

On the ecology of *Salamandra lanzai*
NASCETTI, ANDREONE, CAPULA & BULLINI, 1988.
Number and movement of individuals, and influence of
climate on activity in a population of the upper Po Valley
(Caudata: Salamandridae)

Zur Ökologie von *Salamandra lanzai* NASCETTI, ANDREONE, CAPULA & BULLINI, 1988.
Individuenzahl, Wanderverhalten und der Witterungseinfluß auf die Aktivität
bei einer Population aus dem oberen Po-Tal
(Caudata: Salamandridae)

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KURZFASSUNG

In den Jahren 1992 (Juni und September) und 1993 (Juli) untersuchten wir eine Population von *Salamandra lanzai* NASCETTI, ANDREONE, CAPULA & BULLINI, 1988 in the Kottischen Alpen (NW Italien) in einem etwa 16.000 m² großen Mooregebiet auf 2.020 m Seehöhe. Die ermittelte Populationsgröße (Fang-Wiederfang-Methode, Individualerkennung durch Zehenamputation) betrug 479 ± 77 Tiere (Männchen: 43,5%, Weibchen 49,8%, Jungtiere 6,7%). Die zwischen Fang und Wiederfang ermittelten Entfernungen weisen *S. lanzai* als eine ziemlich standorttreue Art aus. Die mittlere Entfernung (innerhalb 0 bis 16 Tagen) lag bei $4,70 \pm 6,02$ m (Männchen) und $5,90 \pm 6,82$ m (Weibchen). Die mittlere Geschwindigkeit des Standortwechsels $2,63 \pm 4,69$ m/Tag (Männchen) und $1,74 \pm 2,35$ m/Tag (Weibchen). Die Unterschiede zwischen den Geschlechtern sind dabei nicht signifikant. Weiters wurde der Einfluß des Wetters auf die Aktivität des Salamanders untersucht. Bei Regen oder bedecktem Himmel waren die Tiere gleichermaßen tagsüber und nachts aktiv, während sie bei wolkenlosem Wetter hauptsächlich nachtaktive waren. Wind beeinflusst die Aktivität des Salamanders im allgemeinen negativ.

ABSTRACT

In 1992 (June and September) and 1993 (July) a population of *Salamandra lanzai* NASCETTI, ANDREONE, CAPULA & BULLINI, 1988 was studied in the Cottian Alps (NW Italy) in a moor area of about 16,000 m² at an altitude of 2,020 m. Estimated population size (capture-recapture method, individual recognition by toe-clipping) was 479 ± 77 individuals (males: 43.5%, females 49.8%, juveniles 6.7%). The capture-recapture distances of the individuals indicate that *S. lanzai* is a quite stationary species. Mean distance (interval 0 to 16 days) was 4.70 ± 6.02 m (males) and 5.90 ± 6.82 m (females). Mean velocity of displacement was 2.63 ± 4.69 m/day in males and 1.74 ± 2.35 m/day in females. Between sexes, there were no significant differences in these parameters. Furthermore, the influence of weather conditions on the activity of this species was analysed. At rainy or overcast weather, animals were found during the daylight hours as well as at night, whereas salamanders were much more nocturnal when the weather was clear. In general, windy weather negatively influences the activity of the salamanders.

KEY WORDS

Caudata, Salamandridae, *Salamandra lanzai*, population size, movements, activity, weather conditions; ecology, high altitude, Alps, Italy

INTRODUCTION

Among European amphibians the genus *Salamandra* includes two strictly montane species with disjunct distributions: *S. atra* LAURENTI, 1768 is widespread in the central and eastern Alps with some isolated areas in the Dinaric Alps, while *S. lanzai* NASCETTI, ANDREONE, CAPULA & BULLINI, 1988 is restricted to the French and Italian Cottian Alps (ANDREONE & SINDACO 1989; DELIRY 1996; GROSSENBACHER 1997; AND-

REONE 1998). Both of these salamanders have several characters in common, such as black coloration, terrestrial life and viviparity, although it has been argued that *S. lanzai* is genetically quite differentiated from *S. atra* and possibly closer to *S. corsica* (SAVI, 1838) (VEITH 1996).

Despite the urgent need of biogeographic and ecological details for conservation purposes, pertinent information on *S.*

lanzai is limited to some data on a French population (RIBERON & al. 1996) and habitat preferences (ANDREONE & al. 1996) and diet in Italian populations (ANDREONE & al. 1990, in press).

