

## Review Article

# Relationship of environmental temperatures and activity of *Chelydra serpentina* in Southeastern Pennsylvania, USA

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**ABSTRACT** – Thermal ecology and daily and annual activity periods of the turtle *Chelydra serpentina* were studied from 1964-1992 in southeastern Pennsylvania, USA. Turtle activity and related cloacal body temperature (BT) were most influenced by the temperature of the medium the turtle experienced; water temperature when aquatic (WT,  $r = 0.92$ ) or air (AT,  $r = 0.87$ ) when on land. Most captures were aquatic. Annually turtles were active after emergence from hibernation in early March, and remained active until reentering hibernacula in early October. Daily activity normally lasted from about 07:00 h to when it became too dark to locate the animals. Most activity occurred between 08:00-13:00h, but some crepuscular or nocturnal foraging activity occurred as some turtles were found in the morning in traps that had been freshly baited the evening before. Also, some nesting females oviposited after dark or during the crepuscular morning hours. Activity on land was essentially restricted to nesting females.

## INTRODUCTION

Body temperature data from free living *Chelydra serpentina* in the MidAtlantic region of the USA are generally lacking, as most studies of its temperature tolerances have been conducted in laboratories using controlled thermal gradients. The data we report offer a valuable comparison to previous studies; and are comparative also as baseline data for other populations of *C. serpentina* in the MidAtlantic region.

The main purposes of this study were to determine the thermal ecology of the snapping turtle, *C. serpentina*, at a southeastern Pennsylvania pond/marsh complex, and to calculate the turtle's operating body temperature (OBT) range for several daily and annual behaviours at the site for comparison with other such data from previously published studies conducted farther north or south of Pennsylvania.

## MATERIALS AND METHODS

Snapping turtles were studied during over 1,000 collecting trips from 1964 to 1992 at the White Oak area, a 2.5 ha soft-bottomed mill pond bounded by 10 ha of mixed marsh and woodland habitat formed by the damming of Big Chickies Creek, a tributary of the Susquehanna River, slightly more than 2 km north of Manheim, Lancaster County, Pennsylvania. The site is described in detail in Ernst (1969, 1971). All research and collection of turtles at White Oak was covered by annual permits from the Pennsylvania Fish Commission, including the years 1964-1992.

The site supported a variety of vertebrates, particularly migratory waterfowl. Other turtles present were the aquatic *Chrysemys picta*, *Clemmys guttata*, *Glyptemys insculpta*, *G. muhlenbergii*, *Sternotherus odoratus*, and the

Category	BT	AT	ST	WT
All capture records (331)	21.8 ± 4.9 (4.0-34.0)	23.0 ± 4.7 (6.0-33.0) <i>r</i> = 0.87	23.7 ± 5.2 (5.0-34.0) <i>r</i> = 0.87	20.7 ± 4.6 (4.0-30.0) <i>r</i> = 0.92
Adult females	22.1 ± 5.2 (4.0-30.0)	22.2 ± 4.9 (8.0-33.0) <i>r</i> = 0.88	22.9 ± 5.5 (8.0-34.0) <i>r</i> = 0.90	20.2 ± 4.4 (4.0-27.0) <i>r</i> = 0.92
Adult males	21.0 ± 5.7 (4.0-34.0)	22.5 ± 5.3 (6.0-30.0) <i>r</i> = 0.91	23.3 ± 5.6 (5.0-33.0) <i>r</i> = 0.89	20.3 ± 5.4 (4.0-28.0) <i>r</i> = 0.96
Immatures	22.6 ± 3.5 (12.0-30.0)	23.9 ± 3.7 (12.0-31.0) <i>r</i> = 0.78	24.6 ± 4.6 (6.0-34.0) <i>r</i> = 0.82	21.6 ± 3.6 (10.0-30.0) <i>r</i> = 0.86

**Table 1.** Relationships of cloacal body temperature and environmental temperatures of common snapping turtles, *C. serpentina*, presented as means and ranges, in Lancaster County, Pennsylvania: cloacal body temperature (BT), air temperature (AT), land surface temperature (ST), water temperature (WT), standard deviation (SD), correlation coefficients (*r*) with BT. All temperatures in degrees Celsius.

terrestrial *Terrapene carolina* in the woodlands. The population of *Chelydra* was more scattered and smaller than those of the more populous *C. picta*, *C. guttata*, and *S. odoratus* (Ernst, 1971).

During the study, 280 *C. serpentina* (adult males, 118, 41.9%; adult females, 60, 21.5%; and immatures, 102, 36.6%) were captured a total of 331 times. The minimum CLs of captured White Oak mature males and mature females were 204 mm and 271 mm, respectively; based on the tail length and anal vent position sexual dimorphism reported by Ernst & Lovich (2009).

Adult and larger immatures were live-trapped in six hoop-net traps baited with canned or fresh fish, bovine liver, or chicken entrails at seven pond stations where turtles were seen to bask or feed (Ernst, 1965). The traps were checked and rebaited daily in the early morning and late afternoons. Smaller individuals in the shallow marsh or brooks were captured by hand or with a dip net. Hibernating snapping turtles were located either by hand muddling in the soft bottoms of the shallow waterways or by using the long-pole technique known as “sounding” in deeper waters (Carpenter, 1955).

At each capture, the date, 24-h military time, location, and, except for trapped individuals, the turtle’s behaviour were recorded. All *Chelydra* were sexed, aged, measured, weighed, and individually shell notched for future identification (Ernst *et al.*, 1974; Ernst &

Lovich, 2009). The straight-line carapace length (CL) was measured with dial calipers accurate to 0.1 mm, and mass was determined using a triple-beam balance. Algal colonies and leeches present on the turtle were identified and counted (Ernst *et al.*, 2012).

The turtle’s cloacal body temperature (BT) was taken with a Schultheis cloacal thermometer accurate to 0.1 °C. Also recorded with a multi-channeled Yellow Springs quick-reading telethermometer accurate to 0.2 °C were the air temperature (AT) 10 cm above the capture point, and, at the exact capture point, the surface temperature (ST) if terrestrial, or water temperature (WT) at a depth of 10 cm if aquatic.

All data were statistically analyzed using R, Version 2.15.2; levels of significance were set a priori at  $\alpha = 0.05$ . Analysis was by correlation coefficient, and by ANOVA using Tukey’s multiple comparisons.

Capture data were plotted using violin plots. These plots are essentially box plots modified by using a kernel smoother. The relative thickness of the plotted area represents the relative number of animals, both within and between the different groups.

## RESULTS AND DISCUSSION

### Body Temperature

Temperature data recorded during 331 captures of *C. serpentina* at White Oak are reported in Table 1. Anova comparisons followed by

## Environmental temperatures and activity of *Chelydra serpentina*

Activity (captures)	BT	AT	ST	WT
Move (161)	22.3 (5.0-30.0)	24.8 (10.0-30.0)	25.0 (12.0-34.0)	21.3 (5.0-30.0)
Trapped (79)	22.3 (16.0-26.0)	22.9 (18.0-30.0)	22.9 (18.0-33.0)	20.4 (16.0-25.0)
Bask (19)				
Atmospheric (17)	24.9 (15.0-34.0)	23.1 (12.0-30.0)	22.8 (12.0-31.0)	21.1 (10.0-26.0)
Aquatic (2)	21.5 (17.0-26.0)	23.0 (20.0-26.0)	24.0 (20.0-28.0)	20.5 (15.0-26.0)
Feeding (28)	24.1 (20.0-29.0)	26.2 (14.0-31.0)	26.0 (18.0-32.0)	23.4 (18.0-28.0)
Nesting Females (30)	22.6 (18.0-30.0)	21.6 (17.0-29.0)	21.7 (17.0-30.0)	19.3 (16.0-26.0)
Male Combat (2)	16.0	20.0	20.0	16.0
Inactive (12)				
Hibernate (8)	6.3 (4.0-12.0)	9.3 (6.0-14.0)	9.5 (5.0-10.0)	6.1 (4.0-12.0)
Land Form (4)	21.0 (16.0-24.0)	23.0 (17.0-29.0)	23.8 (18.0-31.0)	20.0 (16.0-22.0)

**Table 2.** Relationships of cloacal body temperature of *C. serpentina* to behaviour presented as mean and range: number of records (N), cloacal body temperature (BT), air temperature (AT), land surface temperature (ST), water temperature (WT); all temperatures in degrees Celsius.

Tukey's multiple comparisons between the BTs, ATs, STs, and WTs of the sex/age classes of adult males, adult females and immatures indicated that significant differences were present between the three classes in the mean temperatures of AT ( $P = 0.0327$ ) and ST (0.0297) but not between their BTs and WTs. Correlation coefficients ( $r$ ) for BT versus WT also showed the highest correlations in all three classes with values above 0.90, indicating that WT was the most important ectothermic influence at the time of capture on all three sex/age groups.

Separate ANOVA comparisons were also performed of BT to AT, ST and WT for the individual adult sexes and immature as were separate additional Tukey's multiple comparisons to tease apart the separate temperatures for these three groups. For adult males, WT was significantly different from both AT and ST, and BT was significantly different from ST. WT is the most important thermal source for males, as indicated by the correlation coefficient ( $r$ ), as adult males were more highly aquatic and less often captured on land than adult females. The same relationships

occurred in immatures, as they too spend the greatest amount of time in water. During the nesting season in late May and June, ovipositing females spend considerable time on land, causing a significant difference between WT and ST. These differences indicate that *Chelydra* of all sexes and ages are influenced most by the warmest medium in which they are in contact.

Few comparative literature reports of field environmental temperatures (ETs) at the time and point of capture of *Chelydra* are available, and these are almost exclusively from localities farther north or south of our research site. Brown et al. (1990) noted that the mean BT of eight free-ranging Ontario, Canada, *C. serpentina* was 22.7 °C at a mean corresponding ET of 24.9 °C. Knight et al. (1990) reported that Ontario hatchlings placed in a laboratory thermal gradient selected a similar ET. In a second Ontario study, Brown et. al. (1994) reported that the mean radio telemetry recorded BTs and ETs of snapping turtles at two principal sites were: BT 19.5 °C and 22.5 °C, WT 19.5 °C and 22.6 °C, and AT 16.8 °C and 20.4 °C, respectively; and Obbard & Brooks (1981) and

Species	BT	AT	ST	WT	Source
<i>Chelydra serpentina</i>	21.8 (4.0 -34.0)	23.0 (6.0-33.0)	23.7 (5.0-34.0)	20.7 (4.0-30.0)	Present study
<i>Chrysemys picta</i>	22.2 (4.5-34.0)	25.8 (8.0-29.0)	27.5 (3.8-41.0)	16.2 (4.0-21.5)	Ernst, 1969, 1972
<i>Clemmys guttata</i>	20.2 (3.0-32.0)	20.2 (0.0-30.0)	19.4 (4.0-32.0)	16.6 (2.0-32.0)	Ernst, 1982
<i>Glyptemys insculpta</i>	21.0 (3.5-30.1)	21.9 (3.0-35.0)	20.2 (4.0-33.0)	17.4 (5.6-28.0)	Ernst, 1986a
<i>Glyptemys muhlenbergii</i>	20.3 (16.2-31.0)	22.0 (17.0-23.4)	21.8 (19.4-24.1)	18.4 (15.0-22.8)	Ernst, 1977
<i>Sternotherus odoratus</i>	21.7 (14.0-30.0)	23.3 (4.2-32.0)	21.4 (9.0-28.5)	20.2 (3.8-30.0)	Ernst, 1986b

**Table 3.** A comparison of temperature relationships (presented as mean and range) of the six aquatic turtles at White Oak, Pennsylvania; all temperatures in degrees Celsius: cloacal body temperature (BT), air temperature (AT), land surface temperature (ST), and water temperature (WT).

