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Distribution range expansion of *Salamandra infraimmaculata* Martens, 1885 (Caudata: Salamandridae) in Anatolia, Turkey, with a new locality record

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***Abstract.—Salamandra infraimmaculata* is one of the prominent members of the Turkish herpetofauna, which is currently classified as Near Threatened by the IUCN. Although many studies of its morphology, ecology, and phylogeny have been conducted in recent years, many issues concerning its taxonomic structure and morphometry remain unresolved. In the present study, morphometric characters and color-pattern features of the specimens of *Salamandra infraimmaculata* captured from İvriz, Halkapınar, Konya Province are given in detail and compared with the data available in previous studies. In addition, the climatic niche preferences of this species were determined using ecological niche modelling, and three WorldClim bioclimatic variables were found to restrict the species presence: Minimum Temperature of Coldest Month (Bio6), Mean Temperature of Wettest Quarter (Bio8), and Precipitation of Warmest Quarter (Bio18). Even though this study revealed the potential habitat preferences of this species, clearly more detailed studies are needed to resolve the problematic taxonomical issues.**

Keywords. Amphibia, color pattern, morphometry, niche modelling, WorldClim bioclimatic variables, ecological niche

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Introduction

The genus *Salamandra* currently includes six recognized species: *S. algira* Bedriaga, 1883; *S. atra* Laurenti, 1768; *S. corsica* Savi, 1838; *S. infraimmaculata* Martens, 1885; *S. lanzai* Nascetti, Andreone, Capula and Bullini, 1988; and *S. salamandra* Linnaeus, 1758 (Rodríguez et al. 2017). One of them, the Near Eastern Fire Salamander *S. infraimmaculata*, is a member of the Turkish herpetofauna (Baran et al. 2012). *Salamandra infraimmaculata* was first described as *Salamandra maculosa* var. *infraimmaculata* from Bcharré, Lebanon (Martens 1885). This species is now known from Turkey, Syria, Lebanon, northern Israel, northern Iraq, and western Iran and includes three subspecies: *S. i. infraimmaculata* Martens, 1885, *S. i. orientalis* Wolterstorff, 1925, and *S. i. semenovi* Nesterov, 1917 (Joger and Steinfartz 1995; Steinfartz et al. 2000). In Turkey, these three subspecies are found in Hatay province (*S. i. infraimmaculata*); in Adana, Mersin, and Malatya provinces of southern Turkey (*S. i. orientalis*); and in Bitlis and Erzincan provinces of eastern Turkey (*S. i. semenovi*) (Joger and Steinfartz 1995; Veith et al. 1998; Steinfartz et al. 2000).

Specimens of this taxon from Turkey were previously treated as *S. salamandra* (Eiselt 1966; Schmidtler and Schmidtler 1970; Öz 1987; Öz and Arıkan 1990; Arıkan et al. 1990; Baran and Öz 1994). However, the Kemaliye (Erzincan) population was assigned to *S. s. infraimmaculata* (Fachbach 1971), and the subspecies was later elevated to the full species level based on serum protein patterns (Gasser 1978). According to comparisons of blood-serum proteins among the various *Salamandra* populations by polyacrylamide disc gel electrophoresis, the populations in Turkey were classified as *S. infraimmaculata* (Joger and Steinfartz 1995). The study by Böhme et al. (2013) on various attributes of *S. infraimmaculata* reported that *S. i. semenovi* has a typical scrolled pattern of yellow rings, semicircles, and similar pattern elements, while the color pattern of both nominates of form *S. i. orientalis* has larger broad solid flecks and small, yellow spots over the whole body except for the belly. In *S. i. infraimmaculata*, the yellow dots are large and extend over the whole body, except the belly. There are usually four yellow spots on the head, one on each parotoid and one above each eye (Rastegar-Pouyani

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and Fizi 2006). Previous molecular phylogenetic studies identified six major monophyletic groups belonging to this genus, which were separated from each other by 5 to 13 million years (Veith et al. 1998; Steinfartz et al. 2000; Weisrock et al. 2006; Vences et al. 2014; Pyron and Wiens 2011; Rodríguez et al. 2017).

One molecular study claimed that the populations occupying the Zagros Mountains (Iran) are genetically close to the southeastern populations of Turkey, and it has been suggested that some populations in southern Turkey can be considered as a new subspecies because the type locality of *S. i. semenovi* is in the other clade (Ahsani et al. 2019). Based on additional herpetological studies in Turkey, the known geographical distribution of *S. infraimmaculata* has recently been expanded (Coşkun et al. 2013; Olgun et al. 2015; Sarıkaya et al. 2017; Akman et al. 2018; Sami and Yıldız 2018; Yıldız et al. 2019), although the taxonomic state of the species division into three subspecies is still not fully clarified (Steinfartz et al. 2000; Olgun et al. 2015; Ahsani et al. 2019).

