

# Studying migratory activity and home range of adult *Neurergus microspilotus* (NESTEROV, 1916) in the Kavat Stream, western Iran, using photographic identification (Caudata: Salamandridae)

Untersuchungen von Aktivitätsraum und Wanderverhalten adulter *Neurergus microspilotus* (NESTEROV, 1916) im Kavat Fluß (Westiran) mittels fotogestützter Individualerkennung  
(Caudata: Salamandridae)

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## KURZFASSUNG

Photographische Identifikation ist ein nützliches, nicht-invasives Instrument zur individuellen Erkennung und damit zum Studium von Aktivität und Populationsparametern. In Anwendung dieser Technik unterschieden die Autoren eine Saison hindurch (1. April - 6. Juli 2011) adulte *Neurergus microspilotus* (NESTEROV, 1916) aus dem Kavat Fluß (Zagros Gebirge, Westiran) individuell anhand ihres gelben Fleckenmusters. Insgesamt wurden 150 Molche gefangen und fotografiert. An drei nachfolgenden Tagen (11. Mai, 24. Mai, 6. Juli) wurden insgesamt 21 (14 %) dieser photographisch markierten Tiere zumindest einmal, in drei Fällen mehrmals wiedergefangen. Im Mittel betrug der zwischen Fang und Wiederfang von den Molchen zurückgelegte Weg mindestens  $49.19 \pm 71.75$  m. Diese Zahl charakterisiert den Aktivitätsraum von *N. microspilotus* in der Fortpflanzungsperiode, welche die Molche ausschließlich im Gewässer zubringen. Aus zwei Mehrfach-Wiedergefangen innerhalb von vier Monaten ergab sich eine mittlere Größe des Aktivitätsraumes von  $230 \text{ m}^2$ . Die vorliegenden Daten legen nahe, daß adulte *N. microspilotus* in bezug auf den aquatischen Lebensraum mäßig standorttreu sind. Mit Fortschreiten des Jahres nahm die Wasserführung des Flusses ab. Stromauf photographierte Individuen wurden dann häufig weiter stromab wiedergefangen.

## ABSTRACT

Photographic identification is an important non-invasive tool for individual recognition and the study of activity and population characteristics. Applying this technique, the authors used the pattern of yellow spots to distinguish adult individuals of *Neurergus microspilotus* (NESTEROV, 1916) of the Kavat Stream (Zagros Mountains, west Iran) within one season (April 1 - July 6, 2011). A total of 150 newts were captured and photographed. On three occasions (May 11, May 24, July 6), twenty one (14 %) of the marked individuals were recaptured at least once and in three cases multiple times. Average minimum distance covered by recaptured individuals was  $49.19 \pm 71.75$  m. This value indicates the home range of *N. microspilotus* during the breeding season when the newts live exclusively in the water. Average home range size was estimated to be  $230 \text{ m}^2$  based on two recapture events over four months. The data suggests that adult *N. microspilotus* display moderate site fidelity in the aquatic habitat. As the season advanced and the water discharge decreased, individuals captured in the headwaters were frequently recaptured downstream.

## KEY WORDS

Amphibia: Caudata: Salamandridae; *Neurergus microspilotus*, home range, migratory behavior, ecology, hydroperiod, photographic identification method, capture-recapture method, Zagros Mountains, Iran

## INTRODUCTION

Studies on urodelan activity pattern are rare, in particular with regard to home range which reportedly varies between  $1 \text{ m}^2$  in *Plethodon cinereus* (Green, 1818) and  $1 \text{ km}^2$  in *Salamandra inframaculata* (MARTENS, 1885) (LANGTON et al. 2001; GRAETER 2005; LANNOO 2005; SCHULTE et al. 2008; BAR-DAVID et al. 2007; OUSTERHOUT & LIEBGOLD 2010). No information is available on the

home range of species of the genus *Neurergus*.

The genus *Neurergus* encompasses four species including *N. crocatus* SCHMIDT, 1952, from northwestern Iran, northeastern Iraq and southeastern Turkey, *N. strauchii* (STEINDACHNER, 1887) from eastern Turkey, *N. microspilotus* (NESTEROV, 1916) from western Iran and Iraq, and *N. kaiseri*

SCHMIDT, 1952 from the southern Zagros Mountains in Lorestan, Province in southern Iran. According to IUCN criteria, *Neurergus microspilotus* is listed as a critically endangered species because of its small range of less than 10 km<sup>2</sup>, and a continuing decline in the extent and quality of its stream habitat. Moreover, the small number of subpopulations as a result of habitat degradation, climate change and over-collecting for both the national and international pet trades are other factors that affect the conservation status of this species (SHARIFI et al. 2009). Habitat loss through diversion of streams for irrigation is probably the most important factor that threatens the species in its Iranian range (SHARIFI & ASSADIAN 2004).

