

**THE BREEDING MIGRATION AND POPULATION CHARACTERISTICS  
OF A COMMON TOAD (*BUFO BUFO*, LINNAEUS 1758) POPULATION  
VISITING A SEMINATURAL POND IN SIGHIȘOARA**

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**KEYWORDS:** *Bufo bufo*, breeding migration, sex ratio, sexual selection, Târnava Mare River Watershed, Romania.

**ABSTRACT**

We studied the breeding migration of a common toad population in Târnava Valley near Sighișoara in 2001 and 2002. The duration and intensity of the migration is highly influenced by air temperature and precipitation. No terrestrial movement was observed under 5 °C. The sex ratio is male biased in both years, but in 2002 the relative number of migrating females tends to be larger in daylight. The pairs were formed randomly, we found no correlation between the SVL of amplexant males and females. There is no significant difference between the average SVL of paired and unpaired males. There is no significant correlation between the SVL of males and the distance from the pond from which they migrate.

**ZUSAMENFASSUNG:** Frühlingsmigration und die Merkmale einer Erdkrötenbevölkerung die sich in einem halbnatürlichen Teich in Schassburg reproduziert.

Zwischen den Jahren 2001 und 2002 haben wir die Frühlingswanderung der Erdkröte bei Schassburg (Kokeltal) studiert. Die Dauer und die Intensität der Migration waren von der Temperatur und den Niederschlägen signifikant beeinflusst. Wir haben keine Wanderungen unterhalb 5 °C beobachtet. Der Anteil der wandernden Männchen war während des Tages in beiden Jahren größer, aber 2002 schien der Anteil der wandernden Weibchen tagsüber zuzunehmen. Es gibt keine Korrelation im Amplex zwischen dem Anteil der Männchen und dem der Weibchen. Der Mittelwert (SVL) der Männchen im Amplex unterscheidet sich nicht bemerkenswert von dem der einsamen Männchen. Es gibt keine signifikante Korrelation zwischen dem Anteil der Männchen und der Distanz zwischen Migrationsort und Reproduktionsort.

**REZUMAT:** Migrația de primăvară și caracteristicile populaționale ale unei populații de broască râioasă brună (*Bufo bufo*) care se reproduce într-o baltă seminaturală în Sighișoara.

În 2001 și 2002 am studiat migrația de primăvară a broaștei râioase brune lângă Sighișoara, Valea Târnavei Mari. Durata și intensitatea migrării a fost influențată semnificativ de variațiile de temperatură și precipitații. Nu am observat mișcare terestră sub 5 °C. Rata pe sexe este balansată în favoarea masculilor, dar numărul femelelor relativ la acela al masculilor este mai mare ziua (2001). Nu există corelație între dimensiunea masculilor și cea a femelelor în amplex. Dimensiunea medie (SVL) a masculilor în amplex nu diferă semnificativ de aceea a masculilor solitari. Nu există corelație semnificativă între dimensiunea masculilor și distanța de la care migrează spre locul de reproducere.

## INTRODUCTION

For the majority of the temperate amphibians, the important habitat resources are separated in space and time. The annual activity of adults is characterized by periodical migrations from one habitat to another (Sinsch, 1988). During the breeding migration, the amphibians left the hibernation places and then migrated towards the breeding pond. Considering the intensity of the breeding period and the behaviour of the reproductive males and females during the breeding Wells (1977) distinguished two breeding systems in anurans: explosive breeding and prolonged breeding. In Europe, the explosive breeding system is represented typically by the common toad (*Bufo bufo*). The start and duration of the breeding migration is influenced by several environmental factors, like winter temperature (Reading, 1998) or the climatic conditions during the breeding migration (Wisniewsky et al., 1980). During the breeding migration, the amphibians use a variety of cues (e.g. acoustic, magnetic, mechanical, olfactory and visual) for orientation (for a review see Sinsch, 1991). In most amphibian species the sex ratio between the breeding males and females is male-biased. This results in an intense competition between males for females (Halliday, 1998).