In this study, the morphological characters of *S. infraimmaculata* salamanders collected from a new locality in Turkey are described, which may shed some light on the taxonomy of this species. In addition, the climatic conditions affecting the distribution of *S. infraimmaculata* were determined using ecological niche modelling.

Materials and Methods

Sampling. On 17 November 2019, one adult male (Fig. 1A) and one adult female (Fig. 1B) of *S. infraimmaculata* were collected from İvriz, Halkapınar, Konya Province (Fig. 2). The salamanders used in this study were found under stones during the daytime (between 1100 and 1200 h) and collected by hand after a heavy rain. The localities where the specimens were collected are situated near small creeks, and their geographic positions were recorded with a GPS receiver (Garmin eTrex 30). The sex of the captured individuals was determined through secondary sexual characters, i.e., males have a prominent (swollen) cloaca (Başoğlu and Özeti 1973). Morphometric measurements and the color and pattern characteristics of the specimens were recorded in the field and the specimens were released at the capture locations.

Morphological characteristics. All morphological measurements were recorded using a digital caliper (Mitutoyo, Kawasaki, Japan) with an accuracy of 0.01 mm. Measurements of body parts and their ratios follow previously published papers on salamanders (Öz 1987; Olgun et al. 2015), and are as follows: total body length (TBL), tip of snout to tip of tail; body length (LCP), length from snout to anterior end of cloaca opening; snout-vent length (SVL), tip of snout to posterior end of cloaca opening; tail length (TL), length from posterior end of cloaca opening to tip of tail; forelimb length (FLL); hindlimb length (HLL); distance between fore- and hind limbs length (DFHL); head length (HL), distance from snout to gular fold; head width (HW); parotoid length (PL); parotoid width (PW); and distance between anterior of each parotoid (DAP). In addition, the ratios of DFHL/SVL, PL/HL, PW/HW, PW/PL, HW/HL, TL/SVL, HL/LCP, FLL/SVL, TL/SVL*100, HL/LCP*100, HW/HL*100, FLL/SVL*100, HLL/SVL*100, and TL/TBL*100 were calculated. Statistical analyses were carried out using STATISTICA 6.0 (StatSoft, Inc., Tulsa, Oklahoma, USA) to determine descriptive statistics for the measurements of the salamanders. Morphometric measurements were then compared to previously published data (Öz 1987; Öz and Arıkan 1992; Olgun et al. 2015).

Ecological niche modelling. A total of 56 records were collected from the published literature and on-going fieldwork over the course of a few years (Fig. 2; Supplementary Table 1). The 56 records were thinned to 44 localities using 'spThin' (Aiello-Lammens et al. 2015) in R (R Core Team, 2019), and the thinning distance was selected as 10 km. WorldClim bioclimatic variables (Bio1–19, Supplementary Table 2) were downloaded at 0.5 arcmin resolution using the *raster* package (Hijmans 2017) as environmental predictors. The minimum convex polygon was used as the background extent of the study region, and buffered by 0.5 degrees. Predictor rasters by the background extent and the random background points sampled were masked with values of 10,000. These processes were handled with the *sp* (Pebesma and Bivand 2019) and *rgeos* (Bivand and Rundel 2019) packages in R. The occurrence records were partitioned by the block method (k = 4) using the *ENMeval* (Muscarella et al. 2014) package in R, and MaxEnt was run successfully with output evaluation results for 45 clamped models. Wallace, which is a flexible platform for reproducible modeling of species niches and distributions, was used for the complex workflows above (Kass et al. 2018). Later, according to the lowest AICc value (Supplementary Table 3), MaxEnt was run again with the following parameters: Linear, Hinge and Quadratic as features; regularization multiplier: 4; and number of replicates: 30. The Area Under the Receiver Operating Characteristic (ROC) Curves (AUC) value, averaged over the 30 replicated runs, was considered as an additional measure of model performance. Models with AUC = 0.5 indicate a performance equivalent to "random," AUC > 0.7 indicates "useful" models, and AUC ≥ 0.9 indicates models with "excellent" performance (Manel et al. 2001).

Results

Descriptive statistics of the metric measurements of the specimens are given in Table 1. The total length of specimens (TBL) was measured as 226.83 mm for the male and 155.85 mm for the female. The SVL of the male was 134.92 mm, while it was 99.25 mm for the female.

Table 1. Mensural characters, ratios, and indices of *Salamandra infraimmaculata* samples. N, number of samples; S.D., standard deviation; S.E., standard error of the mean; the abbreviations of characters are given in Materials and Methods.

