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DISTRIBUTION AND ABUNDANCE OF THE ENDANGERED YELLOW SPOTTED MOUNTAIN NEWT *NEURERGUS MICROSPILOTUS* (CAUDATA: SALAMANDRIDAE) IN WESTERN IRAN

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***Abstract*.—The endangered Yellow Spotted Mountain Newt, *Neurergus microspilotus*, occurs in highland streams of the Hawraman Mountains in western Iran, eastern Iraq, and possibly in southern Turkey. Until recently, *N. microspilotus* was known from 26 localities in a 3,974 km^2 area. We documented 16 new localities that increased the known distribution to 6,366 km^2. Most localities were breeding streams in a 205 km section of the Zagros Mountain Range along the shared border of Iran and Iraq. Terrestrial habitats adjacent to the streams ranged from tree-less floating meadows to dense oak woodlands. All breeding localities were high elevation (mean = 1,314 m above sea level [m.a.s.l.]; range: 630–2,057 m.a.s.l.) first-order streams. The mean nearest neighbor distances among the 42 localities was 7.95 km (range: 1.5–45 km). We surveyed 32 of the 42 localities within the Iranian range of the newts 1−4 times and counted 1,379 adult, juveniles, and larvae (mean/stream = 43; range, 1−601) in 5.5 km of stream reaches. Most of the observed newts (51%) were found in just two of the localities, 44% were found in 14 streams, and the remaining 5% were scattered among 16 streams.**

Key Words.—amphibian declines; locality data; minimum convex polygon; nearest neighbor distances; salamander; Zagros Mountain Range

INTRODUCTION

Global amphibian population declines are well documented (e.g., Wake 1991; Stuart et al. 2008). Several factors are suspected to cause these declines, including habitat loss and modification, introductions of non-indigenous species, over-harvesting, UV-B radiation, chemical contaminants, emerging infectious diseases, local and international trade, and climate change (Stuart et al. 2004; Hayes et al. 2010). Although most of these factors are associated with human intervention, amphibian declines, and extinctions have also been documented in many areas not obviously affected by habitat loss or other threats caused directly by humans (Davidson and Knapp 2007). Such unidentified processes threaten approximately 50% of rapidly declining amphibian species (Stuart et al. 2008). The uncertainty on the causes of declines and extinctions imply that mechanisms underlying amphibian declines are complex, and may be caused by several factors. Moreover, this demonstrates our lack of knowledge on the cause of declines, which can seriously impair our capacity to develop conservation actions to halt them (Bishop et al. 2012).

Because of high aridity, relatively few amphibian species occur in Iran (Kami and Baluch 1994). Twenty-five species have been reported, including 18 species of anurans (one species of *Pelobates*, 13 species of *Bufo*, one species of *Hyla*, and three species of *Rana*) and seven species of salamanders (two species of *Paradactylodon*, one species each of *Triturus* and *Salamandra*, and three species of *Neurergus*: *N. crocatus*, *N. microspilotus* and *N. kaiseri*; Kami and Baluch 1994). The two northern most species of *Neurergus*, *N. microspilotus* and *N. crocatus*, are similar in general appearance (Kami and Baluch 1994). Each species has dark-colored bodies containing bright yellow spots extending from the head to the tip of the tail on the dorsum, including the limbs, head, and flanks (Fig. 1). Traditionally, number and size of yellow spots have been used to distinguish species of *Neurergus* (Cope 1862; Nesterov 1916; Schmidtler and Schmidtler 1975; Najafimajd and Kaya 2010; Schneider and Schneider 2010). However, use of this feature in taxonomy has caused confusion because more than one species in Iran and neighboring Iraq have yellow spots (Schneider and Schneider 2010; Sharifi et al. 2013b). Currently, the Yellow Spotted Mountain Newt in Iran is classified as *N. microspilotus*.