Brown & Brooks (1991) stated that Ontario *Chelydra* were active at WTs of 7.5-28.8 °C. Punzo (1975) reported Florida *C. s. osceola* had a WT activity range of 18.7-32.6 °C. In another Pennsylvania study farther east, at approximately the same latitude, near Philadelphia, active *Chelydra* were found in water of 5-33 °C (Saba, 2001). At Mason Neck, 268 (95.7%) of the WTs of active snapping turtles were 16-26 °C, falling between the preceding reports.

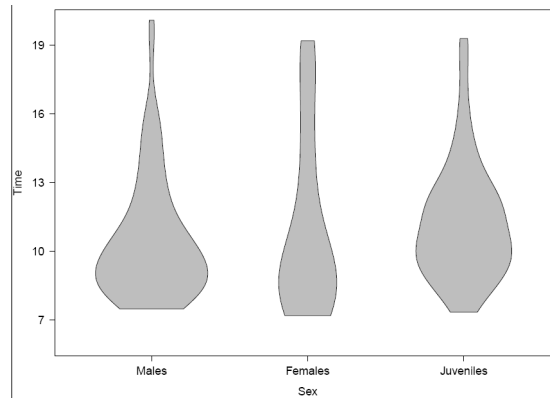
Most White Oak BTs fell between 15.0-27 °C (n = 222, 67.1%); and WTs between 10-30 °C. Other pertinent ranges were: 20-26 °C (n = 173, 52.3%), 22-26 °C (n = 133, 46.2%), and 24-26 °C (n = 93, 28.1%). These field records indicate the most normal BT for naturally active White Oak *Chelydra* lies between 20-26 °C, the turtle's operating body temperature (OBT) range at White Oak; a range lower than the mean selected temperature of this species and other aquatic turtles in laboratory studies using thermal gradients (Schuett & Gatten, 1980; Williamson et al., 1989; Nutting & Graham, 1993; Bury et al., 2000). However, the BTs of wild White Oak *Chelydra* were recorded throughout the annual activity period of the turtle at various ETs while the laboratory studies

were conducted with acclimated individuals under controlled laboratory temperatures (additional laboratory thermal data are reported in Spotila & Bell, 2008). Temperatures selected in previous laboratory thermal gradients are more properly termed preferred body temperatures (PBT) as opposed to OBT, which is strictly a field measurement.

The recorded BTs of Mason Neck *Chelydra* are closely correlated with corresponding ETs. None of these BT ranges approach the reported mean critical thermal maximum (CT<sub>max</sub>) for young *Chelydra* of 39.1 °C acclimated to 15 °C and 41.1 °C for those acclimated to 25 °C in laboratory thermal gradients by Williamson et al. (1989). Similarly, Hutchison et al. (1966) reported a mean CT<sub>max</sub> of 39.5 °C (37.4-40.6 °C) for various age/size snapping turtles acclimated in constant temperature chambers. Baldwin (1925) noted that in the laboratory *Chelydra* subjected to an ET of 41.2-44.5 °C had cloacal BTs of 33.5-39.0 °C and were in severe distress, but recovered when cooled. Brattstrom (1965) had previously noted minimum and maximum voluntary field BTs of 5.0 °C and 24.5 °C for a single individual. Boyer (1965) reported that *Chelydra* in full



**Figure 1.** Violin plot of annual activity periods by months of adult male, adult female, and immature *C. serpentina* at White Oak, Lancaster County, Pennsylvania.



**Figure 2.** Violin plot of daily activity period by 24-hour (military) time of adult male, adult female, and immature *C. serpentina* at White Oak, Lancaster County, Pennsylvania.

sunlight reached BTs of close to 38 °C, indicating, in view of the above studies, why *Chelydra* seldom basks out of water (Ewert, 1976).

The cloacal BT activity range of Florida *C. serpentina* was 18.7–32.6 °C (Punzo, 1975); while the mean field BTs of active and inactive Ontario snapping turtles were 19.5–21.7 °C and 18.9–20.8 °C, respectively (Obbard & Brooks, 1981), and live gravid females buried in an Ontario wood chip pile did not survive after the AT reached 31.8 °C (De Solla et al., 2001). The MidAtlantic BTs from White Oak present a useful comparison with these records from the extreme southern and northern limits of the species range.

The highest BTs recorded for White Oak *Chelydra* were from three basking adults at 30–34 °C; a nesting female, 30 °C; and another traveling overland to nest, 30 °C. Brown et al. (1990) reported that basking Ontario snapping turtles maintained a mean BT of 28–30 °C.

While *C. serpentina* can exercise behavioural control of its BT by seeking a cooler temperature regime when experiencing high ETs, it has little control over lower ETs during winter and becomes torpid. Although many data are available on the critical thermal minimum (CT<sub>min</sub>) tolerated by hatchlings in thermal laboratory studies (Ernst & Lovich, 2009), the reported field BTs of cold dormant snapping turtles are rare and do not approach those recorded in laboratory tests. White Oak *Chelydra* normally avoided extreme winter ETs by selecting well insulated hibernation sites (see below). Brattstrom (1965) gave 5 °C as the

lowest BT for activity of this turtle, while Obbard & Brooks (1981) noted that Ontario individuals became active at 7.5 °C, and captives kept in an outdoor enclosure in Germany by Hass (1985) became active at 9 °C. In Ohio, *Chelydra* buries into soft aquatic bottoms when the WT drops to 15 °C, possibly because it ceases to feed at this WT or cooler (Meeks & Ultsch, 1990). The lowest BT recorded at White Oak in a similar hibernaculum was 4 °C (Table 2). Many aspects of the physiology of cooling in *Chelydra* and other species of North American turtles have been well studied by a variety of researchers (see Ernst & Lovich, 2009).

Comparative temperature data for the six aquatic turtle species at White Oak are presented in Table 3. The six species had a combined mean BT of 21.0 (3.0–31.0) °C. The most common basker, *Chrysemys picta*, exhibited a higher mean AT and ST than the others, probably due to its longer exposure to the sun and selection of more exposed aerial basking sites. *C. serpentina* did a minority of its basking while floating at the water surface with its dorsal carapace exposed, experiencing lower means of AT and nearby ST. *Clemmys guttata*, a known cool weather semiaquatic species, exhibited the lowest mean ETs; followed by the two semiterrestrial species of *Glyptemys*. None of these temperature differences were unexpected in view of the different species' microhabitat requirements and normal behaviours (Ernst & Lovich, 2009).



### Behavioural Body Temperature Versus Environmental Temperatures

Ectothermic animals, such as turtles, must be warmed to a critical temperature from environmental sources before capable of any activity. Subsets of activity apparently have their own lower temperature thresholds and ranges, possibly due to seasonal effects; indications of these are reflected in Table 3 where the BTs and ETs of active White Oak *Chelydra* are reported. At White Oak *Chelydra* began to move in the water or over land, as indicated by either trapping or hand collection, at BTs and WTs of 5.0 °C (aquatic capture), and ceased moving when their BTs reached 34 °C. Obbard & Brooks (1981) reported similar overall BT and WT ranges for Ontario *Chelydra*.

Snapping turtles bask less out of water than do emydine species (Ewert, 1976), and some basking is achieved when floating at the water surface with the dorsal surface of the carapace exposed. The temperature regimes of these two basking classes at White Oak are shown in Table 3. One spring aerial basking *Chelydra* had a BT of 15 °C at an AT of 12 °C and WT of 10 °C; and an adult male achieved a BT of 34 °C at an AT of 30 °C, the highest BT recorded at White Oak. Basking *Chelydra* did not reach BTs near their reported  $CT_{max}$  of > 37 °C. Obbard & Brooks (1979) reported that the number of atmospheric basking Ontario *Chelydra* was positively correlated with total daily solar radiation and with maximum AT but negatively correlated with daily precipitation, and that maximum WT had little influence. Data and observations from White Oak are in agreement with their conclusions. The maximum recorded BT for the Ontario snapping turtles was also 34 °C, but their mean BT for atmospheric baskers was higher, 27.6 °C, than that of the 17 White Oak turtles. Both the Ontario and White Oak studies found that *Chelydra* basks out of water more often than implied by Ewert (1976). Aquatic basking at White Oak began at WTs as low as 15 °C, and the two captured basking on the water surface only attained a BT of 26 °C.

Aquatic North American turtles generally begin to feed at BTs and WTs of 16 °C (Ernst & Lovich, 2009), and *Chelydra* fits this pattern (Brown & Brooks, 1991); although Punzo (1975) reported the lowest BT for active Florida

*C. s. osceola* was 18.7 °C where WTs are generally higher. At White Oak, the turtle was attracted to baited traps at WTs of 16 °C; although those actually observed feeding were in shallow water at BTs and WTs of 20 °C and 18 °C, respectively. Feeding continued from the spring until in late summer the WT reached 28 °C and the AT and adjacent ST 31–32 °C. *Chelydra* was later attracted to baited traps or observed to feed when the WT dropped again below 28 °C, but ceased when it fell to 17 °C.

Nesting at White Oak was observed from 31 May to 12 June. In southern Florida oviposition occurs as early as late February or March and in northern Florida it has been reported from early May until late June (Punzo, 1975; Ewert, 1976; Iverson, 1977; Aresco *et al.*, 2006). White Oak nesting took place in both morning and evening under similar ETs; such a daily pattern of nesting has also been noted elsewhere for *Chelydra* (Hammer, 1969, 1971; Ewert, 1976; Ernst *et al.*, 1997; Iverson *et al.*, 1997). Obbard and Brooks (1987) reported that Ontario females required at least 344 heat units/degree days based on a quantified summation of the daily maximum and minimum temperatures of the water in their habitat before initiation of oviposition (Arnold, 1960); this normally occurred in early June. The AT and ST ranges for White Oak nesters were 17–29 °C and 17–29 °C, respectively. Nesting females achieved BTs as high as 30 °C.

*Chelydra* hibernate in winter. At White Oak, cessation of activity began when the autumn WT fell to 10 °C. The duration of winter activity usually extended from midOctober to midMarch; although in Ohio inactivity first occurs from late September and early October to as late as early November, and, in northwestern West Virginia, the mean date of entry into hibernation was 9 October and the mean emergence date was 13 April (Meeks & Ultsch, 1990; Strain *et al.*, 2012). Virginia *Chelydra* are active from 19 March to 22 October (Bazuin, 1983). During extended warm winter periods some snapping turtles, although not observed at White Oak, may emerge and surface bask near their hibernaculum or move about (Meeks & Ultsch, 1990; Mitchell & Barrish, 1996; Ernst & Lovich, 2009).

