

Commentary

Partial terrestrial wintering in a northern common frog population (*Rana temporaria* L.)

Seppo Pasanen & Jorma Sorjonen

*Pasanen, S., Karelian Research Institute, University of Joensuu
Sorjonen, J., Department of Biology, University of Joensuu, P. O. Box 111, 80101
Joensuu, Finland*

Received 4 October 1993, accepted 30 November 1993

As a poikilothermic animal, the common frog (*Rana temporaria* L.) must attempt to shelter from the winter cold. Frogs winter in Finland mainly in a water habitat (Koskela & Pasanen 1974). But there have also been some observations of frogs terrestrial wintering. Collin mentions an observation made in the last century concerning male frogs wintering on land (Hagström 1970). Three frogs on one occasion and one on another have been found in the wintering dens of the viper (Viitanen 1967). In Middle-Europe and in England, for example, frogs may winter in water or on the ground, and in midwinter they have been observed moving about the wintering areas on warm days and even foraging (Smith 1950, Smith 1954, Savage 1961). During 1988–93 while studying the population ecology of the common frog in Laikko, Rautjärvi, Finland (61°22'N, 29°17'E) (Pasanen et al. 1989, 1990, 1993), we made observations, which suggested that part of the population may winter terrestrially. Some frogs wander toward the spawning site while the wintering place and the surrounding forest are still iced and under snow. In spring some frogs were found under logs and planks as if wintering. An pilot experiment was carried out in the autumn of 1992 to determine whether the common frog can winter terrestrially.

Frogs in Laikko

A wintering and spawning site of the common frog is located in an old gravel pit in Laikko, Rautjärvi (61°22'N, 29°17'E). Thousands of frogs winter in the pond of the gravel pit. The area surrounding the wintering ponds is dry coniferous forest. The nearest lakes are 700 metres from

the gravel pit. There are no other open waterbodies or peatbogs near to the gravel pit.

In spring 1988 when frogs started to move from the wintering pond, 2012 mature frogs were marked collectively by toe-clipping. These were only animals marked for this study. In autumn 1988 a fence-with-traps was built around the wintering pond so that the number of frogs com-

ing to winter could be counted. The fence was made of a 30 cm high plastic sheet stretched vertically between wooden sticks without any horizontal plank on the top. To provide a tight seal against the ground the lower edge of the sheet was covered with sand. Buckets (diameter 25 cm, depth 22 cm, angle 95°) were buried into the soil at 10 m intervals just outside of the fence.

In 1988 the trapping period lasted from September 27 to October 27 (permanent snow) and in 1989 from August 25 to November 3. The buckets were examined and emptied every second day. In 1990 and 1991 samples (187 and 152 mature frogs) were taken from the wintering pond and proportion of marked frogs was determined. In 1992 the fence-with-traps was built again and the trapping period lasted from September 1 to October 19.

In October five wintering frames were built for frogs. The size of each frame (2 × 4 " planks) was 80 × 100 cm. The frames were dug to the mineral ground and sealed carefully. Four frames were placed in the forest near the wintering place, and the inside of the frame was left untouched (mainly mosses). One frame was built in the gravel pit so that there was water on the bottom in October, but already in November the water level went down. Ten mature (five female and five male) and three immature frogs were put into every frame, which was then covered with boards. Some loose boards were placed inside the frame so that the frogs could go under them to winter. One max-min thermometer was put into each frame.

Three frames in the forest were insulated (the upper and vertical sides) with styrox sheets size 100 × 120 cm and thickness 2.5, 5 and 10 cm. One frame in the forest was without styrox sheet. The gravel pit frame was also covered with 10 cm styrox. All boxes were covered with plastic sheet. In addition, two logs were placed in the gravel pit as possible wintering sites for frogs. The frames were opened between April 27 and May 12, when they were free of ice and snow.

The fence-with-traps used in autumn 1992 to count frogs coming to the wintering pond was left in place until spring. Buckets were outside of the fence so that in spring the fence caught frogs coming from outside the pond to spawn in the area.

