

Short Communication

First evidence of Sette Fratelli cave salamander *Speleomantes sarrabusensis* (Urodela: Plethodontidae) consumption by the Sardinian grass snake *Natrix helvetica cetti* (Squamata: Natricidae)

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Abstract - European cave salamanders, classified under the genus *Speleomantes*, are primarily endemic to Italy, with one sub-endemic species also occurring in southeast France. These terrestrial salamanders seek refuge in subterranean habitats with stable, humid, and cool microclimates, especially during periods of high heat or dryness. Above-ground sightings mostly occur during cooler, damp periods, either at night or on very humid days. Many studies have explored their diet, but information on predators is limited. This work presents the first documented evidence of predation on adult Sette Fratelli cave salamander *S. sarrabusensis* by the Sardinian grass snake *Natrix helvetica cetti*. During a field survey in the Sette Fratelli forest complex, South Sardinia, three adult cave salamanders were regurgitated by a captured grass snake, indicating predation. Notably, the observation suggests nocturnal activity of the grass snake in early spring despite low temperatures. This finding underscores significant gaps in our understanding of the Sardinian grass snake's ecology and the predation risks faced by European cave salamanders, highlighting the need for further field research.

Key words: *Hydromantes*, Ophidia, plethodontid, predation, Sardinia.

Riassunto - Prima evidenza di consumo di geotritoni del Sarrabus *Speleomantes sarrabusensis* da parte della natrice di Cetti *Natrix helvetica cetti*.

I geotritoni, ascritti al genere *Speleomantes*, sono urodela endemici dell'Italia, eccetto una specie, *S. strinatii*, presente anche nel sud-est della Francia. Queste salamandre terrestri trovano rifugio in ambienti sotterranei con microclimi stabili, umidi e freschi, specialmente durante periodi caldi e siccitosi. Gli avvistamenti epigei avvengono principalmente durante periodi freschi e umidi, di notte o in giornate particolarmente umide. Numerosi studi hanno esplorato la loro dieta, ma le informazioni sui predatori

sono limitate. Questo lavoro presenta la prima evidenza documentata di predazione su adulti di geotritone del Sarrabus (*S. sarrabusensis*) da parte della natrice di Cetti (*Natrix helvetica cetti*). Durante un'attività di campo nel complesso forestale dei Sette Fratelli, Sud Sardegna, tre geotritoni adulti sono stati rigurgitati da una natrice catturata, indicando un'avvenuta predazione. L'osservazione suggerisce l'attività notturna della natrice di Cetti a inizio primavera nonostante le temperature relativamente basse. Questo ritrovamento evidenzia significative lacune nelle conoscenze dell'ecologia di questa natrice e dei rischi di predazione affrontati dai geotritoni, sottolineando la necessità di ulteriori ricerche di campo.

Parole chiave: *Hydromantes*, Ophidia, plethodontide, predazione, Sardegna.

Eight species of lungless salamanders (Urodela: Plethodontidae) are currently recognised in Europe, all classified under the genus *Speleomantes* Dubois 1984 (although sometimes identified as *Hydromantes* – see Costa *et al.*, 2023) and commonly known as the European cave salamanders. In particular, they are endemic to Italy, except for *S. strinatii* which reaches a limited area of south-eastern France (Renet *et al.*, 2012; Speybroeck *et al.*, 2020; Di Nicola *et al.*, 2021). Three of these species are continental: *Speleomantes strinatii* (Aellen 1958), which ranges from the northern Apennines to Provence in France (including the Principality of Monaco), *S. ambrosii* (Lanza 1955) and *S. italicus* (Dunn 1923), which inhabit the Apennine Peninsula (the latter also occurring the Republic of San Marino). The remaining five species – *S. flavus* (Stefani 1969), *S. genei* (Temminck & Schlegel 1838), *S. imperialis* (Stefani 1969), *S. sarrabusensis* Lanza, Leo, Forti, Cimaruta, Caputo & Nascetti 2001, and *S. supramontis* (Lanza, Nascetti & Bullini 1986) – are all endemic to Sardinia [see Di Nicola *et al.* (2021) and supplementary material in Corti *et al.* (2022) for distribution maps]. *Speleomantes* are terrestrial oviparous salamanders that exhibit direct development (Lanza *et al.*, 2006; Lunghi *et al.*, 2018b,c). Their peculiar physiological traits make them highly sensitive to their environmental conditions (Lanza *et al.*, 2006; Lunghi *et al.*, 2018b). In response to excessive heat or dryness, they typically seek refuge in subterranean habitats where a stable microclimate characterised by high humidity and cool temperatures can be found throughout the year. Consequently, sightings of European cave salamanders in above-ground settings are generally confined to the cooler and more humid periods of the year, especially

