The Moroccan Herpetology "Basic research to the conservation of species"

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Riassunto. Il Marocco è il paese dell'Africa settentrionale, così come del Mediterraneo occidentale, dall'erpetofauna più ricca e varia, di cui fanno parte anche 33 specie endemiche (ossia il 20% del totale di anfibi e rettili che ci vivono). Se da un lato si conosce bene la composizione attuale dell'erpetofauna marocchina, d'altra parte non si sa quasi nulla delle fluttuazioni all'interno delle popolazioni e negli areali di distribuzione che potrebbero interessare alcune specie a causa di cambiamenti climatici e ambientali. La rapidità del declino delle specie più critiche rimane a tutti gli effetti sconosciuta. Tuttavia, è certo che diverse specie siano in declino, se non addirittura in grave rischio di estinzione. Inoltre una parte della fauna marocchina (soprattutto tra i rettili: le testuggini, i camaleonti, gli uromastici, i varani etc.) viene illegalmente venduta ai turisti, danneggiando così il patrimonio naturale del Marocco. Esistono sì delle leggi marocchine, ed internazionali (CITES), che proibiscono queste pratiche, ma i turisti spesso non le conoscono o fingono di ignorarle. D'altra parte, anche se questi animali "esportati" dal Marocco sono spesso sequestrati alle dogane degli aeroporti europei, diventa poi impossibile riportarli nei luoghi di cattura. A causa dell'entità delle minacce che incombono sulla biodiversità erpetologica, la valutazione dell'entità del declino e la salvaguardia delle specie che compongono la minacciata erpetofauna marocchina diventano una necessità assoluta. È in questo contesto che a partire da febbraio 2000 abbiamo impostato un programma di ricerca che cerca di capire l'evoluzione spazio-temporale di questi vertebrati ectotermi e di come gestirli. Questa ricerca, che è solo l'inizio di un complessivo prendersi carico di questo patrimonio nazionale, è rivolta prioritariamente alle nostre specie più caratteristiche e a quelle endemiche. Durante questa conferenza esponiamo

una sintesi dei risultati finora acquisiti e delle ricerche ancora in corso sull'impatto delle variabili ambientali, naturali o indotte dall'uomo, sulla biologia di:

- ☒ *Testudo graeca*, unico rappresentante della famiglia Testudinidae e delle testuggini terrestri in Marocco, nell'ambiente arido e sovra pascolato della catena dei "Jbilets centrales";
- ☒ *Quedenfeldtia trachyblepharus*, endemismo marocchino, nell'Alto Atlante a Oukaimeden;
- ☒ *Bufo brongersmai*, endemismo marocchino, in ambienti aridi o dove l'acqua è poca;
- ☒ *Alytes maurus*, il rospo ostetrico marocchino, nel parco nazionale di Tazzeka nel Medio Atlante.

Verranno discusse sia le necessità ecologiche di questi vertebrati ectotermi sia gli elementi chiave dell'ambiente, che devono essere lo scopo della gestione affinché queste specie possano sopravvivere nella nicchia ambientale a cui sono adattate.

Keywords. Global changes, ecophysiology, conservation, herpetofauna, Morocco.

Morocco is the North African or, more in general, West Mediterranean country, hosting the richest and most diverse herpetofauna, including also 33 endemic species (20% of amphibians and reptiles in the country).

If there is now a good knowledge about the current composition of the herpetofauna in Morocco (Bons and Geniez, 1996), almost nothing is known about the fluctuations in numbers and range that could affect some species due to climate and environmental changes. The speed of decline of critical species is still unknown and we cannot say anything more accurate than noting that during the heyday of Moroccan herpetology (1930-1697) field researches used to find many more animals than during contemporary ones.

Despite the critical situation of the herpetofauna in Morocco, limited information is available on its ecology, population fluctuations and causes of decline. Actually, most of the current herpetological research focuses on distribution and/or taxonomy instead of biology, population dynamics and trends.

Given the scale of threats to the herpetological biodiversity, there is an absolute need of an assessment of the extent of the decline and the conservation management of the endangered Moroccan herpetofauna. With this context in mind, since February 2000 we have begun a research program with the aim of understanding the spatiotemporal evolution of these ectotherm vertebrates and how to manage them. This research, which represents only the first step in taking charge of this national heritage, is aimed first and mainly to the most distinctive and the endemic species. Our approach, combining both behavioural study in the field and use of advanced laboratory techniques, should help identify the ecological requirements of these vertebrates and the key environmental elements. Ultimately we will be

able to predict the viability of populations in variably degraded sites and evaluate the proper management options, mitigation strategies and restoration measures.

This research program covers therefore several different areas and projects:

- adaptation in *Testudo graeca* to overgrazing operated by domestic animals;
- ecophysiological and demographic consequences of a high altitude habitat and climatic changes in *Quendenfeldtia trachyblepharus* and *Quendenfeldtia moerens*;
- the ecology of *Bufo brongersmai* in an arid and highly variable habitat;
- quality of habitats and reproductive capacity in *Alytes maurus*.