In this study we present the breeding migration of a population of common toad (*B. bufo*), in the Târnava Mare Valley. The aims of this study are: (i) to gather informations about the beginning and intensity of the breeding migration and its influencing climatic factors, and (ii) to find if there is a sexual selection, by comparing the sizes (SVL) of the amplexant adults with those that are not in amplex.

## MATERIAL AND METHODS

This study was conducted near Sighișoara (46°13'47.8''N; 24°46'47.6''E; 349 m elevation), Târnava Mare Valley. The study area has approximately 5 ha, and the pond has a 2.23 ha surface area. The study site is situated on the right side of the Târnava Mare river at approximately 100 m distance from this (Fig. 1). In the vicinity of the pond (on right side) at a distance of about 400 - 600 m there is a deciduous forest (Fig. 1).

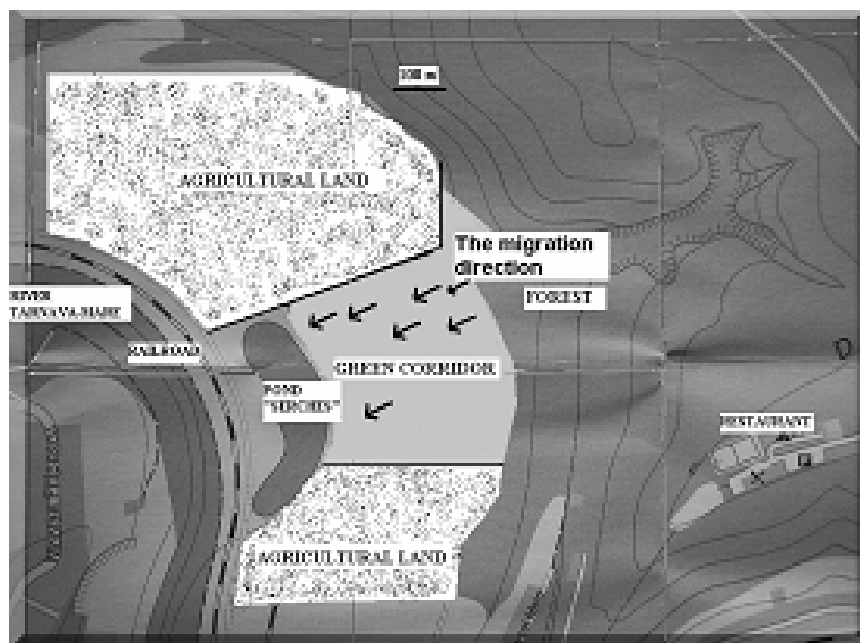


Fig. 1: The map of the study area.

In 2001 the toads were counted in the night hours, over 19 days in eight plots between the pond and the forest. The surface of each plot was 300 m<sup>2</sup> (three m width and 100 m long).

In 2002, the migrating toads were counted both by day (between 16-18 hours, a 20 day interval) and at night (32 day interval), each day for one or two hours in both periods in a standardized route. All these observations were made by two persons at each time.

We measured the snout - vent length (SVL) of individuals with a precision of 0.1 mm. The sampled toads were weighed to the nearest 0.05 g. The air temperature at ground level was measured, and the presence or absence of wind (blowing from NW) and precipitation was recorded.

The effect of temperature on the intensity of breeding migration, the size relationships of the amplexant pairs and the correlation between the terrestrial activity of the two sexes was studied using Pearson product-moment correlation. The average size (SVL) of the males and females was compared using t test (after the normal distribution of the data was tested using Kolmogorov-Smirnov test). The significance level is 0.05.

## RESULTS

### The effect of environmental conditions on the breeding migration

In 2001 the breeding migration lasted for 19 days (Fig. 2). The average air temperature during the migration in 2001 was 8.6°C (range 1°C to 16°C). It has been raining three times (Fig. 2). In 2002 the migration was prolonged relative to 2001: the migration lasted 36 days (Fig. 3 and 4). In the night hours, the temperatures varied between -2°C and 19°C (Fig. 3) with an average of 8.17°C. In the afternoon hours the average value of the air temperature was 10.81°C (range 2.5 °C to 19°C, Fig. 4). Precipitation (rain, snow) fell seven times.

