

Cases of albinism and leucism in amphibians in Italy: new reports

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Abstract - Findings of abnormally pigmented amphibian individuals provide interesting insights on intraspecific phenotypic variability as well as on variation among populations inhabiting different habitats. Amphibian coloration is determined by chromatophores (specific epidermal cells), and a variety of abnormalities related to them have been reported. In this study we reported cases of albinism and leucism in 10 species of Italian amphibians, including some endemic species. For

some taxa, like *Hydromantes sarrabusensis*, *H. flavus*, *H. supramontis* and *Bufo viridis*, we describe the first observations of albinism and leucism.

Key words: *Speleomantes*, *Rana*, newt, *Salamandra*, chromatophores, tadpoles.

Riassunto - *Casi di albinismo e leucismo negli anfibii in Italia: nuovi casi.*

Studi sugli anfibii dalla pigmentazione anomala forniscono spunti interessanti sulla variabilità fenotipica intraspecifica degli stessi e sulla variazione tra le popolazioni che abitano diversi habitat. La colorazione degli anfibii è determinata dai cromatofori (specifiche cellule epidermiche), e sono state segnalate una varietà di anomalie ad essi connessi. In questo studio abbiamo riportato casi di albinismo e leucismo in 10 specie di anfibii italiane, tra cui alcune specie endemiche. Per alcuni taxa, come *Hydromantes sarrabusensis*, *H. flavus*, *H. supramontis* e *Bufo viridis*, descriviamo le prime osservazioni di albinismo e leucismo.

Parole chiave: *Speleomantes*, *Rana*, tritoni, *Salamandra*, cromatofori, girini.

INTRODUCTION

Abnormal or uncommon colourations of amphibian specimens have historically interested herpetological literature and are often described and reported, especially in older texts (e.g. Capanna & Foresti, 1974; Vanni & Zuffi, 2001; Barbagli & Violani, 2004). Such aberrations consist of unusual colouration caused by both increase and reduction of pigmented cell (Rivera *et al.*, 2001). Although chromatic aberration have been of interest mainly for descriptive natural history purposes, it may provide interesting indications of phenotypic variability within species (Browder, 1972; Alho *et al.*, 2010). Amphibian coloration is linked to chromatophore (specific epidermal cells) disposition. Chromatophores are pigment-containing cells, and are usually classified considering the chemical composition of the pigment granules and observing their colour under a white light. In amphibian skin, it is possible to find six types of chromatophores: the xanthophores containing yellow granules of carotenoids and pterins, the erythrophores containing red granules, the melanophores

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containing granules of melanin with a black or dark colour, the leucophores containing white granules and located just beneath melanophores, the cyanophores containing blue granules, and the iridophores containing crystals of guanine that have a silver or iridescent aspect (Duellman & Trueb, 1994). The distribution and the occurrence of these chromatophores in the epidermis generally changes from species to species (Pough *et al.*, 2016). There are several causes and typologies of alteration of individual coloration. All the possible cases were summarized by Brame & Freytag (1963) and, more recently, by Dyrkacz (1981) and Rivera *et al.* (2001). In the case of albinism, animals completely lack dark pigmentation because of the total absence of all integumentary pigment. Complete albinos are identified by the white coloration of their skin and by their red irises. Other interesting cases of partial albinism may occur in individuals lacking all integumentary pigments, including eyes, except for some of the chromatophores. Leucistic individuals can be distinguished from albinos by their iris coloration, which remains normal. In contrast with albinos, leucistic animals do not seem to be as sensitive to sunlight exposure, and lack the difficulties with vision linked to missing pigments in the retinal epithelium (Dyrkacz, 1981). Albinism is a rare but reported hereditary anomaly in several urodele species (Dyrkacz, 1981). In Europe, one amphibian species is normally leucistic (*Proteus anguinus*), with the exception of the subspecies *P. anguinus parakelj*, which shows black pigments and developed eyes. Even if Italy has one of the highest numbers of amphibian species in Europe (Sillero *et al.*, 2014) cases of albinism and leucism are quite rare and until now are documented only in 10 species (around 21% of Italian species) (Pavesi, 1879; Lessona, 1880; Capanna, 1969; Capanna & Foresti, 1974; Vanni & Nistri, 1987; Corsini *et al.*, 2002; Spadola & Insacco, 2010; Modesti

