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Research Article

New data on larval development in *Pelobates varaldii*

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ABSTRACT - *Pelobates varaldii* is an endemic anuran from north-western Morocco. It is a poorly studied species and is threatened by the destruction of breeding habitats. In this paper larval development of *P. varaldii*, specifically the relationship between length and stage of development and the possible existence of allometric growth is described. The results indicated a significant relationship between length and Gosner's stage, but with high individual variability, and an isometric growth of the body, tail length and tail height, suggesting a morphofunctional stasis during larval development.

INTRODUCTION

Pelobates varaldii Pasteur & Bons 1959 is the only species of the family Pelobatidae occurring in North Africa (Bons & Geniez, 1996). It is an endemic species of the Atlantic plains of Morocco (Salvador, 1996), where is distributed in coastal regions, favouring areas with abundance of temporary ponds and sandy soils (Pasteur & Bons, 1959; El Hamoumi et al., 2007). This species could be severely threatened due to habitat destruction and the introduction of exotic fish species (Fekhaoui, 1997; El Hamoumi & Himmi, 2010). Pasteur and Bons (1959), Salvador (1996), Schleich et al. (1996), and Beukema et al. (2013), discussed aspects of phenology and reproduction of this species. These authors provided accurate descriptions of the size and coloration of larvae of *P. varaldii*, but not about the morphological variability during larval development stages. The present article provides new data on the morphological development of larvae of *P. varaldii*.

METHODS

Several temporary ponds in the localities of Larache and Kenitra (north-western Morocco) (Fig. 1) were sampled to examine larval habitat and the morphology of *P. varaldii* larvae. The observations were made during three times throughout the breeding season: in January, March and May of 2011. Chemical and physical water parameters were measured in situ using a Crison 524 conductivity meter (for conductivity), an EcoScan ph6 (for pH) and a Hach HQ10 Portable LDO meter (for dissolved oxygen and temperature). Ponds were sampled between 12 h and 15 h (local time) in order to maintain maximum homogeneity of measured parameters. The values of pond morphology (surface area and depth), physical and chemical parameters of the water as well as the number of specimens captured and the range of their developmental stages (Gosner, 1960) are shown in Table 1. A total of 118 tadpoles of *P. varaldii* were measured using a digital calliper to the nearest 0.1 mm. The morphological variables measured were as follows: total length, body length, tail length and tail height (Fig. 2). After handling, tadpoles were released in the same place of capture. This morphological data were used for two purposes: 1) to assess the relationship between the development stages and larval length; 2) to determine the existence of allometric growth during larval development. This relationship between larval development (measured as Gosner's stages) and total length was established by linear regression. The possible allometries during the larval development were assessed by calculating the allometric coefficient (Kowalewski et al., 1997). These analyses were performed using the packages Statistica vs. 7 and R (R

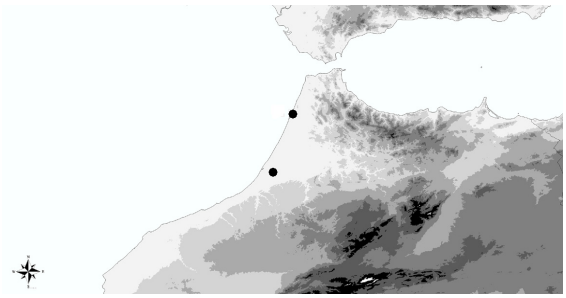

Figure 1. Study region, in the northwest of Morocco. Black circles: sampling areas.

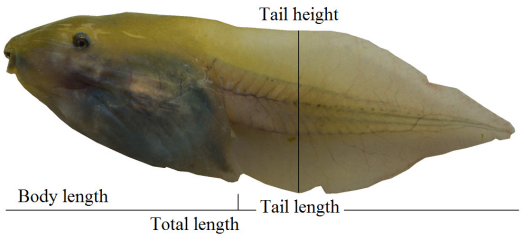

Figure 2. Morphological variables measured.

development core team, 2011).

RESULTS

The survey revealed the presence of *P. varaldii* in relatively large and deep ponds, typically with low conductivity values (Table 1), similar to those values obtained by Hamoumi et al. (2007). The results indicated the existence of a significant correlation ($r^2 = 0.6$, $P < 0.001$) between Gosner stages and larval length, although there is a significant individual variability (Fig. 3). The maximum larval length in our sample was observed at Gosner stage 35 and was 124.2 mm (Fig. 3). In January and March there was higher length variability (standard deviation of total length), than in the month of May. All examined variables produced an allometric coefficient close to 1, indicating an isometric growth during the larval development (Table 2).