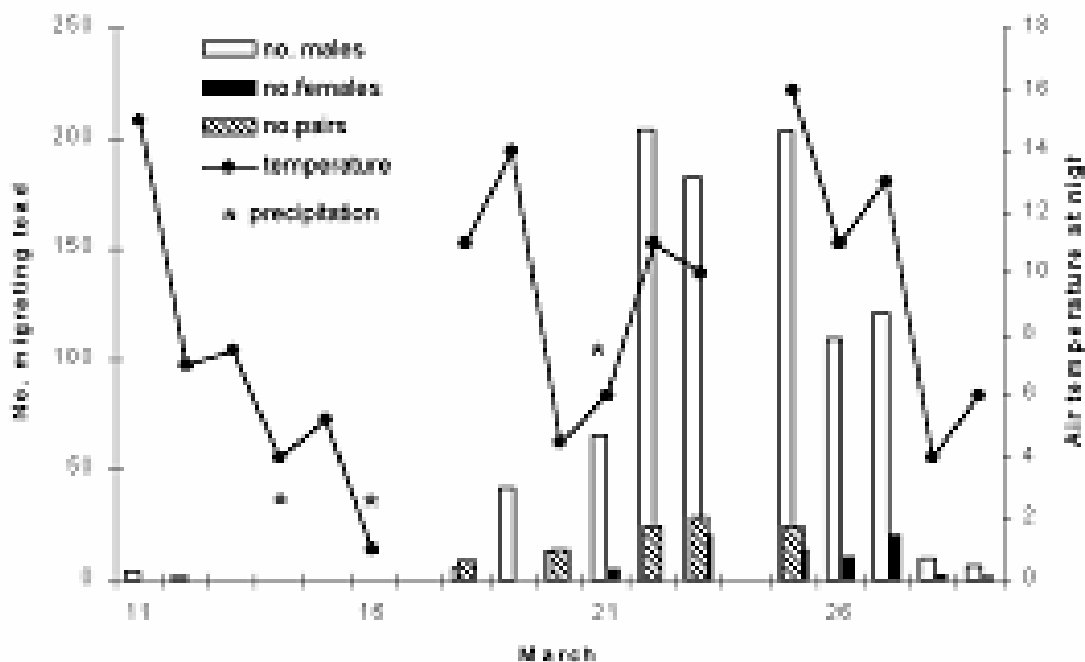


Fig. 2: The duration and intensity of the breeding migration in 2001, night hours.

In 2001 we found toad activity in 14 days (= 73.6%), the low temperature impeded the toad movement in other days (Fig. 2). The males migrated in 13 nights (= 68.4%) and the females in 12 days (= 63.1%). The males outnumbered females during the breeding migration. The average sex ratio was 13 males to one female. A large number of females emigrated from pond towards the forest (data not shown). This indicates that the females stay only for a short period in the water, and leave immediately after the egg deposition. These females were single, and almost no attempt of males to clasp them was observed. Pairs were found in five days (Fig. 2).

In 2002 the toads migration was studied both in the afternoon and in the night hours (Fig. 3 and 4). In the night hours the toads were active in 19 days (=52.7%). The males were active 100% of the days in which we registered toad activity (Fig. 3). By daylight we found toad activity in nine days (= 45%). The sex ratio was male-biased both in the afternoon hours and in the night hours, but by daylight the sex ratio was smaller because of the smaller number of males. The sex ratio by daylight was 2.6:1 and in the night hours 14.7:1. There is a significant positive correlation between the terrestrial activity of males and females in both years (Pearson  $r$ ,  $p < 0.02$ ).