Species of the genus *Neurergus* breed in highland first order streams and forage and hibernate in terrestrial habitats (SHARIFI & ASSADIAN 2004). The biphasic life cycle of adults is characterized by annual migration between aquatic breeding habitats and terrestrial foraging, estivating and hibernating habitats. Almost no information is available about the terrestrial life of *N. microspilotus* during the hot and dry period in late summer and the long, cold and wet autumn and winter periods. The breeding season starts with the spring migration of reproductive adults towards the breeding site and is characterized by the display of a conspicuous sexual behavior including courtship, competition for mates, spermateca deposition and uptake and egg laying, followed by the offsprings' larval development and metamorphosis (SHARIFI & ASSADIAN 2005).

The Kavat Stream (34°52'N, 046°30'E), a well known habitat for *N. microspilotus*, is a relatively long stream with a high discharge level of 625.7 L/s (SHARIFI & ASSADIAN 2004). The water course is locat-

ed in an area of little disturbed open woodland, low-intensity agriculture and an established horticulture (walnuts, mulberry, raspberry and other fruit trees). Other amphibian species found in the Kavat Stream include *Bufo bufo* (LINNAEUS, 1758) and *Pelodytes punctatus* (PALLAS, 1771) (authors' pers. obs.). The horticultural activities rely on an extensive system of terraces, supported by stone walls and the diversion of water from the main stream. A large and permanent karst spring feeds the stream. In early spring, water from subterranean seepages around the stream can feed several parallel shallow streams. The recorded water temperatures during the study period ranged from 11 to 14 °C. As an indicator of cold-temperate climate appropriate for the yellow-spotted Kurdistan Newt, various species of mosses are present as a part of benthic, epilithic and or epipelic vegetation cover. Terrestrial habitats around streams where *N. microspilotus* is seen include diverse community types known as oak-pistachio open woodlands dominated by *Quercus brantii* and *Pistacia* spp. This open woodland grows on various soil types including deep sandy loam soils at the bottom of valleys or gravelly soils at the slopes of steep valleys.

Site fidelity of adult *N. microspilotus* was tested by measuring the individuals' movements during four months of their spring aquatic activity period. The authors hypothesized that if adult individuals displayed strong site fidelity as was shown for other mountain newt species, then the distance covered across time should quickly approach an asymptotic curve. Home range sizes were planned to be estimated from the distances covered by individuals that were recaptured several times.

## MATERIALS AND METHODS

The distribution (viz. number and circularity) of the yellow spots on head and shoulders of *N. microspilotus* was used for individual recognition of recaptured individuals when compared with photographs of individuals captured and released before. Spots on head and shoulders of this species are highly polymorphic and allow visual

alignment with high accuracy by experienced observers. True/false recognition tests in which live newts were compared with 67 photographs taken from these newts showed that this matching process achieved a mean success rate of 93-100 % for both experienced and un-experienced observers, and reached up to 99.5 % suc-

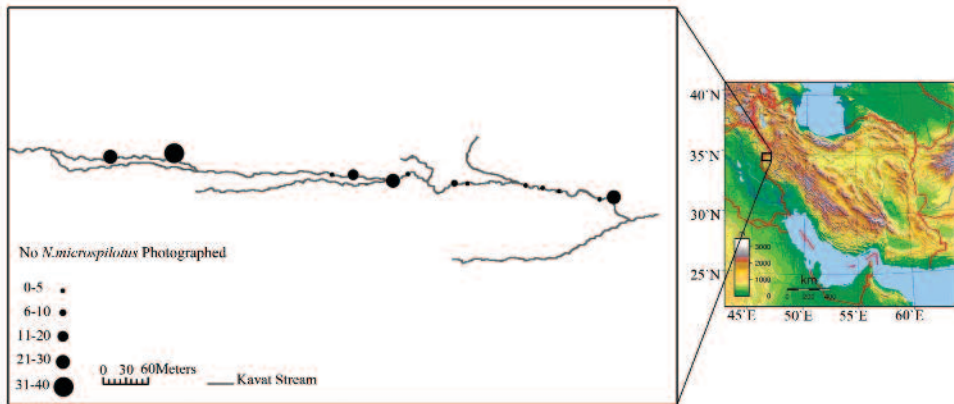


Fig. 1: Sites at the Kavat Stream, Zagros Mountains, western Iran, where the migratory movement pattern of the aquatic phase of *Neuregus microspilotus* (NESTEROV, 1916) was studied and photographs taken.

