



A new case of facultative paedomorphosis in Smooth Newts, *Lissotriton vulgaris* (Caudata: Salamandridae), in Turkey

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Abstract.—A report of the occurrence of a dimorphic population of Smooth Newts in Lake Sazlı (Izmir, Western Anatolia, Turkey). During fieldwork on March 2015, 29 aquatic individuals (seven males, 22 females) were captured and of these individuals, five were paedomorphic (four males, one female). The metamorphic (83%) and paedomorphic (17%) ratio of the population is skewed to metamorphic. The mean snout-vent length (SVL) was 28.30 mm (range = 26.00–30.41), and total length (TL) was 57.66 mm (53.35–61.40) in paedomorphs. The average exterior gill length was 4.12 mm (2.64–4.71). The SVL was 39.99 mm (range = 33.44–39.93), and TL was 69.06 mm (66.19–79.17) in metamorphs. The possible reasons for the presence of facultative paedomorphosis in the population are discussed, with the dimorphic paedomorph hypothesis supported.

Key words. Salamander, Izmir, Lake Sazlı, Gediz Delta

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Facultative paedomorphosis is an environmentally-induced polymorphism that results in the coexistence of sexually mature, gilled, and fully aquatic paedomorphic individuals and transformed, metamorphic individuals in the same population (Denoël et al. 2005a). Paedomorphosis has been known for more than one century and can be either obligate or facultative in 57 urodeles species (Denoël et al. 2005a). Facultative paedomorphosis has been particularly reported in numerous European newts (e.g., Kalezić et al. 1994; Denoël 2005; Denoël et al. 2009a; Skopinov et al. 2009).

Lissotriton vulgaris has a high tendency to be paedomorphic (Beebee and Griffiths 2000) and there are many reports of the phenomenon throughout its distribution range (e.g., Skopinov et al. 2009; Litvinchuk et al. 1996; Litvinchuk 2001; Denoël et al. 2009b; Covaciu-Marcov et al. 2011; Stănescu et al. 2014). In Turkey, there are four records of facultative paedomorphosis in *L. vulgaris* from Thracian and Marmara and Aegean regions

of Turkey (Yılmaz 1983; Çevik et al. 1997; Çiçek and Ayaz 2011; Bozkurt et al. 2015, Fig. 1).

On March 13, 2015, during an amphibian and reptile monitoring survey in the Gediz Delta, paedomorphic Smooth Newts were observed in a population sampled at Lake Sazlı, which is located in the northeastern part of the Gediz Delta, approximately 15 km west of Menemen (38.600149°N, 26.911006°E, at about sea level, Fig. 1). The subspecies *Lissotriton vulgaris schmidtlerorum* (Raxworthy 1988) inhabits the Izmir region. The lake surface area is nearly 30 ha, and is surrounded by agricultural (corn, cotton, and wheat) areas and *Quercus* sp. dominated shrubs (Fig. 2a). Emergent aquatic vegetation of the lake includes Common Reed (*Phragmites australis*), Reed Mace (*Typha* sp.), Common Spike Rush (*Eleocharis* sp.), Tufted Sedge (*Carex* sp.), and Rushes (*Juncus* sp.) (Gediz Delta Management Plan 2007). Climatic conditions in the study area (Izmir) are mainly Mediterranean, with a mean annual temperature

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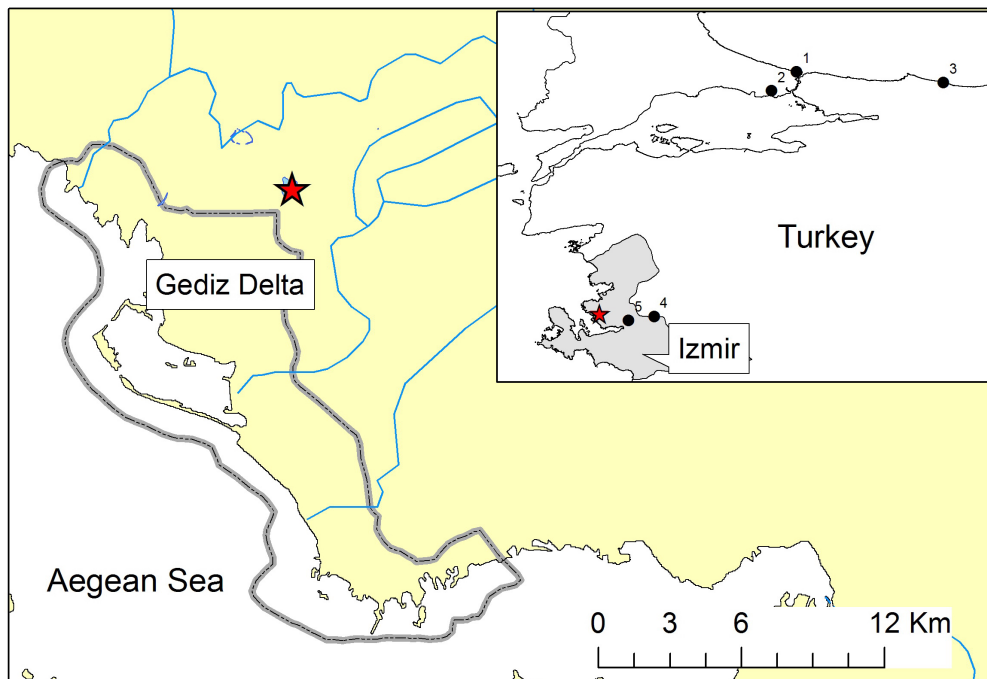