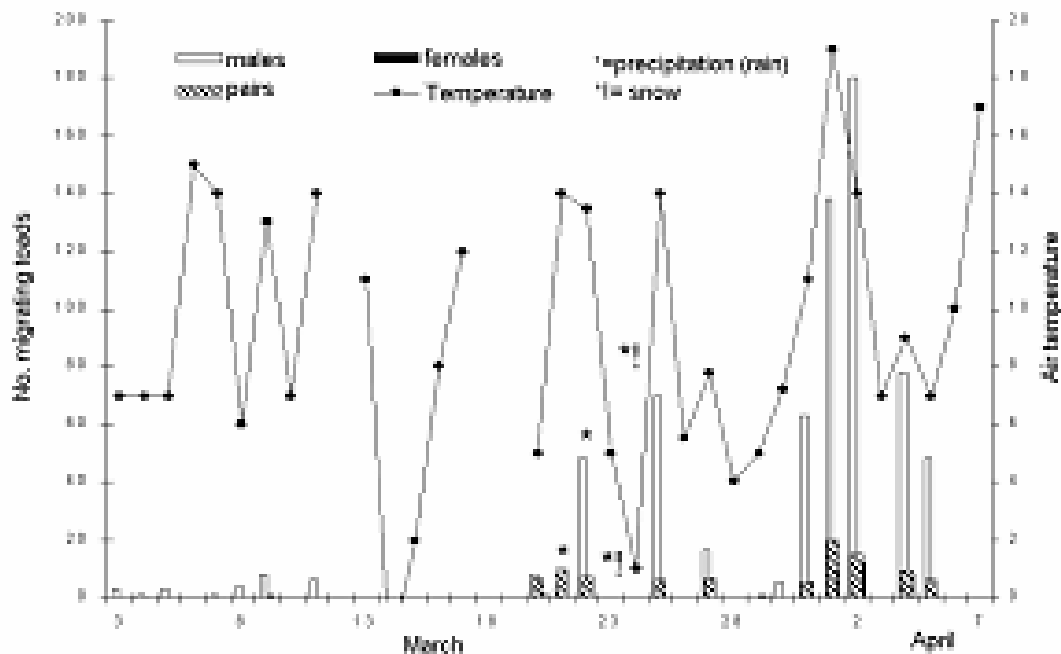


Fig. 3: The intensity and duration of the breeding migration in 2002, night hours.

There is a significant positive correlation between the number of active adults (males and females) and the air temperature (Pearson  $r$ ,  $p < 0.05$  for both 2001 and 2002). There are clear differences between the day and night activity of males, the major peak of their activity being at night. In the case of females the differences are not obvious (Fig. 3 and 4). The average number of migrating males in 2002 is higher in the night than in the afternoon (23.2 vs 14.5). The females tend to migrate in a larger number in the afternoon hours than in the night hours (average 5.9 vs 3.8). In both years the majority of toads were active at higher air

temperatures: in 2001 between 21 - 27 March and in 2002 between 31 March and 5 April. The number of nights with substantial toad movement is constant in both years: five days in 2001, (Fig. 2) and five days in 2002 (Fig. 3). The minimum air temperature at which we recorded toad activity at dusk was 5.5 °C in 2001 and 6.6 °C in 2002 for males and 4.8 °C in 2001 and 9.33 °C in 2002 for females. The average air temperature in which the males were active was 9.87 °C in 2001 and 10.45 °C in 2002. For females the recorded average air temperature was 9.56 °C in 2001 and 11.02 °C in 2002 during the night.