et al., 2011; Ambrogio & Mezzadri, 2014; Crucitti *et al.*, 2016). With this work, we report occurrence of albinism and leucism in six Italian species of amphibians, among which four are novel observation.

MATERIALS AND METHODS

We performed repeated field surveys from 2003 to 2016 in a contest of different herpetological activities. We performed extensive surveys, mainly during spring and autumn seasons for numerous breeding sites and their surrounding areas in northern Italy and Sardinia, in order to perform observation on both adults and larval stage for each amphibian species. Moreover, we performed extensive samplings all the years round on the Italian cave salamanders [genus *Hydromantes*; see Wake (2013) in caves and artificial tunnels (more than 5000 individuals observed)], as these species lack of aquatic larval stage (Lanza *et al.*, 2006) and in underground environments their detectability is high (Lunghi *et al.*, 2015). All encountered depigmented individuals were photographed and measured. Compatibly with our permissions, individuals were also reared for short periods in order to making detailed observations on the depigmentation features.

RESULTS

We found 5 partial albino individuals with xanthophores and 2 leucistic individuals of the species *Salamandra salamandra*, several leucistic individuals in Sardinian cave salamanders (10 *Hydromantes sarrabusensis*, 3 *H. flavus* and 3 *H. supramontis*), one leucistic larva of *Triturus carnifex* and a leucistic tadpole of *Bufo viridis* (all observations are summarized in Table 1, in which is also reported the region in which individuals were found).

Tab. 1 - Cases of albinism and leucism in Italian amphibians observed in this study.

Species	Phase	Individuals	Chromatic aberration	Region of origin
<i>Salamandra salamandra</i>	Larva	3	Partial albinism with xanthophores	Lombardy
<i>Salamandra salamandra</i>	Larva followed after metamorphosis	1	Partial albinism with xanthophores	Lombardy
<i>Salamandra salamandra</i>	Adult	1	Leucism	Lombardy
<i>Salamandra salamandra</i>	Adult	1	Leucism	South Tyrol
<i>Triturus carnifex</i>	Larva	1	Leucism	Lombardy
<i>Hydromantes sarrabusensis</i>	Adults/subadults	6/4	Leucism	Sardinia
<i>Hydromantes flavus</i>	Adult	3	Leucism	Sardinia
<i>Hydromantes supramontis</i>	Adult	3	Leucism	Sardinia
<i>Bufo viridis</i>	Tadpole	1	Leucism	Lombardy