Tortoises are the ectotherm, herbivore vertebrates and thus the rates of ingestion and digestion processes are interdependent and a function of body temperature. The thermal conditions rule the energy balance of animals by their influence on metabolism and digestive processes on one hand (Parmenter, 1980; Trillmich and Trillmich, 1986, Zimmerman and Tracy, 1989; Lichtenbeldt Marken, 1992) but also through their impact on the budget activity of the animal (Hailey *et al.*, 1996 a, b). Thus, any change in the composition of plant communities and their structure affects both the quality and quantity of available food and also of resources like the shelters needed for protection against predators and for an effective behavioural thermoregulation. These vegetation changes are likely to cause huge effects on the overall energy budget and the activity of animals, affecting their reproductive success and thus population dynamics.

To address this complex issue, we adopted a gradual approach on a particularly vulnerable species, clearly affected by these environmental changes: the Spur-thighed tortoise of Morocco (Figure 1).

Fig. 1. Female of *Testudo graeca* equipped with an activity recorder in the Central Jbilets.

First, we measured the trophic characteristics and thermal habitat (El Mouden *et al.*, 2006) and simultaneously we recorded activity and body temperature of tortoises in the field (Lagarde *et al.*, 2008). Precise measurements of the budget activity are essential for understanding feeding or reproductive strategies, but this information is very difficult to obtain in natural conditions. We have developed a new automatic recording technique: tortoises have been equipped with accelerometers, radio transmitter and temperature loggers. Combining this method with the description of trophic and thermal habitats, we can now explain how tortoises survive in an arid, hot environment, where shelters are rare (Figure 2).

Fig. 2. Study site in central Jbilets.

We have demonstrated that the body temperature, and not feeding, is the key parameter. The crucial factor for the tortoises survival is thus the availability of thorny shrubs as only under these large plants tortoises can survive during extreme heat waves (Figure 3).

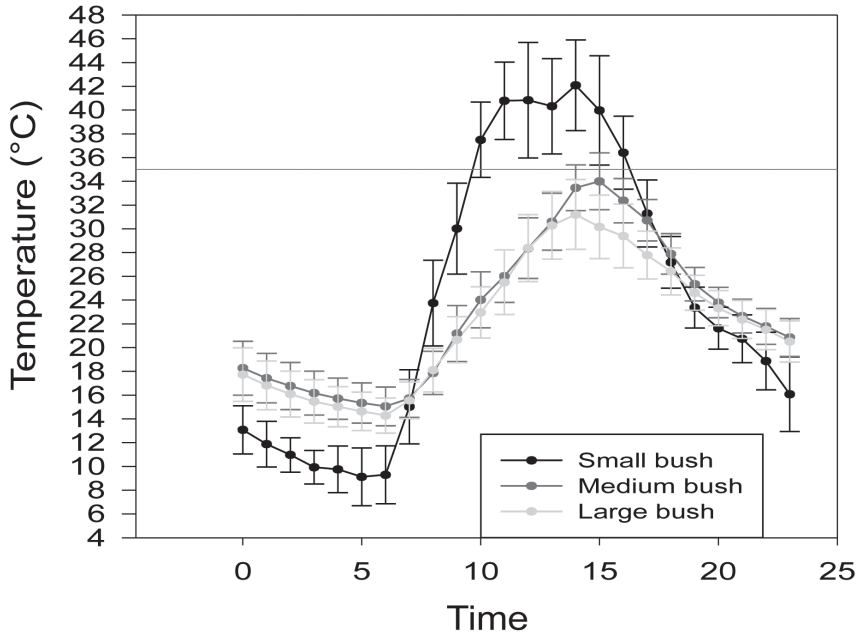

Fig. 3. Temperature variation depending on the quality of shelter (size of bush).

Body temperature (and thus the availability of good quality shelters) is the major physiological constraint to assess reptile conservation programs in dry lands. Thanks to this information, it is now possible to test in the field a central prediction: the tortoises survive only in areas where densities of large bushes are sufficient (study currently in progress). Following the same approach, it is now possible to model the impact of environmental changes on the distribution of many species, like tortoises, that rely on the availability of shelters to maintain their body temperature.

We will hopefully be able to determine the densities and sizes of thorny bushes needed to ensure the survival of plant and animal species which, like tortoises, require this physical protection (spines) in areas subject to increasing human and climate pressure. Once this work is completed, simple and effective conservation programs will be launched.

The two diurnal species of geckos of the genus *Quedenfeldtia* (*Q. trachyblepharus* and *Q. moerens*), oviparous and endemic of Morocco, occur from the sea level up almost to the top of the High Atlas (Bons and Geniez, 1996; Slimani *et al.,* 1996).