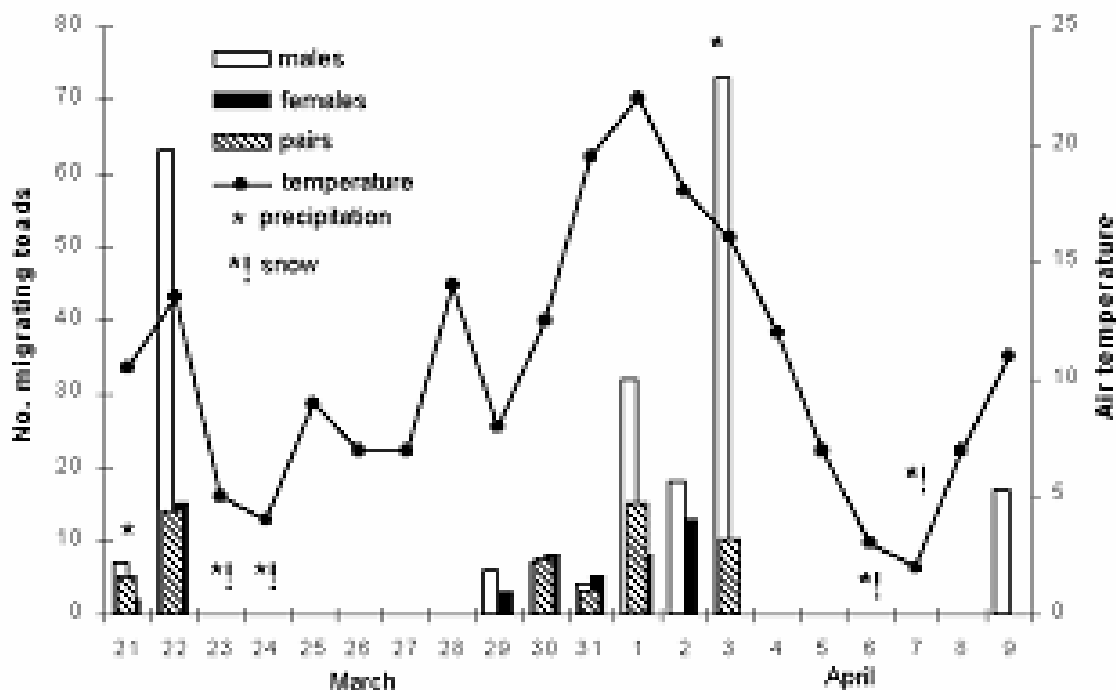


Fig. 4: The breeding migration by daylight, 2002.

No active toads were found when the air temperature was under 5 °C temperature in 2002. The males number in 2002 was higher in windy weather than in calm weather, although the temperatures were lower. At night, because of the cold wind, with an average of 7 °C, most of the males were inactive. This temperature value is close to the minimal threshold temperature which hampers the male toad's activity. The wind blowing from the pond, increased toad activity (Sinsch, 1987). The females average number decreased when the wind was associated with low temperature. The average air temperature was higher when toad movement occurred than in other days.

Most of the migrating individuals were found in a 150 ms distance from the pond (Fig. 5), in 2001 and 2002. We found some individuals in distances up to 450 ms, in the near forest. In these distances the females migrated single, pairs were formed at about 150 ms or closer to the pond where the number of males is higher. However all the females entering the pond were paired. We identified some hibernating places at about 80 - 150 ms from the studied pond. This fact may be a reason why a large number of toads individuals migrated from this distance.