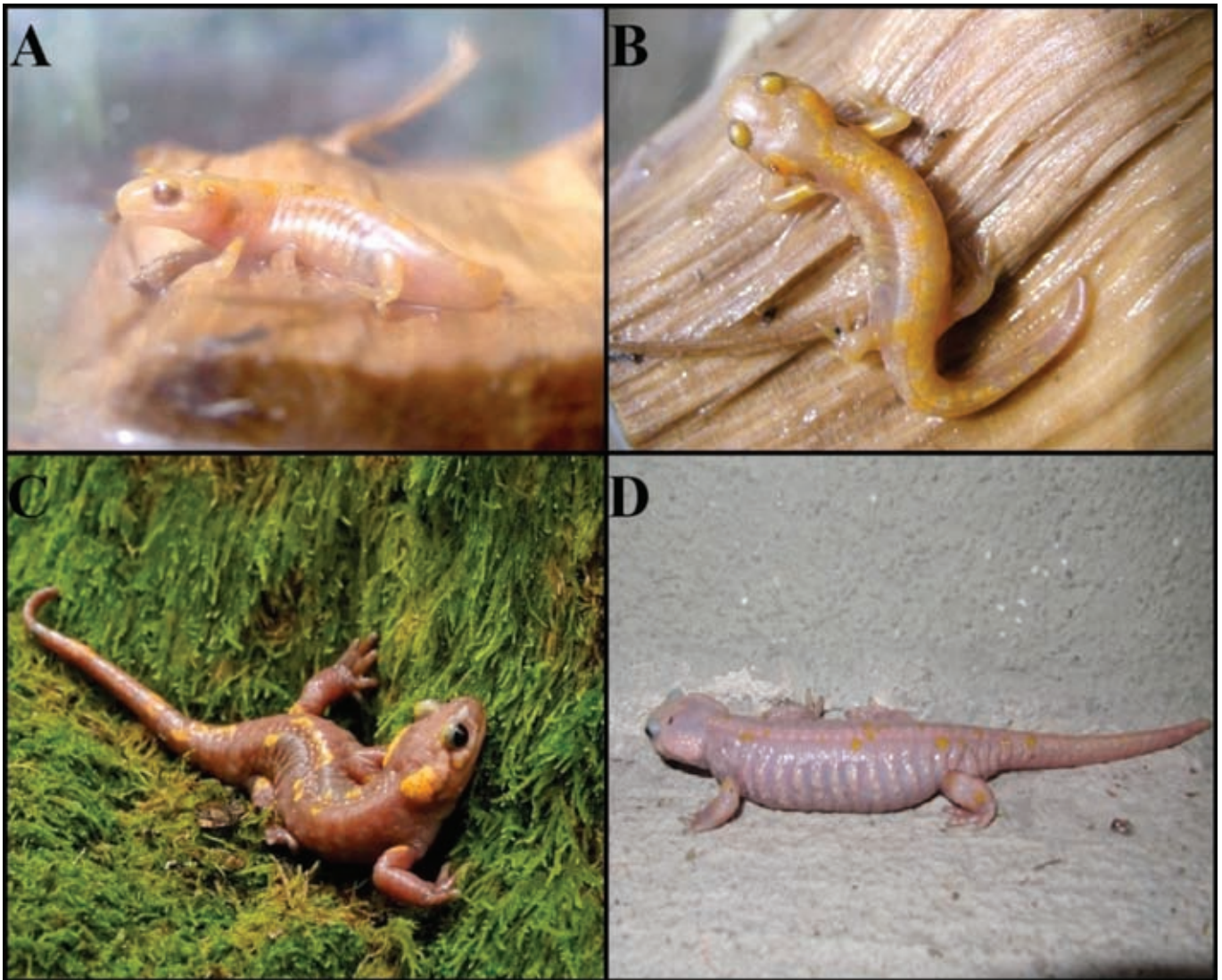


Fig. 1 - Fire salamander (*Salamandra salamandra*) individuals showing albinism and leucism. A) metamorphosed albino with xanthophores found in 2013; B) metamorphosed albino with xanthophores found in 2014; C, D) leucistic adults.

For *S. salamandra*, in March 2013 we found one albino larva with xanthophores (Fig. 1A) of 26 mm of total length, over 56 total larvae were sampled in the southern Como district. In the same locality 3 albino larvae with xanthophores amongst 37 larvae sampled were found in April 2014 (Fig. 1B); total length of all the three larvae was 31 mm. The other albino with xanthophores was found at larval stage on November 25 in a south-eastern area of Como district. The individual (40 mm long upon discovery) was found in a small spring in a broadleaved wood with prevalence of alders and oaks (Fig. 2A). The spring feeds a small creek where other normally pigmented larvae occur. The integumentary pigments except for some tiny yellow spots were absent from the head, limbs and tail. Eyes were markedly red indicating a lack of pigment in the iris. The larva was collected in the context of a three-year long ethological study (Manenti *et al.*, 2013) and reared in controlled conditions (authorization by Lombardy Region, p. n. F12013.0002091; rearing conditions are described in Manenti *et al.* (2016). During the last larval stage the indi-

