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Breeding of the common frog (Rana temporaria L.)

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A population of the common frog using ditches and two ponds for spawning was observed daily. Spawning begins in spring one day after the daily temperature exceeds 5° C. The peak is on the third day, and half of the egg clumps appear within five days. Hatching of the eggs takes 4—17 days (median 14 days). Most egg clumps were isolated from each other in ditches. Hatchability of the eggs was usually over 90 %. In one spring drought caused fairly high mortality.

Great annual variation was observed in the size of a small local population. The females laid 1000 ± 290 eggs; no geographical variation was observed in Finland. In Finland spawning takes place in various types of water. Brackish water, open lake shores without emergent vegetation, and running water are not utilized.

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1. Introduction

The aim of this study was to investigate the breeding phenology and breeding habits of the common frog. Although several studies have been made of the breeding of different Rana species, many details are still unknown. A breeding population was observed very intensively to give detailed information.

Some preliminary observations on the egg numbers and breeding habitat have already been published (Haapanen 1965).

2. Material and methods

The breeding phenology of a population at the University Farm at Viikki, Helsinki (60° 10′ N) was studied in 1973—1977. Observations were made twice a day in the early morning and late afternoon. The population was found breeding in field ditches and in two small ponds.

The variation in the size of a local breeding population on an island off the southern coast of Finland (60° 10′ N) was observed between 1964 and 1973. The adult female population was estimated by one census roughly one week after the beginning of breeding. The census method developed in this paper was therefore not followed exactly. However, the figures show the trends in population size variation, because the population was fairly small and the habitat very homogeneous.

The egg number data was collected in 1964—1969 on trips to different parts of the country while inspecting nature reserves. The data therefore cover an area from the southern coast (60° N) to northernmost Lapland (70° N). The collected samples also represent different drainage basins and water courses flowing into the Gulf of Finland and Gulf of Bothnia and into the White Sea and Barents Sea, and so all the populations which might be isolated to some extent were surveyed. The egg clumps were photographed on a pale background, with the eggs spread out to form a single layer. The eggs were counted by measuring the egg density and the area. Some films photographed using the same method were obtained from other people. Observations of the breeding habitats were made on these same trips.

The temperatures were measured and other climatic observations made by the Finnish Meteorological Institute at the permanent station 10 km north of the University Farm.

3. Results

3.1. Breeding of the population

Spawning in Helsinki began one day after the spring air temperatures reached above 5° C (Table 1). Snow had disappeared in all cases and ground frost in most cases before the start of spawning, as shown, together with the spawning pattern, in Fig. 1 and Table 2.

Table 1. The average 24 h temperatures in Helsinki at a height of 2 m above ground level just before spawning and during the ten most active spawning days in 1974 (an exceptional year) and in the five year period between 1973 and 1977 (the means). 1 = the first day of spawning. *SD* is the standard deviation of temperatures in 1973—1977.

	−2	−1	0	1	2	3	4	5	6	7	8	9	10
1974	−0.5	1.9	5.5	8.8	8.6	9.0	6.8	7.3	5.7	3.8	2.7	4.2	3.1
1973—77	1.6	3.7	6.8	7.9	8.6	8.7	7.4	7.5	8.1	7.5	7.0	7.5	8.3
SD	2.2	0.9	1.8	0.9	0.9	0.7	2.4	1.9	4.5	2.8	3.6	3.7	3.9