Overwintering

In autumn 1988, 2876 mature frogs came to the wintering pond and in autumn 1989 1549 mature frogs came (Table 1). The fence-with-traps was not used in autumn 1990, but the number of wintering frogs was about the same as during the previous autumn. During the winter the water level dropped considerably and in spring many dead frogs were found in the pond (ca. 1000). In autumn 1991 the fence-with-traps was not used, but the number of wintering frogs was clearly smaller than during the previous autumn. Again, the water level dropped during the winter and many frogs died (700–800). In autumn 1992 the fence-with-traps was built again and all the frogs that came to the wintering pond

Table 1. Number of mature frogs in the wintering pond from 1988 to 1992 and the percentages of frogs marked in spring 1988 (2012 mature frogs).

	1988	1989	1990	1991	1992
Number of frogs	2876	1549	1500*	800*	136
Sample (in autumn)			187	152	
female	1668	871	50	73	61
male	1208	678	137	79	75
♂/♀	58:42%	56:44%	27:73%	48:52%	45:55%
Marked frogs	18.2%	15.9%	16.1%	11.8%	1.5%
female	15.7%	12.9%	8.0%	12.3%	3.3%
male	21.5%	19.9%	19.0%	11.4%	0%

* = estimated number (the size of the frog pile on the bottom of the pit compared with earlier years)

were counted. The size of the population was only 136 mature frogs. During winter the water level readed a record low and in spring all the frogs in the wintering pond were dead.

In 1988–1991 the percentage of marked frogs in the wintering population was 12–18, but in 1992 the corresponding percentage was only 1.5 (Table 1). Of the 2012 marked frogs, 523 (26%) returned in the autumn of 1988 and 246 (12%) in the autumn of 1989.

In the spring of 1993 the fence-with-traps was set so that it caught only animals coming to the pond from the outside. The first male frog was seen on the bottom of the gravel pit in April 27 when the wintering site was still covered with ice. Altogether 65 mature frogs and 108 smooth newts (*Triturus vulgaris* L.) were caught between April 27 and May 12 (Table 2). Most of the frogs came from the direction of the gravel pit, but newts more frequently came from the direction of the forest.

Minimum temperatures in the wintering frames during winter were follows: frame without styrox -5° , frame with 2.5 cm styrox -3.5° , frame with 5 cm styrox -1° and two frames with 10 cm styrox -0.5°C . In these frames that were in the forest no frogs were alive in the spring, but in the bframe in the gravel pit there were six living (three mature, three immature) and seven dead mature frogs. In the forest shrews dug into two frames (the frame without styrox and that with 5 cm styrox) and ate the frogs. In order to prevent this kind of problem, in future frames must be furnished with a bottom net.

Under two logs near wintering place two immature frogs and three newts were alive and

there were no dead animals. We don't know the minimum temperature under the logs, but at the time we observed wintering frogs there was frost under the logs. In addition, in spring two wintering newts were found outside of the bucket in a crevice in the ground.

Comments

We estimated that in spring 1988 we were able to mark about 80% of the mature frogs in the wintering population. The next autumn only 26% of the marked frogs returned to the wintering pond and the proportion of marked frogs in the population was less than 20%. During the intervening summer one new mature generation developed and some frogs died. On the other hand, the mortality was quite small, because the proportion of marked frogs decreased slowly during the years 1989–90. The decrease in the proportion of marked frogs from the spring to autumn 1988 is quite large. In the autumn of 1989 a fence-with-traps was also placed on the lake at a distance of 700 metres from the gravel pit, and two mature marked frogs were captured there (Pasanen et al. 1990).

In the spring of 1993 the number of frogs and newts coming from outside to the wintering pond was rather large. The environment of the wintering place is dry coniferous forest and in the beginning of May there were still snow and ice. The nearest lakes had still ice covers so it is unlikely that the animals would have overwintered there. It seems probable that these frogs and newts wintered terrestrially in the same way as the frogs and the newts found under the two logs. Most frogs came from the gravel pit side. On the bottom of this pit were stacks of wood under which frogs and newts could winter. Most of the newts came from the forest side, and it is possible that many newts winter in holes and cracks in the forest.

This means that during the winter 1992–93 one third of the mature frogs (65/136) wintered terrestrially. In 1988 frogs were marked during spawning and also frogs wintered terrestrially could be marked. This would explain the great decrease in the proportion of marked frogs in 1988 from spring to autumn, because these frogs also tried to winter on the ground in the next autumn.

Table 2. Catches of the fence-with-traps in spring 1993 (Frogs and newts were coming to the spawning place from the forest and the gravel pit side).

