Salamandra algira atlantica in the Tazzeka National Park, Morocco

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N orth-west Africa has relatively few amphibian species although many of these are endemic, including *Salamandra algira* (Escoriza & Ben Hassine, 2019). The populations of this species are fragmented in the mountain systems of the extreme north of the region, between the Tingitana Peninsula (north-west Morocco) and Djebel Edough (north-east Algeria) (Escoriza & Ben Hassine, 2015). Some of these isolated populations are currently recognised as distinct subspecies based on genetic and morphological differences, and distributional range (Beukema et al., 2013; Hernandez & Escoriza, 2019). *Salamandra algira atlantica* Hernandez & Escoriza, 2019 is a recently described subspecies, completely confined to the Middle Atlas Mountains. However, its habitat requirements and the limits of its distribution are still poorly understood (Hernandez, 2018a,b).

From 2006 to 2020, we surveyed the Tazzeka National Park (Middle Atlas Mountains, Taza province, north-east Morocco) for *S. algira atlantica*, mostly during late autumn to early spring. Habitats were sampled for adults by flipping logs and stones in terrestrial habitats and by inspecting streams and pools for larvae. Caves were selected based on topographic

maps provided by speleological expeditions (Association de Spéléologie Marocaine, Randoxygène). Geographical coordinates and elevational data were collected in situ by GPS (Garmin Montana 680; Garmin Ltd., Olahe, KS, USA). The temperature of water was measured in situ using an Expresstech @ LCD PH Medidor Digital Meter (Expresstech; Kingpow Company Limited; Hong-Kong; China).

We recorded 19 localities occupied by *S. algira atlantica* (Fig. 1), (see also Supplementary Materials) four of which were caves (Grotte Izora, Gouffre du Friouato, Grotte de Chaâra and Grotte Lazrak). The salamander was detected mainly in the elevational zone dominated by oak forests, from the thermophilic (*Quercus coccifera*) to the mesophilic (*Quercus canariensis*) formations at 730 to 1679 m asl (Fig. 2). However, in other regions of the Middle Atlas this subspecies has been found as high as 2455 m asl (Hernandez, 2018a; Hernandez & Escoriza, 2019). In general, the habitats used by *S. algira atlantica* show a relatively dense forest cover, but the species can also occupy more open habitats in other regions of the Middle Atlas. These habitats are similar to those described for the other subspecies of



Figure 1. Map of the study region (Jebel Tazzeka National Park and surrounding region), with the localities of *S. algira atlantica* superimposed (red dots). The green gradient showed the degree of forest cover (higher density, greener colour) and the pink gradient showed bush cover (higher density, redder colour). Blank represents cultivated fields, barren terrain and villages (based on Tuanmu & Jetz, 2014).



Figure 2. Example of the typical habitat of *S. algira atlantica*, at the mid elevational strip of its ecological range, a mature forest of Quercus suber, Bab Azhar



Figure 3. A. Habitat view of the flowing stream inhabited by larvae of the target species at Grotte de Chaâra, Taza province, **B.** Larva of *S. algira atlantica* found in a cave pool fed by water from the stream

S. algira (Escoriza & Ben Hassine, 2017), although S. algira atlantica is the only subspecies that is known to occur in the supra-forest grasslands such as alpine meadows (Hernandez, 2018a). In February, at Grotte de Chaâra, the air temperature at midday was 13.1° C and water temperature 11.1°-12.6° C. The conditions of stable temperature and high humidity allowed these salamanders to remain active independently of the diel cycle, unlike the populations living outside, whose daytime activity is usually only occasional. Cave specimens were located from the entrance up to 2 km inside the caves. During 2018-2019, larvae were located in rock pools in caves such as Grotte de Chaâra (Fig.3), in complete darkness. The cave dwellers did not show any particular specialisations for life in caves and most were phenotypically identical to those found outside caves. A typical example of S. algira atlantica is shown in Figure 4 but alongside these we also found individuals that were hypomelanistic through to full coral red (Hernandez & Escoriza, 2019).

The current study and those of Hernandez (2018b, 2019) confirm that there are several cave populations of S. algira atlantica in the Tazzeka National Park. Reproduction has also been observed in at least two caves, so although the subspecies generally lives above ground it would appear to have the capacity to maintain a permanent population in caves (i.e. the species is eutroglophilic). Other sub-species of S. algira that inhabit caves (e.g. in the Beni Snassen and Jebel El Haouz) similarly show no particular phenotypes adapted to this environment but do appear to differ in their ability to reproduce in caves. For example, in the Beni Snassen, S. algira spelaea occupies systems of small cavities and in Jebel El Haouz, S. algira tingitana also occupies small galleries but in neither case has reproduction within the caves been documented. For S. algira spelaea at Beni Snassen, reproduction in the cave is unlikely since larvae were only found in a small pond at the entrance to the small cave. It would appear that these other two other subspecies may be rather less well adapted to life in caves and may therefore be considered subtroglophilic.

This study has indicated that *S. algira atlantica* is still widespread and abundant within the Tazzeka National Park area, particularly in some well-preserved patches of oak



Figure 4. An adult male of S. algira atlantica found at Grotte de Chaâra, Taza province

forest. However, given the geographical isolation of this population it can be considered vulnerable (Hernandez & Escoriza, 2019). One important conservation problem is the growing demand for specimens in the pet trade because of their beautiful coloration. In addition, visits to caves by collectors and tourists also have an indirect negative effect, as visitors damage the fragile ecosystem (Gamble, 1981). We suggest that measures be implemented as a matter of urgency to conserve these very interesting populations of cave salamanders.

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