vidual developed a number of large yellow dorsal spots (Fig. 2B-D) that became more defined after the metamorphosis, which occurred on February 22, 2015, at a total length of 64 mm (Fig. 2E). A leucistic adult fire salamander (total length 15 cm) was found on September 2015 in the northern Como district active in a wood at an altitude of 814 m a.s.l (Fig. 1C). Another leucistic fire salamander has been found in two consecutive years (September 2009 and September 2010) in Trento district, at 1057 m a.s.l (Fig. 1D). The survey was done near a house surrounded by hay meadows (*Arrhenatherum sp.* with umbelliferous plants), vegetable gardens and woods with ashes and maples. The area has small wells and woodsheds as well as ephemeral ponds in the surrounding areas while streams occur farther from the site.

For *Hydromantes sarrabusensis*, in Cagliari district were found several individuals showing different levels of leucism. The site was checked five times (from April to October 2015) and the maximum number of individuals with anomalous coloration observed during one survey was 10; we observed leucism only in adults and sub-adults. The

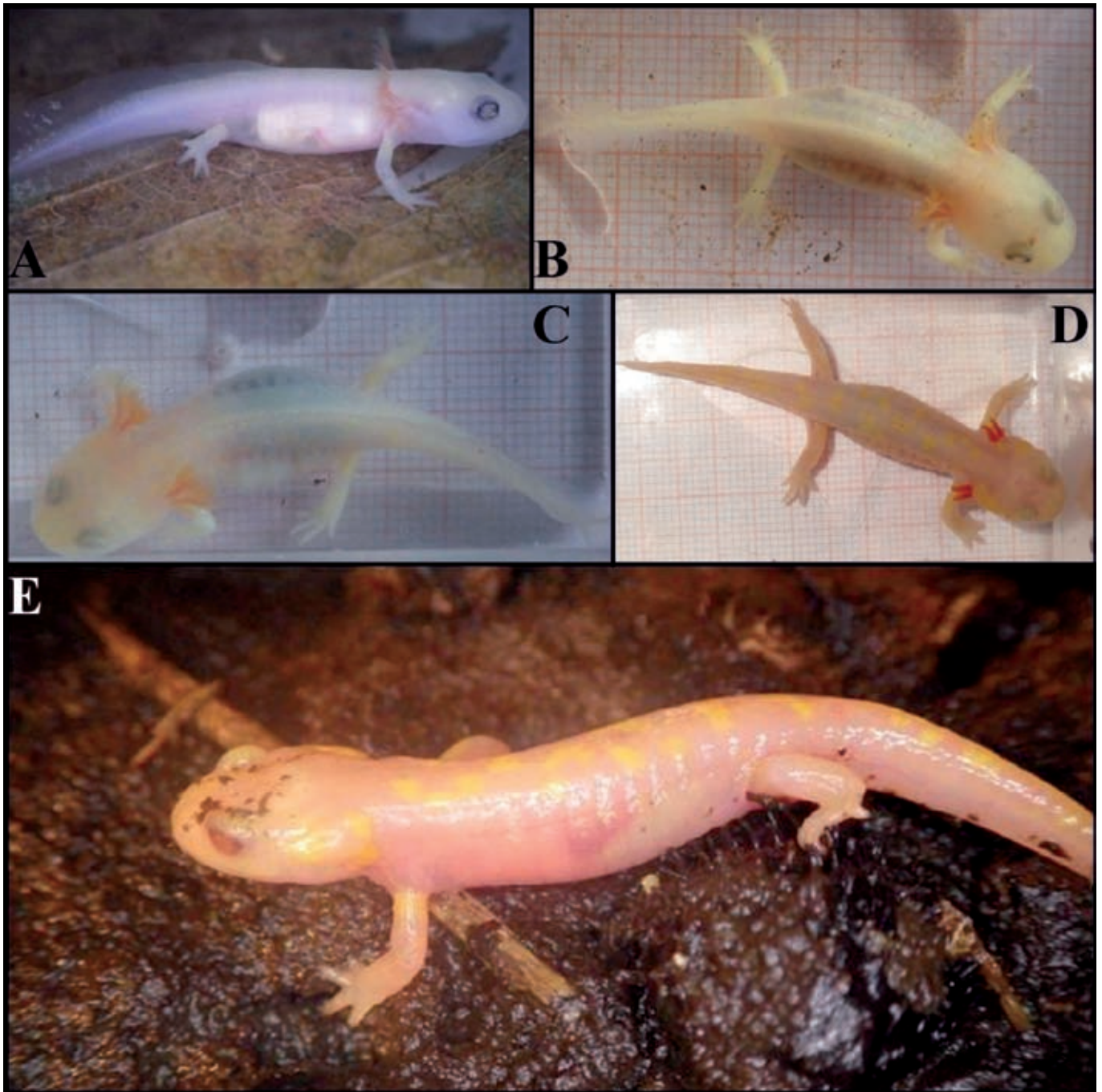