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Received for publication: 18 July 2024

Accepted for publication: 27 September 2024

Online publication: 27 September 2024

at night or on rainy or foggy days (Lanza *et al.*, 2007; Lunghi *et al.*, 2015; Lunghi *et al.*, 2018b). The subterranean habitats they utilise vary widely, ranging from temporary shelters such as under rocks, logs, or in the leaf litter, to larger cavities like burrows in the soil, karstic caves, and artificial structures including mines and cellars (Lanza *et al.*, 2007; Di Nicola *et al.*, 2021).

Several studies have extensively explored the dietary spectrum of these amphibians (*e.g.*, Salvidio, 1992; Vignoli *et al.*, 2006; Salvidio *et al.*, 2012; Lunghi *et al.*, 2018a,b; Lunghi *et al.*, 2022; Casali *et al.*, 2023; Cianferoni & Lunghi, 2023), while little documented information is available on their predators. Notably, predation on juvenile continental *Speleomantes* by the spiders *Meta menardi* (Latreille 1804) (Pastorelli & Laghi, 2006) e *M. bournetii* Simon 1922 (Lunghi & Corti, 2021) has been confirmed. Additionally, Gene (1839) reported the finding of a *S. genei* in the stomach of a small Sardinian grass snake *Natrix helvetica cetti* Gene 1839 near Iglesias, Sardinia, Lanza (1946, 1948) found a *S. ambrosii* in the stomach of a slow worm *Anguis veronensis* Pollini 1818 on the Apuan Alps, Tuscany, and Gerlach & Biggi (2022) documented a Barred grass snake *N. helvetica sicula* (Cuvier 1829) swallowing a *S. stri-natii* near Genova, Liguria. The hypothesis of cannibalism is discussed in section 3.5 of Cianferoni and Lunghi (2023). Lastly, there are no documented reports of predation by birds or mammals (Salvidio *et al.*, 2017).

In this study, we present the first evidence of predation on adult Sette Fratelli cave salamanders *Speleomantes sarra-busensis* by a Sardinian grass snake.

The Sardinian grass snake is a subspecies endemic to Sardinia, where it has a rather fragmented distribution, primarily in the highlands of the island's eastern and southern areas (Schultze *et al.*, 2020; Di Nicola *et al.*, 2021). A recent study by Di Nicola *et al.* (2023) has reviewed the taxonomy, morphology, and ecology of this taxon, provided updated distribution data, and modelled its potential range. Information on the distribution and ecology of *N. helvetica cetti* remains relatively insubstantial, possibly due to its elusive

nature, low population density, and insufficient research effort. This has led to a limited knowledge of this snake habits. The diet of the Sardinian grass snake is among the least studied aspects, with information derived from a sample of only twelve food items found in nine snakes from a single area (*i.e.*, Supramonte of Oliena, Nuoro Province). These included six adults and five tadpoles of *Hyla sarda* (de Betta 1853) and one *Podarcis tiliguerta* (Gmelin 1789) (Capula *et al.*, 1994; Di Nicola *et al.*, 2023).

On April 3rd, 2024, in the Sette Fratelli forest complex, South Sardinia (39°18' N, 9°24' E, WGS 84), the authors conducted a field survey aimed at screening for *Ophidio-myces ophidiicola* (Guarro, Deanna A. Sutton, Wickes & Rajeev) Sigler, Hambl. & Paré, 2013, a pathogenic fungus affecting snakes that has not yet been detected in Sardinia (see Di Nicola *et al.*, 2022; Marini *et al.*, 2023). The survey followed a transect along a dirt path through a *Quercus ilex* L. forest on a northwest-facing slope, covering a distance of 2.2 km round trip, with an altitudinal range between 420 and 730 m a.s.l.