Neurergus microspilotus is listed as Critically Endangered by the International Union for Conservation of Nature (IUCN, Red List criteria: A3cde+4cde; B2ab [iii, iv, v] ver. 3.1) because of its very small area of

FIGURE 1. Adult *Neurergus microspilotus* on the bank of Kavat stream in northern Kermanshah Province, Iran. Note the small yellow spots on the black body. (Photographed by Mozafar Sharifi).

occupancy (< 10 km^2), fragmented habitats, a continuing decline in the extent and quality of its stream habitat, reduced number of subpopulations and individuals associated with habitat degradation, drought, and over-collection of animals for both the national and international pet trade (Sharifi et al. 2009; IUCN 2014). The breeding habitat of *N. microspilotus* in the Zagros Mountain Range has been degraded recently by water pollution, water extraction, and severe droughts, which have led to the extirpation of some populations (Sharifi and Assadian 2004). Extraction of stream water for use in nearby orchards is also a major threat to this species (Sharifi et al. 2009, IUCN 2014). Our primary objective in this study is to determine the distribution and relative abundance of *N. microspilotus* at breeding sites in Iran and Iraq. We also suggest measures to help conserve this species.

MATERIALS AND METHODS

Study area.—Iran covers an area of approximately 1,600,000 km^2. Two-thirds of Iran is located in the Iranian Plateau, which is a part of a greater geographic unit extending from east of the Anatolian Plateau to the western edge of the Tibetan Plateau (Noroozi et al. 2007). The Iranian Basin is a large triangular depression flanked by the Elborz Mountains to the north and Zagros Mountain Range to the west, within which two large central deserts are located. Extreme topographical relief, diverse climatic conditions, and geographic position of the area between several geographic zones have resulted in high biodiversity (Wright et al. 1967). The Zagros Mountain Range acts as a barrier to incoming air masses from the west and receives precipitation based on the elevation and longitude. In general, the northern and western portions of the range receive considerably more precipitation than areas in the south and east. Much of the vegetative cover in the range of *N. microspilotus* has been converted into agricultural lands (Fig. 2). In southern parts of the distribution of the species in Kurdistan and Kermanshah Provinces, natural vegetative cover ranges from thin scrublands on steep rock outcrops to dense woodlands with diverse tree species (Fig. 2). In areas where soil is thick, an open oak-pistachio woodland may be present. These woodlands are dominated by Brant's Oak (*Quercus brantii)* and by two species of pistachio (*Pistachio vera* and *P. khonchic*). These tree species may play an important role in supporting primary production in the streams by exporting foliage to the benthic community of the highland streams where the

