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Lissotriton (vulgaris) kosswigi (Freytag, 1955) (Urodela;
Salamandridae), endemic to northwestern Turkey**

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First record of facultative paedomorphism in the Kosswig's newt *Lissotriton (vulgaris) kosswigi* (Freitag, 1955) (Urodela; Salamandridae), endemic to northwestern Turkey

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Abstract: Facultative paedomorphism is regularly observed in salamanders, including newts of the *Lissotriton vulgaris* group. We document the first record of paedomorphism in *L. (v.) kosswigi* from a locality near Karasu, in the vicinity of Sakarya, Turkey. We compare measurements of 5 paedomorphic individuals with those of 10 metamorphic individuals from the same population and with measurements taken from the literature. Paedomorphs are on average bigger than metamorphs; intriguingly, the opposite pattern has been observed in the Turkish *L. (v.) schmidtlerorum*.

Key words: Anatolia, *Lissotriton lantzi*, *Lissotriton vulgaris schmidtlerorum*, neoteny, smooth newt

Paedomorphosis encompasses the retention of larval features while attaining sexual maturity (Denoël, 2003; Çiçek, 2011). The onset or delay of metamorphosis is affected by genetic and/or environmental components (Denoël et al., 2009). Key environmental components are prey and predator abundance and habitat composition, with paedomorphosis generally being correlated with permanent, nutrient-rich water bodies without predators, but paedomorphosis has been observed in a wide range of habitats under a wide variety of conditions (Semlitsch, 1987; Voss, 1995; Denoël et al., 2001; Denoël and Joly, 2001; Denoël and Schabetsberger, 2003). The term facultative paedomorphosis is applied to species in which some of the individuals metamorphose while others reach adulthood without undergoing metamorphosis, often within the same population (Semlitsch and Wilbur, 1989). Advantages of this strategy are resource partitioning and risk spreading within a single population (Denoël et al., 2005).

Paedomorphosis is common in urodeles; it has been documented in 57 species of 9 out of 10 salamander families (Denoël et al., 2005). Facultative paedomorphosis has been observed in 5 of these families (Salamandridae, Ambystomatidae, Dicamptodontidae, Hynobiidae, and some Plethodontidae) (Denoël et al., 2005). In the smooth newt *Lissotriton vulgaris* group (Salamandridae), facultative paedomorphosis is observed throughout most of the range

and has been reported from most taxa (Schmidtler and Franzen, 2004). In Turkey, 2 and perhaps 3 *Lissotriton* taxa occur (Schmidtler and Franzen, 2004) that are usually referred to as subspecies, but are sometimes regarded as specifically distinct (e.g., Dubois and Raffaëlli, 2009; Speybroeck et al., 2010). The range of the taxon *lantzi* (Wolterstorff, 1914) might extend just into the extreme northeast of Turkey, near the border with Georgia (Schmidtler and Franzen, 2004; Skorinov et al., 2014). The taxon *kosswigi* (Freitag, 1955) is restricted to northwestern Anatolia (Schmidtler and Franzen, 2004). The taxon *schmidtlerorum* (Raxworthy, 1988) occurs in western Asiatic and European Turkey, and its range protrudes further into Greece and Bulgaria (Nadachowska and Babik, 2009; Pabijan et al., 2015). Previous records of nominate *vulgaris* (Linnaeus, 1758) from Turkey reflect incomplete taxonomy and refer to the other taxa (Schmidtler and Franzen, 2004; Nadachowska and Babik, 2009).

In *schmidtlerorum*, facultative paedomorphosis has been reported from 4 Turkish populations (Yılmaz, 1983; Çevik et al., 1997; Çiçek and Ayaz, 2011; Çiçek, 2011), and we have observed it in a fifth locality (Bozköy; 39.024°N, 27.111°E). Although not known for Turkey (reflecting the poorly understood distribution), facultative paedomorphosis is well documented in *lantzi* (e.g., Skorinov et al., 2009). In contrast, paedomorphosis has, as far as we are aware, never been reported for *kosswigi*. We

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here report on facultative paedomorphosis in a *kosswigi* population near Karasu (Sakarya, Turkey).

On 7 April 2014, we caught 5 paedomorphic and 10 metamorphic *kosswigi* individuals by dip netting. Specimens were anaesthetised with MS222, sacrificed by immersion in 96% ethanol, and deposited in 70% ethanol at the Zoology Laboratory of the Department of Biology, Faculty of Arts and Sciences, Adnan Menderes University in Aydın, Turkey.

