Ann. Zool. Fennici 31:279–282 ISSN 0003-455X
Helsinki 15 July 1994

Commentary

Orientation of the common frog to the wintering place

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Received 14 November 1993, accepted 23 January 1994

There have been several studies concerning the orientation of amphibians to their breeding places (e.g. Savage 1961, Tracy & Dole 1969a, Wisniewski et al. 1981, Gittings 1983, Petchmann & Semlitsch 1986, Elmberg & Lundberg 1988, Ryser 1989), or homing experiments in summer (e.g. Twitty et al. 1964, Phillips & Adler 1978, Taylor & Auburg 1978, Able 1980), or wintering of the common frog (*Rana temporaria* L.) (e.g. Juszczyk 1959, Savage 1961, Hagström 1970, Pasanen & Koskela 1974, Koskela & Pasanen 1974, Pasanen & Sorjonen 1994), but special orientation experiments during the autumn migration are lacking.

We have studied the ecology of the common frog in Finland for some years (Pasanen et al. 1989, 1990, 1994). We observed that the autumn migration was strongly oriented towards the wintering site, and only a few frogs were captured by a control fence at a distance of 300 m. During the summer of 1990 we laid out squares (50 × 50 metres) in the pine forest near the wintering place in order to estimate the density of the frog population. In the autumn we determined the directions frogs departed from these squares. In addition, we transferred frogs from another location to the squares in order to compare their departure with that of the local population. In July 1990 we also dug a small new wintering pit in front of the control fence to test whether a frog population can find new wintering sites and if so, how rapidly.

Study site and material

The frogs were collected and the experiments carried out in 1988–90 in Laikko, Rautjärvi (61°22′N, 29°17′E). Thousands of frogs winter in the pond in the gravel pit. The area surrounding the wintering pond is dry coniferous forest. The nearest lakes are 700 metres southwest of the gravel pit.

In the present study we used the same fence-with-traps method as in our earlier studies (Pasanen et al. 1989, 1990, 1994, Pasanen & Sorjonen 1994). In October 1988 we erected a control fence (plastic sheet, height 30 cm, length 100 metres) on the bottom of the gravel pit at a distance of 300 metres from the wintering site (Fig. 1). The lower edge of the sheet was covered with sand to provide a tight seal against the ground. Buckets (ø 25 cm, depth 22 cm, angle 95°) were buried in the soil at 10 m intervals along the fence, which crossed the middle of each bucket so that frogs from both sides could fall into the buckets. There was about 15 cm water on the bottom of the buckets.

The frogs were grouped in the following way: less than one year old (< 3.5 cm), other immature

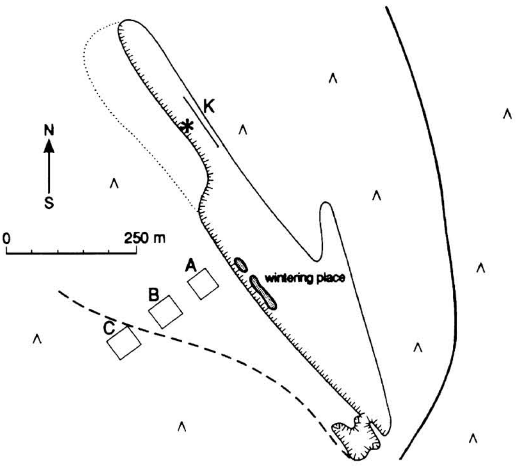

Fig. 1. Study area. * = new wintering pit, K = control fence-with-traps, A–C = squares. There was also a fence-with-traps around the wintering place.

(3.5–6.4 cm), and mature (> 6.4) animals. We have found that the smallest frogs are able to climb over the fence, but we still count their numbers in order to obtain at least relative results for young frogs coming to winter for the first time.

In July 1990 we erected a fence-with-traps (5 buckets) around a newly dug (ø 5 m, water depth 1 m), placed in fron of the control fence (Fig. 1), to estimate the number of frogs going to winter. In the summer of 1990, three 50 × 50 metre enclosures (A–C) (Fig. 1) were built to estimate frog densities (Pasanen et al. 1994). The plastic fence was 50 cm high and the lower edge of the fence was buried 10 cm in the soil. In each square 20 buckets were buried along the inside of the fence at a distance of 10 m from each other. In the autumn of 1990 we used these squares to study the orientation of the frogs as they departed to winter.