Eight White Oak individuals were found buried in the soft bottom of waterways in

March with BTs of 4-12 °C (Table 3). The turtle with the highest BT (28 March) appeared to be digging its way out of its hibernaculum.

Four *Chelydra* (June: an adult male, an adult female, and a 175 mm CL juvenile; August: an adult female) were found in land forms when ETs were warm. It is not known if these turtles were seasonally estivating or had just spent the night on land, but the June female may have remained on land after nesting. Their mean BT was lower than both that of AT and ST, but more closely matched the nearby WT; indicating that possibly these turtles had just emerged from the water.

The temperature data presented in Tables 1 & 3 indicate that the BT of White Oak *Chelydra* is determined predominately by either the WT or AT, depending on how much of the turtle's body is exposed to the air.

#### Annual Activity Cycle

Active White Oak *Chelydra* were captured from 5 March to 8 October (217 days, Fig. 1), and, in all years of full time study, had a mean annual activity cycle of 173 days. Of 12 (3.6% of total captured turtles), found in March, 11 were inactive and either hibernating or in early arousal. The one surface active individual was moving in shallow water on 31 March. Only 21 *Chelydra* (6.3%) were considered active in April (including overwintered hatchlings). The earliest two surface active April *Chelydra* were found moving in shallow water on 1 April and basking at the water surface on 10 April. Two combating males were captured in shallow water on 14 April.

The most active period at White Oak (193 captures, 58.3%) was May-July, which included a nesting season from 31 May to 12 June. Nesting has occurred as early as 18 May in Florida to as late as 1 July in Maine, and peaks in Ontario in midJune (Coulter, 1958; Obbard & Brooks, 1981; Iverson et al., 1997). Activity (movements, foraging, and trapped animals) declined drastically for White Oak adults during August (16 captures, 4.8%), a trend we also saw in Virginia *Chrysemys picta*, that is apparently correlated with higher WTs. All eight turtles (2.4%) found in October were active, either moving (7) or basking (1). This pattern does not match the "unimodal" cycle reported for Pennsylvania *C. serpentina* by Hulse et al.

(2001), although their most active period, June-July, falls within that exhibited by White Oak *Chelydra*.

The annual activity period at White Oak matches that reported for Virginia, but is shorter than the more extended annual period in North Carolina (Bazuin, 1984; Mitchell, 1994; Palmer & Braswell, 1995). Farther North, Maine *Chelydra* are active from late May into October, and those in southern Ontario from midMay to early October (Obbard & Brooks, 1981; Hunter et al., 1999).

White Oak adults of both sexes were equally active between emergence from hibernation and midMay after which females increase their activity until midJune during the nesting season. From July to cessation of annual activity in October, both sexes at White Oak had similar levels of activity. Such a sexually different annual activity period has been previously reported in Ontario *Chelydra* by Brown & Brooks (1993).

#### Daily Activity Cycle

The daily collection period normally lasted from approximately 07:00 h to when it became too dark in the evening to find turtles. Data on daily captures of *Chelydra* are presented in Fig. 2. The earliest was found at 0720 h, and only eight (2.4% of total captures) were detected before 0800 h. Most active turtles (208, 62.8%) were captured during 0:800-12:59 h; after this activity began to slow and four (1.2%) were found inactive in land forms. Although 28 (8.5%) of captured *Chelydra* were found between 13:00 h and 14:59 h, activity slowed after 13:00 h, with only 15 (4.5%) captured before 18:00 h. However, some crepuscular or nocturnal foraging must have occurred, as traps freshly baited in the late afternoon or early evening before contained *Chelydra* the next morning. Obbard & Brooks (1981) reported Ontario *Chelydra* crepuscular; and Smith & Iverson (2004) noted that most of their trap captures were made at dawn or early evening.

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## Research Article

# Herpetofauna associated with termite mounds in a pasture, Mato Grosso do Sul State, Brazil

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**ABSTRACT** - The termites (Isoptera) are known as “engineers of the ecosystem”, because they have the ability to modify the environment where they live with the construction of their mounds, which have specific climatic conditions, constituting a unique microenvironment used by other species. The present study was designed to characterise and quantify the occurrence of termitophile herpetofauna in an area of Cerrado (savanna) converted into pasture in Mato Grosso do Sul, Brazil. It also aims to evaluate termite mounds as an ecological resource for the herpetofauna. We investigated 90 mounds of *Cornitermes cumulans* in an area of 50 ha. We found a total of 18 species of herpetofauna (n=121 individuals). This included six amphibian species and 12 species of reptile. The amphibians were recorded in 41 mounds, with reptiles in 44 mounds. The structure of termite mounds and their cavities can assist amphibians and reptiles in thermoregulation, avoiding excessive exposure and desiccation in open areas, providing ‘stepping stones’ in the landscape. In addition to offering favourable living conditions, and protection from predators for many species, the mounds of *C. cumulans* may provide an important source of food, which suggests that termite mounds in open fields have an important ecological function for herpetofauna.

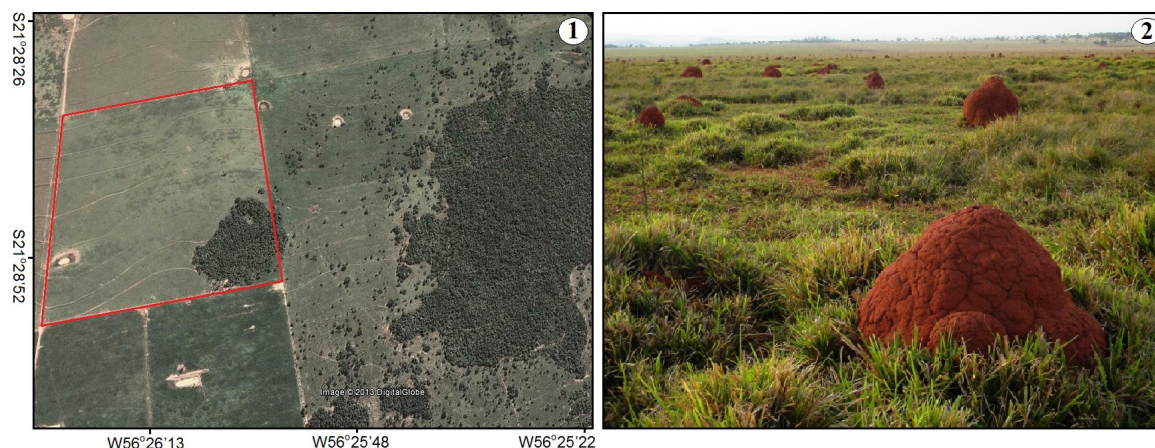
## INTRODUCTION

The Cerrado, nominated as one of 34 biodiversity hotspots worldwide, is considered an area of extreme importance for conservation by presenting high biological richness and a high rate of endemism (Myers, 1988; Myers et al., 2000). Despite its biological value, it is estimated that more than 55% of its native vegetation has been removed, and less than 3% of its area is protected in reserves (Machado et al., 2004a, b). The constant degradation that this biome is suffering, especially through agricultural intensification and the suppression of native vegetation, implies changing or even complete degradation of specific microhabitats utilised by several groups of fauna, include herpetofauna, which may result in the loss of biodiversity, reducing the size of populations, and causing local extinctions (Primack, 2002). Information about the use of resources in natural or altered environments is important for the understanding of ecological processes, such as local intra- and interspecific

interactions.

Termites (Isoptera) are well known as social insects with about 2751 described species in the world (Constantino, 1999). Many are considered pests. They build nests (known as termite mounds) that outcrop as knolls on the surface of pastures, and in other areas not subject to tilling (Maranho & Avila, 2007). They are abundant in almost all tropical terrestrial ecosystems, and in the Brazilian Cerrado, some species have achieved high densities (Constantino, 1999). The ability to modify the environment in which they live, by construction of their nests, makes termites “engineers of the ecosystem” (Dangerfield et al., 1998). Ecosystem engineers are organisms that affect the availability of resources for other species through physical changes in biotic and abiotic materials (Jones et al., 1994).

The termite mounds consist of an outer layer of very hard soil around a soft inner core, composed of fecal material, and crushed and ground vegetable matter, which often extends



**Figure 1.** 1) Overview of the fragments of Cerrado and areas of pastures of Cabeceira do Prata, Jardim, MS. Delimitation in red indicates the area of study where termite mounds were examined for study of the herpetofauna associated. 2) The Area of pasture, showing the termite mounds of *C. cumulans* investigated in this study.

below ground up to 40 cm. Due to the peculiarity of their structure, size, and nature of their construction, termite mounds can provide conditions for various uses by herpetofauna, including breeding places (Knapp & Owens, 2008) with stable temperature and humidity (Darlington, 1991), foraging and food resources (Gandolfi & Rocha, 1996; Peña, 2000; Flemming & Loveridge, 2003) and microhabitats for temporary or permanent shelter. Termites are also considered an abundant and important component of the diet of many generalists and specialists (Wood & Sands, 1978), which can be termed “termitophilous” (Cunha & Morais, 2010).

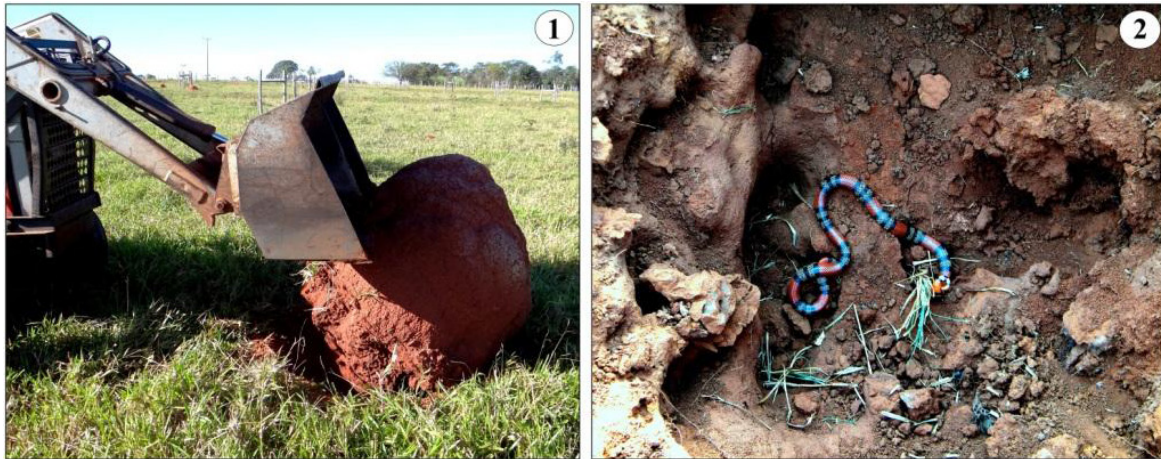
The Cerrado herpetofauna plays important and well-defined roles in the food chain, including the population control of a series of organisms. However, information about interactions between amphibians and reptiles and termite mounds in Brazil are scarce (Gandolfi & Rocha, 1996; Peña, 2000; Colli et al., 2006; Moreira et al., 2009; Rodrigues et al., 2009). This study aimed to characterise and quantify the occurrence of termitophile herpetofauna in termite mounds of *Cornitermes cumulans* (Kollar, 1832) in an area of Cerrado in the southern portion of the state of Mato Grosso do Sul, originally covered by typical vegetation of the Cerrado and currently converted into pasture. Another objective was to examine whether the external shape (height and circumference) of nests determines the rate of occupancy by amphibians and reptiles.