	Forest side	Gravel pit side	Total
Female	5	19	24
Male	6	35	41
Immature	4	2	6
Total no of Frogs	15	56	71
Newts	78	30	108

We conclude that there is some turnover in the wintering population. Part of the frog population travels to other wintering places, but another part can winter terrestrially as in winter 1992–93. Previously we supposed that nearly all frogs that remained on the ground usually died during the winter; but according to the results of the present study, some frogs and newts survive. In our earlier papers we have said that common frogs try to reach aquatic habitats to winter and in autumn it is possible to see frogs until the permanent frost (Koskela & Pasanen 1974, Pasanen et al. 1989, 1990).

In the autumn of 1992 there was a long cold period from October 10 to 19. The temperature was continuously below zero and for some days was even below -10°C . During that time it also snowed. The fence-with-traps was checked on October 12, but after that not until October 19, when 21 frogs (10 female, 7 male and 4 immature) were caught — in spite of the severe winter weather (for that time of year).

Suitable temperature and humidity are important for successful wintering of the frog. Two of the frames had 10 cm styrox and in both frames the minimum temperature was -0.5°C , but only in one frame did some frogs succeed in overwintering. The frame with no survivors was built in the forest so that there was humus and moss inside it; and the other was at the bottom of the gravel pit, in which the humidity was 100%. The relative humidity in the forest frame was also extremely high probably about 100%, because soil and moss were very wet. An important difference between these frames might have been the concentrations of oxygen and carbon dioxide. In the forest frame the layer of humus and moss may have consumed the oxygen and produced carbon dioxide inside the frame so that the frogs suffocated.

On the basis of this experiment, we cannot say, whether the common frog or the smooth newt can endure freezing. The minimum temperature fell to only -0.5°C , and these amphibians still do not freeze still at this temperature. On the North American continent there are three frog species which have tolerance to freezing and one of these species (*Rana sylvatica*) is

closely related to common frog (Storey 1985, Storey & Storey 1987). When frozen, these animals show no movement, respiration, heart beat or blood circulation, and their neurological activity is barely detectable (Storey & Storey 1990).

The ponds of the gravel pit are the only water where frogs can winter and spawn over a wide area. As we can see from the results of the present study, this type of population is quite vulnerable. Wintering or spawning or both may fail in a given year and the population may decrease drastically. During the winter of 1992–93, all the frogs in the wintering pond died because the level of the ground water dropped. Because the winter was not severe, the remaining frogs wintering on the ground survived and came to the pond to spawn. Thus the whole population was not wiped out.

References

- Hagström, T. 1970: Några svenska amfibiearters övervintring. — Göteborgs naturhistoriska museum Årstryck 1970:17–21.
- Koskela, P. & Pasanen, S. 1974: The wintering of the common frog, *Rana temporaria* L., in northern Finland. — *Aquilo Ser. Zool.* 15:1–17.
- Pasanen, S., Sorjonen, J., Günther, O., Martikainen, S., Olkinuora, P. & Kantonen, P. 1990: Laikon sammakot. — *Pohjois-Karjalan Luonto* 18:41–45.
- Pasanen, S., Sorjonen, J., Kantonen, P. & Peiponen, J. 1989: Tuhansien sammakoiden talvehtimiskeko. — *Pohjois-Karjalan Luonto* 17:28–30.
- Pasanen, S., Sorjonen, J. & Olkinuora, P. 1993: Summertime population density of the common frog (*Rana temporaria* L.) in a Finnish coniferous forest. — *Alytes* 11(4):155–163).
- Savage, R. M. 1961: The ecology and life history of the common frog (*Rana temporaria temporaria*). — Sir Isaac Pitman & Sons Ltd, London.
- Smith, C. L. 1950: Seasonal changes in blood sugar, fat body, liver glycogen, and gonads in the common frog, *Rana temporaria* L. — *J. Exp. Biol.* 26:412–429.
- Smith, M. 1954: The British amphibians and reptiles. — Sir Isaac Pitman & Sons Ltd, London.
- Storey, K. B. 1985: Freeze tolerance in terrestrial frogs. — *Cryo-Letters* 6:115–134.
- Storey, K. B. & Storey, J. M. 1987: Freeze tolerance in animals. — *Physiol. Rev.* 68(1): 27–84.
- 1990: Frozen and alive. — *Scientific American* 62–67.
- Viitaniemi, P. 1965: Hibernation and seasonal movements of the viper, *Vipera berus berus* (L.) in southern Finland. — *Ann. Zool. Fennici* 4:472–546.