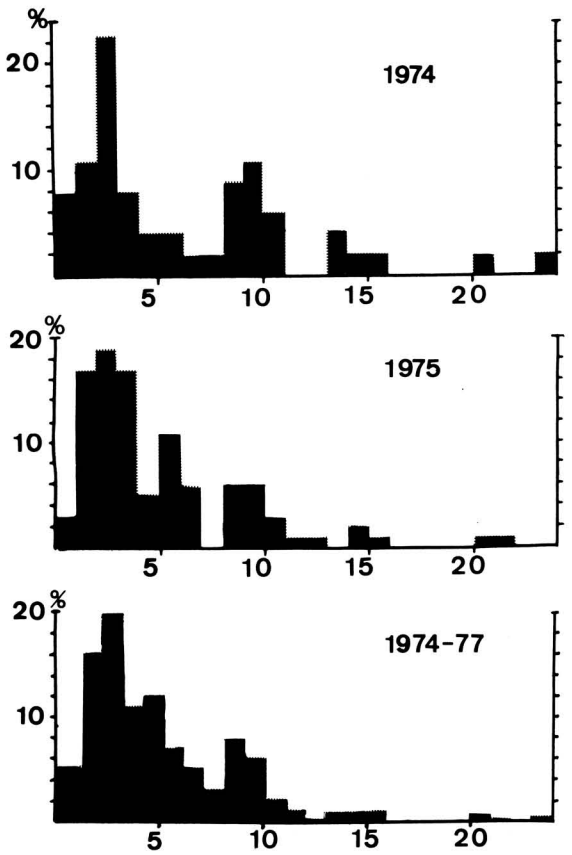

Fig. 1. Percentages of egg clumps of the common frog spawned each day during the spawning periods of 1974, 1975 and 1974—1977 (pooled data). Abcissa — days after the start of spawning.

The most active spawning period lasted 10—11 days. The average air temperature during the spawning at 2 m above ground level was 6.4—9.0 °C (Table 1). In 1974 temperatures were as low as 2.7 °C, and during some nights even temperatures of below 0 °C were recorded. These low temperatures may have caused the special spawning pattern in 1974.

The hatching of eggs was taken as complete when all the tadpoles were outside the eggs. However, in many cases they were still attached to the egg clump. The length of this development period varied from 4 to 17 days (Table 3). Fig. 2 shows a strong negative correlation between the length of the development period and the average daily temperatures. In 1976 the spawning period was particularly warm, and the rising average temperatures resulted in the eggs first spawned developing slower than those spawned later.

The egg clumps were found either singly or in groups (Table 4). In 1974 and 1976, when the population was small, most clumps were found singly, whereas in 1975 42 % of egg clumps were found in groups of more than 10 clumps each.

Over 90 % of the eggs apparently hatched. None of the egg clumps disappeared (i.e. no predation occurred). In 1976 the uppermost eggs of six clumps were killed by desiccation during the warm period; roughly 20 % of the eggs in six clumps (3 % of all eggs) did not hatch. Between 1973 and 1977 only 5 egg clumps (2 % of the total) did not hatch at all.

Counting the number of egg clumps enables the estimation of the number of mature females in a given area. Fairly reliable figures can be obtained if the clumps are counted 10 days after the beginning of the spawning and if fresh egg

Table 2. Disappearance of snow and ground frost together with spawning patterns 1973—77.

	Disappearance of		Spawning				
	snow	ground frost	start	duration (days)	peak day	median day	*N*
1973	13.IV	20.IV	2.V				
1974	15.IV	22.IV	28.IV	24	3	4	52
1975	15.IV	13.IV	21.IV	22	3	4	132
1976	22.IV	7.V	5.V	16	3	5	39
1977	15.IV	21.IV	1.V	9	2	3	19

Table 3. The time elapsed from spawning to egg hatching in different years.

	Days of hatching																
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	*N*	Med.	Mode
1974	0	0	0	0	1	1	1	0	2	2	6	12	6	4	35	15	15
1975	0	0	0	5	0	5	0	3	10	5	7	20	8	0	63	14	15
1976	3	3	1	0	5	0	0	0	0	0	0	0	0	0	12	6	8
1977	0	0	0	1	0	3	0	5	0	0	2	4	2	0	17	11	11
Total	3	3	1	6	6	9	1	8	12	7	15	36	16	4	127	14	15
%	2	2	1	5	5	7	1	6	9	6	12	28	13	3	100		

