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Ecology of Kurdistan newt (*Neurergus microspilotus*: Salamandridae): Population and conservation with an appraisal of the potential impact of urbanization

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***Abstract.*—The Kurdistan newt, *Neurergus microspilotus* Nesterov, 1916, inhabits springs, ponds, brooks, streams, and wet caves in the western Iranian Plateau in both Iran and Iraq. The Iranian distribution of *N. microspilotus* is limited to Kurdistan and Kermanshah Provinces. Several major populations of *N. microspilotus* are threatened by urban development. We gathered autecological data of *N. microspilotus* and evaluated factors that may affect the distribution and abundance of this species. We conducted visual surveys for *N. microspilotus* at twelve localities across the north-western regions of Kermanshah Province from February to July 2012. The survey sites were classified as undeveloped or developed based on their proximity to urban or rural landscapes, and other anthropogenic disturbance and structures. We analyzed the effect of ecological factors, including water pH and specific conductance, temperature, peak of mating behavior, and the time of egg-laying. The daily air temperature of the study sites was provided by the weather bureau of Kermanshah Province. We investigated the correlation between daily maximum air temperature and *N. microspilotus* population density using Pearson Correlation Analysis, and analyzed the impact of urbanization on specific conductance and pH of habitat water and numbers of *N. microspilotus* according to Independent-Samples *t*-test. The densities of *N. microspilotus* across sites were positively correlated with increased water and daily maximum air temperatures. In addition, we found that densities of *N. microspilotus* at undeveloped sites were significantly higher than those of developed sites, whereas no relationship was recorded between specific conductance and pH of the water and urbanization.**

Key words. Kurdistan newt, *Neurergus microspilotus*, ecology, conservation, urbanization

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Introduction

Many species of amphibians globally have declined in abundance and range over recent decades (Collins and Storfer 2003; Stuart and Chanson 2004; Beebee and Griffiths 2005) and 30% of species are now threatened with extinction (IUCN 2010). Related causes of these declines and extinctions are habitat loss and fragmentation, unsustainable harvesting, environmental contaminants, increasing UV radiation, climate change, introduced predators, and emerging diseases (Young et al. 2001; Collins and Storfer 2003; Baillie et al. 2004). Urbanization is a substantial cause of habitat loss and fragmentation (McKinney 2002, 2006). Urbanization is a complex process characterized by increasing in human population density, which generates significant changes in the chemical, physical, and ecological conditions of affected areas, and specifically results in the creation of new assemblages of plants and animals, and possible alteration of the types and frequency of disturbance regimes (McDonnell and Pickett 1993; Kinzig and Grove 2001).

Urbanization alters hydrology through water extraction, the construction of impervious surface and increased runoff, increase sedimentation, and pollution of hydrological systems (Paul and Meyer 2001; Miltner et al. 2004), and through modifying soils (Effland and Pouyat 1997). Urbanization may also result in an increase in invasive plants and animals (Pickett et al. 2001; McKinney 2006), different climates between urban and surrounding rural areas (Grimm et al. 2008). Urbanization is therefore currently one of the most pervasive causes of natural ecosystem modification globally, and thus presents a major threat to biodiversity conservation (Czech et al. 2000; Miller and Hobbs 2002).

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Previous investigations indicated that the distribution of the Kurdistan newt, *Neurergus microspilotus*, is in the mid-Zagros range at the bordering regions of Iran and Iraq (Nesterov 1917; Schmidtler and Schmidtler 1975). Najafimajd and Kaya (2010) reported the first observation of *N. microspilotus* in west-Azarbaijan, Iran, however, molecular studies were not conducted on these specimens to confirm their claimed status. Major localities of *N. microspilotus* are found in both urban and rural areas some of which are centers for tourism (Sharifi et al. 2004; Rastegar-Pouyani et al. 2005; Rastegar-Pouyani 2006). In the present study, we investigated the relationships between presence and density of *N. microspilotus*, and the degree of urbanization, and analyzed factors that may affect this relationship including autecological data and water temperature.