Since little is known on the influence of the weather on the activity of this salamander,

field research was carried out to investigate some aspects of the life-history of Lanza's Salamander in a high altitude moor in north-western Italy (Cottian Alps). This paper provides information on population density, movements of individuals and influence of climatic factors within this subpopulation.

MATERIALS AND METHODS

Study site and period

The study was carried out in the upper Po Valley (Cuneo Province, NW Italy), on the eastern slope of Mount Viso, at an elevation of about 2,020 m. The area analyzed is crossed by small streams, partly occupied by an Alpine moor (ANDREONE 1992; ANDREONE & al. 1996; MIAUD & al., submitted), and partly covered by stones of different size. These stones and a complex of crevices provide hiding places for the salamanders. The vegetation is typical Alpine grassland above the vegetation line (ANDREONE 1992). The territory is covered by snow from October / November to the end of April, limiting the active life of the salamanders to the Alpine summer. The only other amphibian species observed in the area is *Rana temporaria* LINNAEUS, 1758; among the reptiles we know to occur *Zootoca vivipara* (JACQUIN, 1787), *Anguis fragilis* LINNAEUS, 1758 and *Vipera aspis* (LINNAEUS, 1758).

Considering the limited vagility of this salamander, as witnessed by other studies (RIBERON & al. 1997; DE MICHELIS & al., in press; DOGLIO & al. in press; MIAUD & al., submitted) the research was restricted to an area of about 16,000 square meters the salamander population of which was considered as virtually closed. Salamanders were studied in three periods over two years: from 13 until 28 June 1992 (16 days), from 2 until 12 and from 25 until 27 September 1992 (14 days), and from 18 until 26 July 1993 (9 days). August was excluded from field work because of heavily disturbing touristic activities (see also ANDREONE 1992).

Capture and sexing

The field work was done by two persons from 08.00 a.m. until 02.00 a.m., with equal attention to day and night hours.

Salamanders were searched for on wet meadows, in crevices, under stones and in rodent burrows. For some analyses, each day was subdivided into three periods: 08:00 - 14:00, 14:00 - 20:00, 20:00 - 02:00. Records include individual data (date and hour of observation, sex, snout vent-length, weight), as well as locality related data (temperature, weather conditions, minimum daily temperature, humidity). The temperature was recorded every time a salamander was captured. The weather is described as cloudy/foggy/rainy, or as clear/cloudless. Each individual was sexed, measured for snout vent-length (SVL) to the nearest mm and weighed to the nearest 0.1 g. For individual recognition toe-clipping was applied (see TWITTY 1966; DENOËL 1996; DONNELLY & al. 1994). The longest (third) digit of the hind leg was removed in adults and stored in ethanol for skeletochronological analysis (MIAUD & al. 1997; MIAUD & al. in press). Regeneration of toes in specimens marked during 1992 was slow and permitted individual recognition in 1993.

The sex was determined by analysis of external secondary sexual characters (SSC): males are characterized by a slender habitus while females are more corpulent (especially when pregnant); males have small granulations along the vertebral column and a prominent cloaca, both features lack in females. Juveniles (SVL < 60 mm) do not exhibit evident external SSC. After manipulation, each specimen was released at the site of capture.

The places of capture (usually stones) were marked by permanent ink. The distance between the site of the first capture and that of recapture was measured to describe the local displacement of the salamander. Only recaptures which occurred in the same study period were taken into consideration: animals marked in 1992 and re-

captured only in 1993 were excluded from the distance estimation.

For estimating population size, the captures of two or more days had to be pooled and were considered as one sample (capture session). Thus, a total of 10 samples was included in the study, five in June 1992, three in September 1992 and two in July 1993. Population density was esti-

mated with the program Capture[®] (OTIS & al. 1978; WHITE & al. 1982).

The model applied is $M_{(th)}$, for which both time and heterogeneity affect daily capture probabilities, assuming that external factors - such as weather or unequal sampling effort - cause an upward or downward shift in all individual capture probabilities (WHITE & al. 1982).

RESULTS

Population size

In the overall study period, 209 salamanders were toe-clipped: males represented 43.5 % of the sample, females 49.8 %, and juveniles 6.7 %. Mean SVL was 82.2 ± 5.4 mm in males and 84.4 ± 7.3 mm in females.