Individuals were sexed, and the following measurements were taken using a dial calliper with an accuracy of 0.01 mm under a stereomicroscope: total body length (L), from the tip of the snout to the tip of tail; snout-vent length (SVL), from the tip of the snout to the posterior of the cloacal opening; body length (LCP), from the tip of the snout to the anterior of the cloacal opening; forelimb length (FLL); hind limb length (HLL); distance between fore- and hind limb (FHL); length of the longest gill (GL); and tail length (TL), from the posterior of the cloacal opening to the tip of the tail. The following ratios

were calculated: L/SVL, L/LCP, TL/SVL, and HLL/FLL. We used a t-test with STATISTICA 7.0 to compare the morphometric measurements of the paedomorphic and metamorphic individuals.

The facultative paedomorphic *kosswigi* population was found in İhsaniye, near Karasu, on the eastern bank of the Sakarya River (41.119°N, 30.648°E, 3 m a.s.l.; Figure 1). The newts were caught in a wetland pond (Figure 2). The pond is up to approximately 50 cm deep and has rich vegetation. Confirmed members of the herpetofauna community in the pond are *Triturus ivanbureschi*, *Bombina bombina*, *Pelophylax ridibundus*, and *Emys orbicularis*.

Of the 5 paedomorphic individuals, one was identified as male based on a swollen cloaca, body pattern, coloration, and male sexual characters such as webbed feet and tail filament, typical for the taxon *kosswigi* (Figure 3). The other 4 paedomorphs were identified as female.

Measurements and ratios of the 10 metamorphs and 5 paedomorphs are provided in Tables 1 and 2. Note that for 3 individuals part of the tail was missing (presumably

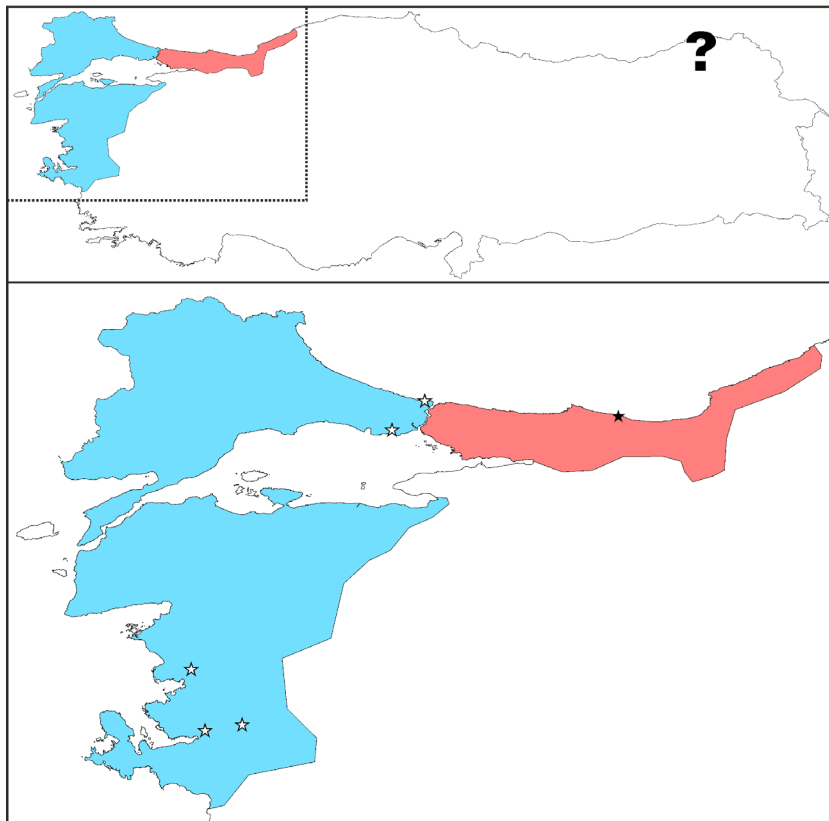


Figure 1. Map showing the distribution of the *Lissotriton vulgaris* group in Turkey. The range of *kosswigi* is in red; the range of *schmidtlerorum* is in blue; the question mark denotes the potential occurrence of *lantzi* in the extreme northeast of Turkey. Facultative paedomorphic populations for *schmidtlerorum* are marked with a white star. The first facultative paedomorphic population for *kosswigi*, newly reported in this paper, is marked with a black star.



Figure 2. The wetland pond at İhsaniye, Karasu where the facultative paedomorphic population of *Lissotriton (vulgaris) kosswigi* was found.



Figure 3. Lateral view of 4 *Lissotriton (vulgaris) kosswigi* individuals from İhsaniye, Karasu, representing (from top to bottom) a male metamorph, a male paedomorph, a female paedomorph, and a female metamorph.

Table 1. Morphometric measurements of 10 metamorphic and 5 paedomorphic individuals from İhsaniye, Karasu. Three individuals (2 metamorphic males and 1 paedomorphic female) had lost their tail tips; hence, not all measurements could be taken for these individuals.