## MATERIALS AND METHODS

The study was carried out at Cabeceira do Prata Farm (S 21°27' / W 056°26'), located in the municipality of Jardim, Mato Grosso do Sul (MS), in the vicinity of the Bodoquena Range National Park, inserted within the biodiversity corridor Miranda - Bodoquena Range (Brambilla & Pellin, 2006). The region is situated inside the Cerrado (savanna grassland) habitat zone, which also contains Atlantic Forest remnants (Hirota & Piotzoni, 2012). The climate of the region is characterised by a spring rainy season with high ambient temperatures (especially December to March) and a dry winter season with low pre-dawn temperatures that can reach close to 0°C (especially May and July). The average annual temperature is 22°C. Surplus water ranges from 1200 to 1400 mm for seven to eight months, and a water deficiency of 200 to 350 mm for three months (Amaral, 1989). The area is characterized by small remnants of Cerrado, surrounded by pasture of the grass cultivar *Urochloa decumbens*, and livestock. All mounds of *C. cumulans* examined in this study were distributed in an area of pasture of 50ha (Fig. 1).

The fieldwork was carried out in spring (rainy season, a period whose temperatures are higher) during the period of 29-31 January 2010. A total of approximately 200 termite mounds present in the study area, we randomly selected 90 mounds of *C. cumulans*. With the aid of a tape measure, measurements were taken of the height and circumference of the base of





**Figure 2.** 1) Tipping termite mounds with the help of the tractor. 2) A specimen of coral snake *Micrurus frontalis* (Elapidae) found in an underground cavity within a nest.

each mound in metres. For each mound, we calculated the base area ( $\pi r^2$ ). For tipping and opening termite mounds, we used a tractor with an excavator bucket, which removed the epigeal (above ground) and hypogeal (below ground) portions of the nests simultaneously (Fig. 2). We then searched for amphibians and reptiles using snake hooks and tweezers for five minutes, prioritising cavities found in the hypogeal portion of the nest (Fig. 2). Subsequently the mound was fragmented with the aid of a pick-axe, to examine the interior. All specimens of amphibians and reptiles captured were wrapped in plastic and/or cotton bags to facilitate photography and identification. Specimens that couldn't be identified in the field were retained, fixed in 10% formalin, preserved in alcohol 70°GL for further identification, and deposited in the Zoological Reference Collection of the UFMS (ZUFMS). The nomenclature used for amphibians follows Segalla et al. (2012), and for reptiles Bernils & Costa (2012). To examine whether the basal area of termite was related to occupation abundance by termitophile herpetofauna, simple regression analysis was performed.

## RESULTS

Among the 90 termite mounds examined, 80% were occupied by amphibians and/or reptiles. Nests ranged in height from 50 to 110 cm ( $77.3 \pm 13.19$ ); in diameter from 196 to 390 cm ( $280.46 \pm 40.87$ ); and in basal area from 31 to 121 cm ( $64 \pm 19.21$ ). The frequency of occupation by herpetofauna showed no

statistical relationship with the external characteristics of termite mounds (height, diameter and basal area).

We found a total of 18 species ( $n=121$ ). Six anuran amphibians ( $n=68$ ) were distributed in families Leptodactylidae (2 spp), Hylidae (2 spp) and Microhylidae (2 spp). The 12 reptile species ( $n=53$ ) comprised eight snakes (Colubridae, 5 spp; Viperidae, 2 spp; Elapidae, 1 sp), three lizards (Gymnophthalmidae, 2 spp; Mabuyidae, 1 sp) and one amphisbaenid (Amphisbaenidae) (Table 1).

Amphibians were recorded in 41 termite mounds (45.5%). Of these, on four occasions multiple species were recorded. The most abundant species were *Scinax fuscovarius* ( $n=30$ ) and *Chiasmocleis albopunctata* ( $n=23$ ), found in 23.3% and 10% respectively of termite mounds investigated (Table 1). Reptiles were found in 44 of the sampled termites (48.8%), dominated by *Cercosaura* cf. *ocellata* ( $n=16$ ), found in 16.9% of nests (Table 1). The snakes accounted for 19.8% of the total number of animals recorded.

In 18 nests we observed the simultaneous presence of anuran amphibians and reptiles, with the former greater in number. The greatest abundance observed in the same mound was five individuals. On one of four such occasions, we observed four specimens of the frog *C. albopunctata* and the snake *Sibynomorphus turgidus*.

## DISCUSSION

The high herpetofauna occupancy rate (80%)



## Herpetofauna associated with termite mounds

AMPHIBIA	No. of specimens	Frequency occurrence (%)
HYLIDAE		
Snouted tree-frog ( <i>Scinax fuscovarius</i> ) (A. Lutz, 1925)	30	29.5
Sharp-snouted tree-frog ( <i>Scinax nasicus</i> ) (Cope, 1862)	2	2.8
LEPTODACTYLIDAE		
Cei's white-lipped frog ( <i>Leptodactylus chaquensis</i> Cei, 1950)	4	5.6
Mustached frog ( <i>Leptodactylus mystacinus</i> ) (Burmeister, 1861)	4	5.6
MICROHYLIDAE		
White-spotted humming frog ( <i>Chiasmocleis albopunctata</i> ) (Boettger, 1885)	23	12.6
Muller's termite frog ( <i>Dermatonotus muelleri</i> ) (Boettger, 1885)	5	7.0
REPTILIA		
MABUYIDAE		
Dunn's Mabuya ( <i>Manciola guaporicola</i> ) (Dunn, 1935)	6	8.4
GYMNOPHTHALMIDAE		
<i>Cercosaura cf. ocellata</i>	16	16.9
<i>Cercosaura cf. schreibersii</i>	5	7.0
AMPHISBAENIDAE		
Red worm lizard ( <i>Amphisbaena alba</i> Linnaeus, 1758)	2	2.8
COLUBRIDAE		
Almaden ground snake ( <i>Erythrolamprus almadensis</i> ) (Wagler, 1824)	3	4.2
Striped ground snake ( <i>Lygophis meridionalis</i> ) (Schenkel, 1901)	1	1.4
Green racer ( <i>Philodryas mattogrossensis</i> Koslowsky, 1898)	4	5.6
Slug-eating snake ( <i>Sibynomorphus turgidus</i> ) (Cope, 1868)	4	5.6
False lancehead ( <i>Xenodon merremii</i> ) (Wagler, 1824)	2	2.8
ELAPIDAE		
Coral snake ( <i>Micrurus frontalis</i> ) (Duméril, Bibron & Duméril 1854)	5	7.0
VIPERIDAE		
Crossed pit viper ( <i>Bothrops alternatus</i> Duméril, Bibron & Duméril, 1854)	1	1.4
South American lancehead ( <i>Bothrops mattogrossensis</i> Amaral, 1925)	4	5.6

**Table 1.** Richness, abundance and frequency of reptiles and amphibians found in termite mounds (*C. cumulans*) in an area of pasture in Cabeceira do Prata Farm, Jardim, Mato Grosso do Sul, Brazil.

demonstrates the importance of *C. cumulans* mounds as a resource for amphibians and reptiles in an area of pasture, especially an area that is degraded. No association was found between the size of termite mounds and the richness of anuran amphibians and reptiles inhabiting them ( $r^2 = 0.02$ ). Conversely, in a study carried out on pasture in the state of Goiás in Brazil, Cunha & Morais (2010), found a positive relationship between the basal area of the epigeal mound and the richness of termitophilous inhabitants, such that older and

larger termite mounds had a tendency to contain a greater number of species, including ants, cockroach, earthworms, beetles, spiders, anurans and diplopods.

In addition to offering favourable conditions for nesting (SD pers. obs.) and refuge against predators for many species, the nests of *C. cumulans* may provide an important source of food, sheltering a wide range of items as potential food resources. Termites constitute an important resource for lizards of the Brazilian Cerrado (Costa, 2005). Some microhylids, such

as *D. muelleri* recorded in this study, have an ecological niche compatible with its occurrence in termite mounds with fossorial habits and specialised prey of ants and termites actively seeking these prey, which they consume in large quantities (e.g. Lieberman, 1986).

The modulated temperature and humidity found in nests of *C. cumulans* (Sight & Sight, 1981) can help amphibians and reptiles by aiding thermoregulation. The form of semi-spherical cavities, present mainly in the underground portions of nests, may constitute thermoregulation sites for many ectothermic species. It has previously been shown that lizards are able to thermoregulate by actively selecting termite mounds (Gandolfi & Rocha, 1996), and these sites can have an important influence on lizard thermoregulation (Rocha & Bergallo, 1990; Bujes & Verrastro, 2006). The present study was carried out in spring (rainy season, a period whose temperatures are higher), but it is expected that seasonal fluctuations can change the behaviour and the use of available resources. Depending on the season, different groups may appear or be absent in termite mounds. Hence sampling in different climatic conditions (mainly temperature and moisture) would probably identify a greater number of amphibians and reptiles using termite mounds in the region studied. Under unfavourable conditions, such as low temperatures, suitable microhabitats are important both for the maintenance of their basal metabolic conditions, to avoid predation (Huey et al., 1977; Avery et al., 1982; Adolph, 1990). In this sense, the richness and species composition and abundance of individuals can be even higher in the winter, when these termite mounds operate as important resources for herpetofauna.

Termites are generally misunderstood, and tend to be viewed as pests that degrade pasture, rather than insects that perform a valuable ecological role for termitophile species. Termites are considered key species by Redford (1984), and the destruction of their colonies can lead to a negative effect over the broader biodiversity of an area (Fleming & Loveridge, 2003), promoting a cascade of local extinctions (Gilbert, 1980). Therefore, the “ecological engineering” value of termite mounds should be more thoroughly studied as a potential tool for the maintenance and conservation of ecosystems.

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## Research Article

# Reptile dispersal from a hibernaculum in an agricultural landscape in Western France

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**ABSTRACT** – Observations have been made on post hibernation movements in four species of reptile, *Heiropis viridiflavus*, *Natrix natrix*, *Vipera aspis* and *Lacerta bilineata*, around a hibernaculum in western France. Movement around the hibernaculum was observed between late March and late May with most sightings in April. Sightings gradually declined as April progressed with no reptiles seen after May 28.