The trapping period lasted from October 10 to November 6 in 1988, from September 1 to November 4 in 1989, and from September 18 to November 3 in 1990. The buckets were examined and emptied at two-day intervals and the frogs were released outside the squares. On October 10 we transferred one hundred fence-trapped frogs from an island near Joensuu to the Laikko experimental site. All these frogs were collectively marked by toe-cutting and set free in the middle of squares B and C (Fig. 1). Ten mature and 40

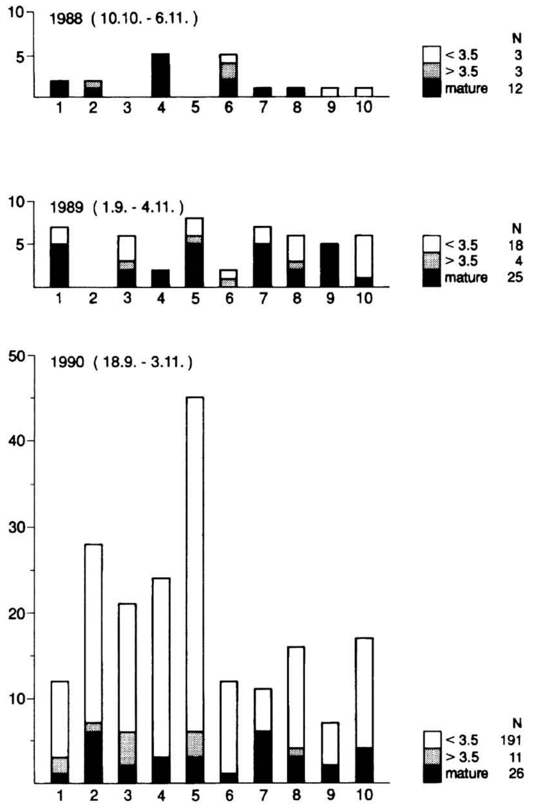

Fig. 2. Frog catches at the control fence in the the autumns of 1988–90.

large immature (> 3.5 cm) frogs were put into B and correspondingly, nine mature and 41 large immature frogs into C. Retrapped frogs were counted and released outside the squares in connection with routine trapping.

Orientation of the frog

The frog catches at the control fence were 18 in 1988, 47 in 1989 and 228 in 1990 (Fig. 2). At the fence around the wintering place the catches were 4261 frogs (2876 mature) in 1988 and 3438 (1549) in 1989. At the control fence in 1988 we caught on average 1.8 and in 1989 4.7 frogs/bucket, while corresponding values at the fence around the wintering place were 250.7 and 202.2. Each year the numbers of mature and large immature frogs were nearly the same at the control fence, but in 1990 the number of frogs less than one year old increased dramatically: the catch at

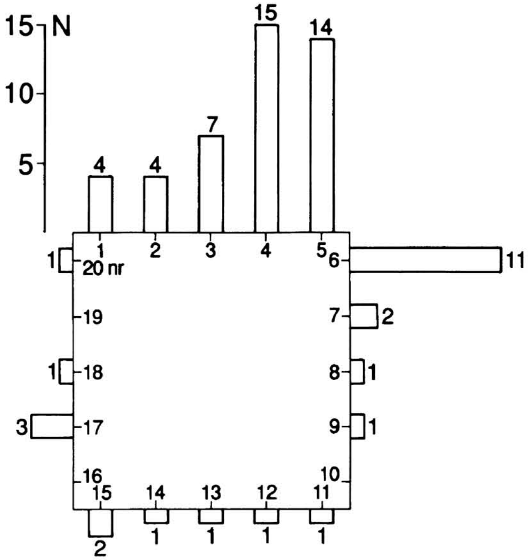

Fig. 3. Departure of native frogs (squares A–C together) from the squares.