During the survey, which lasted approximately 3 hours from 11 am to 2 pm, twelve snakes were observed, all basking along the path's edge, near shelters formed by rocks and plant material located at the edge of the forest on a sloping hillside. These included nine adult *N. helvetica cetti* (all temporarily captured to collect skin swabs, photo documentation, and routine measurements and then released; see Fig. 1 and Tab. 1) and three adult *Hierophis viridiflavus viridiflavus* (Lacépède 1789).

When two or more snakes were found close together and captured simultaneously, they were placed in individual cloth bags to avoid possible cross-contamination and temporarily kept there pending completion of health screening procedures on the other snakes. In one instance, upon removing a Sardinian grass snake from the bag, the individual regurgitated three prey items. The preys were three adult male individuals of *Speleomantes sarra-busensis*, one of which still complete (total length: 98 mm) and the other two missing their posterior parts, likely due to ongoing digestive

Tab. 1 – Key measurements of the nine observed *Natrix helvetica cetti*. The asterisk indicates the individual that regurgitated the three cave salamanders. / Principali misure delle nove *Natrix Helvetica cetti* osservate. L'asterisco indica l'individuo che ha rigurgitato i tre geotritoni.

Individual	Snout-vent length (mm)	Tail length (mm)	Total length (mm)	Tail to total proportion	Subcaudal scales	Sex
A	420	91	511	0.18	53 + terminal	F
B	329	84	413	0.20	59 + terminal	M
C	399	108	507	0.21	62 + terminal	M
D	459	80	539	0.15	49 + terminal	F
E	507	127	634	0.20	57 + terminal	M
F*	413	99	512	0.19	55 + terminal	M
G	444	111	555	0.20	59 + terminal	M
H	539	102	641	0.16	N/A (injured)	F
I	433	106	539	0.20	59 + terminal	M
Females	473±60.7	91±11.0	564±68.4	0.16±0.015	51±2.8	F
Males	421±58.4	106±14.2	527±72.1	0.20±0.007	58.5±2.3	M

F, female; M, male; N/A, not available.

processes. The sex was recorded by checking for the presence of the male mental gland (Lanza *et al.*, 2006; Di Nicola *et al.*, 2021). The condition of the cave salamanders indicated that regurgitation started from the head; hence, the consumption began from the tail. Given the circumstances, we believe the three individuals have been predated. The Sardinian grass snake responsible for the predation was an adult female showing melanistic colouration (total length: 512 mm; snout to vent length: 413 mm; tail length: 99 mm; No. of ventral scales: 169; No. of subcaudal scales: 55, plus the terminal scale) (Fig. 2).

All European cave salamander species produce toxic skin secretions, which are thought to act as a defence mechanism against predators (Lanza *et al.*, 2006; Salvidio *et al.*, 2017). The predation on *Speleomantes* provides additional confirmation of the grass snakes' (*N. natrix* complex) aptitude to prey on amphibian taxa capable of secreting relevant toxic substances, such as species from the genera *Bombina* Oken 1816, *Bufo* Garsault 1764, *Bufo* Rafinesque 1815 and *Salamandra* Garsault 1764 (see Luiselli *et al.*, 2005; Rodríguez *et al.*, 2017; Kowalski *et al.*, 2018; Lüddecke *et al.*, 2018; Laciak *et al.*, 2023).

Such evidence of predation on cave salamanders in early April, observed in the Sette Fratelli forest complex, which comprises granite formations (Melis *et al.*, 2017) and thus offers limited subterranean habitats compared to karst environments, suggests the nocturnal activity of the Sardinian

grass snake even during cool periods. Indeed, the predation event took place despite the relatively low minimum temperatures recorded that week (mean T_{min} : 10.0 °C, mean T_{max} : 19.7 °C; first week of April 2024), as similarly noted by Capula *et al.* (1994). Their survey in the Supramonte of Oliena (eastern Sardinia) revealed that individuals were active at night in water searching for prey when air temperatures were below 15°C.