Materials and methods

Study sites and survey techniques

The survey area is located in north-western regions of Kermanshah Province, western Iran, and surveys were conducted from February to July 2012. Twelve sites including a range of ponds, pools, brooks, and streams were selected for surveys. The selection of sites was based on our previous knowledge of these sites providing a consistent occurrence of *N. microspilotus*.

Sites investigated were Darian (35º08′ N 46º19′ E), Darre-Najjar (35º06′ N 46º19′ E), Deshe (35º04′ N 46º16′ E), Dorisan (35º11′ N 46º23′ E), Hajij (35º09′ N 46º19′ E), Kavat (34º53′ N 46º31′ E), Lashgargah (35º01′ N 46º08′ E), Nilan (35º09′ N 46º12′ E), Nodeshe (35º11′ N 46º14′ E), Noseme (35º00′ N 46º22′ E), Qholani (34º54′ N 46º27′ E), and Qhuri-Qhala (34º21′ N 46º30′ E) (See Table 1).

We categorized study sites into two categories; 1) Developed-sites placed at the center or vicinity of urban, rural, or tourism areas, and 2) Undeveloped-sites remote from urbanization with limited ecological change such as grazing.

The counting of *N. microspilotus* in the Kavat and Dorisan habitats begun on 08 March 2012 and, with weekly intervals, ended on 05 July 2012. *Neurergus microspilotus* were surveyed and counted through stream bank observation without substrate disturbance. The peak of mating behavior was recorded as the maximum amount of courting behavior, and the time of egg-laying through the observation of eggs in the water for the first time during the season.

Collection of habitat data

To assay the specific conductance and pH of water, water-sampling was performed on a 50 ml water sample from each site. A Jenway 3345 Ion Meter was used for determination of conductivity measurements. The pH of water was calculated via pH meter model Metrohm 827 pH lab equipped with a combined glass electrode, calibrated against two standard buffer solutions at pH 4.0 and 7.0 and used for monitoring of the pH values. The daily maximum air temperature of the study sites, over the period of the study, was provided by the weather bureau of Kermanshah Province (Table 3).

Statistical analysis

To statistically analyze the effect of urbanization on specific conductance and pH of water, and the population density of *N. microspilotus*, we subjected the data to Independent-Sample *t*-tests. To analyze the relationship between daily maximum air temperature and increasing populations of *N. microspilotus* subjected the data to

Table 1. Study site names and coordinates (North, East), *N. microspilotus* numbers (no.), water specific conductance (SC; µS cm^{-1}), and pH, natural (normal font) or developed (italic font) sites, and threats.

Sites	Coordinates	No.	SC	pH	Threats from development
Kavat	34º53′ N 46º31′ E	750	0.3	8.2	—
Qholani	34º54′ N 46º27′ E	79	0.4	7.8	—
Darre-Najjar	35º06′ N 46º19′ E	19	0.4	7.6	—
Darian	35º08′ N 46º19′ E	24	0.2	7.8	Fish aquaculture and gardening
Nilan	35º09′ N 46º12′ E	48	0.3	7.6	Gardeners in this suburban development, clearing the bottom of the pools of aquatic plants that provide shelter for eggs, larvae, juveniles, and adults
Hajij	35º09′ N 46º19′ E	7	0.3	7.4	Dam-construction in the Sirvan River, ecotourism, gardening
Noseme	35º00′ N 46º22′ E	5	0.3	7.2	Habitat degradation or loss through irrigation and domestic water usage, accumulation of rubbish in water, and home-construction in the village
Deshe	35º04′ N 46º16′ E	1	0.3	7.3	″
Dorisan	35º01′ N 46º23′ E	58	0.3	7.3	″
Nodeshe	35º11′ N 46º14′ E	30	0.3	7.5	Organic-pollution of water and gardening
Qhuri-Qhala	34º21′ N 46º30′ E	3	0.4	7.4	Major tourist destination. Accumulation of rubbish in the water and the manipulation of habitat through sanitation processes and cleaners in streams
Lashkargah	35º01′ N 46º08′ E	5	0.46	7.6	Many *N. microspilotus* are road fatalities

Table 2. Statistical analysis of the effect of urbanization on the specific conductance and pH of water and the number of *N. microspilotus*.