Capture-recapture data are presented in table 1. For estimation of the population size, the number of animals was 179; 141 out of them were captured only once, 30 twice, 7 three times, 1 four times.

The estimated population size was 479 specimens (standard error = 77.70) over a surface of about 16,000 m², with a density of about three animals per 100 m². This value is 2.68 times the sampled population.

Movements (table 2)

Within periods of 1 to 5 days, mean local displacement (\pm standard deviation) of 6 captured-recaptured males was 4.70 ± 6.02 m (range: 0.00 - 12.0 m); mean local displacement per day was 2.63 ± 4.69 m (range: 0.00 - 12.0 m).

Within periods of 1 to 16 days, mean local displacement of 10 captured-recaptured females was 5.90 ± 6.82 m (0.00 - 21.6 m); mean local displacement per day was 1.74 ± 2.35 m (range: 0.00 - 7.20 m). These values do not significantly differ between sexes (Mann Whitney U test; distance: $U = 26.5$, $P = 0.704$; distance per day: $U = 28$, $P = 0.828$).

Influence of climate

Salamanders (males, females, and juveniles pooled) were active (= moving at the surface) especially during the first hours of the morning, and late in the evening, while reduced activity was observed in

the central hours of the day (fig. 1).

The difference in the number of salamanders found during clear/cloudless ($n = 31$) versus cloudy/foggy/rainy periods ($n = 275$) is obvious (fig. 2). During cloudy/foggy/rainy weather the number of salamanders does not differ significantly in the three time belts analyzed: 87 in the first belt, 100 in the second, and 88 in the third ($\chi^2 = 1.14$; $P > 0.05$). When the number of individuals observed under clear/cloudless conditions was analyzed, we found that the number of observations made in the first (5), second (0), and third (26) period are significantly different ($\chi^2 = 36.96$; $P < 0.01$). Almost all animals were active during the night time hours.

The number of salamanders observed on windy days was 209, while it was 193 on calm days (fig. 3). These values are not significantly different ($\chi^2 = 0.64$; $P > 0.05$). In June the number of salamanders captured on windy days were 59, while it was 103 on calm days ($\chi^2 = 11.96$; $P < 0.01$). In July the numbers were 144 and 72, respectively ($\chi^2 = 24$; $P < 0.01$), and in September 6 versus 18 ($\chi^2 = 6$; $P < 0.05$). Noting the predominance of salamanders captured on windy days in July opposed to the predominance of salamanders on calm days in June and September, it is not surprising that activities differ significantly between the months ($\chi^2 = 41.38$; $P < 0.01$).

The influence of temperature on the activity is shown in fig. 4. The greatest number of salamanders was active on a day following a mean night temperature of 6.07° C. Computed from data of all individuals observed, the mean air temperature during salamander observations was 10.59 ± 2.95 °C (range: 1.5-19 °C), while the mean substrate temperature was 11.31 ± 2.98 °C (range: 3-20 °C).

Table 1: Capture-recapture data of the *Salamandra lanzai* sub-population studied in the upper Po Valley (Cottian Alps, NW Italy); n - number of salamanders captured in the n-th sample; u - number of unmarked salamanders captured in the n-th sample; M - total number of unmarked salamanders captured until and including the n-th sample.

Tab. 1: Fang-Wiederfang-Daten der im oberen Po-Tal (Kottische Alpen, NW-Italien) untersuchten Subpopulation von *Salamandra lanzai*; n - Gesamtzahl der in der n-ten Stichprobe gefangenen Salamander; u - Anzahl der Erstfänge in der n-ten Stichprobe; M - Anzahl der Erstfänge bis zur und inklusive der n-ten Stichprobe.

	Sample (capture session) / Stichprobe (Fangperiode)									
	1	2	3	4	5	6	7	8	9	10
n	15	18	15	38	54	4	10	24	29	19
u	15	17	15	34	48	3	9	23	12	3
M	15	32	47	81	129	132	141	164	176	179

Table 2: Sixteen capture-recapture events from the *Salamandra lanzai* sub-population studied in the the upper Po Valley (Cottian Alps, NW Italy), including data on the distances covered between capture and recapture. f - female; ID - specimen identifier; m - male.

Tab. 2: Sechzehn Fang-Wiederfang-Ereignisse aus einer im oberen Po-Tal (Kottische Alpen, NW-Italien) untersuchten Subpopulation von *Salamandra lanzai*. f - Weibchen; ID - Identifikationsnummer des Exemplars; m - Männchen.

