularly high proportion of frogs with newly captured prey at any time of the 24-hour cycle for adult frogs and only a tendency that most prey were captured during the day for juveniles (Loman in press). These frogs were captured by hand when flushed, *i.e.* they moved in response to my approach. If they were more easily flushed when active, a correlation that is by no means certain, this suggests that active frogs are feeding frogs. Another explanation of adult frogs being found feeding during the day and also during the night is that they really feed equally during night and day, adopting a sit-and-wait strategy, but that spontaneous movements, *e.g.*, from one feeding site to another, are restricted to night. This could be in order to reduce the risk of predation. Important predators on frogs in the study area are badgers (*Meles meles*) and tawny owls (*Strix aluco*) (night-active), pole cat (*Putorius putorius*) (probably mainly night-active), crow (*Corvus cornix*) and heron (*Ardea cinerea*) (mainly day-active). The risk of predation is thus severe also during night. One important predator, the grass snake (*N. natrix*), is also day-active. It is not found in the study area but could, among others, be responsible for the evolution of night-time activity in these frogs.

It is clear that the tendency to night-time activity was more pronounced in the laboratory test than in the field. I do not think this was because, although it is possible, the traps were less efficient by night than by day, rather it might be because in the laboratory tests, which lasted 24 h for each individual, no prey animals were supplied and the frogs were not disturbed by predators. This is also a warning against drawing too far-reaching conclusions from laboratory tests.

The most striking pattern found in the analysis of yearly activity is that common frogs have a larger part of their activity during the winter months than do moorfrogs. This is probably related to common frogs being more extensively distributed in northern Scandinavia than are moorfrogs.

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