		♂+♀							♂+♀				
Characters	**N**	**Mean**	**S.D.**	**S.E.**	♂	♀	**Characters**	**N**	**Mean**	**S.D.**	**S.E.**	♂	♀
TBL	2	191.34	50.19	35.49	226.83	155.85	**PL/HL**	2	0.55	0.03	0.02	0.57	0.53
LCP	2	93.14	19.66	13.91	107.01	79.23	**PW/HW**	2	0.30	0.02	0.02	0.31	0.28
SVL	2	117.09	25.22	17.86	134.92	99.25	**PW/PL**	2	0.44	0.03	0.02	0.46	0.42
TL	2	74.25	24.97	17.66	91.91	56.60	**HW/HL**	2	0.83	0.05	0.04	0.86	0.79
FLL	2	37.48	7.92	5.60	43.08	31.88	**TL/SVL**	2	0.63	0.06	0.08	0.68	0.57
HLL	2	38.35	8.26	5.84	44.19	32.51	**HL/LCP**	2	0.30	0.00	0.00	0.30	0.30
DFHL	2	62.40	10.88	7.69	70.09	54.71	**FLL/SVL**	2	0.33	0.01	0.05	0.33	0.32
HL	2	27.56	5.80	7.10	31.66	23.46	**TL/SVL*100**	2	62.57	7.85	5.55	68.12	57.02
HW	2	22.52	3.48	2.46	24.98	20.06	**HL/LCP*100**	2	30.00	0.00	0.00	30.00	30.00
PL	2	15.05	2.40	1.70	16.70	13.31	**HW/HL*100**	2	82.50	4.95	3.50	86.00	79.00
PW	2	6.62	1.45	1.02	7.64	5.60	**FLL/SVL*100**	2	32.50	0.71	0.50	33.00	32.00
DAP	2	12.79	0.95	0.68	13.46	12.11	**HLL/SVL*100**	2	32.88	0.18	0.13	33.00	32.75
DFHL/SVL	2	0.54	0.02	0.02	0.55	0.52	**TL/TBL*100**	2	38.42	2.97	2.10	40.52	36.32

Table 2. Comparison of metric measurements, ratios, and indices of our specimens (this study) with those given for specimens from specific localities in three previous studies: [1]Öz (1987), [2]Öz and Arıkan (1992), and [3]Olgun et al. (2015).

Characters	[1]Erzincan	[1]Malatya	[1]Hatay	[1]Adana/Mersin	[2]Bitlis	[3]Tunceli (male/female)	[3]Şanlıurfa	This study
TBL	184.70	191.60	150.80	180.60	172.60	187.60/183.50	222.60	191.34
LCP	---	---	---	---	---	102.50/106.50	121.2	93.14
SVL	---	---	---	---	---	110.80/114.30	130.30	117.09
TL	---	---	---	---	---	76.70/69.80	92.30	74.25
FLL	---	---	---	---	---	34.60/32.40	35.10	37.48
HLL	---	---	---	---	---	34.00/34.70	37.30	38.35
DFHL	---	---	---	---	---	46.60/58.00	73.30	62.40
HL	---	---	---	---	---	28.40/25.20	22.00	27.56
HW	---	---	---	---	---	22.30/20.60	24.00	22.52
PL	---	---	---	---	---	16.80/15.30	16.80	15.05
PW	---	---	---	---	---	5.60/6.00	6.10	6.62
DAP	---	---	---	---	---	13.40/13.40	15.90	12.79
HW/HL	---	---	---	---	---	0.78/0.82	1.09	0.83
PL/HL	---	---	---	---	---	0.60/0.61	0.76	0.55
PW/HW	---	---	---	---	---	0.25/0.29	0.26	0.30
PW/PL	---	---	---	---	---	0.33/0.39	0.37	0.44
DFHL/ SVL	---	---	---	---	---	0.42/0.51	0.56	0.54
TL/SVL*100	81.68	82.92	73.55	77.10	79.30	---	---	62.57
HL/LCP *100	32.15	29.53	33.03	32.46	31.30	---	---	30.00
HW/HL*100	77.65	87.60	78.52	80.08	83.90	---	---	82.50
FLL/SVL*100	30.92	30.81	29.35	31.11	31.70	---	---	32.50
HLL/SVL*100	32.85	32.81	31.67	33.67	33.30	---	---	32.88
TL /TBL*100	44.92	45.32	42.32	43.48	44.10	---	---	38.42