This finding constitutes the first documented evidence of predation on *Speleomantes* by *Natrix helvetica cetti*, confirming Gené's (1839) report and supporting the inclusion of cave salamanders in the diet of the Sardinian grass snake (cf. Lunghi *et al.*, 2018d; Di Nicola *et al.*, 2023), a previously overlooked condition.

The surveyed transect does not include any permanent watercourses in its immediate vicinity. However, for a large part of the year, rivulets and little pools appear along the trail, where the authors frequently observed adults and tadpoles of *Discoglossus sardus* Tschudi in Otth 1837. These frogs could possibly represent another amphibian prey for the Sardinian grass snake.

The present work emphasises the significant gaps that still exist in our understanding of the ecology of the Sardinian grass snake. Further field efforts are crucial not only for this localised snake but also for more easily detectable species, such as European cave salamanders, for which knowledge about potential predators remains extremely limited.



Fig. 1 – Dorsal pattern of the nine observed *Natrix helvetica cetti*. / Pattern dorsale delle nove *Natrix helvetica cetti* osservate.



Fig. 2 – Melanistic female *Natrix helvetica cetti* with three freshly regurgitated *Speleomantes sarraabusensis*. / Femmina melanotica di *Natrix helvetica cetti* con i tre *Speleomantes sarraabusensis* appena rigurgitati.

Acknowledgements

MRDN's field research is funded by Asociación Herpetológica Española. The capture and temporary handling of snakes were carried out following MRDN's permits: MiTE/Ministry of Ecological Transition (MiTE N. 0024526.28-02-2022), approved by ISPRA on February 23, 2022 (Protocol N. 0009384/2022); Regione Autonoma della Sardegna (Determination N. 251, Protocol N. 6747 of 14/03/2022).

REFERENCES

- Capula M., Rugiero L. & Luiselli L., 1994 – Ecological observations on the Sardinian grass snake, *Natrix natrix cetti*. *Amphibia-Reptilia*, 15 (2): 221-224.
- Casali S., Pagliarani M., Cofani M., Cianferoni F. & Lunghi E., 2023 – First data on the consumed prey by *Speleomantes italicus* from the Republic of San Marino. *Acta Herpetologica*, 18 (2): 159-163. doi: 10.36253/a_h-14748
- Cianferoni F. & Lunghi E., 2023 – Inferring on speleomantes foraging behavior from gut contents examination. *Animals*, 13 (17): 2782. doi: 10.3390/ani13172782
- Corti C., Biaggini M., Nulchis V., Cogoni R., Cossu I. M., Frau S., Mulargia M., Lunghi E. & Bassu L., 2022 – Species diversity and distribution of amphibians and reptiles in Sardinia, Italy. *Acta Herpetologica*, 17 (2): 125-133. doi: 10.36253/a_h-13627
- Costa A., Lunghi E., Rosa G. & Salvidio S., 2023 – Recent advances in the behavioral ecology of European plethodontid salamanders. *Animals*, 13 (23): 3667. doi: 10.3390/ani13233667
- Di Nicola M.R., Caviglioli L., Luiselli L. & Andreone F., 2021 – Anfibi & Rettili d'Italia. Edizione aggiornata. Edizioni Belvedere, Latina.
- Di Nicola M. R., Coppari L., Notomista T. & Marini D., 2022 – Ophidiomyces ophidiicola detection and infection: a global review on a potential threat to the world's snake populations. *European Journal of Wildlife Research*, 68 (5): 64. doi: 10.1007/s10344-022-01612-8
- Di Nicola M. R., Pozzi A. V., Mezzadri S., Faraone F. P., Russo G., Dorne J. L. M. C. & Minuti G., 2023 – The endangered sardinian grass snake: distribution update, bioclimatic niche modelling, dorsal pattern characterisation, and literature review. *Life*, 13 (9): 1867. doi: 10.3390/life13091867
- Gené C. G., 1839 – Synopsis Reptilium: Sardiniae Indigenorum. Memorie della Reale accademia delle scienze di Torino.
- Gerlach U. & Biggi E., 2022 – *Speleomantes strinati* (Strinati's Cave Salamander). Predation. *Herpetological Review*, 53 (4): 643-644.
- Kowalski K., Marciniak P., Rosiński G. & Rychlik L., 2018 – Toxic activity and protein identification from the parotoid gland secretion of the common toad *Bufo bufo*. *Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology*, 205: 43-52. doi: 10.1016/j.cbpc.2018.01.004
- Łaciak M., Adamski P., Bielański W., Ćmiel A., Lipińska A., Łaciak T. & Zajac T., 2023 – Tastier than thought? Telemetric research reveals predation on the poisonous yellow-bellied toad *Bombina variegata*. *Ecology*, 104 (4): e3996. doi: 10.1002/ecy.3996
- Lanza B., 1946 – L'*Hydromantes* Gistel in Toscana e notizie sui suoi costumi (Amphibia; Caudata; Plethodontidae). *Archivio Zoologico Italiano*, 31: 219-237.
- Lanza B., 1948 – Esplorazioni speleologiche in Toscana. Le Grotte di Bedizzano e di Ritomboli (Alpi Apuane) e la loro fauna. *L'Universo*, 28 (5): 529-539.
- Lanza B., Andreone F., Bologna M. A., Corti C. & Razzetti E., 2007 – Genere *Speleomantes* Dubois, 1984. In: Fauna d'Italia, vol. XLII: Amphibia. Calderini, 24: 142-152.
- Lanza B., Pastorelli C., Laghi P. & Cimmaruta R., 2006 – A review of systematics, taxonomy, genetics, biogeography and natural history of the genus *Speleomantes* Dubois, 1984 (Amphibia Caudata).