Fig. 1. The map of Gediz Delta (Izmir, Turkey). 1: Kumköy, Istanbul, 2: Küçükçekmece, Istanbul, 3: Ihsaniye, Karasu, Sakarya, 4: Lake Sülüklü, Manisa, 5: Lake İkiz, Izmir, The star shows the record (Lake Sazli, Gediz Delta, Izmir), The dotted line shows Ramsar protected area borders.

of 18 °C (8.9–28 °C) and annual rainfall of 690 mm (20–1,430) (1950–2015, Turkish Meteorological Service 2016).

Sampling was conducted from the shore to one m depth by two persons using 45 cm radius dip nets. 29 aquatic individuals (seven males, 22 females) were captured, and of these individuals, five were found to be paedomorphic (four males, one female, Fig. 2b, c). The paedomorphs were captured 30–50 cm depth on shore of lake. The males presented sexual characteristics, including the distended cloacae, spots on the side, and a well-developed dorsal crest. The paedomorphs were easily discerned from the metamorphs by their gills. The sex of the captured individuals was recorded; snout-vent length [from the tip of the snout to the posterior of the cloacal opening], total length, and exterior gill length (mm) were measured with digital callipers to 0.01 mm precision. Three paedomorphic individuals were brought to the laboratory and kept in an aquarium (40 × 30 × 30 cm, in 25 cm natural spring water) for a brief period to be photographed. The paedomorphs were then released back to where they had been captured.

The mean snout-vent length (SVL) was 28.30 mm (range = 26.00–30.41, SE = 0.76), and total length (TL) was 57.66 mm (53.35–61.40, SE = 1.09) in paedomorphs. The average exterior gill length (GL) was 4.12 mm (2.64–4.71, SE = 0.38). The SVL was 39.99 mm (range = 33.44–39.93, SE = 0.81), and TL was 69.06 mm (66.19–79.17, SE = 1.33) in metamorphs (Table 1).

According to these data, the metamorphic (83%) and paedomorphic (17%) ratio of the population is skewed to metamorphic. This species shares its habitat with four

other amphibians: The Balkan-Anatolian Crested Newt (*Triturus ivanbureschi*), Levant Water Frog (*Pelophylax bedriagae*), Oriental Tree Frog (*Hyla orientalis*), and the Variable Toad (*Bufo variabilis*); five reptiles, the European Pond Turtle (*Emys orbicularis*), Western Caspian Turtle (*Mauremys rivulata*), Grass Snake (*Natrix natrix*), Dice Snake (*Natrix tessellata*), and East-Four-Lined Ratsnake (*Elaphe sauromates*). Fifteen fish species belonging to eight families are cited in the Gediz Delta Management Plan (2007), including the introduced exotic Western Mosquitofish (*Gambusia affinis*).

Başoğlu et al. (1994) stated that when *L. vulgaris* larvae complete their metamorphosis, their TL can be 35 to 40 mm, adults can be 70 to 80 mm in TL in Western Anatolia. In the western Anatolian population, the adult snout-vent length ranged from 28.8 to 35.4 mm in males, and 30.5 to 36.4 mm in females, while TL ranged from 54.6 to 65.9 mm in males, and 56.1 to 66.8 mm in females (Olgun et al. 1999). The average SVL of *L. vulgaris* was 40.15 mm (34.7–43.7), 40.77 mm (35.3–44.6) in females (Colleoni et al. 2014). Stănescu et al. (2014) reported that the SVL of paedomorphs was 32.7 mm for females, 34.5 mm for males from the Danube Delta Biosphere Reserve (Romania). They also indicated metamorphs were larger than paedomorphs. Colleoni et al. (2014) reviewed sexual dimorphism in newts and found female-biased sex size dimorphism in the species. Bozkurt et al. (2015) found paedomorphic *L. v. koswigi* from (Sakarya) northwestern Turkey and they measured 31.60 mm for males and 30.06 mm for females. The authors claimed that the size of paedomorphs is larger than metamorphs. In the Montenegrin Smooth Newts paedomorphs may or may