## INTRODUCTION

Winter temperatures are a key factor in the survivorship of temperate reptiles and hence selection of an appropriate winter hibernaculum is a crucial life history attribute (e.g. *Vipera berus*: Viitanen, 1967; Presst, 1971; *Thamnophis sirtalis*: Gregory, 1977; *V. aspis*: Altweg et al., 2005). The biology of hibernacula has been fairly well-studied in some North American reptiles (e.g. Macartney, et al., 1989; Brent Charland, 1989, Harvey & Weatherhead, 2006; Gregory, 2011) but less information is available on species from Europe (Viitanen, 1967; Presst, 1971; Whiting & Booth, 2012). At high latitudes in the northern hemisphere, most reptiles are in their wintering sites from mid-October to mid-March. Following Spring re-emergence activity usually consists of basking and short distance movement close to the den entrance (Street, 1979). Unless the hibernaculum lies within the home range, dispersal to a summer home range usually follows. Although an important aspect of their ecology these initial movements around the hibernation area and eventual dispersal from the den are rarely reported. This note describes post hibernation movements around a hibernaculum in western France.

## METHODS

The study locality was in Vendée, Western France (46°27'N; 1°53'W) in a fragmented landscape consisting mainly of agricultural land, small urban areas and patches of woodland usually connected by extensive hedgerows.

Situated in the northern end of a hedgerow system surrounding what had previously been a drainage ditch, the den area consisted of a discontinuous series of drainage pipe remnants of approximately 1 m diameter. European ash (*Fraxinus excelsior*) formed the canopy with a dense understory of bramble growth (*Rubus fruticosus*). A combination of autumn leaf fall, drifting soil from agricultural land and lack of maintenance resulted in debris entering the pipes, leaving only limited openings of less than 15 cm at the top of the pipes for entry. The exact and full extent of the chamber was difficult to determine, but it is possible that it extended under the break in the hedgerow system at its northern limit near the den entrance (Fig. 1), since it had previously opened into a still in use drainage system.

Surveying commenced 22 March after the first sighting and continued throughout the active year. Most visits were twice daily but were dependent on weather. Surveying was undertaken between 09:20 and 10:50 hrs and 15:30 and 18:40 hrs (CET) and usually completed within one hour. Detection was by visual encounter by walking alongside both sides of the hedgerow surrounding the den at a distance of 4-6 m. This included hedgerows to the north/north east, west and south (Fig. 3). Also searched were areas of approximately 5-10m of farmland to the east and west of the hedgerows and the grassy areas next to the road. These areas had little vegetation at the time and only *Lacerta bilineata* was seen 2-3 m onto the



**Figure 1.** View of the area surrounding the hibernaculum from the north-east (photograph taken December) showing cover of dense bramble and ash. Insert shows location of one of the main entrances, an almost submerged drainage pipe, which was located about 4m into the bramble to the rear of the bottom arrow.

agricultural area west of the western hedgerow. Each hedgerow was surveyed once during a visit. When possible individual snakes or lizards were photographed for identification. All reptile locations were recorded and plotted on a map (Google Earth) along with date of observation. To estimate the areas within the sighting locations, convex polygons that enclosed all the sightings were constructed using the measuring tool on Google Earth. Areas within the polygons  $A$  were calculated using the formula of Heron of Alexandria,

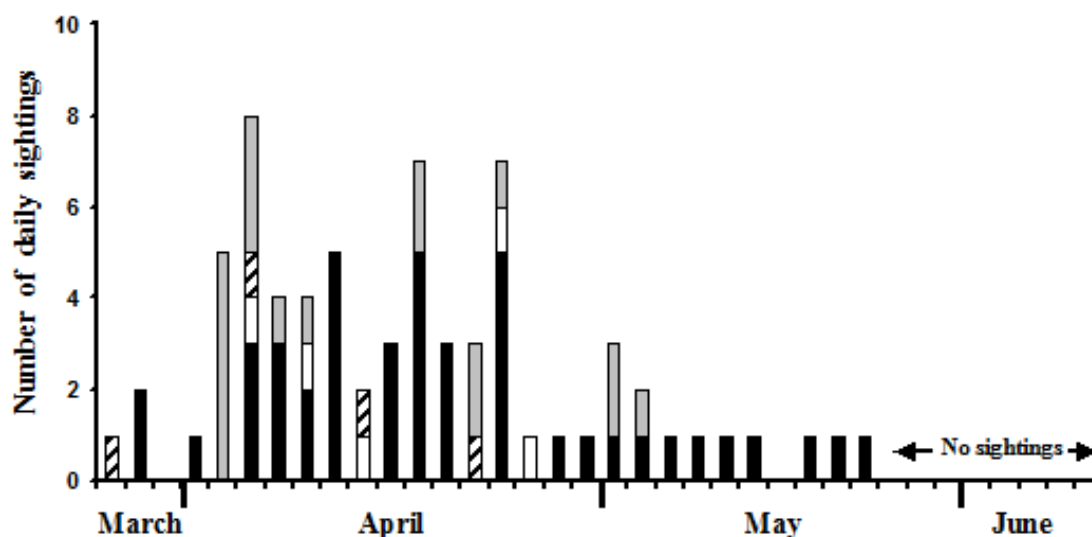
$$A = \sqrt{p(p-a)(p-b)(p-c)}$$

where  $p$  is the semi-perimeter and  $a$ ,  $b$  and  $c$  the

lengths of the sides. If the polygons had more than three sides the area was subdivided into irregular triangles and the values summed.

## RESULTS

On 27 occasions between 22 March and 28 May three species of snake, *Natrix natrix*, *Hierophis viridiflavus* and *Vipera aspis* and the western green lizard, *L. bilineata*, were recorded around the hibernaculum. The initial observation was of an adult *H. viridiflavus* (in ecdysis) on 22 March close to the main den entrance. Five adult *L. bilineata* were subsequently seen basking alongside the western edge of the hedgerow on April 6. Three *L. bilineata* (based on body colouration and pattern) were later seen alongside the western hedgerow between April 7 and April 9 indicating road crossings. The most frequently seen species was *V. aspis*, initially observed on the afternoon of 28 March when 2 were basking on the western edge of the main hedgerow. On 3 occasions, between April 15 and 24, 5 *V. aspis* were recorded in a single visit. Based on size differences, three *N. natrix* were present but no more than one was observed on a single visit. The largest of these crossed the road bisecting the two hedgerows and was seen basking alongside the western hedgerow on April 7. Only *V. aspis* were not found at the western hedgerow, which would have required



**Figure 2.** Sighting frequencies during surveys at the hibernaculum between 22 March and 28 May. Solid bars indicate *V. aspis*, crosshatched *H. viridiflavus*, open *N. natrix* and grey *L. bilineata*. Most sightings during May were of a single *V. aspis* (see Meek, 2013).



**Figure 3.** Aerial photographs (Google Earth) of the study locality showing main entrance to the hibernaculum (white circle) located at the northern end of the hedgerow. Lines are convex polygons that enclose all post hibernation sighting locations for *H. viridiflavus* and *V. aspis* (continuous) and *N. natrix* and *L. bilineata* (broken).

a road crossing.

Most sightings (all species) were during April (*mean per visit* =  $3.7 \pm 3.27$ , *range* = 1 – 8) but towards the end of the month sightings declined. Observations of *V. aspis* after April 24 were of a single snake, which was found predated on 28 May (Meek, 2013). The final spring sightings of the remaining species were: *H. viridiflavus*, 23 April, *N. natrix*, 25 April and *L. bilineata*, 5 May. Figure 2 shows daily sightings during the spring period. After 28 May no reptiles other than wall lizards (*Podarcis muralis*) were recorded until a *H. viridiflavus* was seen basking daily (am) at the opening of the hollow base of an oak tree (*Quercus sessiliflora*) situated in the hedgerow to the North East between 14-29 August. Late summer/autumn sightings at the den area of *V. aspis* and *L. bilineata* were made during mid October and early November. Areas within the polygons were for *H. viridiflavus* 0.86ha (*n* = 1), *L. bilineata* 0.32 ha (*n* = 5), *V. aspis* 0.25 ha (*n* = 5) and *N. natrix* 0.36 ha (*n* = 3). Figures 3a & b show aerial photographs of the study area with the polygons that enclose the sightings.

## DISCUSSION

The results indicate that after emergence from hibernation the reptiles remained close to the den area for an approximate 45-day period between March and late May then dispersed from the hibernaculum. However, activity before their initial detection (22 March) was likely and hence the time around the den longer. Previous studies have indicated reptiles remain in the vicinity of dens for around 5 weeks when hibernacula may be used as cold weather shelters (Gregory, 1982; 2011, Whiting & Booth, 2012). It is not known if the reptiles were spatially separated within the den but communal hibernation is known in *N. natrix*, *V. aspis* and *L. bilineata* (Street, 1979). The observation of *H. viridiflavus* is problematical. Based on body pattern it is likely that this was a single snake that may not have overwintered at the main den, but in the hollow base of a nearby oak tree where a *H. viridiflavus* was seen during August. Adults of this species are wide-ranging foragers that make short distance post hibernation movements before foraging more widely (Ciofi & Chelazzi, 1994). They do not normally hibernate communally (although see



Capula et al., 1997).

Many species show fidelity to hibernacula (Brown & Parker, 1976; Clark et al, 2008 – although see Harvey & Weatherhead, 2006) and although late autumn vegetation limited reptile detection, sightings of *L. bilineata* and *V. aspis* during October and early November in the vicinity of the den could suggest a return to the hibernaculum. Sightings of *L. bilineata* and *V. aspis*, including *V. aspis* neonates (most likely born Autumn 2013) at the den during spring 2014 support the notion of frequent winter den use – although not necessarily by the same reptiles. Longer distance movements from hibernacula would be unusual in lizards but in *L. bilineata* may be a consequence of living in an agricultural landscape with limited usable habitat or due to errors in detection. The latter is important since changes in basking, for example from open locations in spring to more secluded areas in hotter weather, may influence sighting frequencies and distort temporal estimates. Areas within the polygons are also subjective since they are derived from different sample sizes and could be impacted by errors in detection. Therefore the polygons are not comparable and simply indicate areas within which sightings were made.

The characteristics of the hibernaculum were similar to those found in previous studies (e.g. Burger et al., 1988). The entrance(s) were located deep in dense bramble a semi-evergreen that may have value in providing insulation from wind and low temperatures and by trapping drifting snow providing further insulation (Dolby & Grubb, 1999). Crucial is the potential for flooding, which although occurs at the southern end of the main hedgerow during midwinter has never been observed at the main den area at the northern end of the hedgerow which was on slightly higher ground. The south to north linear nature of the hedgerow presented basking opportunities at most times of day and must have advantages after spring emergence (e.g. Gienger & Beck, 2011; Whiting & Booth, 2012). The western hedgerow functioned as a buffer against cold north or north-west winds. The results highlight the importance of small patches of potentially key habitat for population persistence in hibernating reptiles, especially in environments dominated by agriculture where suitable sites may be limited.