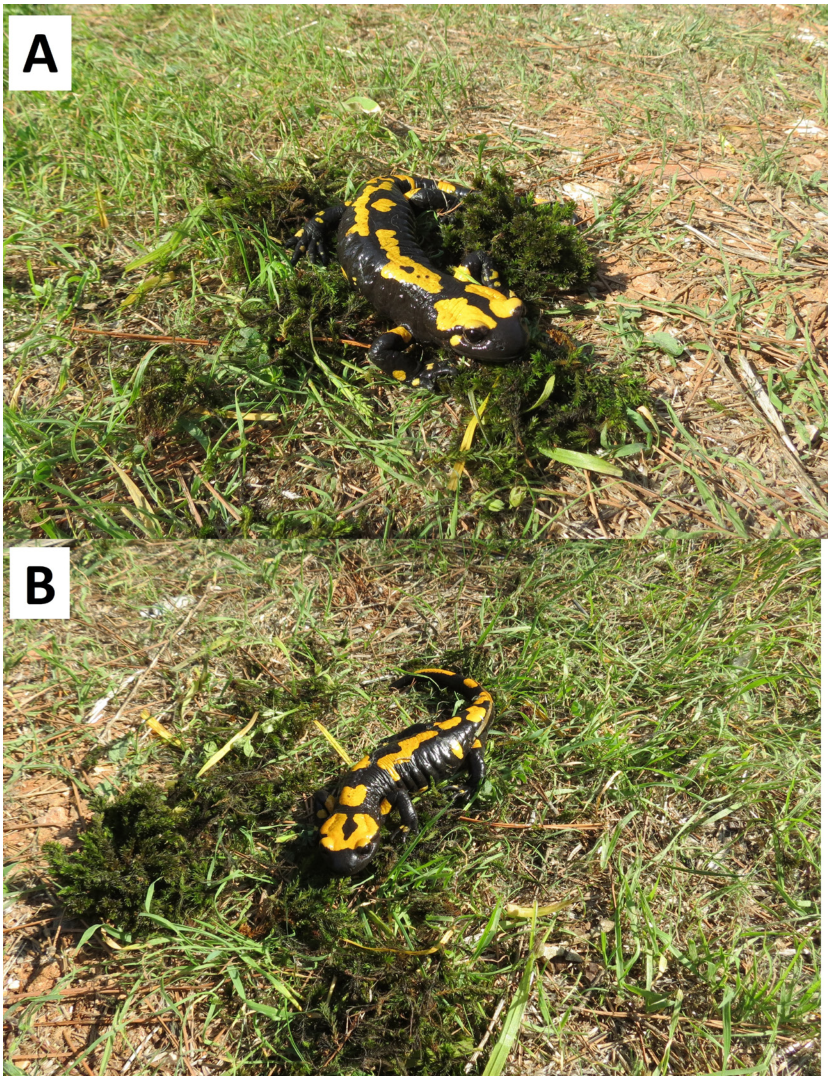

Fig. 1. Samples of *Salamandra infraimmaculata* captured from the new locality: **(A)** male and **(B)** female.

In the two specimens, the ground color of the upper side of the head is black with two larger solid yellow flecks (Fig. 1). In the male, these flecks are separated from each other, but in the female, they are in contact. While the female has small yellow spots on the side of the head on a black background, the male specimen is spotless. There is no pigmentation forming a faint dark dot on the parotoid glands. The ground color of the dorsum is blackish with a scattered pattern of large varying forms of yellow maculation that are sometimes in contact with each other. There are yellow spots on the side of the body, especially in the female. Although the gular region has maculation, the female has two obvious yellow flecks rather than dot-shaped staining, which is more common in males. In males, the ventral surface shows sparse dots consisting of small yellow spots, while females have purely black undersides. Both specimens show medium-sized yellow flecks on the black background of the extremities (Fig. 1). Comparative morphological data on the populations of this species in different regions of Turkey are given in Table 2.

The average test AUC for the replicate runs was 0.863, and the standard deviation was 0.145. Among the bioclimatic variables, Bio6 showed the highest percentage contribution (51.9%), whereas Bio18 and Bio8 had lower percentages of 20.7 and 12.1, respectively, and all other variables were under 10%. The optimal habitat for this species within the minimum convex polygon appeared to be across the middle Taurus and Amanos mountains in southern Anatolia (Fig. 3).

Discussion

Salamandra infraimmaculata is a polytypic species, which is currently recognized as three discrete taxonomic units: *S. i. infraimmaculata* Martens, 1885 (Turkish Hatay, Syria, Lebanon, and northern Israel), *S. i. orientalis* Wolterstorff, 1925 (south and southeastern