Fig. 2 - Larval development and metamorphosis of an albino with xanthophores fire salamander larva. A) collection moment in November 2014 (40 mm of total length); B) the same individual in December 2014; C) the same individual in January 2015; D) pre-metamorphosis stage of the same individual on February 15 2015; E = the same individual just metamorphosed on February 22, 2015.

complete leucistic individuals showed pale-pink coloration with white spots (Fig. 3A). For *H. flavus*, during a cave survey in eastern area of Nuoro district, in April 2016 we found three partial leucistic individuals. These individuals showed a pale/pink coloration of both limbs and tail, while the color of the back was light-grey: in two of them yellow spots were still visible, while in the third spots were almost white (Fig. 3B). For *H. supramontis*, in two caves of southern area of Nuoro district surveyed during May 2016, we found three leucistic individuals: one was totally pale,

showing only very light yellow spots (Fig. 3C). Transparency of the skin made some internal structures and organs visible, such as the back bone and blood vessels.

A leucistic *Triturus carnifex* was found in April 2003 in Milan district (Fig. 4A). The individual was a large larva that likely overwintered in a large source that continuously retained water during winter. The leucistic tadpole of *Bufo viridis* was found in April 2016 in the district of Milan (Fig. 4B). It was in an artificial pool together with hundreds of normally pigmented conspecifics.