DISCUSSION

The data revealed that *P. varaldii* showed broad variability in the length at the same development stages, in the same way as described for the sister species, *P. cultripes* (Álvarez et al., 1990). This larval growth was also isometric. This could be due to the conservation of a similar morphofunctional/trophic niche along larval development. It is possible that the larvae forage in the same microhabitats (i.e. water column) at the beginning and at the end of their development, as described for *P. cultripes* (Díaz-Panigua et al., 2005), although there is no specific information on *P. varaldii*. This data also indicated a decline in length variability in the month of May, which is possibly caused by the end of larval development and the absence of new larval recruitment (caused by the end of reproductive activity of the adults).

P. varaldii is one of the most endangered anurans occurring in Morocco (Stuart et al., 2008). Amphibians of North Africa are experiencing a sharp decline and several species could be close to extinction (Escoriza & Comas, 2007; Ben Hassine & Nouira, 2012a,b; Samraoui et al., 2012). My data also showed that *P. varaldii* breeds in relatively large ponds, which may be affected by intensive agricultural practices, particularly for the extraction of

	n	Surface Area (m²)	Average depth (cm)	T (ºC)	O_2 (mg/L)	pH	Cond (µS/cm-1)	*P. varaldii*	
January	15	5007	41	17.3	9.1	7.1	68	N; Length SD; Gosner stage	71; 19.7 26-35
March	11	4551	33	16.7	5.3	7.5	254	N; Length SD; Gosner stages	42; 18.2 27-38
May	3	15244	49	23.4	7.9	7.2	82	N; Length SD; Gosner stages	5; 4.3 31-39

Table 1. Descriptive statistics (mean values) of the parameters measured in temporary ponds. n: number of surveyed ponds; T: water temperature; O_2: dissolved oxygen in water; Cond: water conductivity; N: number of specimens; Length SD: standard deviation of total length.

	Body length	Tail length	Tail height
Allometric coefficient	1.07	1.08	0.96
95% confidence intervals	1.03-1.10	1.04-1.12	0.91-1.01

Table 2. Allometric coefficient obtained for morphological variables. Values>1 indicates positive allometry whereas that values <1 indicates negative allometry. Mean and 95% confidence intervals for the allometric coefficients obtained after 2000 bootstraps replicates.

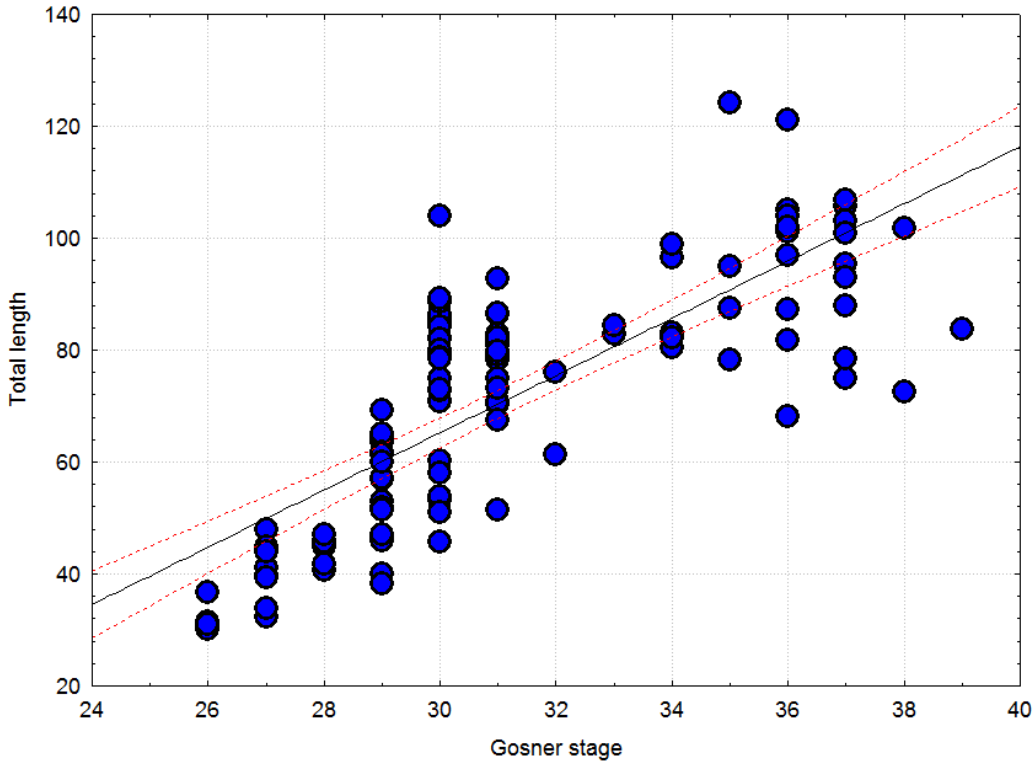

Figure 3. Linear regression obtained by relating the total length (in mm) against Gosner's stages (continuous line). Dashed line indicates the 95% confidence intervals.

water for irrigation (Hamoumi & Himmi, 2010), so it would be advisable to carry out an intensive monitoring of these remaining populations.

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