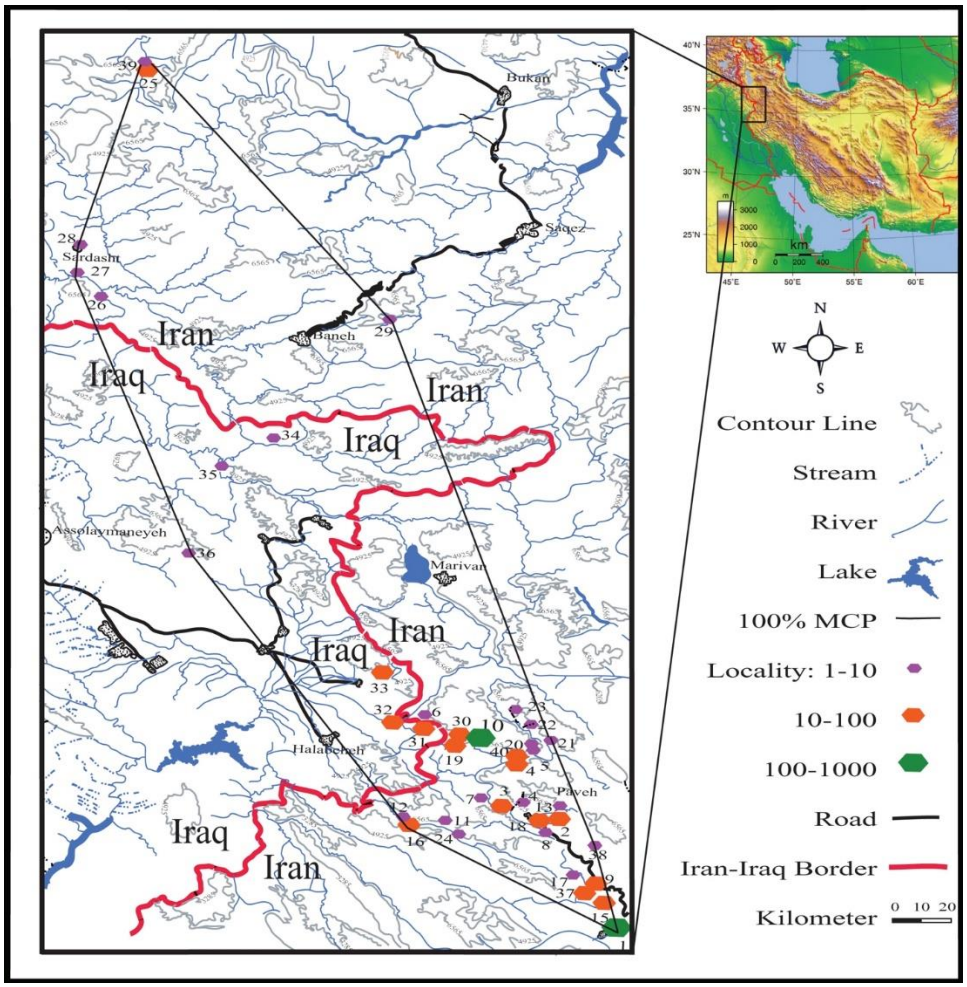

FIGURE 2. Distribution of *Neurergus microspilotus* in Iran and Iraq depicted by a minimum convex polygon encompassing all known localities for the newt. The locality numbers on the legend indicate the range of maximum visual counts obtained at the site.

macroinvertebrate community is the sole food source for *N. microspilotus* (Farasat and Sharifi 2014).

Sampling methods.—We searched for *N. microspilotus* in first-order streams, irrigation channels, and small ponds on 22 sampling dates during a three year period. We conducted 11 surveys during 2012 (one during April, three during each month of May, June, and July, and one during November), two surveys during 2013 (one during May and one during June), and nine surveys during 2014 (one during February, five during May, two during April, and one during March). All of the streams, ponds, and irrigation channels we surveyed were located in the western Zagros Mountain Range in the Kermanshah, Kurdistan, and West Azarbayejan Provinces in western Iran. At each site, we searched and counted adults, juveniles, and larvae in the stream and along the stream banks during daytime, usually between 1000 and 1600 h. At least two of the authors were present for each survey. We investigated crevices under loose rocks and in bedrock to locate sheltering animals. We also searched in tall grasses, sedges, and underneath rocks near the water edge. During early March, when the newts typically began to appear in the breeding streams, we focused primarily on the slow-flowing stream sections and stream-side pools. During May and June, when the stream discharge had decreased considerably, adults, post metamorphic individuals, and larvae were visible in the stream. During autumn very few newts remained in the streams.

We determined the geographic coordinates and elevation of each site using a Garmin global positioning system unit (GPSMAP 60CSx; Garmin International, Inc., New York, New York, USA). We used Google Earth (Google, Inc., Mountain View, California, USA) and ArcGIS 10.1 (ESRI, Redlands, California, USA) to

determine linear distances between localities and nearest neighborhood distances, and to calculate the area of the minimum convex polygon encompassing all localities where newts have been observed. We reported site coordinates at 0.1° precision to protect the species from poaching (Chapman and Grafton 2008). Furthermore, we included data from the literature for nine localities in Iraq.

RESULTS

We found 1,379 newts *N. microspilotus* in 32 of 51 localities surveyed in Iran. The localities inhabited by *N. microspilotus* included 29 first-order streams, two springs, and one manmade pool; additionally, some newts were found in irrigation channels located adjacent to first-order streams. Sixteen of the 32 localities were not known to be occupied by this species.

The distribution of *N. microspilotus* as indicated by the minimum convex polygon encompassing all sites increased to 6,366 km^2. The maximum linear distance of the distribution was 205 km (Fig. 2; locality 1 to 25), but we found newts in only 5.5 km of stream reach (Table 1). Furthermore, localities inhabited by the newts were separated from each other, with the nearest neighbour distances averaging 7.95 km (SD ± 1.5). Distances separating localities ranged from 1.5 km between Selein and Jivar streams in Kurdistan Province to 43 km between Benjun and Baskedo streams in West Azerbaijan Province. The number of newts we observed among the 32 Iranian sites ranged from one to 601 individuals (Table 1). All localities occurred along the mid-Zagros Mountain Range at an average elevation of 1,314 ± 327 m above sea level (masl; range: 630–2,057 masl).