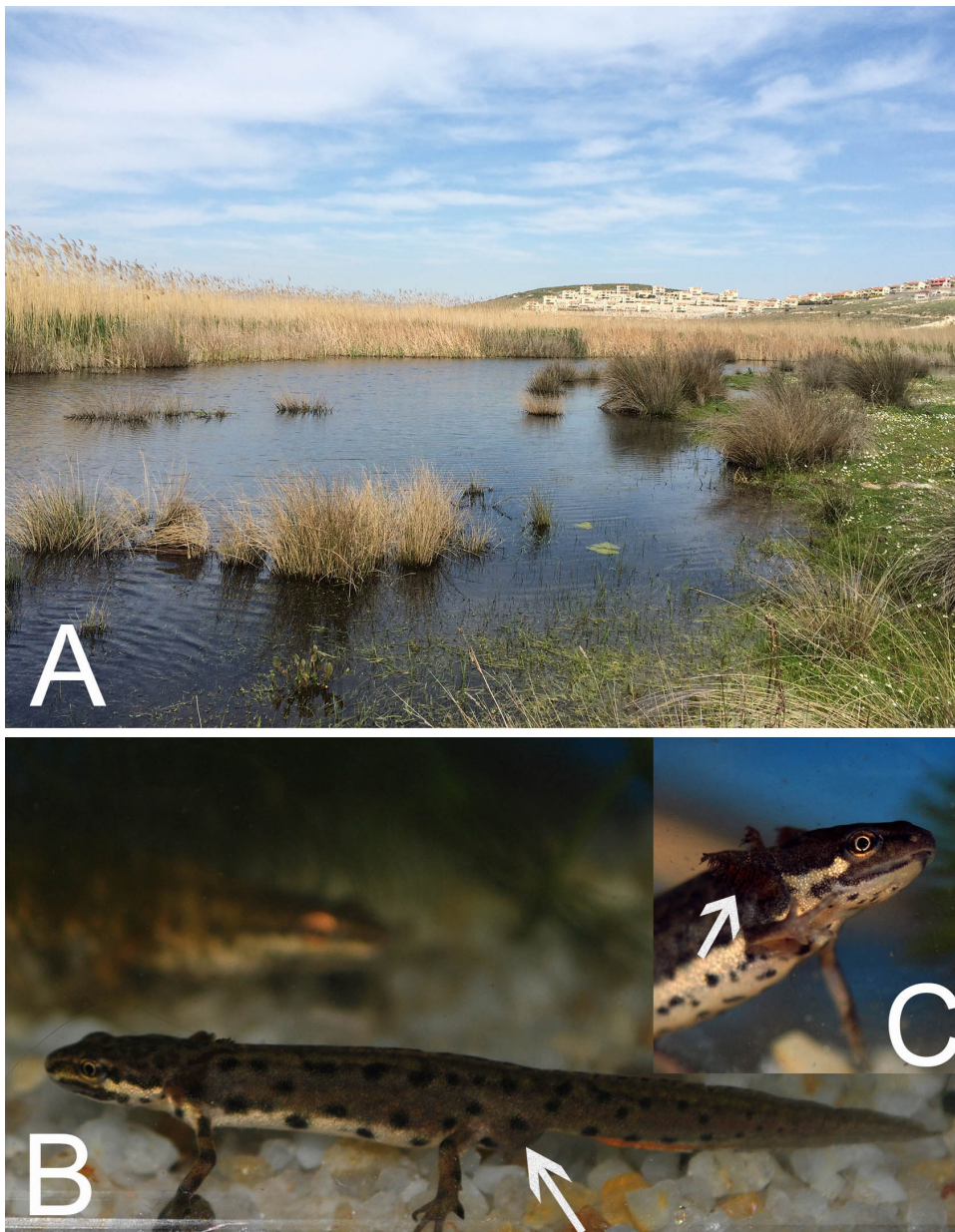


Fig. 2. The general view of habitat (A) and a male paedomorphic *Lissotriton vulgaris* (B, C) from Lake Sazlı (Izmir, Turkey). The arrows show the cloaca (B) and the gills (C).

not be bigger than metamorphs in their developmental pathway (i.e., metamorphosis versus paedomorphosis), as well as their species and population (Denoël et al. 2009a).

