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Commentary

Wintering site selection by the common frog (*Rana temporaria*) and common toad (*Bufo bufo*) in Finland: A behavioural experiment

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Introduction

Little is known about the wintering biology of amphibians in Finland. The best-studied species is the common frog, *Rana temporaria* (Koskela & Pasanen 1974, Pasanen & Koskela 1980, Pasanen & Sorjonen 1994), but there are no published studies on four other Finnish amphibians (*Rana arvalis, Bufo bufo, Triturus vulgaris* and *T. cristatus*) and unpublished observations are extremely scarce. Many Finnish animal handbooks still provide information on amphibians that is based on studies carried out elsewhere, often in Central Europe where seasonal conditions differ greatly from those in Finland.

In the temperate climate of Central Europe, frogs and toads overwinter mainly on the ground but they are also able to overwinter in water due to their ability to switch their oxygen uptake mechanism from lung- to skinbreathing (Smith 1950, 1954, Savage 1960). In Finland, the common frog generally winters in water (Koskela & Pasanen 1974) but a part of the populations also winters on the ground (Pasanen & Sorjonen 1994). According to Koskela (1984), common toads (*Bufo bufo*) winter in aquatic sites in southern Sweden but their wintering environment in Finland is still unknown. Unlike the common frog there is no tangible evidence that in Finland common toads prefer to winter in water and there have been occasional observations that they could winter on the ground (e.g. Viitanen 1967).

The aim of this experiment was to test whether the common frog or common toad exhibit a preference for wintering environment (aquatic or terrestrial) under experimental conditions and whether the air or water temperature influences their choice.

Experiments

The experiments were performed during the winters of 1995–1996 and 1996–1997 in the Tammen Mylly field station of the University of Jyväskylä, central Finland. Mature and immature common toads (*Bufo bufo*) were collected in autumn 1995 beside lake Iso-Tenhetty (61°34´N, 25°E) and in autumn 1996, 90 common frogs (*Rana temporaria*) and 5 mature common toads were captured

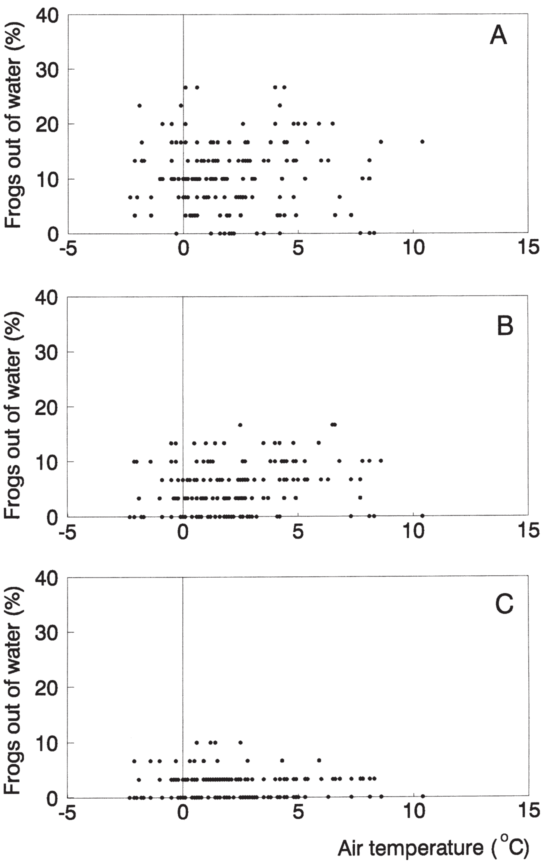

Fig. 1. Daily percentage of frogs out of water as a function of air temperature during the winter of 1996–1997. A = mature frogs , B = older immature frogs, C = less than one-year-old frogs.

by trapping beside river Rutajoki (62°N, 26°E) (Koskela & Pasanen 1974).

In autumn 1995, 18 toads were transferred to a container (length × breadth × height = 1 × 1 × 0.5 m) through which water from river Rutajoki flowed at a rate of 30 l day^{-1}. The container was situated inside a building with additional warming just to prevent the water from freezing. Air temperature fluctuated between + 7.4 and – 5.8°C. Emergent rocks placed in the container allowed the toads to choose between being in or out of the water. From 31 October 1995 until 5 May 1996 the number of toads out of the water were counted daily, and air and water temperatures were simultaneously recorded.