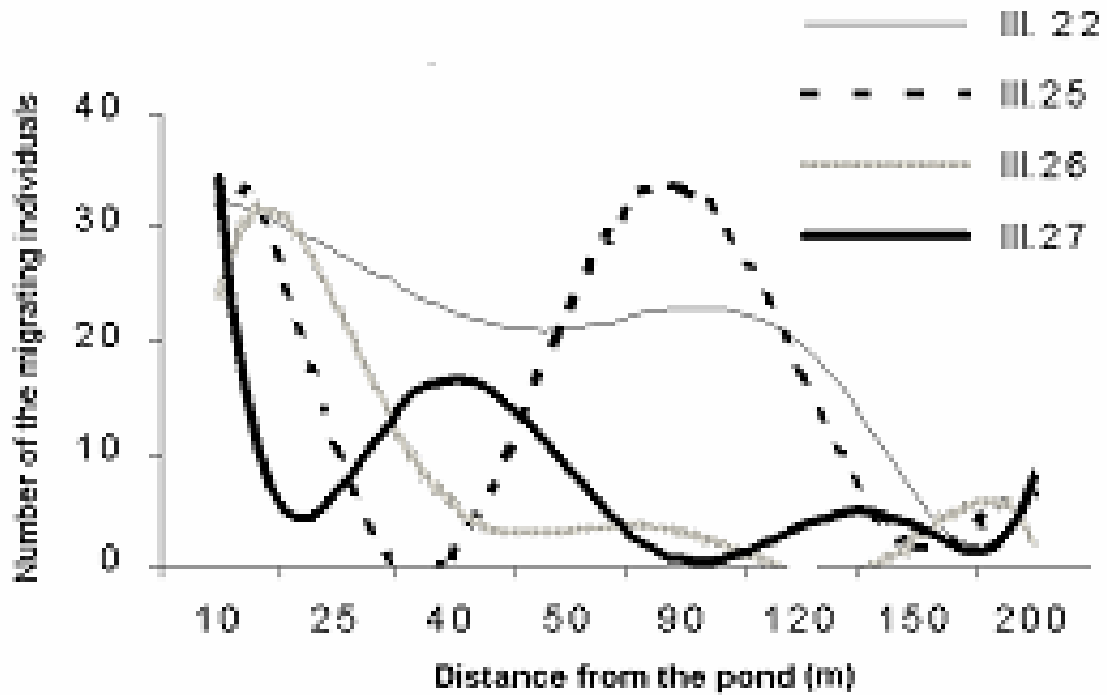


Fig. 5: The intensity of the toads migration at different distances and days, 2001.

The pasture between the pond and the forest is the main migration route for toads. The average number of migrating adults was larger in the pasture than in the arable areas (Fig. 6).

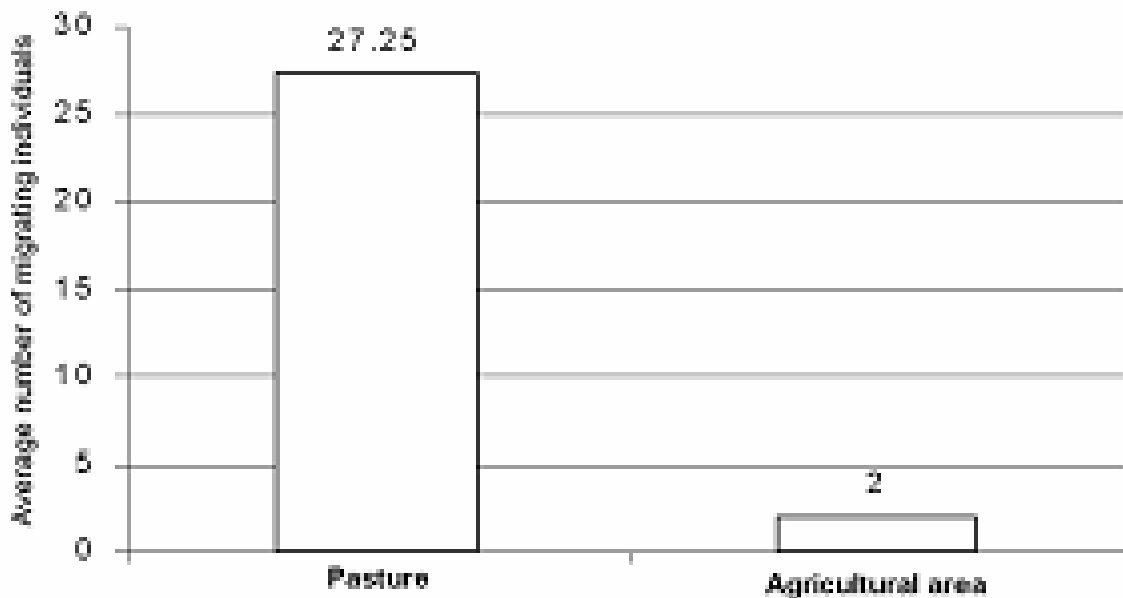


Fig. 6: The average number of migrating toads found in the pasture between the forest and the pond, and the arable area between 10-25 m distances from the pond (2001).

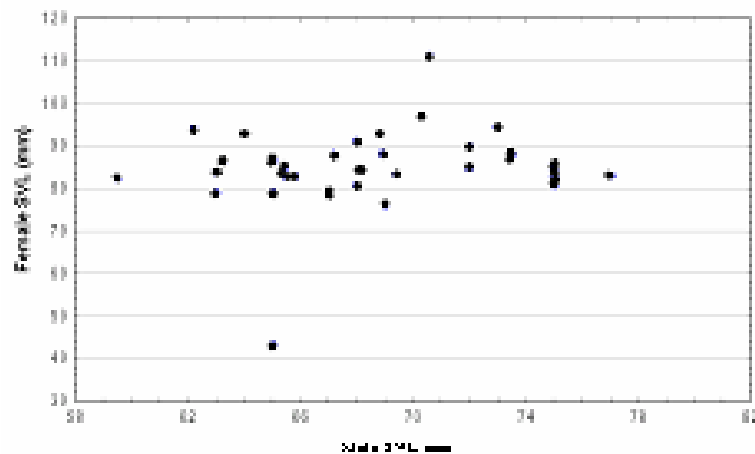


Fig. 7: The relationship between the body length of the amplexant toads.