Variable	Developed habitats (*n* = 9) Mean ± SD	Undeveloped habitats (*n* = 3) Mean ± SD	t	df	*p*-value
Specific conductance	0.3 ± 0.1	0.48 ± 0.1	1.1	10	0.32
pH	7.5 ± 0.2	7.9 ± 0.3	2.9	10	0.02
Number	20.1 ± 21.3	299.7 ± 393.9	2.4	10	0.04

Pearson Correlation Analysis using the program SPSS (version 16 for Windows; SPSS Inc. Chicago, Illinois, USA). Data were considered statistically different at $P < 0.05$.

Results and discussion

Our results suggest that nine out of 12 localities of *N. microspilotus* from the populations were lowered by urbanization. These localities are Darian, Deshe, Dorisan, Hajij, Lashgargah, Nilan, Nodeshe, Noseme, and Qhuri-Qhala.

The Independent-Samples *t*-test revealed that developed/undeveloped sites do not have any difference in specific conductance ($p = 0.31$), but do in the water pH and number of newts ($p = 0.04$). Bowles et al. (2006) used specific conductance to investigate the effect of urbanization on water of habitats in *Eurycea tonkawae*, but our results indicate that specific conductance could not be used as a separator tool to measure the impact of urbanization on *N. microspilotus*. The resulting data of the specific conductance indicates that there is not much overlap between developed ($0.22 \leq X \leq 0.46$) and undeveloped sites ($0.27 \leq X \leq 0.44$). Instead, the analysis suggests that the pH is a better indicator ($p = 0.02$) of the effects of urbanization on *N. microspilotus* (in our studied populations) (Table 2).

The resulting data on the counting of the newt in the Kavat and Dorisan habitats, the temperature of the two synoptic stations, dates of observations and statistical assessment of correlation between maximum daily air temperature, and the number of *N. microspilotus* are presented in Table 3. The Pearson Correlation Analysis revealed that there is a strong association between the temperature and presence of individuals of two populations in Kavat and Dorisan (p-value = 0.919, $r = 0.000$; p-value = 0.812, $r = 0.000$, respectively).

According to the data, *N. microspilotus* adjusts its transition from torpor, and presence in the environment and mating behavior, at a time when food availability of insects and other invertebrates is maximum and the thickness of the forest canopy and leaves on the water surface provides the maximum shelter from predators (Table 3; Fig. 1a, b). At this time a maximal cover of aquatic vegetation provides the best environment for reproductive activities, the deposition of sperm, and egg attachment. In March and early April, the vegetative cover of the Kavat and Dorisan habitats is low. Habitat suitability for the reproduction of *N. microspilotus* within the Kavat and Dorisan habitats, as well as on Shahoo Mountain (northwestern Kermanshah Province), gradually reaches an optimum with the onset of increased moisture (from melting snow and spring rain) and temperature, with a peak in mid-June and early July (Fig. 1a, b).

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Table 3. The number of individuals of *N. microspilotus* and mean daily air temperature of Kavat and Dorisan sites.

Parameters	8 Mar	15 Mar	23 Mar	30 Mar	6 Apr	13 Apr	20 Apr	27 Apr	3 May	11 May	18 May	24 May	1 Jun	8 Jun	15 Jun	22 Jun	29 Jun	5 Jul	r	*p*-value
Numbers in Kavat habitat	4	11	20	39	55	59	81	95	100	130	230	370	410	500	590	690	750	710	0919	0.000
Mean temperature of Kavat habitat (ºC)	3.7	7.5	6.0	6.8	13.6	13.2	12.6	16.2	19.9	22.9	20.7	18.1	22.5	25.0	29.9	32.2	34.1	36.1		
Numbers in Dorisan habitat	0	0	0	1	1	6	5	6	10	13	20	32	33	49	54	55	58	31	0.812	0.000
Mean temperature of Dorisan habitat (ºC)	5.8	8.3	8.8	6.9	14.5	12.6	12.8	15.8	22.7	23.5	21.0	20.8	22.4	24.9	28.8	29.4	30.3	33.7		