ID	Sex	Date of capture / Fangdatum	Date of recapture / Wiederfangdatum	Distance (m) / Strecke (m)	Days / Tage	Distance per day (m) / Strecke pro Tag (m)
74	m	25 June 1992	26 June 1992	12.00	1	12.00
74	m	19 July 1993	24 July 1993	0.00	5	0.00
75	m	25 June 1992	27 July 1992	1.44	2	0.72
81	m	19 July 1993	24 July 1993	0.00	0	0.00
103	m	19 July 1993	24 July 1993	12.80	5	2.56
172	m	21 July 1993	25 July 1993	1.98	4	0.50
1	f	23 June 1992	26 June 1992	21.60	3	7.20
34	f	20 June 1992	21 June 1992	0.00	1	0.00
34	f	21 June 1992	22 June 1992	0.00	1	0.00
39	f	21 June 1992	23 June 1992	9.36	2	4.68
59	f	23 June 1992	27 June 1992	5.40	4	1.35
70	f	24 June 1992	26 June 1992	1.44	2	0.72
77	f	19 September 1993	25 September 1993	12.00	6	0.50
83	f	26 June 1992	28 June 1992	2.34	2	1.17
136	f	10 September 1992	26 September 1992	5.40	16	0.34
144	f	19 July 1993	20 July 1993	1.44	1	1.44

DISCUSSION

Salamandra lanzai appears a stationary species which does not move far away from its refuges. RIBERON & al. (1997) interpreted the salamander's site fidelity as well as its display of advertisement postures as indications of territoriality. These authors found a mean capture-recapture distance of 8.7 m in males and 12 m in females (period as given in their abstract: "...during the same active season and from one year to another") in a French population (Guil Valley). This is not much compared with *S. salamandra*. DEGANI & WARBURG (1978) noticed displacement of 100 - 160 m between November and February in one specimen of a *S. salamandra infra-immaculata* MARTENS, 1885 population

studied in Israel. 23.5% of the individuals studied by them were recaptured at a distance greater than 40 m, 53% at a distance less then 10 m and 23.5% at a distance between 10 and 40 m. According to our observations, males and females of *S. lanzai* do not differ considerably in SVL (see also ANDREONE & al., in press) and the capture-recapture distances do not differ between sexes. Thus, the individuals of *S. lanzai* are considered as rather stationary although with aggressive interactions during the mating period (ANDREONE 1992).

The density of 0.30 individuals per 10 m² observed in our study is in accord with the density of 0.29 as found for the French population of the upper Guil Valley (2,200

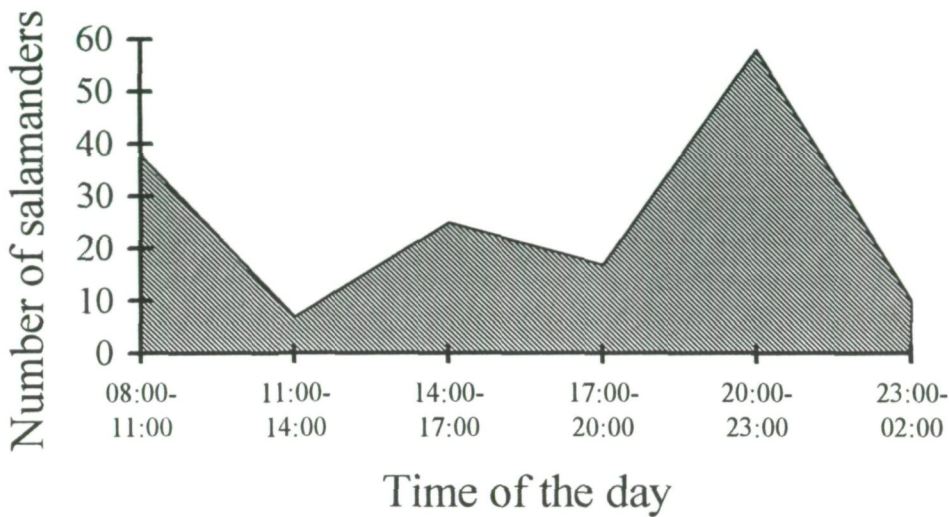


Fig. 1: Observed frequencies of *Salamandra lanzai* in six periods of the day (upper Po Valley, Cottian Alps, NW Italy).