In autumn 1996, toads and frogs were placed in smaller containers (length × breadth × height = 30 × 40 × 25 cm) receiving water from river Rutajoki at a rate of 40 l day^{-1}. Frogs were divided into 3 age groups: less than one-year-old, older immature and mature frogs. There were three replicate tanks for each age group (ten frogs per tank) and one additional tank contained 5 toads. From 11 November 1996 until 21 April 1997, the amphibians out of water were counted daily, and air and water temperatures were simultaneously recorded.

Discussion

For frogs there was no significant (NS) correlation in any age group between the number of individuals out of the water and the air or water temperature (Fig. 1) However, the choice of wintering site differed significantly between the three age groups (Kruskall Wallis one-way ANOVA, $H = 158.208$, d.f. = 2, $p < 0.001$). The youngest frogs were nearly always in the water regardless of air temperature (Fig. 1C), whilst the older but immature were significantly more often out of the water than the youngest group (Mann-Whitney U-test, $p = 0.000$) (Fig. 1B). However, the mature frogs spent significantly more time out of the water than either of the two younger groups ($p < 0.001$) (Fig. 1A).

In toads, there was a significant correlation between both air and water temperatures and the number of individuals staying out of water during the winter of 1995–1996 (Fig. 2). The relationships were described by linear regressions with the equations $y = 31.505 + 5.034 \times T$ (T = air temperature) and $y = 26.994 + 8.675 \times T$ (T = water temperature) ($p < 0.001$ for each). During the winter 1996–1997 similar trends were recorded but due to the small number of observations (on only five individuals) the relationships were not statistically significant ($p > 0.05$).

The variation in wintering site selection followed a much less pronounced pattern in frogs than in toads (Figs. 3 and 4). The numbers of adult frogs out of water (Fig. 3) varied considerably throughout the winter whereas the immature frogs spent increasing amounts of time out of water in January. Most frogs in the young-of-the-year group remained in the water throughout the observation period. A different pattern of activity

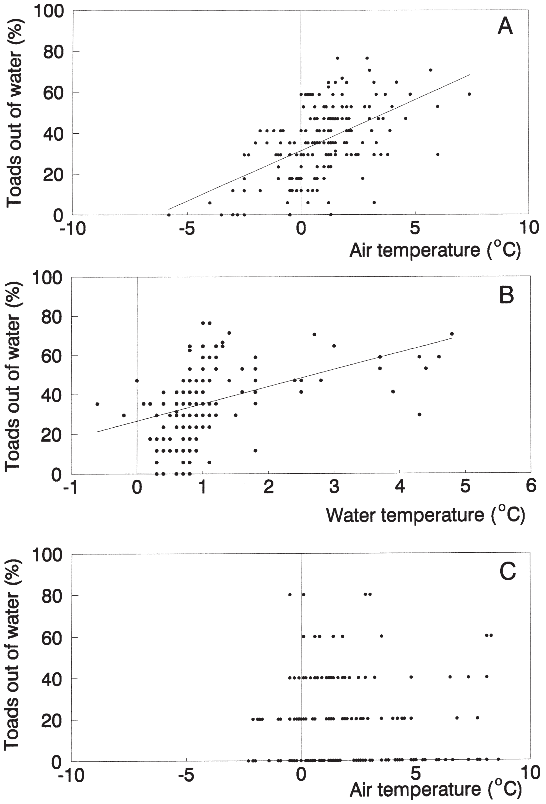

Fig. 2. Daily percentage of toads out of water as a function of air temperature (A) and water temperature (B) during the winter of 1995–1996 (N = 18) and air temperature C) (N = 5) during 1996–1997.