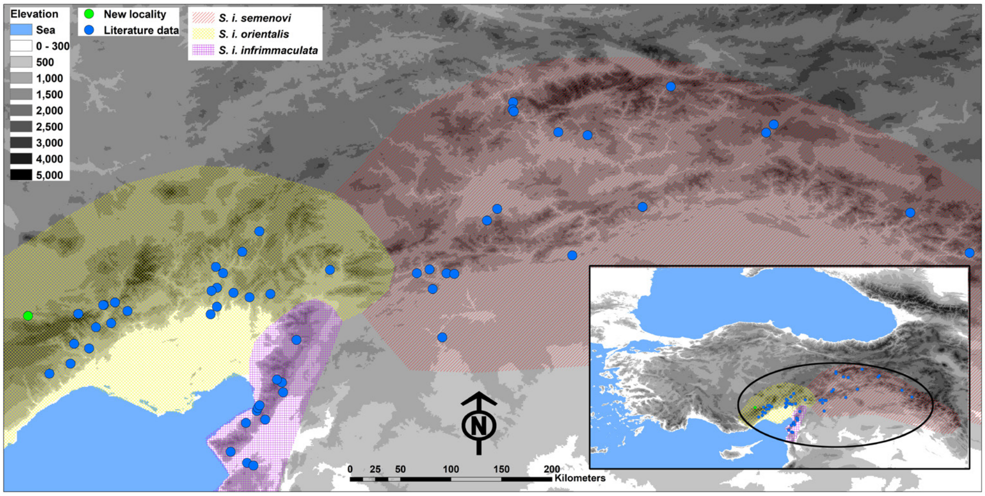

Fig. 2. Distribution patterns of *Salamandra infraimmaculata* throughout southern Anatolia together with the new locality record.

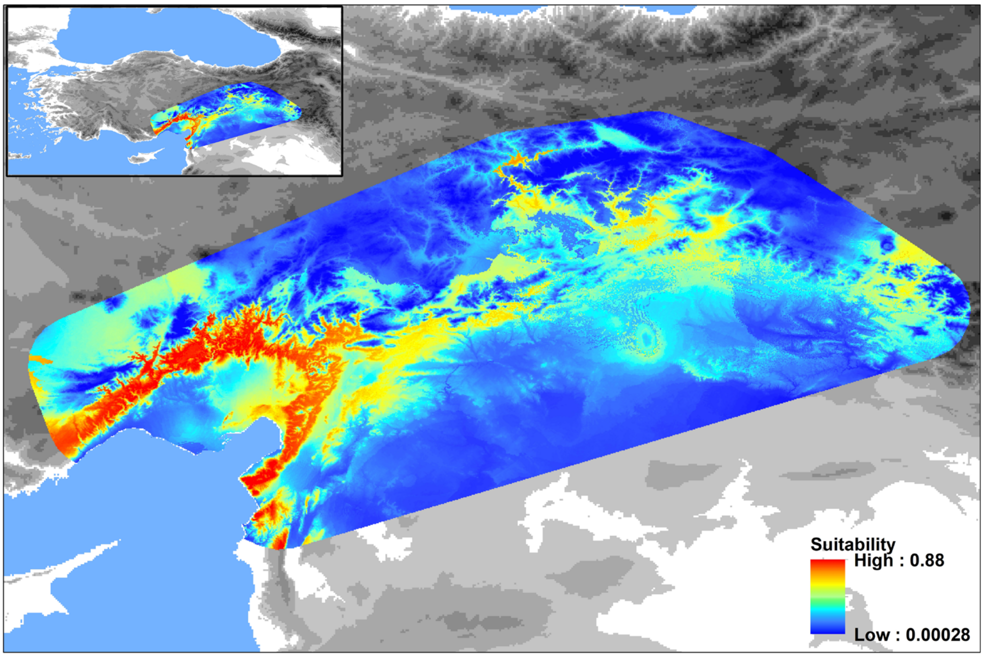

Fig. 3. Predicted distribution of *Salamandra infraimmaculata* under current climatic conditions. Warm colors (red and yellow) show suitable habitats, whereas the blue color represents unsuitable habitats for *S. infraimmaculata*.

Turkey), and *S. i. semenovi* Nesterov, 1917 (easternmost Turkey, western Iran, and northern Iraq) (Joger and Steinfartz 1995; Steinfartz et al. 2000; Böhme et al. 2013). However, the taxonomic status of its subspecies and their distributions are still unclear (Steinfartz et al. 2000; Böhme et al. 2013).

The new locality record presented in this study extends the known range of *S. infraimmaculata* by about 70 km to the northwest, as measured from the nearest previous locality of Fındıkpınarı, Mersin. The new locality (İvriz, Halkapınar, Konya) indicates that the distribution area of the species may extend throughout the Eastern Taurus Mountains to the western direction.