Most localities inhabited by *N. microspilotus* were located in the southern portion of the geographic range (Fig. 2), with approximately 81% of the *N. microspilotus* localities in Iran and 19% in Iraq. However, 40.5% (n = 9) of the Iraqi localities were at or near the border with Iran (within about 10 km of the border; Fig. 2). The largest populations, based on abundance, occurred in the southern section of the range of the species (Kavat, Gholani, Ghorighaleh, Dorisan, and Khangah; Table 1; Fig. 3). Average (± SD) nearest neighbor distance between localities in the southern section of the Kermanshah Province (3.2 ± 1.8 km) was significantly smaller than this distance in the both northern section (14.9 ± 18.5 km) and Iraq (10.2 ± 10.2 km).

DISCUSSION

Despite the additional 16 localities documented for *N. microspilotus* in the current study, the number of known localities (n = 42), and total number of individuals observed (n = 1,379) remains small. In addition, connectivity of distinct populations of *N. microspilotus*, as defined by possible dispersal or gene flow between the individuals of different breeding streams, is unknown. In nearly 53% of streams surveyed, fewer than 10 individuals have been found and in 53% of occupied streams lack records of either breeding or development through metamorphosis. Furthermore, information on movement patterns, including migration among the breeding streams, is scarce. The home range of *N. microspilotus* in the Kavat Stream in western Iran is estimated to be 230 m^2 during the breeding season when the newts live exclusively in the water (Sharifi and Afroosheh 2014). Sharifi and Afroosheh (2014) found that average minimum distance covered by recaptured individuals was 49.19 ± 71.75 m. Although these data show that *N. microspilotus* has high fidelity to its aquatic environment, there is no evidence showing fidelity to either terrestrial foraging grounds or to overwintering habitats.

All breeding streams reported in the current study occurred at elevations between 630 and 2,057 masl where oak open woodland and other vegetation, such as deciduous dwarf-scrublands, amygdales scrublands, and cushion shrub land, potentially grow (Khalyani et al. 2012). However, the Zagros forests of western Iran have a long history of use and also exploitation, in addition to cycles of forest expansion and contraction as the result of fluctuating climate during the Pleistocene. These factors have resulted in dramatic changes in both the amount and structure of forest cover (Khalyani et al. 2012). The Zagros oak forests in western Iran have been used for livestock breeding, grazing, and agriculture since the beginning of the 5th Millennium BP (Wright et al. 1967; Djamali et al. 2009). Traditional livestock grazing and disturbance coupled with recent population growth are the driving factors that have lead to deforestation or changes in the vertical structure, composition, and configuration of forests in the Zagros Mountain Range (Metzger et al. 2005). There are various habitat types that can be considered as the remnants of formerly widespread and open woodlands that are currently present only in the southern part of the geographic range of *N. microspilotus*. The few remaining populations of *N. microspilotus* in the northern part of its distribution in Benjun, Razgeh, and Saqez are located in areas that presumably lost their natural vegetation cover decades ago, including flooding meadows, agricultural lands, rangelands, and orchards.

Aquatic habitats used by *N. microspilotus* vary greatly in terms of water discharge and hydroperiod. Streams such as Kavat, Gholani, Ghorighaleh, Dorisan, Slamash, Khangah, and Hani Garmaleh have very high discharge, with some exceeding an average annual discharge of 625.7 L/s (Sharifi and Assadian 2004). These large streams are also targeted by farmers for expanding their horticulture by redirecting water flow toward their cultivations. In these larger streams, newts can be found in the stream fringes and irrigation channels far away from strong water currents and in rapid riffles. Many of

TABLE 1. First-order streams inhabited by the Yellow Spotted Mountain Newt (*Neurergus microspilotus*). Abbreviations are SL = stream length, NR = length of stream along which we observed newts, TH = terrestrial habitat adjacent to stream, SV = number of site visitations, and n = number of adult, juvenile, and larval newts found. In streams that we visited more than once, the number of individuals reported is the maximum number among the visits. Habitat types are orchards (O), open woodland (OW), mixed orchard and woodland (M), scrubland (S), grassland (G), and farmland (F). An asterisk (*) is a new locality.