In the days with intense toads activity, their density on land was on average 0.16 toads/m<sup>2</sup> in 10 m distance from the pond. In the more distant points the average number of breeding toads was lower: 0.055 toads/m<sup>2</sup> (in 150 m distance from the pond). We never found significant toad migration from the Târnava River (only 3 males in 2001). The temporary ponds of the deciduous forest near the pond have never been used for reproduction (Hartel, unpublished data).

#### **The body length and weight of males and females individuals in the breeding population**

The mean SVL of male toads was 68.65 mm (n = 164, range 53.8 - 82.) in 2001 and 68.05 (n = 134, range 55.6 - 84.2 mm) in 2002. The mean body weight of males in 2002 is 31.8 g (n = 25). The mean SVL of females has an average value of 94.57 mm (n = 71, range 70.12 - 114.8 mm) in 2001 and 86.10 mm (n = 54, range 70.10 - 113.4 mm) in 2002. The mean female body weight before breeding in 2002 was 88.53g (n = 30). We didn't find differences between SVL of males in 2001 and 2002 (t = 0.42, df = 296, p = 0.64). The females were shorter in 2002 than in 2001 (t = 2.92, df = 123, p = 0.04). The SVL of paired and unpaired males did not differ in two years (t = 0.31, df = 72, p = 0.7 in 2001 and t = 0.84, df = 124, p = 0.38 in 2002). We found no correlation between the body length of males and that of the females found in amplexus (r = 0.14, p > 0.05, n = 35, Fig. 7). There was found no correlation between the body length of toads males and the distance from the pond during the breeding migration in 2002 (22<sup>nd</sup> of March: r = -0.16, n = 13, p > 0.05; 1<sup>st</sup> of April: r = -0.38, n = 12, p > 0.05; 3<sup>rd</sup> of April: r = 0.14, n = 39, p > 0.05).

## DISCUSSION

### The breeding migration, sex ratio and environmental conditions

The activity of most amphibians is highly correlated with the environmental conditions (ex. the temperature, Kusano and Fukuyama, 1989). Air temperature has a strong influence on the starting (Reading, 1998) and intensity (Kusano and Fukuyama, 1989) of the toads breeding migration. Amphibians are more sensitive to temperature in the prespawning period than in the postspawning period (Wisniewsky et al., 1980). The toads males are active in lower temperature conditions than females in more amphibian species (Douglas, 1979; Wisniewsky et al., 1980).

The activity pattern of anurans is reported to be generally crepuscular or nocturnal (Pechmann and Semlitsch, 1985, Duellmann and Trueb, 1986). The main selective forces favoring amphibian nocturnal activity may be the avoidance of desiccation and predators (Pechmann and Semlitsch, 1985). This behaviour pattern may be modified periodically for a while by the alterations of climatic conditions (Sinsch, 1988). This study presents evidences that females are more active during daylight than at night hours, whereas the majority of the males are active at night. Two reasons can cause such a difference: the more favorable climatic conditions during the day and the avoidance of the high density of males (see below).

The minimal threshold air temperature in which the number of active toads on land is low, seems to be specific for populations and species. In the case of *Bufo bufo* species, the minimal threshold air temperature may be 0 °C (Sinsch, 1988), 1°C (Puky et al., 1990), 3,3 °C (Wisniewsky et al., 1980), 4°C (Gittins et al., 1980), 6 °C (Reading, 1998) in different populations. In our study we found no aquatic or terrestrial movement when the temperature was below 5 °C.

We found little toad activity in cold wind. The wind associated with higher air temperature and humidity (Dem and Hartel, 1999) offers favorable conditions for migrating toads. The locomotory activity can be influenced by a variety of environmental conditions, e.g. temperature, rainfall, air humidity, atmospheric pressure and moon phases, but as Sinsch (1988) and Fukuyama and Kusano (1992) suggested, these factors should be studied over several years, and multiple regression analysis can be helpful in elucidating the relationship between weather conditions and migratory and breeding activity (Semlitsch et al., 1996).

