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Geographical variations in adult body size and reproductive life history traits in an invasive anuran, *Discoglossus pictus*

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ABSTRACT

Variability in life history traits positively affects the establishment and expansive potential of invasive species. In the present study, we analysed the variation of body size in seven populations – two native and five invasive – of the painted frog (*Discoglossus pictus*, Anura: Discoglossidae), native to North Africa and introduced in southern France and the north-east of the Iberian Peninsula. Other life history traits (age at maturity, size at maturity, longevity, median age and potential reproductive lifespan) were analysed in a native and an invasive population. We observed geographic variations in adult body size, related mainly to mean annual precipitation. Thus, populations had greater body size as mean annual precipitation increased, resulting in bigger specimens in the invasive populations. Adult body size and growth rates also varied between sexes in all studied populations, with males significantly larger than females. Age distribution varied between native (1–5 years) and invasive populations (2–4 years) and also between sexes. Our results suggest that higher precipitation promotes faster growth rates and larger adult body size that could facilitate the successful establishment of invasive populations.

1. Introduction

Introduced species commonly fail to establish in a new environment (Williamson, 1999). However, successful ones may find biotic and abiotic conditions that, in conjunction with their particular biological attributes, drive the temporal process of occupation and dispersion in the new environment (Sakai et al., 2001). The debate on which factors determine successful introduction is complex, pointing to a mixture of event-level factors and particular species features. Although propagule pressure and other introduction event-level factors seem crucial determinants of a successful introduction of vertebrates (Cassey et al., 2004; Lockwood et al., 2005), there are several studies on fishes reporting species-specific features to be of importance to invasion success. Invasive fishes usually show wide latitudinal ranges and variations of life history traits along biotic or abiotic gradients (Bohn et al., 2004; Alcaraz and Garcia-Berthou, 2007; Benejam et al., 2009) that allow a successful establishment in a new environment. In contrast, the failure of some introduced species to successfully invade has been attributed to their poor ability to survive and adapt to geographical gradients (Becker et al., 2005).

In amphibians, a study by Rago et al. (2012) reports that pathway of introduction, introduction locality, and favourable climatic conditions are the most important features determining the establishment success of an introduced amphibian population, with little support for a role of species characteristics or phylogeny. However, there is also evidence suggesting that some phenotypic features – such as clutch size and reproductive strategies – can contribute to the success of range expansion on both ecologically and evolutionary time scales (Van Bocxlaer et al., 2010). Thus, it is arguable that adaptable amphibian species can more easily overcome habitat or climatic differences and become invasive. For example, the invasive American bullfrog (*Lithobates catesbeianus*) shows morphological variation along an invaded area in response to different