Abb. 1: Gebiete am Kavat Fluß (Zagros Gebirge, Westiran), wo das Wanderverhalten der aquatischen Phase von *Neuregus microspilotus* (NESTEROV, 1916) untersucht wurde und die Photodokumentation der Individuen erfolgte.

cess rate for experienced observers (SHARIFI et al. 2013).

For the present study, which was conducted in 2011 in the upper reaches of the Kavat Stream, Zagros Mountains, western Iran (34°52'N, 046°30'E) newts were collected and photographed at four occasions on 1 April (150 individuals), 11 May (135 individuals), 24 May (272 individuals) and 6 July (15 individuals) (Fig. 1). The specimens caught on 1 April were considered as marked and those caught in 11 May, 24 May and 6 July were considered as recaptured if they were identified as captured on April 1st. The newts were caught by hand and put in wet cotton pouches. Geographic coordinates (degrees/minutes/seconds) were recorded using a GPD (Garmin 60CSx).

The specimens were photographed on a blue colored plate using a digital camera (Sony DSC-HX9V) mounted on a tripod at a constant height (25 cm) and released at their collecting sites immediately thereafter. At the computer, parts of the pictures not subject to visual alignment were removed using the image processing software Photoshop CS5.1. The coordinates of the captured newts were entered on a digital map of the Kavat Stream and used to draw polygons illustrating the newts' individual movements and home ranges employing ArcGIS. An estimate of the seasonal home range was calculated for three individuals, which were captured three times each. The first capture locality was defined as the home reference position.

## RESULTS

Twenty one (corresponding to 14 %) of 150 initially captured and photographed individuals were recaptured and recognized once or more than once. Three *N. microspilotus* (corresponding to 2 %) of these newts were recaptured two times. The proportion of non-recaptured individuals was 86 % cor-

responding to 129 individuals of 150 specimens (Table 1). The monthly linear distances from their reference positions of the 21 monitored adult *N. microspilotus* increased significantly as time between capture and recapture increased (Spearman rank correlation  $rs = 1$ ,  $P < 0.01$ ,  $n = 5$ ). In

Table 1: Descriptive statistics of distances (m) covered by 21 *Neurergus microspilotus* (NESTEROV, 1916), recaptured on three occasions following the initial capture and release of 150 individuals on 1 April.

Tab. 1: Beschreibende Statistiken der zurückgelegten Entfernungen (m) von 21 *Neurergus microspilotus* (NESTEROV, 1916), die an drei Tagen nach dem vorausgegangenen Fang und der Freilassung von 150 Individuen am 1. April wiedergefangen wurden.

Date Datum	No of captures Anzahl Fänge	No of recaptures Anzahl Wiederfänge	Distance / Entfernung			
			Minimum	Maximum	Mean / Mittelwert	SD / Standardabweichung
1 April	150	-	-	-	-	-
11 May	135	11	6.01	37.93	23.14	9.28
24 May	272	9	15.81	333.79	77.11	103.91
6 July	15	1	84.44	84.44	-	-

the first recapture event on May 11, the average moving distance of 11 individuals was  $23.15 \pm 9.29$  m (range: 6.01 - 37.93 m). At the time of the second recapture procedure on May 24, nine newts had moved  $77.11 \pm 34.64$  m (range: 15.81 - 333.79 m) since their capture in April. The longest distance covered between first and last capture event (period: 1 April - 6 July) was 84.44 m (Table 1). The overall, average linear distance moved by 21 individuals was  $49.19 \pm 71.75$  m.

Aquatic home range size, the area of plotted movement (triangular convex polygons) estimated for three recaptured adults, was calculated as 574.37 m<sup>2</sup>, 74.04 m<sup>2</sup> and 38.02 m<sup>2</sup> with an average of about 230 m<sup>2</sup> (Table 2). The movements of the specimens recaptured during the study period were directed downstream where small pools formed habitats to overcome temporary drought.

## DISCUSSION

Since studies on activity pattern and home range of *N. microspilotus*, and other species of the genus *Neurergus*, are virtually lacking, findings of this study are compared with those of other newts and salamanders. The present study used the approach by BONATO & FRACASSO (2003) applied to a population of *Salamandra atra aurorae* TREVISAN, 1982. In this study an increase in the distances moved over time was taken as evidence for a tendency to disperse, whereas strong site

fidelity to a limited spatial area is indicated by stagnating movement distances over time. Studies of urodelen seasonal activity in the species *Triturus cristatus* (LAURENTI, 1768) by LONGTON et al. (2001), *Salamandra salamandra* (LINNAEUS, 1758) by SCHULTE et al. (2007), *Plethodon cinereus* (GREEN, 1818) by OUSTERHOUT & LIEBGOLD (2010), *Salamandra inframaculata* (MARTENS, 1885) by BAR-DAVID et al. (2007) and *Ambystoma talpoideum* (HOLBROOK, 1838) by LANNON (2005)

Table 2: Size (m<sup>2</sup>) of the aquatic home range (HR) resulting from the positions taken by three adult individuals of *Neurergus microspilotus* (NESTEROV, 1916) on three occasions in spring 2011.