The gill length (GL) of paedomorphs measured 2.58 to 7 mm in northwestern Turkey (Bozkurt et al., 2015), 5.88 mm (3.30–7.90) in Lake Sülüklü (western Turkey, Çiçek, and Ayaz, 2011), 6.7 mm in Romania (Covaciu-Marcov and Cicort-Lucaciu 2007), and 1.5 mm in Ukraine (Litvinchuk 2001). Our data was within the range of previous reports. GL varies among populations and might be connected to the oxygen level or other water quality parameters, but this remains to be demonstrated.

According to Semlitsch (1987), facultative paedomorphosis is controlled by environmental and

genetic factors that allow individuals to cope with habitat variation, take advantage of environmental heterogeneity in the presence of open niches, and increase their fitness. It can occur in a variety of habitats from deep oligotrophic alpine lakes to small eutrophic temporary ponds, arid areas and humid forests (Whiteman 1994; Denoël et al. 2001). In addition, paedomorphs are encountered in different regions and latitudes, independently of environmental and habitat conditions (Whiteman 1994; Denoël et al. 2001; Denoël et al. 2005a).

Three main hypotheses explain the appearance and maintenance of facultative paedomorphosis: i) the best of a bad lot, ii) the paedomorphic advantage, and iii) the dimorphic paedomorph hypothesis (Whiteman 1994). The paedomorph advantage hypothesis corresponds to the

Table 1. Summary statistics of paedomorphic and metamorphic *Lissotriton vulgaris* from Lake Sazlı (Izmir, Turkey).

	Paedomorphic Males			Paedomorphic Females		
	SVL (mm)	TL (mm)	GL (mm)	SVL (mm)	TL (mm)	GL (mm)
Mean	28.30	57.52	4.02	26.00	53.35	4.52
Range	26.91–30.41	55.49–61.40	2.64–4.71	—	—	—
SE	0.75	1.09	0.38	—	—	—
	Metamorphic Males			Metamorphic Females		
	SVL (mm)	TL (mm)	GL (mm)	SVL (mm)	TL (mm)	GL (mm)
Mean	37.46	68.80	—	36.95	68.48	—
Range	35.53–39.93	66.19–73.48	—	33.44–38.37	66.62–79.17	—
SE	1.08	1.54	—	0.84	0.89	—

basic model of Wilbur and Collins (1973). It predicts large, fast-growing individuals in good growing habitats to be paedomorphic, while individuals smaller than minimum size for the paedomorphs completely metamorphose to escape competition with larger paedomorphs. More unlikely, the best of a bad lot model predicts the reverse solution in poor habitats with low growth conditions. The larger larvae metamorphose, while the smallest ones keep a larval form and become reproductively mature. The latter hypothesis, the dimorphic paedomorph, suggests that the phenomenon results from the two other hypotheses according to the local conditions experienced by each individual (Whiteman 1994). The metamorphic and paedomorphic ratio of populations can exhibit variations across populations and species (Denoël et al. 2001). The fluctuations in natural populations of paedomorphic urodeles may be related to both natural and anthropogenic factors (Denoël et al. 2005b). The absence of predators and the abundance of food resources are known to favor the delay of metamorphosis and the appearance of paedomorphs (Denoël et al. 2001). At Lake Sülüklü (Çiçek and Ayaz 2011), the metamorph/paedomorph rate changes from year to year with no paedomorphs found in five samples in 2015 (K.Ç., pers. obs). The fluctuation in the population size of fish could affect the metamorph/paedomorph rate (Denoël et al. 2015). The Lake Sazlı population could favor the third hypothesis due to the observation that the size of paedomorphs is lower than metamorphs and presence of potential predators in the habitat.

Habitat is an essential key in the persistence of facultative paedomorphosis in natural populations of newts (Denoël 2005). Denoël and Ficetola (2014) compared the likelihood of multiple potential environmental determinants impacting facultative paedomorphosis. They observe that paedomorphs prefer deep ponds, with conditions favorable to aquatic breathing (high oxygen content), with no fish and surrounded by a suitable terrestrial habitat. Despite the presence of predators, Lake Sazlı has dense aquatic vegetation, abundant food sources and is surrounded by unsuitable terrestrial habitat. There is limited available shelter to hide and save terrestrial forms. Particularly, the presence of aquatic shelters has been shown to favor the coexistence between newts and fish (Winandy et

al. 2015). This might have allowed the co-occurrence of newts with fish in the studied population but more surveys are needed to explore these patterns.

Although several studies have documented the presence and the cause of facultative paedomorphosis in Europe (Denoël et al. 2005a and reference herein), data remain limited on Asian species and subspecies. Better monitoring of facultative paedomorphosis in this part of the world would help to explore hypotheses that may provide a more comprehensive understanding of this phenomenon.

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