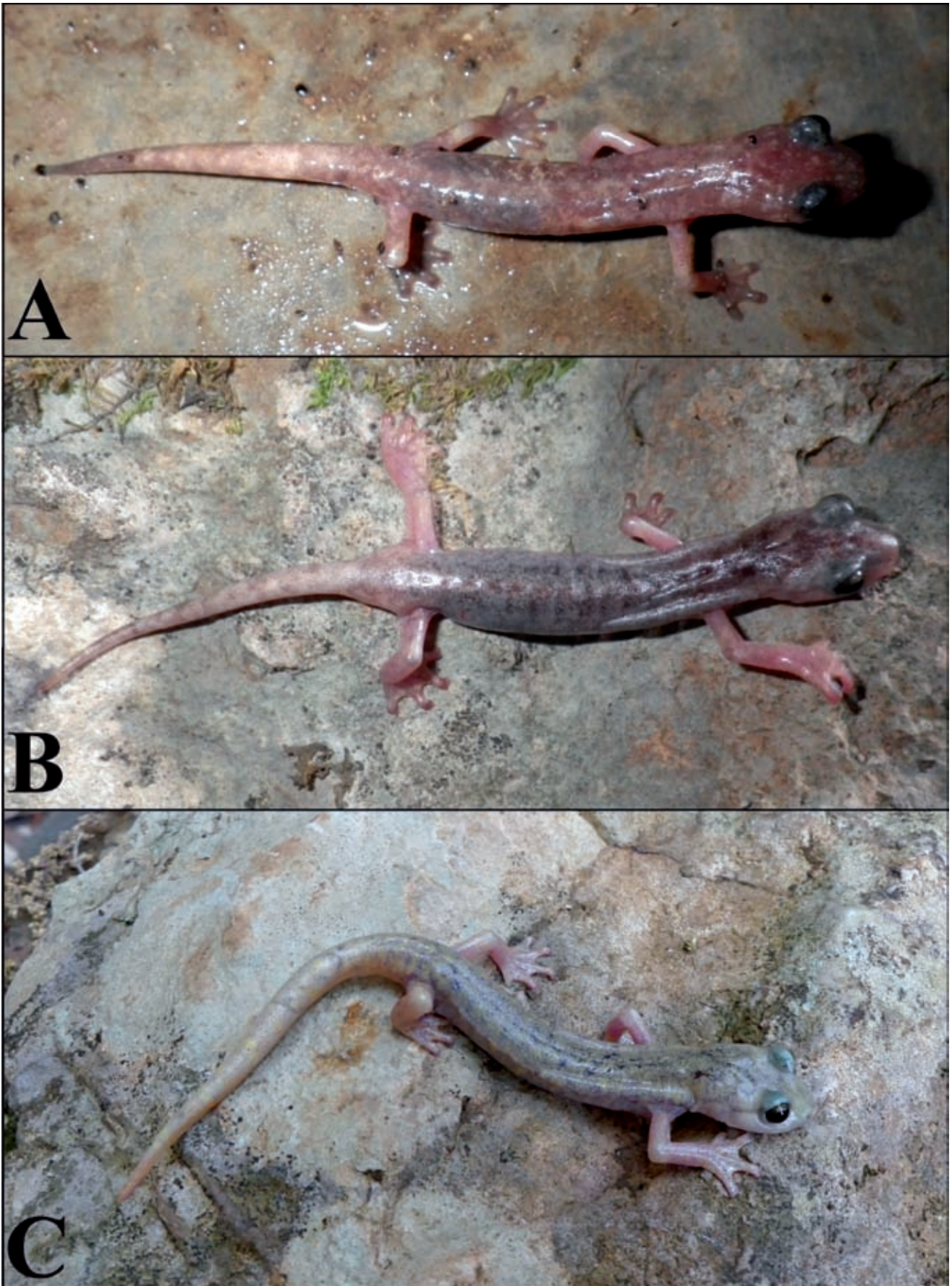


Fig. 3 - Leucistic individual of *Hydromantes sarrabusensis* (A), *H. flavus* (B) and *H. supramontis* (C).



Fig. 4 - Leucistic larvae of *Triturus carnifex* (A) and *Bufo viridis* (B).

DISCUSSION AND CONCLUSIONS

In this work we report 24 cases of albinism and leucism in Italian amphibians. About 79% of the cases involve adults and sub-adults, while the remaining 21% deals with larvae or tadpoles. This proportion is unexpected as viability of albinos is generally reduced compared to the wild type (Browder, 1972; Lira *et al.*, 2016); however, if we consider only species which undergo metamorphosis, the number of albino/leucistic larvae is higher than adults (respectively 6 for larvae and 2 for adults). Within our observations, 16 individuals belong to the genus *Hydromantes*: these animals are characterized by direct development so they lack a larval stage (Lanza *et al.*, 2006). Moreover, *Hydromantes* species often exploit underground environments to avoid unsuitable epigeal environmental conditions (Lunghi *et al.*, 2015). Thus, the short time in which these animals are more vulnerable (juvenile stage) and the subterranean habitat in which there are few predators, may reduce cave salamander mortality. The most abundant chromatic aberrations that we recorded were the less extreme ones, such as leucism (83%); while the albinism, even partial, remains rare (17%).

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