Tab. 2: Größe des aquatischen Aktionsraumes (m<sup>2</sup>) auf Grundlage der Aufenthaltsorte dreier adulter Individuen von *Neurergus microspilotus* (NESTEROV, 1916) bei drei Beobachtungen im Frühjahr 2011.

Specimen No. / Exemplar Nr.	Number and dates of sighting / Beobachtungszahlen und -daten	HR (m <sup>2</sup> )	Period of observation (days) / Beobachtungsdauer (Tage)
1	3 (1 April, 11 May, 24 May)	574.37	54
2	3 (1 April, 11 May, 24 May)	76.04	54
3	3 (1 April, 11 May, 24 May)	38.02	54

Table 3: Comparative data from the literature on size estimates of the home range of adult caudate amphibians.

Tab. 3: Vergleichende Schätzgrößen aus der Literatur zum Aktionsraum von adulten Schwanzlurchen.

Species / Art	Size / Größe (m <sup>2</sup> )	Source / Quelle
<i>Salamandra infraimmaculata</i> (MARTENS, 1885)	1100-1300 m *)	BAR-DAVID et al. (2007)
<i>Salamandra lanzai</i> NASCETTI et al., 1988	16-98	RIBERON & MIAUD (2000)
<i>Salamandra salamandra</i> (LINNAEUS, 1758)	494	SCHULTE et al. (2007)
<i>Triturus cristatus</i> (LAURENTI, 1768)	250	LANGTON et al. (2001)
<i>Ambystoma talpoideum</i> (HOLBROOK, 1838)	3.61 - 5.29	LANNOO (2005)
<i>Plethodon cinereus</i> (GREEN, 1818)	1	OUSTERHOUT & LIEBGOLD (2010)

\*) Linear distance from breeding site / Entfernung vom Laichplatz.

revealed a rather wide spectrum of home range sizes (Table 3).

*Neurergus microspilotus* of the Kavat Stream showed comparatively small aquatic home ranges. Data suggests that the newts display strong site fidelity as only few individuals established larger home ranges. This is supported by the estimated mean home range size of 230 m<sup>2</sup> (Table 3).

The hydroperiod of a stream (the length of time and portion of year the stream holds water) defines which amphibian species can breed successfully in its waters. In this way the hydroperiod determines not only the maximum duration of larval development but also the number and types of predators to which they are exposed (TARR & BABBITT 2010). The Kavat Stream is a permanent stream that receives its main inflow from a cave spring (Kavat Cave). Long term average of water discharge in this stream segment is 625.7 L/s in spring (May); however, depending on annual precipitation there are high fluctuations around this average value (SHARIFI & ASSADIAN

2004). In the periods of highest discharge, seepages can feed parallel shallow streams, some of which are hidden under dense vegetation.

An important factor that may cause high fidelity to the aquatic habitat in *N. microspilotus* is the consistent availability of aquatic food items during spring and summer when the otherwise terrestrial newts reside in the highland streams. SHARIFI & FARASAT (2013) provided data on the benthic macroinvertebrate fauna from stomach contents regurgitated by newts of the Kavat Stream in April and May. They found that the newts rely almost exclusively on aquatic taxa including Corbiculidae (23.72 %), Baetidae (19.04 %), Mycetophilidae (11.82 %), Gammaridae (9.12 %), Hydropsychidae (4.7 %) and Lumbricidae (4.27 %). A similar aquatic feeding regime was reported for the Lycian Salamander *Lyciasalamandra luschani* (STEINDACHNER, 1891) in southern Turkey. Also, DÜŞEN et al. (2004) showed that this latter mountain newts prey mostly on aquatic Coleoptera.

#### ACKNOWLEDGMENTS

The authors thank the organizations that supported this study, in particular the Iran National Science Foundation (Project No. 91057277) and the Razi University (Kermanshah) which financially sup-

ported this study as a part of a PhD research project. The authors are also grateful to the help provided by Hossein FARASAT, Somayeh VASSI and Abuzar YUSEFI during the fieldwork.

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DATE OF SUBMISSION: June 17, 2013

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