Stream	Latitude, Longitude	Elevation	SL (km)	NR (m)	TH	SV	n	Reference
1 Kavat	34°52'N,46°30'E	1550	10	700	M	4	601	3, 6, 7
2 Dourisan	35°01'N,46°23'E	1600	2.5	600	O	4	70	2, 3, 7
3 Najjar	35°05'N,46°18'E	900	3.12	300	F	2	50	3, 7
4 Darian	35°08'N,46°19'E	1000	3.05	20	M	2	24	3, 7
5 Hajij	35°10'N,46°21'E	950	1.14	20	O	1	7	7
6 Nowsood*	35°10'N,46°12'E	1300	3.5	60	M	1	1	6
7 Deshe	35°04'N,46°16'E	1000	3.80	90	M	1	1	7
8 Nosme	35°00'N,46°22'E	1500	11.76	40	O	1	6	7
9 Gholani	34°54'N,46°27'E	1350	2	500	OW	2	80	7
10 Nowdeshe	35°11'N,46°14'E	1250	2.7	400	O	1	100	7
11 Shamshir	35°02'N,46°11'E	1800	11.76	40	O	1	1	3, 7
12 Marrakhil	35°01'N,46°08'E	950	19	50	OW	1	1	3, 7
13 Pave	35°03'N,46°24'E	1900	1.56	20	S	1	2	3, 7
14 Mirabad*	35°03'N,46°20'E	1450	1.75	60	M	1	1	3, 7
15 Ghorighale	34°52'N,46°29'E	1600	5.06	300	M	1	30	2, 3, 7
16 Lashkargah	35°00'N,46°08'E	1010	0.001	300	OW	1	10	7
17 Shahoo*	34°55'N,46°28'E	1663	0.26	4	M	1	4	7
18 Khangah*	35°01'N,46°20'E	1010	3.14	100	OW	1	20	7
19 Hani Garmale*	35°14'N,46°08'E	1272	14	400	O	1	50	7
20 Naav*	35°10'N,46°21'E	1100	1.67	10	O	1	6	7
21 Novin*	35°11'N,46°21'E	1278	0.005	3	O	1	7	7
22 Selein*	35°13'N,46°19'E	891	1.08	3	O	1	8	7
23 Jivar*	35°13'N,46°19'E	1070	1.07	10	O	1	7	7
24 Bayangan*	34°59'N,46°13'E	997	19	300	M	2	6	7
25 Benjun*	36°32'N,45°31'E	1883	7.04	400	M	1	50	7
26 Razgeh*	36°03'N,45°31'E	1141	2.12	5	O	1	3	7
27 Shalmash*	36°05'N,45°29'E	1125	3.40	50	OW	1	50	7
28 Baskedo*	36°09'N,45°29'E	1332	0.005	5	O	1	50	7
29 Saqez*	36°03'N,46°02'E	2057	5.79	500	F	1	70	7
30 Tawale	35°11'N,46°11'E	1400	----	5	-	---	24	1, 5
31 Balkha	35°12'N,46°09'E	1513	----	----	-	---	16	1, 5
32 Ahmadawa	35°18'N,46°04'E	630	----	----	-	---	----	5
33 Biyara	35°13'N,46°07'E	1100	----	----	-	---	----	5
34 Gola	35°47'N,45°50'E	1300	----	----	-	---	----	5
35 Garmik	35°43'N,45°46'E	1270	----	----	-	---	----	5
36 Basak	35°33'N,45°43'E	1287	----	----	-	---	----	5
37 Upper Gholani	34°54'N,46°27'E	1380	----	20	OW	1	10	7
38 Zali*	34°59'N,46°28'E	1630	----	20	M	1	5	7
39 Benjun	36°33'N,45°31'E	1833	0.005	5	G	1	5	4
40 Nilan	35°09'N,46°19'E	----	2.97	50	M	1	48	7
41 Penjwin	35°36'N,45°58'E	----	----	----	-	---	20	5
42 Siyah Guvez	35°47'N,45°47'E	----	----	----	-	---	10	5
Total			145	5,390			1,379	