Several studies have reported data on the body sizes of the three subspecies. Schorn and Kwet (2010) reported that *S. i. orientalis* is smaller in size than the other two subspecies (*S. i. infraimmaculata* and *S. i. semenovi*). The maximum value for Israeli Fire Salamanders (*S. i. infraimmaculata*) was given as 316 mm by Eiselt (1958), while it was reported as 202 mm for Iraqi specimens corresponding to *S. i. semenovi* (Böhme et al. 2013). Finally, within the distribution area of the *S. i. orientalis*, Böhme et al. (2013) reported the total length of specimens from Fındıkpınarı, Mersin, and Ilıca

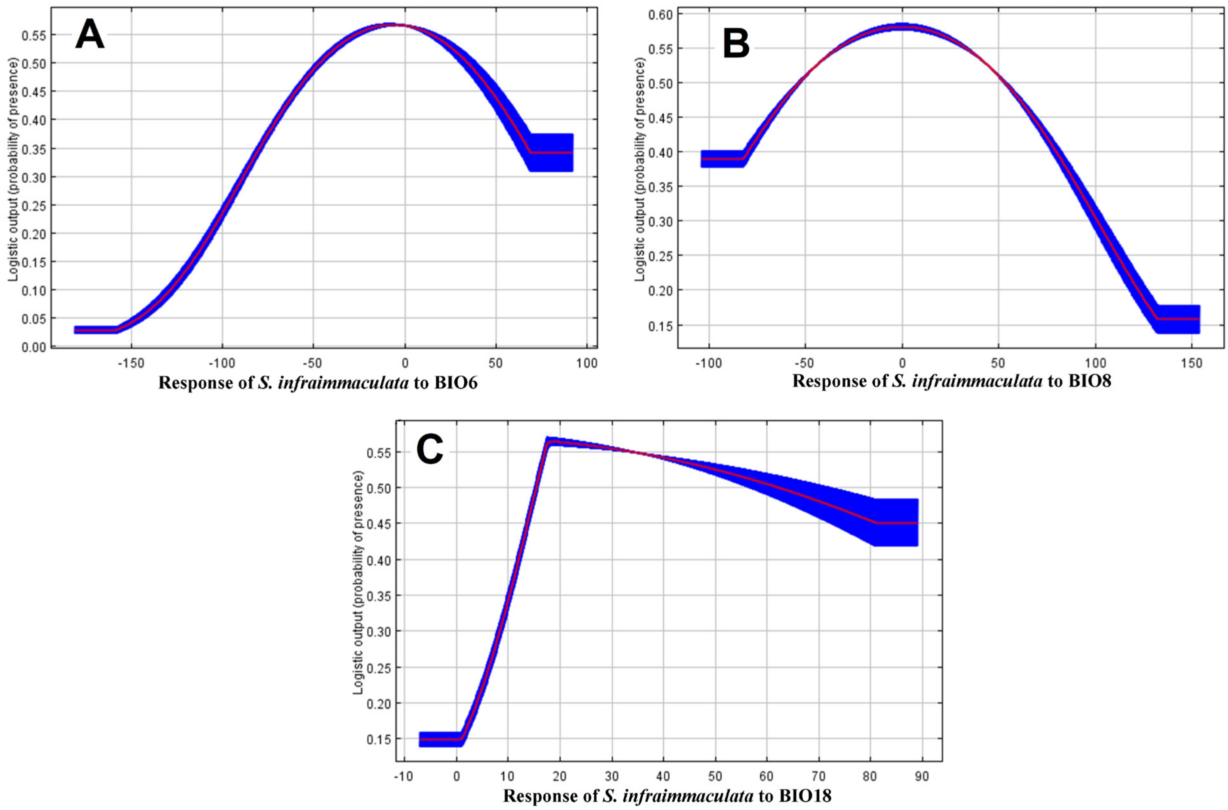

Fig. 4. The marginal response curves of *S. infraimmaculata* to **(A)** Minimum Temperature of Coldest Month (Bio6), **(B)** Mean Temperature of Wettest Quarter (Bio8), and **(C)** Precipitation of Warmest Quarter (Bio18). The red lines and blue shading respectively show the mean responses of the 30 replicate MaxEnt runs and the mean plus/minus one standard deviation.

in Turkey as 200 mm and those from Kahramanmaraş, Turkey as 255 mm. In the present study, the total body length was 226.83 mm for the male specimens. As can be seen from the values given above, the suggestion that adults of *S. i. orientalis* are smaller than the other two forms, as Böhme et al. (2013) stated, is not correct.

According to Böhme et al. (2013), *S. i. semenovi* has the typical, scrolled pattern of yellow rings, semicircles, and similar pattern elements, while the color pattern of both *S. i. orientalis* and the nominotypical form consists of larger solid flecks. The color-pattern characteristics alone are not enough to distinguish the Fire Salamanders for taxonomically assigning individuals (Böhme et al. 2013). However, phylogenetic and phylogeographic information obtained from different molecular techniques can be combined with the knowledge of morphology and distribution, producing a more accurate taxonomic placement for the studied specimens.