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## Research Article

# *Bufo spinosus* in Tunisia: new data on occurrence, parasitism and tadpole morphology

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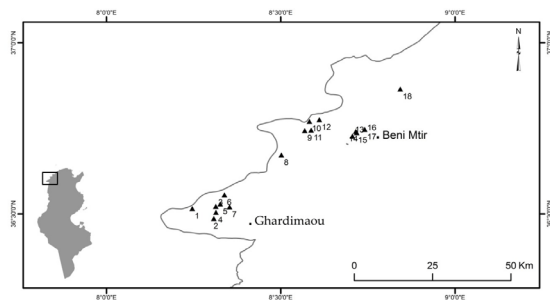
**ABSTRACT** – *Bufo spinosus* belongs to a successful Bufonidae lineage widespread in the western Palaearctic ecozone, reaching its southwestern limits in northern Africa. However in this latter region appears in fragmented populations, mainly restricted to mountain areas, and its biology is poorly known. Here we reviewed the scattered knowledge on *B. spinosus* in Tunisia, including new ecological and morphological data. We quantified the regional and local niche of the species in Tunisia and examined the interactions established with sympatric species, specifically focusing in predation and parasitism. Our data revealed that *B. spinosus* is mainly confined to the humid-subhumid broadleaved forests in the extreme north-western region, where it mainly breeds in streams and streams pools. In these montane habitats the common toad can occur in sympatry with *Amietophrynus mauritanicus* and *Bufotes boulengeri*, although *B. spinosus* is the most common species at higher elevations. In the area we found also two species of natricine snakes and a fresh-water crab, which could prey on the larvae and adults (*Natrix natrix* only) of the common toad. We also reported the first observation in the Maghreb of parasitism on *B. spinosus* by one species of Diptera (*Lucilia sericata*), and three Hirudinea species (*Batrachobdella algira*, *Limnatis nilotica* and *Hirudo troctina*). Finally we described the morphology of African *B. spinosus* larvae based on Tunisian specimens.

## INTRODUCTION

The common toad *Bufo bufo* complex is part of a group of amphibians with Palaearctic affinities (such as *Alytes maurus* and *Salamandra algira*; Escoriza et al., 2006; Márquez et al., 2011) which occur in relict populations in the mountain ranges of north-western Africa (from western Tunisia to the south of the Atlas chain in Morocco; Schleich et al., 1996). As a result of recent phylogeographical analysis of the *B. bufo* lineage (Litvinchuk et al., 2008; Recuero et al., 2012), all populations in the Maghreb, the Iberian Peninsula and parts of France, referred herein to *Bufo spinosus* (Recuero et al., 2012). The recognition at the species level of *B. spinosus* was based on morphological data, a deep genetic divergence and allozyme data analysis (Arntzen et al., 2013 a and b). The African and Iberian populations of *B. spinosus* showed a long isolated evolutionary history, as it is revealed by mtDNA and nDNA phylogenies (Recuero et al., 2012). Based on allozyme and

mtDNA data, two subclades are recognized in North Africa (Recuero et al., 2012).

*Bufo spinosus* is likely a rare species in Tunisia, mainly confined to the mesic forests in the extreme north-western region (Ben Hassine & Nouira, 2012). This toad was recorded for the first time in Tunisia near Aïn Draham by Blanc in 1904 and was confirmed later by Gadeau de Kerville (1908) (Blanc, 1935). No additional sighting in Tunisia was reported until Schneider (1974), who recorded the species in the same region. Later, records at Aïn Draham were confirmed by Joger (2003), Brito et al. (2008), and Litvinchuk et al. (2008). Sicilia et al. (2009) reported the presence of *B. spinosus* at a single locality in an oak forest near the reservoir of Beni Mtir, at 631 m where an adult male specimen was found. This sighting was supported by additional records in Beni Mtir village by others authors (Ben Hassine & Nouira, 2012; Recuero et al., 2012; Bogaerts et al., 2013). Several new populations of *B.*



**Figure 1.** Distribution of *B. spinosus* in Tunisia.

*spinus* at Feija National Park, Statir mountains and Aïn Soltane in Ghardimou (close to the Algerian border) were discovered between 2007 and 2009 (Ben Hassine & Nouira, 2012). However, many regions in the Khemir mountains (north-western Tunisia) are still not well explored and the distribution of *B. spinosus* in Tunisia may be underestimated.

In this study, we provided an up-to-date survey of the range of *B. spinosus* in Tunisia. First we examined its regional niche based on occurrence data and niche modeling. Then, we characterized the terrestrial habitats and breeding sites of the species by measuring several physical and chemical parameters of the aquatic habitats. We also report the first record of parasitism and predation on North African *B. spinosus* by one species of Diptera and three species of Hirudinea. Finally, we described for the first time the tadpole morphology of this species based on North African specimens.

## MATERIAL AND METHODS

### Study area and species

The study area comprised north-western Tunisia, region known as Kroumiria formed by the Mogods and Khemir mountains. As a part of a broader study on the ecology of amphibians (Ben Hassine, 2013), explorations in Kroumiria were carried out during two time periods; phase 1: 2007-2010 and phase 2: 2012-2013. Surveys were conducted from February to May, as previous investigation showed that during the winter-spring period there is an increased activity of all amphibian species in the Maghreb (Doumergue, 1901; Pasteur & Bons, 1959; Sicilia et al., 2009). *B. spinosus* was considered as present if any stage of its development could be identified (i.e., spawn, larvae, newly metamorphosed individuals or adults). Between 19:00 and 02:00 (local time), water bodies and

their surroundings, roads and paths near potential breeding sites were explored to detect adults calling and migratory activity.

Competition, predation and parasitism are believed to be important elements structuring amphibian communities with implications for their population stability (Beebee, 1996; Raffel et al., 2010). In this sense, amphibians species occurring within the same localities of *B. spinosus* and potential predators of the common toad where recorded. All common toad specimens were examined *in situ* for ectoparasites and released in the same capture sites. The occurrence of every specimen was geo-referenced using a Garmin GPS navigator Dakota 100.

### Regional niche analysis

The realized niche of *B. spinosus* was modeled using MaxEnt 3.3.3k (Phillips et al., 2006) in order to assess those environmental factors which better determine the distribution of this species in Tunisia and the possible existence of not prospected but suitable areas for this species. ENM was calibrated using 25% of the localities to test and 75% as training and including three bioclimatic variables, as follows: annual precipitation, mean temperature of warmest quarter (i.e., during a 3 months period) and mean temperature of coldest quarter, obtained from the WorldClim database (Hijmans et al., 2005). These variables describe the thermal extremes and environmental availability of water, which largely contributed to explain the distribution of other species of amphibians in temperate regions (Whittaker et al., 2007). The climate within the studied area was classified following Köppen-Geiger system (Peel et al., 2007) and the bioclimatic stages and climate variant classification of Emberger (1955).

### Breeding and terrestrial habitat characterization

We characterized the breeding habitats where *B. spinosus* tadpole presence was detected. This characterization included variables describing the morphology of the water bodies (depth, cm and pond surface area, m<sup>2</sup>) and water physical and chemical parameters: temperature (°C), dissolved oxygen (mg / L), pH, conductivity (µS·cm<sup>-1</sup>) and water flow (m·s<sup>-1</sup>). Average pond depth is the mean value of five successive





**Figure 2.** Different patterns in adults specimens of *B. spinosus* from Tunisia. A and B: Beni Mtir; C: Close to the fauna reserve of Dar Fatma; D-F: El Feija National Park. F: Photo Daniel Escoriza; A-E: Photos Jihène Ben Hassine.

measurements from the shore to the centre of the pond. Pond surface area was obtained by measuring the maximum length of the longitudinal axis and the length of the transversal axis, and assuming an elliptical shape for the water body. Chemical water parameters were measured using a Crison 524 conductivity meter (for conductivity), an EcoScan ph6 (for pH) and a Hach HQ10 Portable LDO meter (for dissolved oxygen). In the localities where the occurrence of *B. spinosus* was confirmed, local vegetation communities were described based

on field observations and literature (Hoenisch et al., 1970; Stambouli-Essassi et al., 2007).

### Tadpole morphology

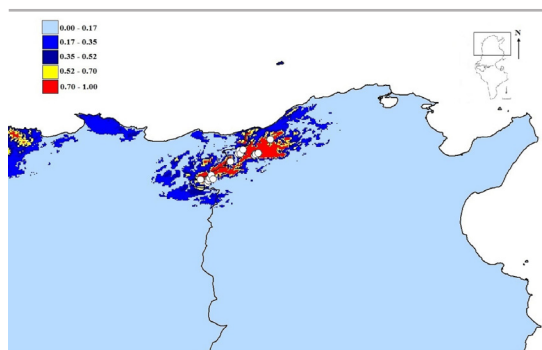
Tadpoles of *B. spinosus* were not previously described based on North African specimens since the description provided by Pasteur and Bons (1959) was based on European specimens, described by Boulenger (1898).

Different Gosner stages of *B. spinosus* were captured using a 250 µm mesh size net from two breeding sites: Beni Mtir and El Feija National Park. General tadpole morphology was examined under a stereomicroscope and Gosner stage between 27 and 39 were used for this study. The morphological description is based on traits which are not correlated to the tadpole length. Features of oral apparatus and labial Tooth Row Formula (LTRF) were described based on Altig and McDiarmid (1999).

## RESULTS

### *Bufo spinosus* distribution in Tunisia

Our findings confirmed that the geographical distribution of *B. spinosus* in Tunisia is limited to the extreme north-west (Fig. 1 and 2; Table 1). We report for the first time occurrence of the common toad in the region between Hammam Bourguiba and Aïn Soltane (localities n° 8 to 12; Fig. 1 and 2). The area close to the fauna



**Figure 3.** ENM obtained for *B. spinosus* based on three WorldClim layers (Annual precipitation; Mean temperature of warmest quarter; Mean temperature of coldest quarter). Suitability in predictive range from clear blue (unsuitable conditions) to red (highly suitable conditions). White circles represent the localities described on Table I.





**Figure 4.** Habitat of *B. spinosus* in Tunisia. A. Close to Dar Fatma (locality n°18); B. El Feija National Park (locality n°7); C. Beni Mtir (locality n°13); D. El Feija National Park (locality n°3). Photos Jihène Ben Hassine.

reserve of “Tourbière Dar Ftama” represents the easternmost known locality of the species range in Tunisia (locality n° 18; Fig. 1 and 2). The presence of *B. spinosus* in Beni Mtir (13 km south-eastern Aïn Draham) was confirmed. Thus the geographical range of *B. spinosus* in Tunisia is extended about 50 km to the south-west, to the region of Ghardimou, not far from the Algerian border (Fig. 1 and 2; Table 1). According to our sampling, *B. spinosus* achieves the maximum altitude for the species in Tunisia at El Ghorra (1062 m, locality N°5; Table 1).

The ENM had a high performance (AUC = 0.97) and revealed that potential suitable areas are mainly confined to Khemir mountains (Fig. 3). The variable annual precipitation had the highest contribution to the model (Table 2). In this sense the actual distribution of *B. spinosus* in Tunisia is strictly confined to the humid bioclimatic stage with temperate-to-cool winters climate variant characterised by high precipitation values (Table 2). It is likely that the annual precipitation is one of the factors

which it acts constraining the presence of *B. spinosus* in Tunisia.