The pairs were formed in the close vicinity of the breeding pond (<150 m) where the number and density of males is high. In a previous study Dem and Hartel (1999) find that a great number of females can migrate unpaired because of low density of individuals.

In our studied population, the males outnumbered females at the breeding site similar to other *Bufo bufo* populations (Davies and Halliday, 1979; Gittins et al., 1980). Reading (1991) assumed that the sex ratio after metamorphosis is equal, and it may be distorted by environmental factors such as temperature. The sex ratio may be male-biased for few reasons: (i) Males breed yearly but the females do not, because the eggs are energetically more costly to produce than sperm (Reading, 1988). (ii) The males reach maturity in 2 - 3 years but the females in 4. The males and females may have a minimal body length in which they reach sexual maturity, and the males reach maturity in shorter body size than females (Reading, 1991). However the body size which sexual maturity is reached is not fixed and could vary between populations (Reading, 1988). (iii) The males reach earlier and spend more time in the breeding pond than females (Davies and Halliday, 1979; Gittins et al., 1980; Loman and Madsen, 1986). The reproductive females number in the breeding site decreased in time, since the females left the pond after breeding (in 1 - 3 hours, Hartel, *personal observations*). It was observed that one male can fertilize more females (Hartel, *personal observations*). (iv) The smaller number of females can be caused by winter mortality (Kuhn, 1994).



The result of the male-biased sex ratio is an intense male - male competition for females (Davies and Halliday, 1979; Halliday, 1994; 1998). The pairs are permanently attacked by single males. Davies and Halliday (1979) found that the largest males are stronger and this can result that these males have best opportunity to obtain females by takeovers. In our study the SVL of paired and unpaired males did not differ significantly. We found no significant correlation between the body length of paired males and females. We conclude that in this population the pairs were formed randomly. Similar result, were found by Loman and Madsen (1986) in a Swedish *Bufo bufo* population. The correlation between amplexant adults SVL was positive and significant in English populations (Gittins et al. 1980; Reading and Clarke 1983). This difference is explained by that the females stay a short period in the water in the Swedish population, and for a longer period in the populations from England (Loman and Madsen 1986). It is not known, whether the density of the males influences or not the behaviour of females. It is known that in explosive breeders (*sensu* Wells 1977) such as the common toad the males actively search for mates. The active searching is usually accompanied by intense competition among males for the possession of females. If several males clasp a single female in order to dislodge the male most securely fixed at female's back, the female could be seriously injured and even killed. This behaviour of males negatively affects the number of the deposited eggs (Halliday, 1998). Considering this it would be interesting to study the behaviour of the females in different densities of males.

Due to strong instinct to clasp females, the male common toads could pair with females, which belong to other species. We found in 2001 males common toads pairing with specimens belonging to *Rana ridibunda* complex. We never found interspecific spawning between *Bufo bufo* and *Rana temporaria*, as Reading (1984) found.

The toads in this population are larger than in Wales (England) (Gittins et al. 1980) but the male body length is close to the values found by Passenheim et al. (2001) in Braken (Germany). The female body length in our population is larger than the female body length in Braken.

More toads males migrate in the relatively undisturbed pasture than in the arable land. The terrestrial areas around the pond (Fig. 1) are used for agriculture. The pasture is only occasionally used, but in the arable areas the land use is intensive, chemical fertilizers being used, that have negative effects on amphibians (Oldham et al. 1997; Oldham 1999). The spatial distribution (i.e. numerous toads in the pasture vs less number in the arable area) could be explained by the land use patterns. A study of the egg mass distribution of *Rana dalmatina* in a pond shows a constant spatial distribution that could be understood by the terrestrial habitat quality around the breeding pond (Hartel *unpublished data*). Considering these, it is important to identify and protect those terrestrial habitats that serve as migration culverts for amphibians, to protect this group of vertebrates. Our observations show that the pasture between the pond and the forest represent a migration culvert for amphibians, and it should be protected from changes (conversion on arable land, buildings, etc.).

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