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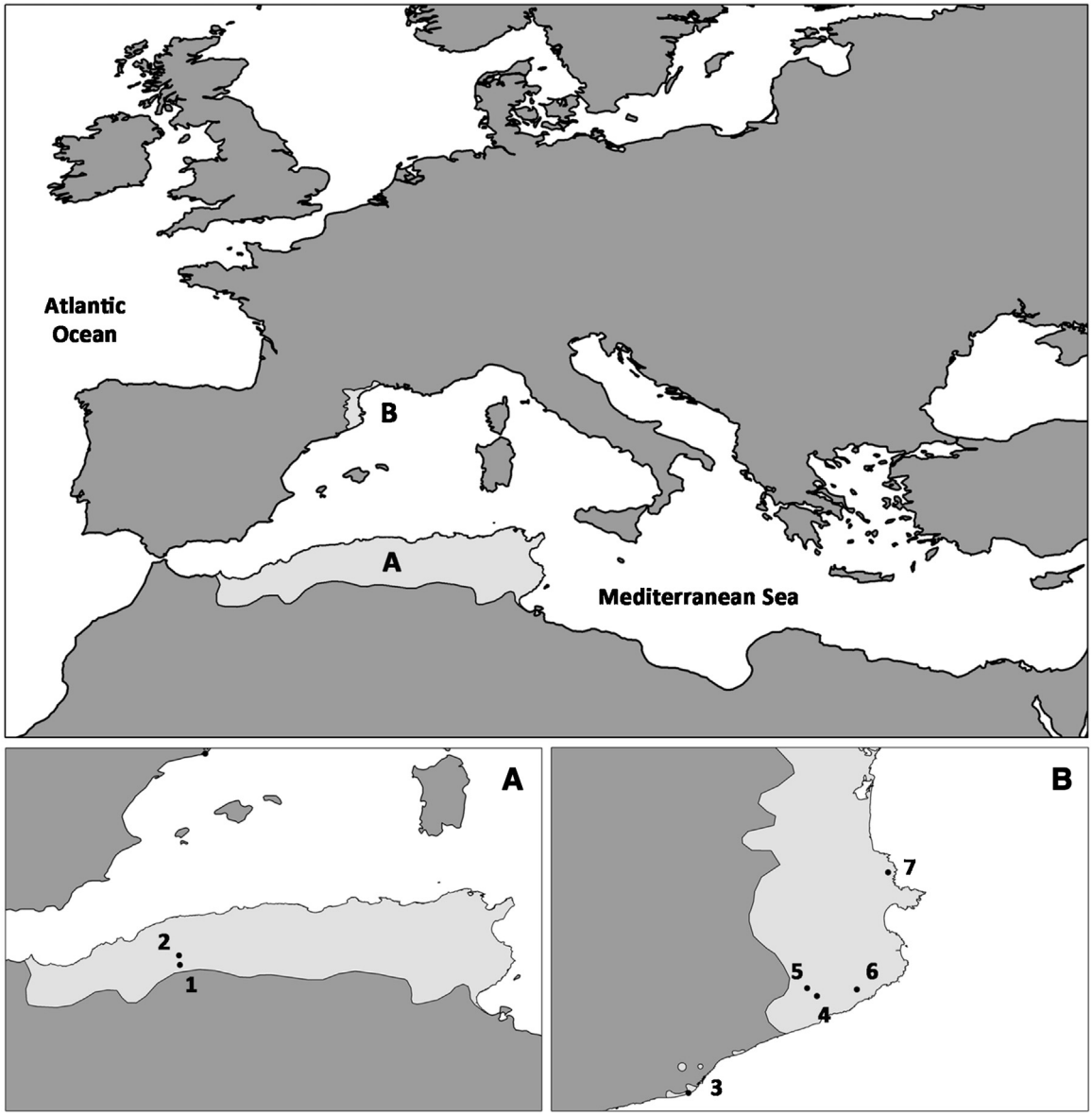

Fig. 1. Distribution of *D. pictus* and the locations of the study populations. (A) Native area: La Fontaine Juba (1) and Jementrie (2). (B) Invasive area: Can Camins (3), Vidreres (4), Riudarenes (5), Mas Pla (6) and Portbou (7).

environmental gradients (Xuan et al., 2010). Another example is the invasive cane toad (*Rhinella marina*) in Australia that has evolved greater tolerance to extreme abiotic conditions, tripling the invasive range predictions based on their native distribution (Urban et al., 2007). And in this sense, tolerance to diverse environmental conditions – through phenotypic plasticity or rapid adaptive shifts – seems to be an important factor in the establishment of a new population in a new site.

The study of life history traits across the current range of invasive amphibian species can be essential to estimate the potential success of establishment and further expansion (Mooney and Hobbs, 2000; Bohn et al., 2004). Moreover, geographical variations of the invasive species must be taken into consideration to evaluate potential impacts on native communities (McGarrity and Johnson, 2009). Life history traits in amphibians – such as longevity and age at sexual maturity – are estimated using individual age determination by skeletochronology (e.g. Castanet, 2002). This procedure is based on the observation of the growth marks (lines of arrested growth = LAGs) recorded in the periosteal part of the bones (phalanges are usually obtained by toe-clipping). LAGs are formed when growth is interrupted by hibernation or aestivation (Olgun et al., 2005). The correspondence of LAGs to seasonal cycles has been verified in many studies, especially for anurans inhabiting temperate environments and low-altitude regions in tropical climates (review in Sinsch, 2015).

In the present study we analyse the size variation in seven populations (two native and five invasive) of the anuran *Discoglossus pictus*. The Mediterranean painted frog, *D. pictus*, is a native species to North Africa and Sicily (Zangari et al., 2006). Some Algerian specimens were accidentally introduced in south-eastern France (Banyuls-sur-Mer) approximately a century ago (Wintrebert, 1908; Lanza et al., 1986). Currently, this species is present in a wide coastal strip from Montpellier in southern France to Vilassar de Mar (Barcelona) in northern Spain, and its distribution is still increasing (Montori et al., 2007; Geniez and Cheylan, 2012; SIARE, 2014). Recently, new introductions outside its range of expansion have been described along the Spanish and French Mediterranean coast (Fradet and Geniez, 2004; Franch et al., 2007). Other life his-