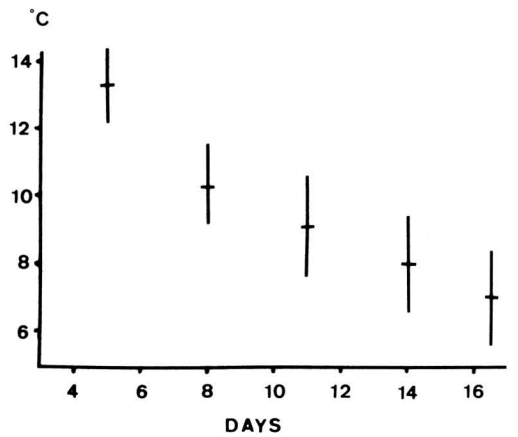

Fig. 2. Correlation between the time from spawning to egg hatching and the average daily temperatures. The negative correlation is strong ($r = -0.9$). As the ditches are shallow (0.1—0.4 m) and narrow (0.5—1 m), the water temperatures closely follow the air temperatures.

Table 4. The occurrence of egg clumps singly or in groups in different years.

	Size of groups					Number of	
	1	2—5	6—10	11—20	21—	groups	clumps
1974	16	4	2	0	0	22	41
1975	18	5	2	1	2	28	130
1976	13	5	1	0	0	19	39
1977	4	4	1	0	0	9	19
Total	51	18	6	1	2	78	229
%	65	23	8	1	3		

clumps are counted again five days later. Over 90 % of the total population can be counted in this way. The egg clumps may be attached to each other, and then it is very difficult or impossible to estimate their numbers. However, if the clump groups are not too big, the different clumps can be carefully separated and counted. In very warm springs the rapid development of eggs makes it necessary to count the clumps three times, and even then the result may be less reliable than if the weather is cooler.

3.2. Variation in size of the breeding population

In small local populations the variation in size may be considerable. The size of the spawning female population at University farm in different years was:

1973	1974	1975	1976	1977	Mean
44	54	132	39	19	58 ± 43

A small population spawning in tiny rock pools (0.2—5 m^2) on a very barren island (220 ha, 60° 15′ N) was censused during seven years and the numbers of spawning females varied between 16 and 58, mean 28 ± 15.

3.3. Numbers of eggs per female

No significant regional variation in the numbers of eggs was observed (Table 5), but the numbers varied locally, 800—900 eggs per clump in some cases and 1200—1300 in others. According to Koskela & Pasanen (1975) the number of eggs spawned by a female is dependent on its size. The size of local populations described in this paper varied very much from year to year, and according to Koskela & Pasanen (1974) the age structure of the population also varies. The females of a local population may, in certain cases, be mostly young spawning for the first time, and in other cases mostly older. Young age classes are usually dominant, so small egg clumps are more common than large ones (Fig. 3).

Table 5. The numbers of eggs in clumps in different parts of Finland.

Latitude	Number of eggs	N	Number of sampling sites
60—61° N	1040±190	9	2
61—62° N	980±290	39	6
65—66° N	1070±390	18	3
68—70° N	910±260	9	1
Pooled data	1000±290	75	12

3.4. The spawning habitat

In Finland bodies of water suitable for frogs are almost always available. The common frog spawns in natural and manmade bodies of water (eutrophic lakes and ponds, small seasonal ponds, river estuaries, peatland flarks, small rock pools, ditches in fields and forest land, and gravel pits). Egg clumps have not been observed in brackish water, on open shores of big lakes susceptible to wave action or in rapidly flowing brooks or rivers. Savage (1961) also observed that the common frog only exceptionally utilizes running water.