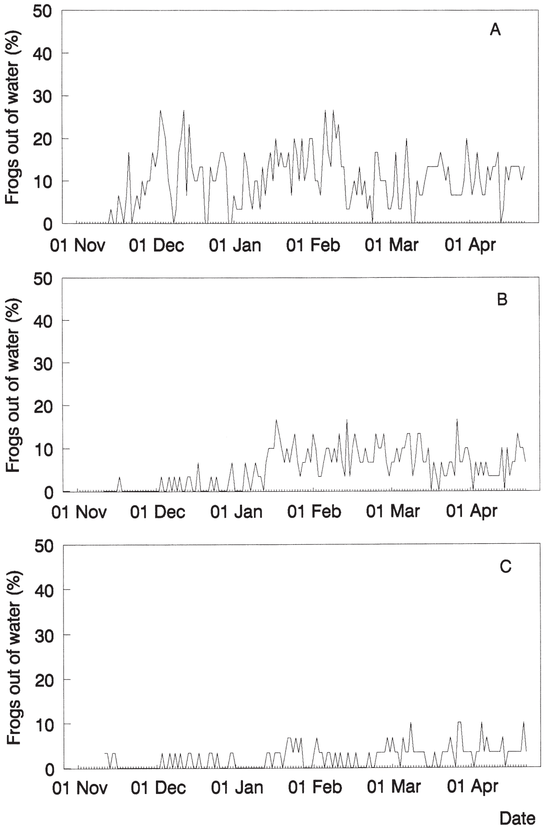

Fig. 3. Seasonal changes in the percentage of frogs out of water during winter 1996–1997. A = mature frogs, B = older immature frogs, C = less than one-year-old frogs.

was observed for toads (Fig. 4). There was a rather sharp decline in their choice of a terrestrial location at the end of December followed by increasing activity approximately two months from the start of the experiment, especially in the study carried out in 1995–1996.

According to our observations, a large proportion of toads prefer to leave the water when the air temperature allows it. Although the correlation and the calculated linear regression for water temperature was significant over the whole range of temperatures, the linearity was most pronounced for water temperatures just below one celcius (Fig. 2B). Air temperature affected the behaviour of toads over a much larger scale than water temperature (Fig. 2A). The critical air temperature (mean ± S.E.) at which all the toads would be in water is estimated from the regression equation to be – 6.25 ± 0.54°C. The terrestrial choice in these experiments, where the animals remained on a stone above the water surface, could indicate that in nature wintering on the ground is likely to be preferred by the toads in sites where the temperature falls little below zero. When wintering on the ground, toads usually seek a place well below the earth surface (e.g. in deep holes, under fallen leaves) and additionally covered by insulating snow.

The frogs clearly spent less time out of water than toads and the aquatic choice was most prominent in the youngest age group. In nature one might therefore expect frogs wintering on the ground to be mainly mature individuals whilst the youngest frogs are restricted to wintering in water. As is also indicated by differences in skin thickness, toads are much better adapted for wintering on land than frogs.

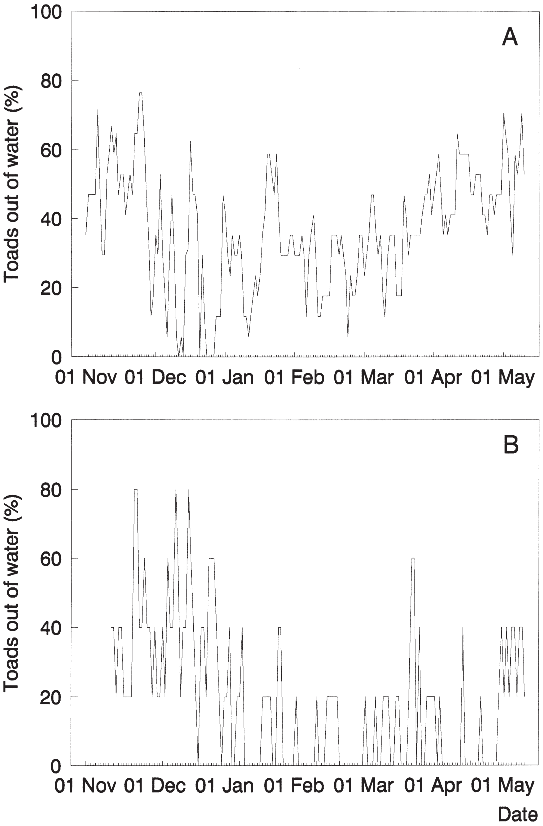

Fig. 4. Seasonal changes in the percentage of toads out of water during (A) winter 1995–1996 (N = 18) and (B) winter 1996–1997 (N = 5).

According to our results, we conclude that in Finland the common toad, like mature common frogs, might prefer wintering out of water. However, this conclusion requires further support from direct observations in nature and more detailed experimental results.

One interesting area for future studies would be to find out how frequently toads leave their wintering sites in water to test whether the air temperature would allow a change from an aquatic wintering site to the natural adult feeding environment, the terrestrial one.

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