	L (mm)		LCP (mm)		SVL (mm)		TL (mm)	
	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂
Metamorphs								
Number	5	3	5	5	5	5	5	3
Mean	53.29	58.11	27.34	25.63	29.16	28.73	24.14	28.61
SD	3.00	8.32	0.88	2.34	1.10	2.60	3.66	5.02
Paedomorphs								
Number	3	1	4	1	4	1	3	1
Mean	59.29	57.48	30.01	26.05	31.60	30.06	27.59	27.42
SD	4.04		1.99		1.77		1.96	
	FLL (mm)		HLL (mm)		FHL (mm)		GL (mm)	
Metamorphs								
Number	5	5	5	5	5	5	n/a	n/a
Mean	10.12	10.31	8.98	9.28	14.06	12.61	n/a	n/a
SD	0.49	1.98	0.37	1.49	0.49	0.49	n/a	n/a
Paedomorphs								
Number	4	1	4	1	4	1	4	1
Mean	10.19	11.11	9.38	10.31	15.82	14.21	4.76	2.58
SD	0.51		0.44		1.08		1.56	

Table 2. Morphometric ratios of 10 metamorphic and 5 paedomorphic individuals from İhsaniye, Karasu. Three individuals (2 metamorphic males and 1 paedomorphic female) had lost their tail tips; hence, not all measurements could be taken for these individuals.

	L/SVL		L/LCP		TL/SVL		HLL/FLL	
	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂
Metamorphs								
Number	5	3	5	3	5	3	5	5
Mean	1.83	1.97	1.95	2.19	0.83	0.97	0.89	0.90
SD	0.15	0.06	0.13	0.13	0.15	0.06	0.07	0.05
Paedomorphs								
Number	3	1	3	1	3	1	4	1
Mean	1.87	1.91	1.97	2.21	0.87	0.91	0.92	0.93
SD	0.02		0.05		0.02		0.05	

due to predation), and not all measurements could be provided. The gills are very large and are formed of 3 parts. The gill lengths vary between 2.58 and 7 mm. Paedomorphic individuals show significantly higher values for L, LCP, SVL, and FHL compared to the metamorphs ($P < 0.05$). Female paedomorphs are significantly larger than metamorphs, as expressed by total body length (L), whereas for males we did not observe a size difference.

Previously published L values for *kosswigi* reveal that L differs widely among populations. Eiselt (1966) reported that L ranged from 59 to 71 mm for males and from 55.5 to 70 mm for females from Sapanca. Schmidtler and Schmidtler (1967) reported that L ranged from 62 to 67 mm in males and from 55 to 62 mm in females from Adapazarı. Tabrizi (1980) reported that L ranged from 51 to 63 mm in males in Abant, while L ranged from 50.5 to 62.4 mm in females. In Düzce, L ranged from 52.8 to 57 mm for males and from 58.5 to 65 mm for females. In İstanbul (10 populations from east of the Bosphorus, excluding one supposedly showing hints of admixture with *schmidtlerorum*), L was measured as 47.4 to 82 mm in males and 56 to 80 mm in females.

In this study, we report what, to the best of our knowledge, is the first observation of facultative paedomorphosis in *L. v. kosswigi*. However, this finding is not unexpected, as facultative paedomorphosis has been regularly observed in other members of the *Lissotriton vulgaris* group, including the Turkish taxon *schmidtlerorum* (Yılmaz, 1983; Çevik et al., 1997; Çiçek and Ayaz, 2011) and in other genera of the family Salamandridae, including the Turkish banded newt species *Ommatotriton ophryticus* (Kaya et al., 2008; Başkale et al., 2013).

Within the facultative paedomorphic *kosswigi* population, female paedomorphs appear larger than metamorphs. In *schmidtlerorum*, the opposite was found: within facultative paedomorphic populations, paedomorphs were smaller than metamorphs (Çiçek and Ayaz, 2011). For both taxa, this pattern does not hold throughout the range, as total body length strongly varies from population to population.

The gill lengths vary among other *L. vulgaris* populations. Covaciu-Marcov and Cicort-Lucaciu (2007) found that the longest gill length reached 6.7 mm in a Romanian population. Litvinchuk (2001) measured the largest gill as 1.5 mm in a Ukrainian population of *L. vulgaris*.

The future of (facultative) paedomorphic populations is particularly precarious: they are negatively affected by human activities such as water extraction (causing ponds to dry up for part of the year) and fish stocking (which predates adult newts and their eggs and larvae) (Denoël et al., 2005). Hence, protection of the only known facultatively paedomorphic population of *kosswigi* is pertinent, especially considering the geographically restricted range of this taxon, endemic to northwestern Turkey (Figure 1).

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