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On age structure and longevity in two populations of *Bufo bufo* (LINNAEUS, 1758), at high altitude breeding sites in Austria

(Anura: Bufonidae)

Zur Altersverteilung und Lebenserwartung in zwei Populationen von *Bufo bufo* (LINNAEUS, 1758) an hoch gelegenen Laichgewässern in Österreich

(Anura: Bufonidae)

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KURZFASSUNG

Das Alter von Erdkröten (*Bufo bufo*) aus zwei hoch gelegenen Laichgewässern in den Nördlichen Kalkalpen Salzburgs (Schlumsee, 1,102 m; Ameisensee, 1,282 m) wurde anhand von Knochenquerschnitten bestimmt. Die Weibchen begannen im Alter von 5-6 Jahren, ein Jahr später als die Männchen, zu reproduzieren. Das maximale Alter betrug 15 Jahre für die Weibchen und 11 Jahre für die Männchen.

ABSTRACT

The age of Common Toads (*Bufo bufo*) collected at two high altitude breeding sites (Schlumsee, 1,102 m a.s.l.; Ameisensee, 1282 m a.s.l.) in the Northern Calcareous Alps of Salzburg, Austria was determined using skeletochronological methods. Females started to reproduce one year later than males at the age of 5-6 years. Maximum age was 15 and 11 years for females and males, respectively.

KEY WORDS

Amphibia: Anura: Bufonidae; *Bufo bufo*, Common Toad; age, age structure, longevity, high altitude environment, Alpine environment, population ecology, Austria

INTRODUCTION

In many amphibians the age at first reproduction is delayed and longevity is increased with increasing altitude and latitude of the breeding site (SMIRINA 1994). In the Alps, the Common Toad *Bufo bufo* (LINNAEUS, 1758), is found up to an altitude of 2,200 m (HEMELAAR 1988). Age distribution and longevity in lowland populations have been studied extensively (HEMELAAR & VAN GELDER 1980; HEMELAAR 1981, 1983; GITTINS et al. 1982, 1985; KUHN 1994; READING 1988, 1991); however, the only information about the age of the Common Toad attained at higher elevation comes from a study made in the Alps of Switzerland (HEMELAAR et al. 1987; HEMELAAR 1988). A comparatively small population of approximately 150 individuals breeding at 1,850 m altitude was investigated and it was shown that these toads can reach an age of up to 18 years.

The aim of the present study was a first description of the age distribution of the Common Toad at high altitudes in the Austrian Alps. Two populations were sampled, one in spring 1998 and the other in spring 1999.

STUDY AREA AND METHODS

In the Northern Calcareous Alps of Austria, karst lakes are found that undergo considerable changes in water level which prevent the survival of introduced fish (SCHABETSBERGER & JERSABEK 1999). Some of these lakes represent the breeding sites of large populations of the Common Toad consisting of thousands of individuals. Due to the settling of cold

air in some of these karst depressions, the temperature is considerably lower than expected at this altitude (JERSABEK & SCHABETSBERGER 1996).

Study area "Schlumsee" (1.8 ha, approximately 6 m maximum depth) is situated in the karst massif "Hagengebirge" south of Salzburg at 1,102 m altitude. The lake fills with meltwater in April and dries out each summer in July/August depending on rainfall. The lake bottom is covered with terrestrial vegetation. The basin is surrounded by a forest and steep slopes covered with limestone-boulders.

Study area "Ameisensee" (1.1 ha, 4 m deep) is situated south-east of Salzburg at the foothills of the limestone-massif "Gosaukamm" at 1,282 m altitude. The lake underwent considerable changes in water level, but never dried out during the course of the study. It is surrounded by coniferous forests and alpine pastures.

Both areas are snow-covered for at least 5 - 6 months per year (November through April or May). The peak of reproduction occurs in late May / beginning of June depending on the weather conditions. However, detailed information on abiotic conditions in the study area, population size, phenology of migration, and breeding of the toads is not available.