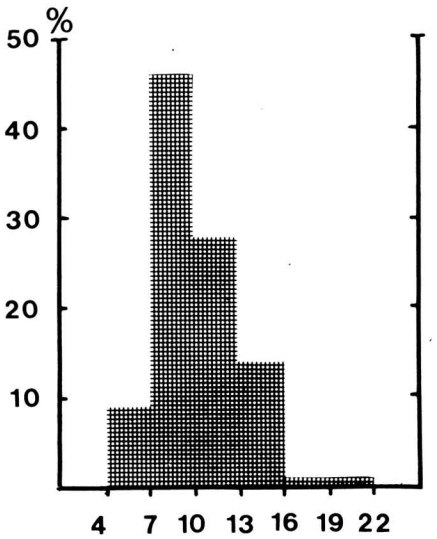

Fig. 3. Numbers of eggs (hundreds) in clumps. The pattern differs from normal distribution. Pearson's skewness model gives a value of 0.8.

Breeding sites are very variable in many respects. Higher vegetation may be very rich or absent, as in rock pools, where the tadpoles must be detritus feeders. The pH varies from acid in peatland flarks to neutral or basic in eutrophic lakes and rock pools. Cooke (1975b) and Blab (1978) also reported the eurytopic nature of the species as far the breeding sites are concerned.

4. Discussion

The spawning period lasted about 20 days, which is about the same reported for Sweden by Curry-Lindahl (1946). He estimated the time on the basis of the calling of the frogs. In North America the egg-laying of the wood frog (*Rana sylvatica*) takes 6—10 days and the frogs stay in the pools for 12—22 days (Herreid & Kinney 1967).

In Finland spawning begins as early as the temperature permits, but it may be interrupted by night frosts. The same is true of the wood frog in Alaska (Kessel 1965). Several authors have reported the minimum temperature of the spawning migration to be 5 °C (Juszczyk 1959, van Gelder & Hoedemeakers 1970, Koskela & Pasanen 1974, Blab 1978). This was also true in the present study area, where the first females began to lay eggs only one day after the threshold temperature was reached (Table 1).

Because the time between reaching the threshold temperature and the start of the spawning is short, spawning might easily start too early. In the springs of 1973—1977, the 5 °C level was exceeded several times for short periods which were followed by long cold periods. In spite of this, spawning hardly ever begins too early, because the snow cover and ground frost keep the ground temperature at a lower level. When these have disappeared the ground and water temperatures can drop below freezing point only for short periods. In spring 1974 short periods during which the air temperature fell below 0 °C did not cause noticeable egg or larval mortality. An inherent rhythm (cf. Juszczyk & Zamachowski 1965, Harri & Koskela 1977) apparently contributes to the correct timing of spawning.

In southern Finland the spawning temperature is reached in late April and early May, in central Finland in mid-May, and in the northernmost part of the country from late May to early June.

Egg development is temperature dependent (Hertwig 1898, Moore 1939, Herreid & Kinney 1967). Under natural conditions the development period of common frog eggs seems to be longer (4—17 days according to the present data, and 18—23 days according to Cooke (1975a) in England) than that of wood frog eggs in Alaska (4—7.5 days according to Herreid & Kinney 1967). During the present study period the variation in temperature was fairly large; the correlation .between temperature and time to hatching is shown in Fig. 2.

According to Herreid & Kinney (1967) the mortality of eggs was 90—95 % at 5.6 °C. In the present study area the lowest average temperature during the time of egg development was 5.9 °C, and during some nights the eggs were apparently frozen, but no noticeable egg mortality was found. In general, the hatchability of eggs was high, as also found by Cooke (1975a).

In the present study area the egg clumps were more often found singly than those of the wood frog in Alaska (cf. Herreid & Kinney 1967), but the number of clumps in a group was found to be highly dependent on the size and density of the frog population (see also Cooke 1975b).

The average number of eggs (Table 5) was smaller than that observed by Koskela & Pasanen (1975). No geographical variation in the numbers of eggs within Finland was observed, but local differences may be large. In Central and Western Europe the average numbers of eggs are higher than those found in Finland (see

Kozlowska 1971, Cooke 1975a). In the wood frog the number of eggs per female seems to decrease from south to north (Herreid & Kinney 1967 and literature cited by them). The local and geographical variation in the numbers of eggs of the common frog requires further investigation.

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