- Plethodontidae). *Atti del Museo Civico di Storia Naturale di Trieste*, 52: 5-135.
- Lüddecke T., Schulz S., Steinfartz S. & Vences M., 2018 – A salamander's toxic arsenal: review of skin poison diversity and function in true salamanders, genus *Salamandra*. *Science of Nature*, 105 (9-10): 56. doi: 10.1007/s00114-018-1579-4
- Luiselli L., Filippi E. & Capula M., 2005 – Geographic variation in diet composition of the grass snake (*Natrix natrix*) along the mainland and an island of Italy: the effects of habitat type and interference with potential competitors. *Herpetological Journal*, 15 (4): 221-230
- Lunghi E., Cianferoni F., Ceccolini F., Mulargia M., Cogoni R., Barzaghi B., Cornago L., Avitabile D., Veith M., Manenti R., Ficetola G. F. & Corti C., 2018a – Field-recorded data on the diet of six species of European *Hydromantes* cave salamanders. *Scientific Data*, 5 (1): 180083. doi: 10.1038/sdata.2018.83
- Lunghi E., Cianferoni F., Ceccolini F., Veith M., Manenti R., Mancinelli G., Corti C. & Ficetola G. F., 2018b – What shapes the trophic niche of European plethodontid salamanders? *PLoS One*, 13 (10): e0205672. doi: 10.1371/journal.pone.0205672
- Lunghi E., Cianferoni F., Corti C., Zhao Y., Manenti R., Ficetola G. F. & Mancinelli G., 2022 – The trophic niche of subterranean populations of *Speleomantes italicus*. *Scientific Reports*, 12 (1): 18257. doi: 10.1038/s41598-022-21819-8
- Lunghi E. & Corti C., 2021 – Predation of European cave salamanders (*Hydromantes*) by the spider *Meta bourneti* (Caudata, Plethodontidae; Araneae, Tetragnathidae). *Spixiana*, 44 (1): 54.
- Lunghi E., Corti C., Manenti R., Barzaghi B., Buschetti S., Canedoli C., Cogoni R., De Falco G., Fais F. & Manca A., 2018c – Comparative reproductive biology of European cave salamanders (genus *Hydromantes*): Nesting selection and multiple annual breeding. *Salamandra*, 54 (2): 101-108.
- Lunghi E., Manenti R. & Ficetola G. F., 2015 – Seasonal variation in microhabitat of salamanders: Environmental variation or shift of habitat selection? *PeerJ*, 3: e1122. doi: 10.7717/peerj.1122
- Lunghi E., Mascia C., Mulargia M. & Corti C., 2018d – Is the Sardinian grass snake (*Natrix natrix cetti*) an active hunter in underground environments? *Spixiana*, 41: 160
- Marini D., Di Nicola M. R., Crocchianti V., Notomista T., Iversen D., Coppari L., Di Criscio M., Brouard V., Dorne J.-L. C. M., Rüegg J. & Marenzoni M. L., 2023 – Pilot survey reveals ophidiomycosis in dice snakes *Natrix tessellata* from Lake Garda, Italy. *Veterinary Research Communications*, 47: 1707-1719. doi: 10.1007/s11259-023-10129-7