Sixty-three adult toads (33 females, 30 males of which 13 females and 10 males were found dead) were collected at "Schlumsee" during the peak of reproduction on 8 June 1997 (collecting permit "Schlumsee": 3/253-769/3-1997, Provincial Government of Salzburg). Animals from either sex were collected randomly so that at least 20 females and 20 males were available for age determination. Live animals were anaesthetized with MS222® (SIGMA-ALDRICH, Vienna) and the entire sample (n = 63) was fixed in 10 % formalin. Snout-vent length of preserved specimens was measured with vernier callipers and the humeri were used for age determination. At "Ameisensee", 55 adult toads (31 females, 24 males) were collected during their spring breeding migration on 9 and 25 May 1999 (collecting permit "Ameisensee": 3/253-810/5-1998, Provincial Government of Salzburg). The animals were anaesthetized in MS222®. Prior to their release, snout-vent length was measured with vernier callipers and the fourth phalanx of the left hind limb was removed and preserved in Bouin's solution (ROMEIS 1968). Humeri and phalanges were decalcified in 40% EDTA (MERCK, Darmstadt), bones were cleaned from tissue, dehydrated in ethanol and embedded in Historesin (LEICA, Heidelberg). Samples were cross sectioned (7 µm) on a heated blade (60°C) and stained with Kresyl-Violet (MERCK, Darmstadt) (3 min). In diaphysial regions, endosteal resorption was low (see GIBBONS & MCCARTHY 1983; HEMELAAR 1985). Following the approach of GOKHELASHVILI & TARKHNISHVILI (1994) in age determination, we added one year in those cases in which the endosteal cavity was considerably wider than in conspecific animals after the first post-metamorphic hibernation (n = 14 in the total sample).