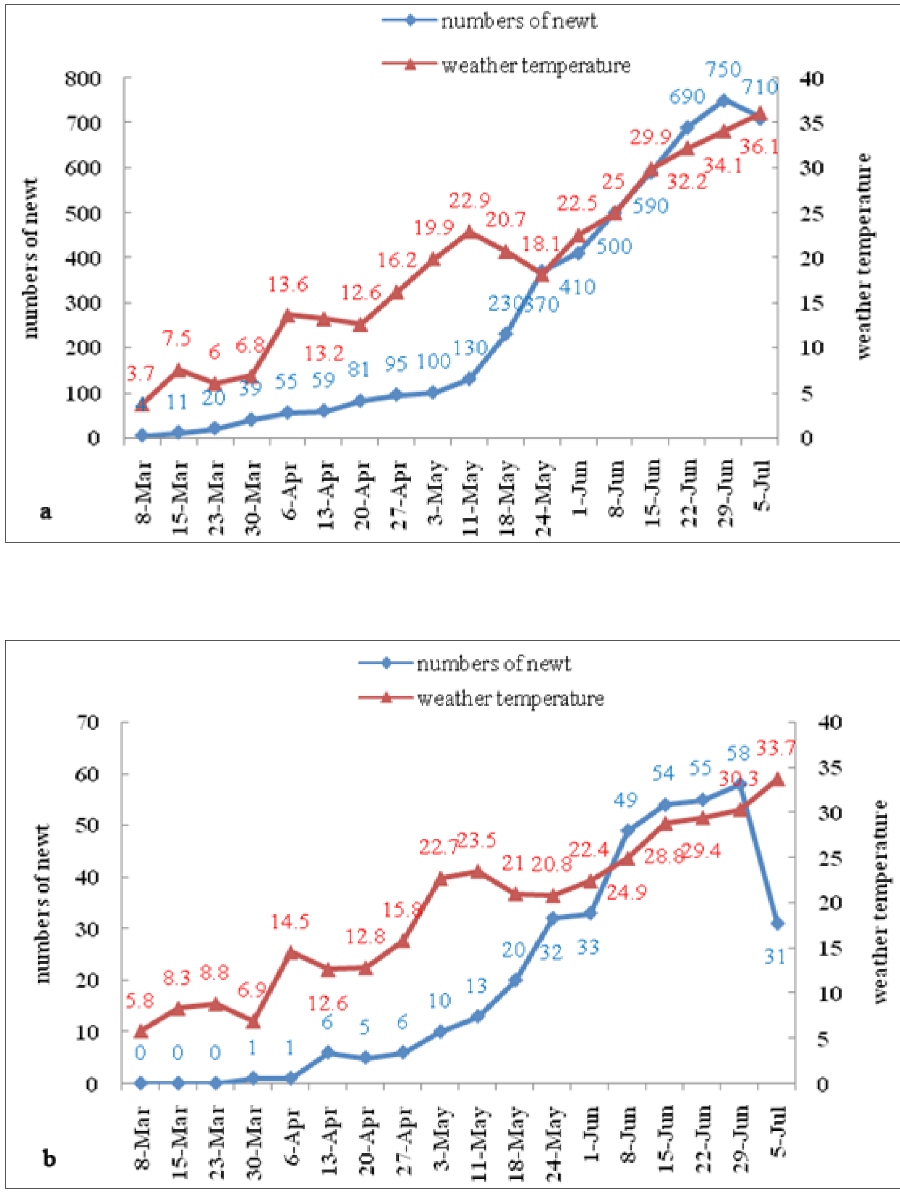

Figure 1a, b. The graphs of weather temperature (red) and number of newts (blue) in the Kavat (a) and Dorisan (b) habitats.

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