Abb. 1: Die beobachteten Häufigkeiten von *Salamandra lanzai* in sechs Zeitabschnitten des Tages (oberes Po-Tal, Kottische Alpen, NW-Italien).

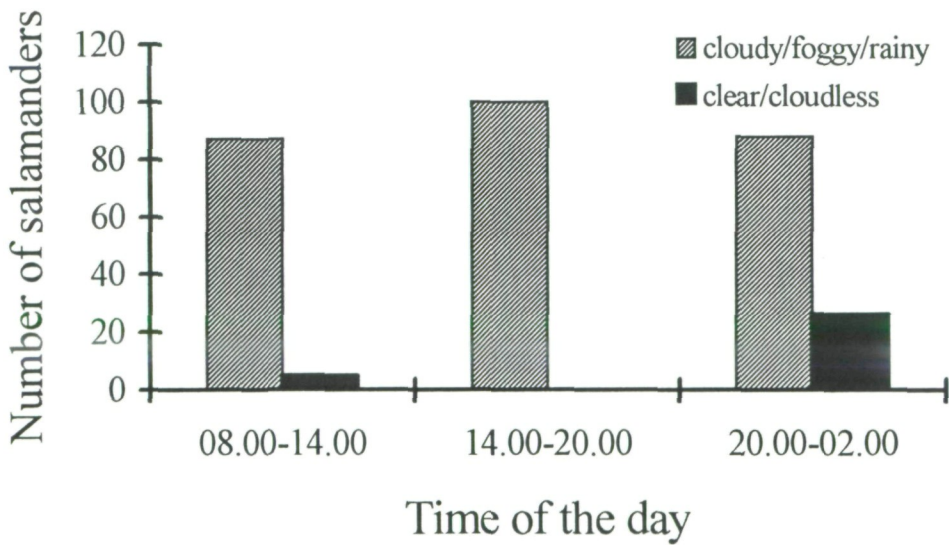


Fig. 2: Numbers of *Salamandra lanzai* specimens as observed during three periods of the day and classified according to weather conditions (upper Po Valley, Cottian Alps, NW Italy).

Abb. 2: Die Anzahlen von *Salamandra lanzai* - Individuen in drei Zeitabschnitten des Tages und gruppiert nach den Wetterbedingungen (oberes Po-Tal, Kottische Alpen, NW-Italien).

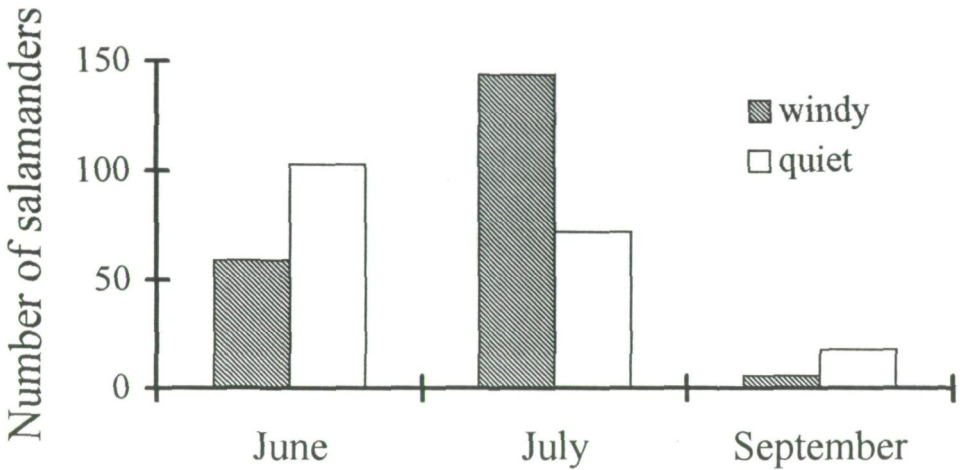


Fig. 3: Numbers of *Salamandra lanzai* individuals as observed in June, July, and September and classified according to the wind conditions (upper Po Valley, Cottian Alps, NW Italy).
Abb. 3: Die Anzahlen von *Salamandra lanzai* - Individuen in den Monaten Juni, Juli und September, gruppiert nach den Windbedingungen (oberes Po-Tal, Kottische Alpen, NW-Italien).