We want to clarify the climatic constraints acting on adults of different populations along the altitudinal gradient by collecting data in several sites with temperature and water loggers. We will then assess the influence of temperature on metabolism and locomotor performance (Huey, 1989), with a particular interest in populations subjected to extreme conditions.

In 2008, monitoring was conducted on a large population of *Q. trachyblepharus* (Figure 4) located in Oukaïmeden at 2700 m asl (Figure 5).

Fig. 4. Diurnal gecko of the High Atlas (Oukaïmeden).

Fig. 5. Study site at Oukaïmeden - High Atlas.

The work helped to address the physiological and behavioural adaptations by combining monitoring in the field and under controlled laboratory conditions.

The results already obtained (Khalil, 2008; Khalil *et al.*, 2008; Khalil *et al.,* 2009, Khalil in progress) clearly demonstrate that the geckos try to keep a high body temperature (> 34° C) despite the altitude constraints. These temperatures are maintained during the day by a very active thermoregulatory behaviour that, regardless of the environmental temperature, allows the geckos to get an effective solar radiation. At the same time, there is a choice of microhabitats both during specific phases of diurnal activity (when exposed cracks are selected) and also for the night shelters. Thus, our results suggest a preference for rocks with specific characteristics (size, exposure) that can mitigate the decrease of temperature during the night.

Further work (PhD thesis in progress) has been directed towards:

- comparative study of the social hierarchy in the field (a measure of habitat selection, thermal preferendum...) and captivity (experimental enclosures with thermal gradients);
- continuation of data collection on the phenology, morphology and behaviour.

The neuroendocrine system plays a fundamental role through the action of hormones governing key aspects of reproduction and the degree of parental investment and is therefore a direct target of natural selection. The intensity of adreno-cortical response (secretion of corticosterone) can be modulated by the stage of life history. Thus, the ability to temporarily suppress the stress response would allow a bigger investment in reproduction, while a robust response to avoid a stressful condition would promote survival (Wingfield and Sapolsky, 2003). The highly variable and ecologically contrasting habitat colonised by *Bufo brongersmai* in the Central Jbilets (Figure 6), makes possible to test these hypotheses by examining the spatial and temporal variation of the stress response and thus the impact of natural or man-related environmental variables in arid and overgrazed areas (Figure 7) and the following modulation of reproductive effort in this endemic Moroccan species (Guillon *et al.,* 2004, Gallix *et al.,* 2005; Fattah, 2008; Fattah, in progress).

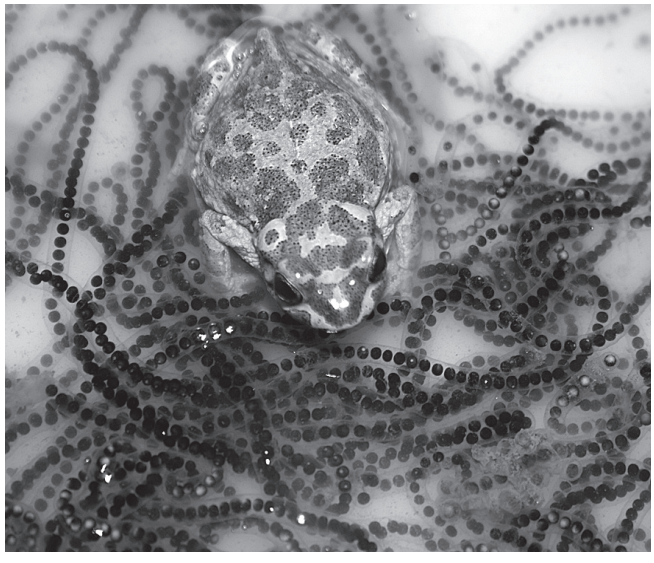

Fig. 6. *Bufo brongersmai* in central Jbilets.

Fig. 7. Biotope of *Bufo brongersmai* in central Jbilets.

On *Alytes maurus*, the Moroccan midwife toad of Morocco, we are trying to clarify the ecophysiology and adaptive ecology of this species.

Fig. 8. Young *Alytes maurus* at Ain Khabab – Tazzeka National Park - Middle Atlas.

Our integrated approach will combine field research and ecophysiological investigations. We will first explain the climatic pressures on adults by measuring temperatures and moisture in the habitats colonised by the midwife toads of the Tazzeka National Park (Figure 9) in the Middle Atlas.

Fig. 9. Recorder bioacoustics operational since April 2010 in Ain Khabab, Tazzeka National Park - Middle Atlas.

We're studying selected population using bioacustics recorders placed in suitable biotopes. With this novel and productive approach we'll be able to to link climate variables (data collected with the recorders) and demographic consequences (got with field monitoring). is producing important results, that although still preliminary are already being used to manage this species across Morocco.

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