- Melis R. T., Di Gregorio F. & Panizza V., 2017 – Granite landscapes of Sardinia: long-term evolution of scenic landforms. In: Landscapes and landforms of Italy. Soldati M. & Marchetti M. (eds.). World Geomorphological Landscapes, Springer International Publishing, New York, 351-363. doi: 10.1007/978-3-319-26194-2_30
- Pastorelli C. & Laghi P., 2006 – Predation of *Speleomantes italicus* (Amphibia: Caudata: Plethodontidae) by *Meta menardi* (Arachnida: Araneae: Metidae). Atti del 6° Congresso Nazionale della Societas Herpetologica Italica (Roma, 27IX-1X2006). Roma: 45-48.
- Renet J., Tordjman P., Gerriet O. & Madelaine E., 2012 – Le Spéléropès de Strinati, *Speleomantes strinati* (Aellen, 1958) (Amphibia, Urodela, Plethodontidae): Répartition des populations autochtones en France et en Principauté de Monaco. *Bulletin de la Société Herpétologique de France*, 141: 3-22.
- Rodríguez C., Rollins-Smith L., Ibáñez R., Durant-Archibold A. A. & Gutiérrez M., 2017 – Toxins and pharmacologically active compounds from species of the family Bufonidae (Amphibia, Anura). *Journal of Ethnopharmacology*, 198: 235-254. doi: 10.1016/j.jep.2016.12.021
- Salvidio S., 1992 – Diet and food utilization in a rock-face population of *Speleomantes ambrosii* (Amphibia, Caudata, Plethodontidae). *Vie et Milieu/Life & Environment*, 35-39.
- Salvidio S., Palumbi G., Romano A. & Costa A., 2017 – Safe caves and dangerous forests? Predation risk may contribute to salamander colonization of subterranean habitats. *Science of Nature*, 104 (3-4): 20. doi: 10.1007/s00114-017-1443-y
- Salvidio S., Romano A., Oneto F., Ottonello D. & Michelon R., 2012 – Different season, different strategies: feeding ecology of two syntopic forest-dwelling salamanders. *Acta Oecologica*, 43: 42-50. doi: 10.1016/j.actao.2012.05.001
- Schultze N., Spitzweg C., Corti C., Delaugerre M., Di Nicola M. R., Geniez P., Lapini L., Liuzzi C., Lunghi E., Novarini N., Picariello O., Razzetti E., Sperone E., Stellati L., Vignoli L., Asztalos M., Kindler C., Vamberger M. & Fritz U., 2020 – Mitochondrial ghost lineages blur phylogeography and taxonomy of *Natrix helvetica* and *N. natrix* in Italy and Corsica. *Zoologica Scripta*, 49 (4): 395-411. doi: 10.1111/zsc.12417
- Speybroeck J., Beukema W., Dufresnes C., Fritz U., Jablonski D., Lymberakis P., Martínez-Solano I., Razzetti E., Vamberger M., Vences M., Vörös J. & Crochet P.-A., 2020 – Species list of the European herpetofauna – 2020 update by the Taxonomic Committee of the Societas Europaea Herpetologica. *Amphibia-Reptilia*, 41 (2): 139-189. doi: 10.1163/15685381-bja10010
- Vignoli L., Caldera F. & Bologna M. A., 2006 – Trophic niche of cave populations of *Speleomantes italicus*. *Journal of Natural History*, 40 (29-31): 1841-1850. doi: 10.1080/00222930600973598