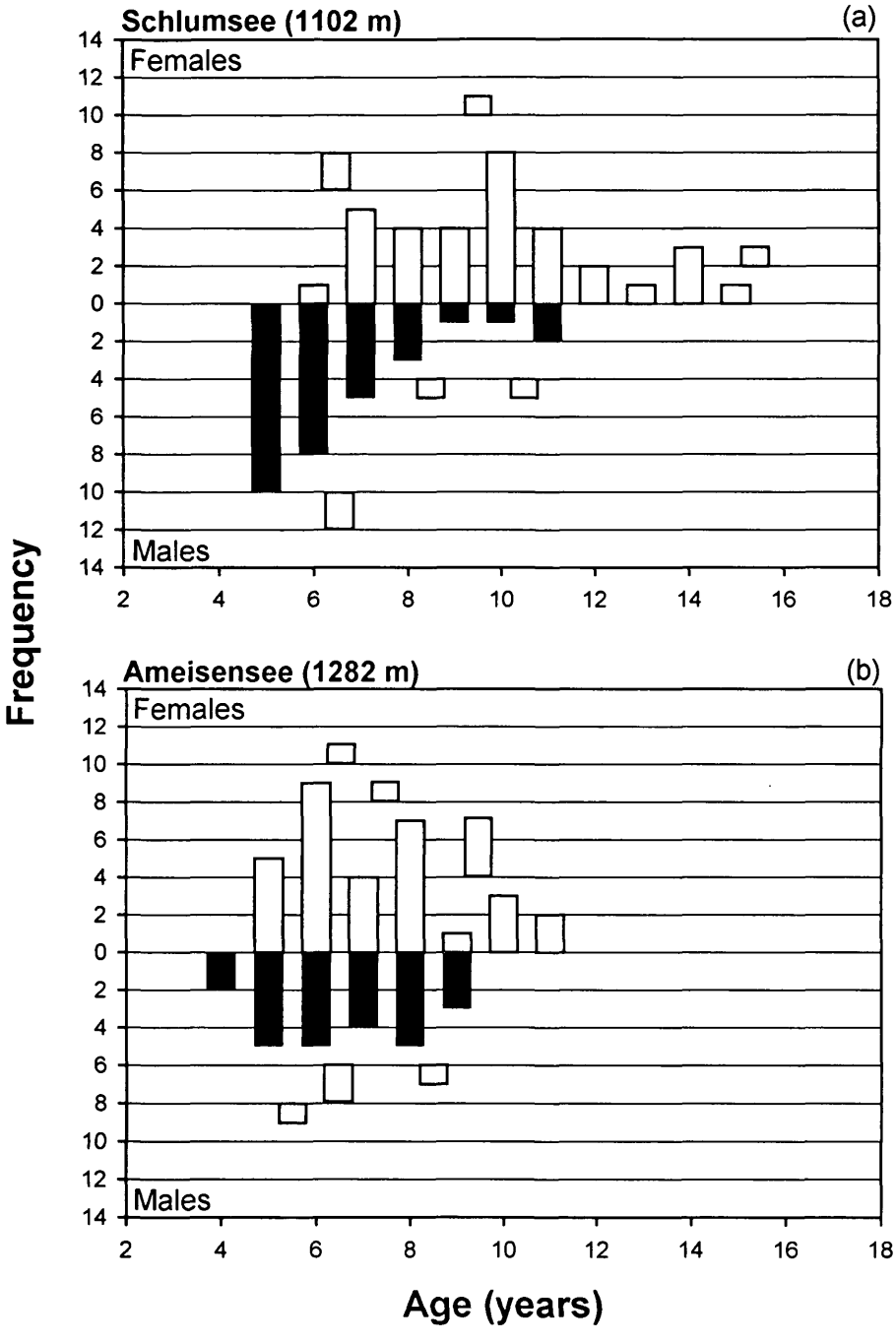
RESULTS

Average snout-vent length was 81.4 ± 0.7 (± S.E.) (n = 33) and 89.1 ± 1.1 mm (n = 31) in females and 66.0 ± 0.7 (n = 30) and 72.4 ± 1.3 mm (n = 24) in males from "Schlumsee" and "Ameisensee", respectively. Length frequencies were not compared, since they were derived from a preserved and a live sample. No significant correlation between body size and age was found in females and males of either population.

Age frequency distributions of females and males were significantly different at "Schlumsee" (Kolmogorov-Smirnov, $D = 0.34$, $p < 0.05$) but not at "Ameisensee" (fig. 1).

Fig. 1 (opposite page): Age structure of female and male *Bufo bufo* breeding populations of two alpine lakes in the Northern Calcareous Alps of Austria. (a) - "Schlumsee" (1102 m a.s.l.); (b) - "Ameisensee" (1282 m a.s.l.). Rectangular symbols overlapping two age classes refer to toads that could not be placed in any of these age classes with certainty. (y-axis: absolute frequency; x-axis: age classes).

Abb. 1 (gegenüberliegende Seite): Die Altersstruktur der weiblichen (Females) und männlichen (Males) Laichpopulationen von *Bufo bufo* an zwei Gebirgsseen in den Nördlichen Kalkalpen Österreichs. (a) - "Schlumsee" (1102 m ü. NN); (b) - "Ameisensee" (1282 m ü. NN). Rechteckige Symbole zwischen benachbarten Größenklassen beziehen sich auf Individuen, die keiner dieser Klassen mit Sicherheit zugeordnet werden konnten. (y-Achse: absolute Häufigkeit; x-Achse: Altersklasse in Jahren).



Comparing the populations of the lakes, age frequency distribution was significantly different in the females ($D = 0.33, p < 0.05$) but not in the males.

In both lakes, the youngest females (6 years at "Schlumsee"; 5 years at "Ameisensee") were one year older than the youngest males. Maximum age was 15 and 11 years in females and 11 and 9 years in males from "Schlumsee" and "Ameisensee", respectively. Only in males from Schlumsee the youngest age class was the most abundant one. The median age was 10.5 and 8 in females and 8 and 6.5 in males from "Schlumsee" and "Ameisensee", respectively. Sample size was too small for the calculation of mortality rates.

DISCUSSION

Although "Schlumsee" lies 180 m lower than "Ameisensee", its sheltered position in a big karst depression (450 m diameter) probably leads to reduced ambient and water temperatures and hence slower growth of the tadpoles, young metamorphs and most likely adult toads.

"Schlumsee" and "Ameisensee" lie 748 and 568 m lower than the breeding site studied in Switzerland. When compared with the results from HEMELAAR et al. (1987), our toads arrived three to four weeks earlier (around mid May) at the breeding sites. Males were one to two years and females two to four years younger at the age of first reproduction. However, longevity was similar as in the toads from Switzerland and at "Schlumsee", animals of age classes 13-15 were more abundant than in the Swiss population. The oldest male and female at "Schlumsee" were two and three years younger than the oldest animals from Switzerland and had attained an age of 11 and 15 years, respectively. In Switzerland the age structure was skewed towards younger age classes and mortality was high after the modal age was reached. However, the Swiss study (HEMELAAR et al. 1987) had shown that the age structure changes between years.

This snap-shot of the age distribution at two high altitude breeding sites in Austria suggests increased mortality in males when compared to that of females, whereas sexual differences in mortality were inconspicuous in the Swiss population studied. However, more information collected over a longer period of time will be necessary to confirm differential mortality between sexes. In the Swiss population, males breed every year, whereas females reproduce in a biennial cycle (HEMELAAR et al. 1987). If females from our populations follow the same pattern, several spawning related risk-factors (unpredictable harsh weather during migration, massive energy loss, predators) would be reduced and could be an explanation for increased longevity in females. However, the results from Switzerland are contradictory to ours in that longevity was almost equal in both sexes there. Longevity may be physiologically decreased in males or they simply may be more active and thus more exposed to natural threats than females.

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