#### ***Bufo spinosus* habitat**

*B. spinosus* mainly inhabits humid montane forests (800–1100 m) composed by the deciduous oak *Quercus canariensis* associated with *Alnus glutinosa*. At lower altitudes (below 800 m), this species also occurs in mixed formations of *Q. canariensis*, *Q. suber* and *Q. coccifera* associated with a dense under storey of small trees and bushes such as *Arbutus unedo*, *Laurus nobilis*, *Erica arborea*, *Olea europea*, *Pistacia* sp., *Myrtus* sp. and *Calycotome* sp. (Fig. 4 A and B).

The reproductive season of *B. spinosus* extends from the first week of March to the second week of April. The tadpoles of common toad were found in only three water bodies in the prospected area (Fig. 4 C and D; Table 2). Physical and chemical parameters of these breeding water bodies at Beni Mtir are summarized in Table 3, showing that *B. spinosus*

Locality number	Longitude°	Latitude °	Altitude (m)	<i>Amietophry-nus mauri-tanicus</i>	<i>Bufotes boulengeri</i>	Bufonidae species richness
1	8.24	36.51	768	x	x	3
2	8.30	36.48	678	x		2
3	8.31	36.52	1039			1
4	8.31	36.50	758	x	x	3
5	8.32	36.52	1062			1
6	8.33	36.55	888	x		2
7	8.35	36.52	642	x	x	3
8	8.50	36.67	575			1
9	8.56	36.74	269	x		2
10	8.58	36.76	185			1
11	8.58	36.74	450			1
12	8.61	36.77	314	x		2
13	8.70	36.72	410	x		2
14	8.71	36.74	448			1
15	8.717	36.73	643	x	x	3
16	8.74	36.74	490		x	2
17	8.68	36.72	645			1
18	8.84	36.86	599	x	x	3

**Table 1.** *B. spinosus* distribution data in Tunisia and Bufonidae species occurring in sympatry.

breed in lotic (but with low flow waters) and lentic habitats, with very variable sizes and with relatively low values of water dissolved oxygen and conductivity, usually with no aquatic vegetation. Tadpole were found at the bottom of the slow-moving section of rivers and streams at El Feija National Park and Beni Mtir (Fig. 4 C and D; Table 3).

#### Species interactions (predators and parasitism)

According to our findings, *B. spinosus* occurs in sympatry with five anuran species: *H. meridionalis*, *A. mauritanicus*, *B. boulengeri*, *Discoglossus pictus*, *Pelophylax saharicus*, and more rarely with *Pleurodeles nebulosus* (only at

El Feija National Park and Aïn Soltane).

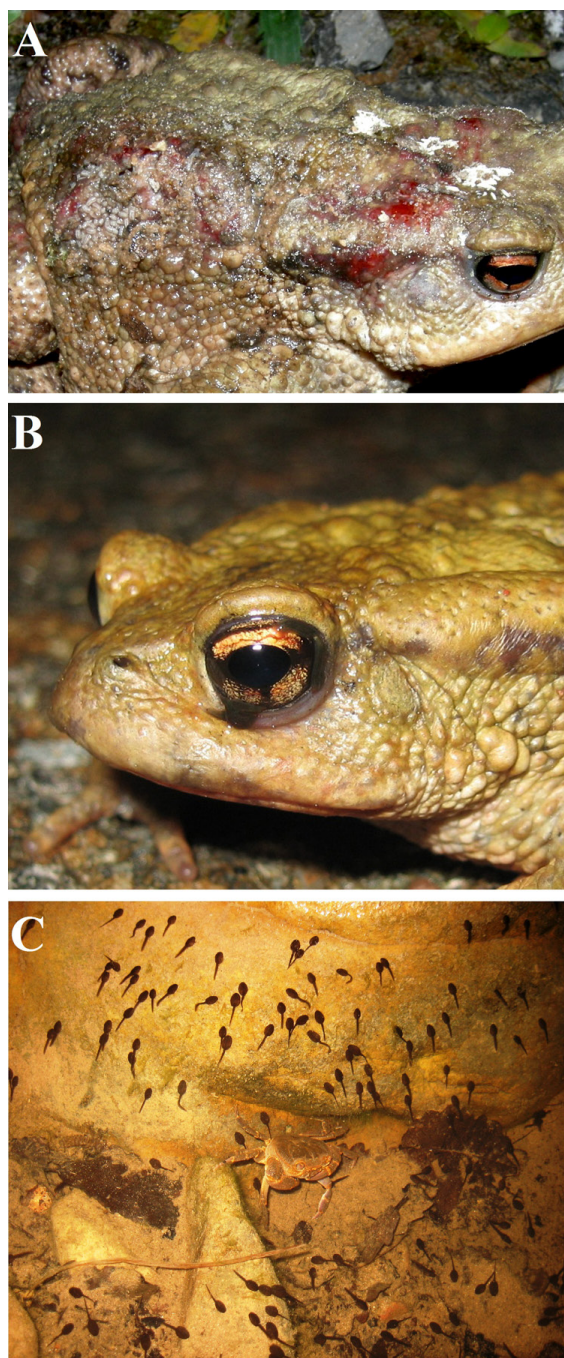
Several potential predators to eggs, tadpoles and adults of *B. spinosus* such as *N. natrix*, *N. maura* and the freshwater crab *Potamon algeriensis* were found in and around these breeding habitats (Fig. 5 C). We report the first records in North Africa of *B. spinosus* parasited by Diptera and Hirudinea species (Fig. 5 A and B). The Diptera was identified as *Lucilia sericata*. The eggs and the larvae of the common green bottle fly were found on the skin of injured common toads. Eggs were laid in wounds and hatched larvae started to feed on the host flesh (Fig. 5A). Some parasited specimens showed a lethargic behaviour.

Three species of predator and parasite

Climate variables	Mean	Minimum	Maximum	% contribution
AP	1013.6	704	1144	96.8
MTW	24.1	21.1	25.6	2.5
MTC	8.3	4.8	11.9	0.7

**Table 2.** Descriptive statistics of main predictor variables for *B. spinosus* localities in Tunisia. Abbreviations: AP: Annual precipitation (mm); MTW: Mean temperature of warmest quarter (°C); MTC: Mean temperature of coldest quarter (°C); % contribution: Relative contribution of the predictive variables to ENM (%).





**Figure 5.** Parasitism and predation. Adult *B. spinosus* parasitized by (A) *Lucilia sericata* (Meigen, 1826) and by (B) *Batracobdella algira* (Moquin-Tandon, 1846); C. *Potamon algeriensis*, an endemic crab predator of *B. spinosus* tadpoles (Beni Mtir, Tunisia). Photos Jihène Ben Hassine.

leeches were observed during our surveys. They were found around the eyes and on the limbs of the common toads. They were identified as *Batracobdella algira* (Moquin-Tandon, 1846) (Rhynchobdellida, Glossiphoniidae), *Limnatis nilotica* (Savigny, 1822) (Arhynchobdellida,

Hirudinidae) and *Hirudo troctina* Johnson, 1816 (Arhynchobdellida, Hirudinidae) (Fig. 5 B).

#### ***Bufo spinosus* tadpole morphology**

A total of 210 tadpoles of *B. spinosus* from Feija National Park (n = 93) and Beni Mtir (n = 117) and between Gosner's stage between 27 and 39 were examined. These common toad larvae had a uniform dark coloration (brown to black), showing the tail a lighter colour and being broadly rounded at the end (Fig. 6). Tail fin ended at the muscular base of the tail, grey coloured and finely speckled with black (Fig. 6). Tail fins with or without black patches independently of ontogeny stages (Fig. 6 B, C and D). Eyes positioned dorsally on head (Fig. 6 B and C). Anus median. Spiraculum sinistral (Fig. 6 A).

In general, tadpoles remain small (up to 30 mm). Total length of the tadpole about once and a half the length of the tail. Tail length four times tail height. Dorsal tail fin and ventral tail fin are nearly equal in depth. Interorbital space nearly 1½ times as wide as the internarial space.

Oral apparatus features are shown in Figure 7. Oral apparatus is subterminally showing lateral emarginations with dorsal and ventral gaps. Labial teeth disposed in a single rows in each series. The labial tooth row formula (LTRF) is 2(2)/3[1].

Three uninterrupted lower dark tooth rows on the posterior labium (some specimens presented P1 interrupted by a very narrow gap) while a pair of upper rows on the anterior labium. Second row of upper labium (A2) separated by a median gap. Only one tadpole of the total examined material showed exceptionally uninterrupted second tooth rows in the upper labium (A2). We don't consider this specimen for the LTRF.

#### **DISCUSSION**

The data present in this paper together with previous studies (Schneider, 1974; Sicilia et al., 2009; Ben Hassine and Nouira, 2012) improve our knowledge about the range and ecology of *B. spinosus*, allow an up-to-date survey distribution, population's status, providing original data on parasitism and predation and tadpole morphology.

#### **Regional niche**

*B. spinosus* is a rare species in Tunisia with



**Figure 6.** *B. spinosus* tadpoles from Tunisia: Tadpole body morphology and coloration. A. Sinistral position of the spiraculum is highlighted by the arrow; B-D. Tadpoles (Gosner stages: 36-37 for B; 28 for C and D) showing tail fins grey finely speckled like powdered with black, with black patches (D) or without black patches (B and C) independently of ontogeny stages. Photos Jihène Ben Hassine.

assumed low population's densities in Maghreb (Schleich et al., 1996), being mainly restricted to the humid-subhumid oak forests of Kroumiria (Ben Hassine & Nouria, 2012). ENM indicated the existence of limited suitable habitats for *B. spinosus*, as expected for peripheral population in the edge of the genus range (Schleich et al., 1996).

The occurrence of *B. spinosus* in Tunisia appeared to be more limited by precipitations than temperatures and, is largely related to forested habitats, as described for other populations in southern Mediterranean areas (Romero & Real, 1996). In this sense its actual range comprised to the upper and lower wet humid climatic stages (Emberger, 1955) characterised by very high annual precipitation values (1500 to 2000 mm; Hoenisch et al., 1970; Stambouli-Essassi et al., 2007) and a short dry summer period (below three months, Hoenisch et al., 1970). In Tunisia *B. spinosus*

occurs at lower altitude than reported from Algeria (~185-1062 in Tunisia vs 900-1200 m in Algeria) (Samraoui et al., 2012). These authors described the existence of clear altitudinal stratification between *A. mauritanicus* and *B. spinosus*. However, in Tunisia we failed to observe this pattern and there is almost a complete overlap in their altitudinal range in the Khemir mountains (Ben Hassine & Nouria, 2012).