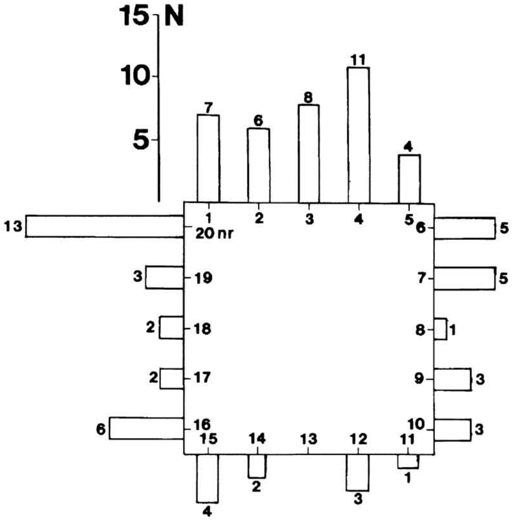

Fig. 4. Departure of frogs transferred from Joensuu (1990) (two simultaneous experiments).

the fence around the new pit was 62 mature, 42 large immature and 458 small immature frogs. Frogs were released inside the fence and they wintered in the new pit.

In the autumn of 1990 we tested the direction in which frogs left in squares A–C (Fig. 3). According to Kruskal-Wallis one way analysis the results differed from random distribution (χ^2 10.39, P = 0.016). In the transportation experiment in the autumn of 1990 the results for the squares B and C were very similar. The proportion of recaptured frogs in buckets 1–10 was 56.7 % in square B and in square C 62.2 % and they are pooled in Fig. 4. Of the hundred frogs transferred into these squares, only 11 frogs (10 ten immature) were not recaptured. In this case also the distribution differed from random (χ^2 8.26, P = 0.041).

Adult frogs orientate by memory and young frogs disperse to new sites

The frog catches at the control fence were very scanty in 1988 and 1989 compared with catches at the wintering site at a distance of 300 metres. After the new pit was dug in front of the control fence in 1990, the catch increased dramatically, caused mainly by the under one-year old frogs (Fig. 2). Apparently the frog population recalls its own wintering place after the first winter, but part of the youngest generation also utilizes new places.

The frogs transferred from Joensuu moved out of the squares in a different direction from that of the native population, but even these transferred frogs did not orient randomly. Obviously the memory of the Joensuu frogs was different from that of the native population.

Only sporadic information is available concerning the physiology of amphibian orientation. Some species of frogs and toads orient according to the sun (e.g. Ferguson 1967). Animals that orient by the sun must have a sense of time (biological clock). It is interesting that blinded individuals — for instance, in the southern cricket frog (*Acris gryllis*) — can orient using their extraoptic receptors (Taylor & Ferguson 1970). Some amphibian species can utilize polarized light in the same way as bees (e.g. Adler & Taylor 1973, Taylor & Auburn 1978). The moon and stars can also help some amphibians to orient (Ferguson et al. 1965, Tracy & Dole 1969b). Although two species of salamander are known to utilize a magnetic field (Phillips & Adler 1978), Elmberg & Lundberg (1988) found that a magnetic field had no effect on orientation of the common frog.

Using one species of toad (*Bufo boreas*), Tracy & Dole (1969b) studied the importance of different senses for orientation. Blinded toads could orient as well as animals that could see, but the sense of smell is necessary for orientation of the toad. Savage (1961) showed that the common frog recognizes the smell of its own pond, whereas Elmberg & Lundberg (1988) concluded that the sense of smell was not important for orientation to the spawning place. Many amphibian species are known to orient to their spawning places by using their sense of hearing (Oldham 1967, Tracy & Dole 1969a, b). During the autumn migration, however, the common frog does not utter any sounds.

The common frog seems to learn to orient to its wintering place and it may use some kind of navigation system. Part of the population may, however, change the wintering place or sometimes winter on the ground (Pasanen & Sorjonen 1994). Many of the youngest frogs remain near the spawning place and easily find their way back to the same pond to winter (Pasanen et al. 1994), but some of the young frogs disperse farther and probably find wintering places by chance.

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