1) Nestrov 1916; 2) Schmidtler and Schmidtler 1975; 3) Sharifi and Assadian 2004; 4) Najafimajd and Kaya 2010; 5) Schneider and Schneider 2010; 6) Naderi 2012; 7) current study.

the sites surveyed in this study were significantly disturbed as a result of various manipulations in land use practice, water pollution, or other construction and roads. For instance, the stream originating from Ghorighaleh Cave was the first reported site for *N. microspilotus* from Iran (Schmidtler and Schmidtler 1975). This stream has deteriorated because of commerical caving activities at this site. The impact of various activities

FIGURE 3. A) A mature open woodland that contained at least four separate streams and springs (Lashkargah, Marekhil, Khangah, Bayangan) with *Neurergus microspilotus*, B) Irrigation canals that contained *N. microspilotus* in many habitats (Nosme, Kavat, Selein, Novin, Jivar), C) Gholani Stream that contained a substantial number of *N. microspilotus*, D) Shalmash Fall in the northern Zagros Range divides *N. microspilotus* habitat, E) A flooding meadow in the northernmost range of *N. microspilotus* distribution (Benjun, Saqez), and F) Kavat Stream that contained the largest population of *N. microspilotus*. (Photographed by Mohadeseh Afroosheh).

associated with commercialization of the cave likely has extirpated the formerly sizable population of *N. microspilotus* (Sharifi and Assadian 2004).

The extent of occurrence (EOO) of *N. microspilotus* encompassing all sites increased from 3,974 km^2 for the original 24 localities reported by Schmidtler and Schmidtler (1975) and Sharifi and Assadian (2004) to 6,366 km^2 for all 42 localities reported in the current study. The EOO of *N. microspilotus* in Iran and Iraq is considerably larger than that of *N. kaiseri* (another rarely encountered newt) with an MCP of 789 km^2 for 12 known localities (Sharifi et al. 2013a). However, this polygon is positioned obliquely along the western edge of the Zagros Mountain Range with elevations ranging from 630 to 2,057 masl. This distribution includes inhospitable intervening terrain and suggests that newt populations at

many of the sites may be isolated from one another. Although some salamander species may disperse up to 1 km (Bar-David et al. 2007; Schulte et al. 2007; Ousterhout and Liebgold 2010), the average nearest neighbour distances for *N. microspilotus* is 7.95 km (range: 1.5–45 km). Thus, potential connectivity in mountain systems where *N. microspilotus* is known to occur in northern and southern portion of the species range is markedly different. Average minimum neighbor distances among breeding streams in the northern part of the distribution (Iraq and Kurdistan and western Azerbaijan Provinces in Iran) are 11.3 km (range: 1.5–42.6 km), but only 3.16 km (range: 1.5–7.3 km) in the southern part of the range.

As with other amphibian species (Alford and Richards 1999), the question of whether isolated populations of *N. microspilotus* form a metapopulation is a relevant question and can be linked to the conservation and management of the species. Conditions necessary to demonstrate the existence of a metapopulation (e.g., Hanski et al. 1995; Hanski 1999) include the support of the habitat to local breeding populations, inability for any single population to ensure long-term survival of the species, reasonable connectivity between habitats, and finally the improbability of simultaneous extinction of all local populations because of non-heterogenosity of local environmental conditions (Smith and Green 2005).

The discovery of 16 new populations of *N. microspilotus* on various catchments of the Zagros Mountain Range in Kurdistan and Azarbayejan is not entirely unexpected: Sharifi and Assadian (2004) anticipated the discovery of new populations. Nevertheless, these discoveries represent a major extension of the known distribution of this species and contributes significantly to its overall conservation. Detection of extremely low numbers of adults or larvae in many breeding streams suggests that the overall population size is still very low. However, because of the presence of other potentially suitable streams, *N. microspilotus* may occur in additional localities.

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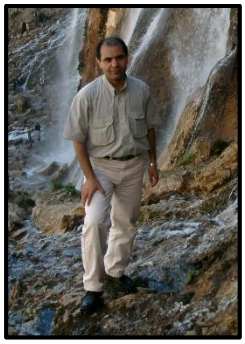

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