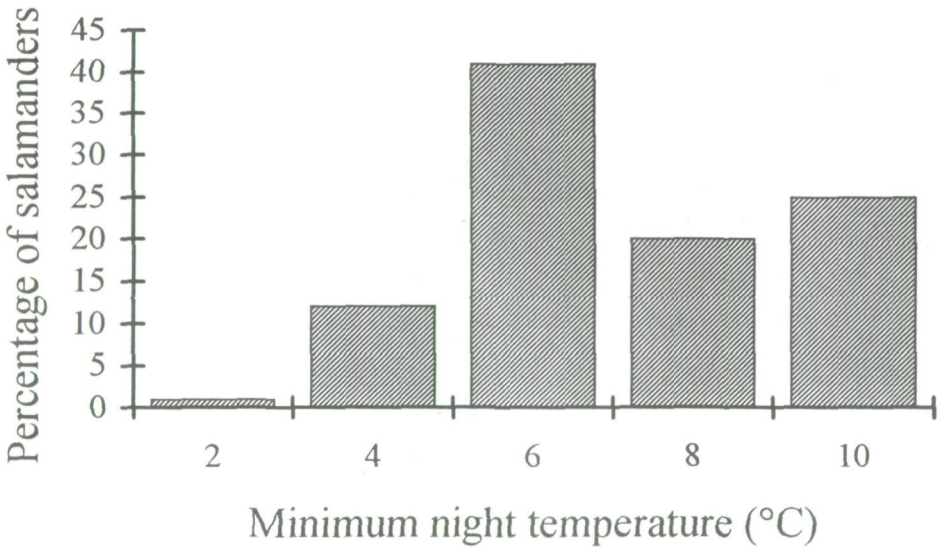


Fig. 4: Observed frequencies of *Salamandra lanzai* classified according to the minimum temperature of the preceding night (upper Po Valley, Cottian Alps, NW Italy).
Abb. 4: Die beobachteten Häufigkeiten von *Salamandra lanzai*, gruppiert nach der Minimaltemperatur der vorangegangenen Nacht (oberes Po-Tal, Kottische Alpen, NW-Italien).

m; RIBERON & al. 1996), and lower than in other Italian populations. DE MICHELIS & al. (in press) found a density of 0.55 in the upper Pellice Valley (Torino Province, 1,800 m), and DOGLIO & al. (in press) found a value of 0.68 in the upper Germanasca Valley (Torino Province, 1500 m). The similar values found in the upper Po Valley (present study) and the upper Guil Valley (RIBERON & al., in press) may be explained by the fact that these two populations live at comparable altitudes (2,200 at Guil Valley, and 2,020 - 2,100 m at upper Po Valley), on same massif (Mount Viso), although on different slopes.

The density of *S. lanzai* appears anyway higher than that of *S. salamandra terrestris* LACÉPÈDE, 1788, for which densities of 0.08 (KLEWEN 1985, 1986, 1988), 0.2 (JOLY (1966), and 0.1 (DENOËL 1996) individuals per 10 m² were observed. However, we must take into account that *S. lanzai* is characterized by the presence of sub-populations (like that one here studied) with a high density, separated by territories in which the density is very low (DOGLIO & al., in press).

Salamandra lanzai is active especially at dusk and dawn. This observation accords with data provided by VILTER & al. (1959) for *S. atra*, a species which shares

similar natural history traits with *S. lanzai*. As a general rule, the results reported here indicate a close relation between the activity of *S. lanzai* and the weather conditions. During cloudy/foggy/rainy weather, the salamanders are equally active in the daytime and at night. In these cloudy/foggy/rainy periods (quite abundant in the eastern slope of Mount Viso; see MIAUD & al., in press) humidity at ground is high. On the other hand, when the weather is clear salamanders become more nocturnal. This is also confirmed by the observation that wind usually inhibits the activity, except in July, a period where we observed a large number of animals active during the daytime although it was windy. In this month, as stressed by ANDREONE & al. (in press) the salamanders move mainly in the vicinity of the small streams, where humidity is higher. In one case it was even observed that some individuals entered into the water and fed upon aquatic insect larvae. This peculiar behaviour, which was unknown in this otherwise completely terrestrial species may be related to the higher temperatures reached in July. The presence of fog at the ground, as often witnessed in July, may allow activities also at midday and in the presence of wind, since humidity is comparably higher then.

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