#### Aquatic habitat selection, larval guild and morphology

Only three breeding habitats were identified during our survey. However, contrary to the described breeding habitats in north-eastern Algeria (one seasonal pond with *Ranunculus baudotii*; Samraoui et al., 2012) and in Morocco (two permanent and stagnant water bodies, relatively deep with aquatic vegetation; El Hamoumi et al., 2007), typical reproductive

	Type	Surface area (m <sup>2</sup> )	Average depth (cm)	Max. depth (cm)	T (°C)	O <sub>2</sub> (mg/L)	pH	Cond. (µS·cm <sup>-1</sup> )	Water flow (m/s)
<b>Beni Mtir</b>	Stream	340.21	26.2	37	15.1	5.92	7.6	234	0.04
	Stream pool	5.89	12.4	22	18	6.84	7.2	173.9	0
<b>Feija</b>	Stream pool	10	30	56	13	6.02	7.3	124	0

**Table 3.** Physical and chemical characteristics of the breeding sites of *B. spinosus* in Tunisia.





**Figure 7.** Oral apparatus morphology of *B. spinosus* tadpole from Tunisia. Photo Jihène Ben Hassine.

habitats in Tunisia were open streams and stream pools (with no aquatic vegetation), such as was observed in other parts of the species range (Strijbosch, 1979; García-París et al., 2004; Malkmus, 2004). This toad is one of the few amphibians in Tunisia that can breed in lotic waters (Ben Hassine & Nouria, 2012).

The morphological description of *B. spinosus* tadpole's native from Tunisia is nearly identical to that proposed by Boulenger (1898) and García-París et al. (2004), describing European common toad. However, these authors reported different tadpole's size along the species distribution in Europe. According to the description made by Boulenger (1896) based on tadpole of *B. bufo* from London, the interruption of second upper tooth series in this specie seems narrower than that observed in Tunisian *B. spinosus*, and the presence of black patches within the tail fin, of a narrow gap for P1 as well as its absence for A2 was also not described by Boulenger (1896; 1898).

### Predation and parasitism

Predation and parasitism of *B. spinosus* populations by *Lucilia sericata*, *Batrachobdella algira*, *Limnatis nilotica* and *Hirudo troctina* are described for the first time in North Africa. Infestation of amphibians by Diptera has been revised by Kraus (2007). While *L. sericata* was described previously to infest American bufonid species (Stewart & Foote, 1974), this is the first record of its occurrence as parasite of *B. spinosus*. This toad was known previously to be commonly parasited by *Lucilia bufonivora*. This diptera has lethal consequences in adult specimens, taking a heavy toll on many populations of amphibians in Europe (Strijbosch,

1980; Schleich et al., 1996; Gosá et al., 2009). We report the first case of *Limnatis nilotica* infesting amphibians in Maghreb. However, the parasitism by *Batrachobdella algira* and *Hirudo troctina* on other Tunisian amphibians have been reported for *P. nebulosus* (Ben Hassine et al., 2013), *D. pictus* (Ben Hassine et al., 2011), *A. mauritanicus* and *P. saharicus* (Ben Ahmed et al., 2008; Ben Hassine et al., 2011).

### Implications for species conservation

Kroumiria has the most humid conditions in Tunisia (Boughrara et al., 2007) and also shelter the highest amphibian diversity. In this relative small region appears all the populations of *B. spinosus* in Tunisia (Ben Hassine & Nouria, 2012). Kroumiria is suffering an intense deforestation (Zaimeche & Sutton, 1997; Rouchiche & Abid, 2003), and this fact together with the limited number of adequate breeding sites for *B. spinosus* could have a very negative effect on the relict populations of the common toad (Ben Hassine & Nouria, 2012).

These anthropogenic disturbances could possibly favor the penetration of more generalist species of toads, such as *A. mauritanicus* and *B. boulengeri*, more adapted to open habitats (Ben Hassine and Nouria, 2012). For this reason a complete understanding of the existence of negative interactions among Bufonid species may be necessary to assess the proximal causes that constrain the range of the common toad in Tunisia.

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## HERPETOLOGICAL BULLETIN REPORT

January 2014

A total of 50 manuscripts were submitted to *Herpetological Bulletin* during 2013 with an additional 3 (not included in the table below) rejected without review as inappropriate for *Herpetological Bulletin*. This represents a steady stream of submissions but is down on submissions for 2012. There was also a slightly lower acceptance rate (68% versus 73%). We hope that the change to A4 for *Herpetological Bulletin*, which has better paper presentation and has generally been well received, will eventually increase submission rates and overall quality of manuscripts.

Following on from a review of herpetological activities at ARC, which appeared in issue 122, a review of herpetological activities at Krag (Kent Reptile and Amphibian Group) appeared

in issue 126. We will continue soliciting additional material of this kind for future issues.

The following people gave their time and expertise reviewing manuscripts for *Herpetological Bulletin* during 2014: Roger Avery; John Baker; Chris Barratt; Trevor Beebee; Daniel Bennett; Jon Coote; Carl Ernst; Chris Gleed-Owen; Stuart Graham; Rowland Griffin; James Hennessy; Rick Hodges; Adrian Hailey; Laurence Jarvis; Robert Jehle; Simon Maddock; Roger Meek; Christine Tilley; Wolfgang Wuster; John Wilkinson; Todd Lewis.

ROGER MEEK, ROGER AVERY

Editors

	Submitted	Accepted	Percent accepted
Full papers	17	12	70.1
Short Notes	6	5	83.3
Natural History Notes	27	17	62.9
Total	50	34	68.0



## Natural History Notes

**BUFOTES BOULENGERI** (African Green Toad): **NEW REPRODUCTIVE POPULATION IN TUNISIA.** To date, extensive data on the amphibians of Tunisia are available in Sicilia et al. (2009), with six species of anurans: *Discoglossus pictus* Otth, 1837; *Bufo spinosus* (Daudin, 1803); *Amietophrynus mauritanicus* (Schlegel, 1841); *Bufotes boulengeri* (Lataste, 1879); *Hyla meridionalis* Boettger, 1874 and *Pelophylax saharicus* (Boulenger in Hartert, 1913). The African green toad, *Bufotes boulengeri* (Lataste, 1879) is a species distributed in North Africa, from western Morocco to eastern Egypt (Nabil et al., 2011; Stöck et al., 2006, 2008). This species has been considered for many years as *Bufo viridis* Laurenti, 1768 (Beukema et al., 2013; Bons & Geniez, 1996; Geniez et al. 2004; Schleich et al. 1996).

*B. boulengeri* prefers open landscapes, is very resistant to salinity and undergoes opportunistic reproductive phenology in ephemeral humid habitats, in order to adjust to the scarce water resources in desert conditions (Beukema et al., 2013; Filippi et al., 2011). This note reports on a newly discovered population at sea level, at an beach on the coastline south of the town of Hammamet, in the northeast region of Tunisia (36° 21' 33" N and 10° 31' 59" E). During our field survey of 6 to 9 September 2008 a high density of *B. boulengeri* was observed in the wet grass in the resorts of Hammamet. The specimens were photographed at night (Fig. 1). The presence of only adults near the beach in late summer supports the idea of a second reproductive phase in Tunisia, as advocated by Filippi et al. (2011).

The population trends and dynamics of *B. boulengeri* in Tunisia are unknown though this species is assessed as Least Concern (LC) by IUCN. The main threat over much of the range appears to be the loss of breeding habitats. Although the species is locally abundant to the south of Hammamet, the extensive construction of buildings along the coastline could negatively affect population persistence. Further surveys along the entire coastline of the Gulf of Hammamet are recommended.



**Figure 1.** *B. boulengeri* gathered on 8 September, at 19 UTC.

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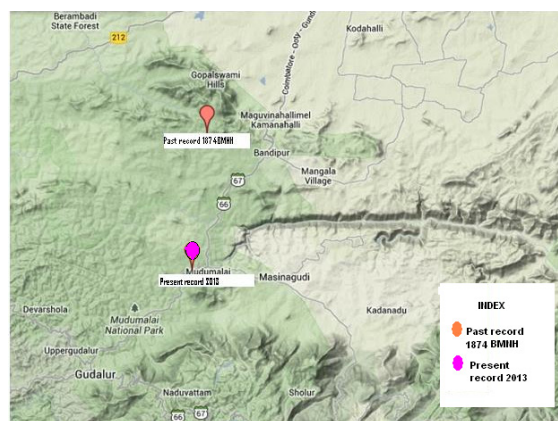
**CALLIOPHIS BIBRONI** (Bibroni Coral Snake): REDISCOVERY IN MUDUMALAI TIGER RESERVE, SOUTH INDIA. Mudumalai Tiger Reserve is a part of the Nilgiri Biosphere Reserve (NBR) of the Western Ghats. It lies between 11.032°N–11.042°N & 76.020°E–76.040°E and is situated at the junction of three Southern States, viz. Tamil Nadu, Kerala and Karnataka. The Reserve is surrounded by Bandipur Tiger Reserve in the north, Wayanad Wildlife Sanctuary in the west and Nilgiri North Forest Division in the east and south and it covers an area of 321 km<sup>2</sup>, with an average elevation of 900–1000 m asl. The Mudumalai Tiger Reserve has several roads including an inter-state highway (Tamil Nadu to Karnataka) passing through the reserve. These roads have been identified as the source of wildlife road mortalities including endangered species (Gokula, 1997).

The Bibroni Coral Snake (*Calliophis bibroni*) was first recorded and identified in January, 1858 by Beddome (1867) and referred as an endemic to the Western Ghats, South India. Boulenger (1896) described scale count of four specimens collected by Beddome. Later on Wall (1919) reported on young specimen of this species and mentioned it as a rare species. Smith (1943) described the known distribution range from the Western Ghats as far north as Coorg. Recent new locality records from the Anamalai Hills and Agastiyar Hills have considerably extended the previously known range (Deepak et al., 2010). The distribution has been described as severely fragmented (P. David pers. comm., 2010), but is likely to occur in more than ten locations due to its relatively wide geographical and elevational range. It is terrestrial in habit, inhabiting moist deciduous forests within an altitudinal range between 900–1000 m msl. The IUCN status of this species is Least Concern in view of its wide distribution, presumed large overall population and because it is unlikely to be declining fast enough to qualify for listing in a more threatened category (IUCN, 2013).

This note reports on the discovery of a road-killed *C. bibroni* during field work on 24th August 2013 in Theppakadu at NH 66 in the Mudumalai Tiger Reserve (N 11.57712°, E 076.57072°) at an elevation of 894 m msl (Fig. 1). The snake was identified using descriptions



**Figure 1.** Road kill of Bibroni Coral snake. Photograph by A. Samson.



**Figure 2.** Map showing the past and present records from the Bibroni Coral Snake in the Mudumalai Tiger Reserve (Map source: Google Earth).

in Smith (1943) and Whitaker & Captain (2004). The previous record of the snake in Mudumalai National Park was in 1874 in the Karnataka region by Bombay Museum Natural History (BMNH) (Fig. 2). This present observation therefore is the first record for 139 years in Mudumalai Tiger Reserve of the Tamil Nadu region (Fig. 2). Other previous records of this snake in the Tamil Nadu region were in the Anamalai Tiger Reserve by Deepak et al., (2010) in 2007, 2008 and 2009. The first specimen was found in the Manamboli Range, second and third specimens were cited in the Top slip regions of Anamalai Tiger Reserve. These three specimens were cited, collected and preserved by the Zoological Survey of India (ZSI). The present observation is a new locality record for *C. bibroni* in the Mudumalai Tiger Reserve of Tamil Nadu region.

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