Considering the niche modelling of *S. infraimmaculata* in Syria, one study reported a positive relationship between fitness and the Precipitation of Coldest Quarter (Bogaerts et al. 2013). In this study, among the climatic variables used in the ecological niche modelling, Minimum Temperature of the Coldest Month (Bio6), Mean Temperature of Wettest Quarter (Bio8), and Precipitation of Warmest Quarter (Bio18) are the most important. Generally, in southern Anatolia, *S. infraimmaculata* can survive in the low temperatures in winter months. In other words, the known occurrences for *S. infraimmaculata* have minimum temperatures between -15 and 0 °C (Fig. 4A). Similarly, *S. infraimmaculata* can tolerate mean temperatures between -8 and 0 °C in summer months (Fig. 4B). Additionally, the species is not found in localities with high precipitation, whereas it can adapt to low precipitation in the summer months (Fig. 4C). In particular, the temperature niches of *S. infraimmaculata* can explain local population abundances in the south of Anatolia (Bowler et al. 2015).

There are still many uncertainties regarding the taxonomic structure of *S. infraimmaculata,* which makes it difficult to determine the distribution limits of the taxonomic groups within this species. In this study, a new locality record for the species is reported by revealing its potential habitat preferences. However, more detailed studies are needed to fully resolve the taxonomic uncertainties and to more thoroughly document the distribution preferences of the species.

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Supplementary Table 1. Presence data of the *Salamandra infraimmaculata* localities used in the model.

Locality	Latitude	Longitude	Reference
İvriz, Halkapınar, Konya	37.430556	34.181111	This study
Maden Village, Ulukışla, Niğde	37.448889	34.630278	Baran and Öz (1994)
Çamlıyayla, Mersin	37.183016	34.591682	Baran and Öz (1994)
Fındıkpınar, Mersin	36.917778	34.372223	Baran and Öz (1994)
Gözne, Mersin	37.005833	34.559722	Olgun et al. (2015)
Ömerli Village, Pozantı, Adana	37.528056	34.8575	Olgun et al. (2015)
Ömerli Village, Pozantı, Adana	37.526944	34.851111	Olgun et al. (2015)
Kamışlı, Pozantı, Adana	37.55	34.955556	Sarıkaya et al. (2017)
Akçatekir, Pozantı, Adana	37.329722	34.786389	Sarıkaya et al. (2017)
Belemedik, Pozantı, Adana	37.365833	34.921944	Sarıkaya et al. (2017)
Saimbeyli, Adana	38.000833	36.090556	Baran and Öz (1994)
Feke, Adana	37.810833	35.919167	Baran and Öz (1994)
Kozan, Adana	37.444722	35.807778	Baran and Öz (1994)
Boztahta, Kozan, Adana	37.635556	36.011388	Sarıkaya et al. (2017)
Çulluuşağı, Kozan, Adana	37.680278	35.864167	Sarıkaya et al. (2017)
Camdere, Kozan, Adana	37.653333	35.816389	Sarıkaya et al. (2017)
Baraj, Kozan, Adana	37.512222	35.863889	Sarıkaya et al. (2017)
Yamanlı, Tufanbeyli, Adana	38.182307	36.242130	Sarıkaya et al. (2017)
Çamlıbel, Aladağ, Adana	37.474429	35.068174	Sarıkaya et al. (2017)
Belenköy, Adana	37.865833	35.855277	Sarıkaya et al. (2017)
Darıpınarı, Adana	37.141883	34.725625	Böhme et al (2013)
Bahçe, Osmaniye	37.217222	36.573055	Özeti and Yılmaz (1994)
Kozaklı Village, İskenderun, Hatay	36.479444	36.122778	Baran and Öz (1994)
İskenderun, Hatay	36.585556	36.218333	Olgun et al. (2015)
Bekbele Plateau, İskenderun, Hatay	36.612550	36.229809	Yıldız et al. (2019)
Demen Plateau, İskenderun, Hatay	36.635556	36.244167	Yıldız et al. (2019)
Çardak Plateau, Hassa, Hatay	36.838611	36.443611	Olgun et al. (2015)
Eğribucak, Hassa, Hatay	36.750833	36.454166	Yıldız et al. (2019)
Kapılı yolu, Dörtyol, Hatay	36.864444	36.399167	Yıldız et al. (2019)
Harbiye, Hatay	36.124722	36.131944	Yıldız et al. (2019)
Kozkalesi, Altınözü, Hatay	36.099980	36.189077	Yıldız et al. (2019)
Yeniköy, Samandağ, Hatay	36.222778	35.986389	Yıldız et al. (2019)
Arkıtça, Kırıkhan, Hatay	36.509167	36.294999	Yıldız et al. (2019)
Altınboğa Village, Andırın, Kahramanmaraş	37.626096	36.340641	Olgun et al. (2015)
Ilıca Village, Kahramanmaraş	37.839878	36.870419	Olgun et al. (2015)
Sugözü, Besni, Adıyaman	37.669669	37.786397	Sami and Yıldız (2018)
Yağmurlu village, Gerger, Adıyaman	37.968325	39.029137	Sami and Yıldız (2018)
Tut, Adıyaman	37.808611	37.91	Sami and Yıldız (2018)
Kaşlıca, Tut, Adıyaman	37.803813	37.979159	Sami and Yıldız (2018)
Meydanköy, Gölbaşı, Adıyaman	37.810277	37.644999	Sami and Yıldız (2018)
Harmanlı, Gölbaşı, Adıyaman	37.843888	37.758056	Sami and Yıldız (2018)
Salihli Village, Kemaliye, Erzincan	39.330269	38.502082	Baran and Öz (1994)
Kemaliye, Erzincan	39.266111	38.4975	Baran and Öz (1994)
Yuva Village, Kemaliye Erzincan	39.247924	38.509211	Olgun et al. (2015)

Supplementary Table 1 Continued. Presence data of the *Salamandra infraimmaculata* localities used in the model.

Locality	Latitude	Longitude	Reference
Aslantepe, Malatya	38.381928	38.361328	Baran and Öz (1994)
Gündüzbey Village, Malatya	38.278889	38.269444	Olgun et al. (2015)
Eskihalfeti, Şanlıurfa	37.239722	37.871666	Olgun et al. (2015)
Tağar Stream, Çemişgezek, Tunceli	39.064444	38.905278	Olgun et al. (2015)
Sütlüce, Tunceli	39.036944	39.165833	Olgun et al. (2015)
Gelinodaları, Pülümür, Tunceli	39.470112	39.906898	Olgun et al. (2015)
Soğuksu Village, Ergani, Diyarbakır	38.399089	39.656633	Olgun et al. (2015)
Sağırkaya, Hizan, Bitlis	37.991108	42.569625	Akman et al. (2018)
Alatepe Village, Ilıca, Bingöl	39.059281	40.756134	Çiçek et al. (2017)
Derinçay Village, Karlıova Bingöl	39.132289	40.824913	Çiçek et al. (2017)
Deliktaş, Bitlis	38.347686	42.041075	Akman et al. (2018)
Kösepınarı, Osmaniye	37.595694	36.155118	Unpub. data (Serkan Gül)

Supplementary Table 2. Definitions of the 19 WorldClim bioclimatic variables.

Variable	Definition
BIO1	Annual Mean Temperature
BIO2	Mean Diurnal Range (Mean of monthly (max temp - min temp))
BIO3	Isothermality (BIO2/BIO7) (×100)
BIO4	Temperature Seasonality (standard deviation ×100)
BIO5	Max Temperature of Warmest Month
BIO6	Min Temperature of Coldest Month
BIO7	Temperature Annual Range (BIO5-BIO6)
BIO8	Mean Temperature of Wettest Quarter
BIO9	Mean Temperature of Driest Quarter
BIO10	Mean Temperature of Warmest Quarter
BIO11	Mean Temperature of Coldest Quarter
BIO12	Annual Precipitation
BIO13	Precipitation of Wettest Month
BIO14	Precipitation of Driest Month
BIO15	Precipitation Seasonality (Coefficient of Variation)
BIO16	Precipitation of Wettest Quarter
BIO17	Precipitation of Driest Quarter
BIO18	Precipitation of Warmest Quarter
BIO19	Precipitation of Coldest Quarter

Supplementary Table 3. Performance of the 48 models created during the evaluation process for *Salamandra infraimmaculata*. The gray-shaded entry shows the settings chosen for the model. FC: Feature Classes, RM: Regularization Multiplier, AICc: corrected Akaike Information Criterion.

FC	RM	AICc
L	0.5	1091.86
LQ	0.5	1076.99
H	0.5	NA
LQH	0.5	NA
LQHP	0.5	NA
L	1	1087.92
LQ	1	1059.28
H	1	1383.18
LQH	1	1289.72
LQHP	1	1332.03
L	1.5	1088.85
LQ	1.5	1060.73
H	1.5	1087.01
LQH	1.5	1057.83
LQHP	1.5	1069.73

FC	RM	AICc
L	2	1094.35
LQ	2	1053.38
H	2	1078.45
LQH	2	1045.37
LQHP	2	1042.53
L	2.5	1090.27
LQ	2.5	1053.95
H	2.5	1067.06
LQH	2.5	1049.89
LQHP	2.5	1049.21
L	3	1091.14
LQ	3	1054.65
H	3	1061.92
LQH	3	1051.48
LQHP	3	1048.21

FC	RM	AICc
L	3.5	1095.11
LQ	3.5	1055.45
H	3.5	1065.6
LQH	3.5	1045.81
LQHP	3.5	1051.03
L	4	1096.62
LQ	4	1056.35
H	4	1055.19
LQH	**4**	**1040.85**
LQHP	4	1065.72
L	4.5	1101.69
LQ	4.5	1057.37
H	4.5	1058.83
LQH	4.5	1042.09
LQHP	4.5	1051.51