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ABSTRACTS

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CAN AN INVASIVE METAPOPULATION OF *TRITURUS CARNIFEX* BE ERADICATED?

BENEDIKT R. SCHMIDT[1,2,*], SVENJA ZEHNDER[3], PETRA RAMSEIER[4]

[1]info fauna karch, Bellevaux 51, 2000 Neuchâtel, Switzerland
[2]Department for Evolutionary Biology and Environmental Studies, University of Zurich, Winterthurerstrasse 190, 8057 Zurich, Switzerland
[3]Department of Environmental Sciences, University of Basel, Basel, Switzerland
[4]Hintermann & Weber AG, Austrasse 2a, CH-4153 Reinach, Switzerland

[*]Correspondence: benedikt.schmidt@ieu.uzh.ch

KEYWORDS: *Triturus carnifex*, invasive species, eradication, population ecology.

Invasive alien species can contribute to the loss of biodiversity. Therefore, attempts should be made to mitigate the negative effects of alien invasive species. Here we report on the occurrence and eradication of an invasive population of the Italian crested newt *Triturus carnifex* in northern Switzerland. The newts occupy a small number of ponds in a small area. As the newt had a negative impact on native amphibians in other areas, the nature conservation authorities decided to attempt eradication. Drift fences were used to capture the newts. We report on the initial results of the eradication programme. We also show results from a metapopulation model in which we modelled different eradication scenarios. Eradication appears feasible, despite the surprisingly large population size, but will require several years of significant effort.

PRELIMINARY DATA ON THE DIET OF A POPULATION OF *SPELEOMANTES ITALICUS* FROM THE REPUBLIC OF SAN MARINO

SANDRO CASALI[1], MATTEO PAGLIARANI[1], MARTINA COFANI[2], FABIO CIANFERONI[3,4], ENRICO LUNGHI[5,6,7,*]

[1]Centro Naturalistico Sammarinese, Borgo Maggiore, Repubblica di San Marino
[2]Dipartimento di Scienze Biologiche, Geologiche e Ambientali, Università di Bologna, Bologna, Italy
[3]Istituto di Ricerca sugli Ecosistemi Terrestri (IRET), Consiglio Nazionale delle Ricerche (CNR), Firenze, Italy
[4]Museo di Storia Naturale dell'Università degli Studi di Firenze, "La Specola", Firenze, Italy
[5]Dipartimento di Medicina clinica, sanità pubblica, scienze della vita e dell'ambiente (MeSVA), Università degli Studi dell'Aquila, L'Aquila, Italy
[6]Associazione Natural Oasis, Prato, Italy
[7]Unione Speleologica Calenzano, Calenzano, Italy

[*]Correspondence: enrico.arti@gmail.com

KEYWORDS: cave salamander, Plethodontidae, stomach contents, trophic niche.

During the last few decades, the trophic niche of the European plethodontid salamanders (genus *Speleomantes*) has been intensively studied. Adopting a harmless technique (i.e., stomach flushing) researchers have been able to collect stomach contents from plethodontid salamanders and analyze multiple traits of their feeding habits, from assessing the diversity of the consumed prey to evaluating if and how many individuals from a specific population show a specialized diet. The Italian cave salamander, *Speleomantes italicus*, is the species with the widest distribution that covers most of the Apennine chain from Tuscany to Abruzzo. It is considered to be endemic to the Italian peninsula and it also occurs in the Republic of San Marino. The trophic niche of this species has been investigated multiple times, but none of such studies were performed on any population occurring in the Republic of San Marino. Here we present the first data on the consumed prey by an epigean population of *S. italicus* from the Republic of San Marino. We performed two surveys at night, one in November 2022 and one in April 2023. This population occurs in a forested area and in dry walls nearby a small, urbanized area. We captured and photographed the salamanders to estimate their size (snout-vent length; SVL), and to sex them (males, females, juveniles) on the basis of both secondary sexual male character (i.e., mental gland) and SVL. Before their release we performed the stomach flushing; stomach contents were preserved in 70% ethanol until their recognition under the stereo microscope. Analyzing the stomach contents of 67 individuals, we recognized 1,018 prey items belonging to 28 prey groups (autumn, $N = 46$, prey groups = 27, prey items = 921; spring, $N = 21$, prey groups = 17, prey items = 97). Larvae of Diptera, Collembola Entomobryomorpha and Hemiptera were the most consumed prey in autumn, while adult Diptera and Araneae were the most consumed in spring. Considering the full dataset, We did not find any significant effect of both size and sex (male, female, juvenile) on the number or diversity (Shannon index) of consumed prey. Overall, we identified a significant high proportion of generalist individuals in this population. This is the first study performed on the diet of *S. italicus* from San Marino, and it also represents one of the fewer studies of epigean populations of *Speleomantes* compared to those occurring in caves. Our findings identified some divergences from previous studies on this species, for example the lower

number of flying preys consumed by individuals, which always represented the larger proportion of prey. These results must be considered a starting point for the study of the trophic niche of *S. italicus* from San Marino, as further repeated samplings are needed to provide a more complete information on the dietary habits of this population.

SIT AND WAIT FORAGING IS NOT ENOUGH IN FOOD-DEPRIVED ENVIRONMENTS: EVIDENCE FROM GROUNDWATER AND SALAMANDERS

RAOUL MANENTI[1,*], CHIARA TEODORO[1], BENEDETTA BARZAGHI[1], ANDREA MELOTTO[1], GENTILE FRANCESCO FICETOLA[1]

[1]Department of Environmental Science and Policy, University of Milano, Milano, Italy

[*]Correspondence: raoul.manenti@unimi.it

KEYWORDS: springs, caves, ambush, predator, prey.

Foraging strategy is a fundamental trait that characterises predators, with strong differences between the sit-and-wait and the active-searching ones. The optimal foraging theory predicts that environmental conditions affect the efficiency of these strategies, with active predators being favoured when prey are scarce and difficult to be detected. Subterranean habitats are ideal models to study the effectiveness of foraging strategies. Laboratory studies on fish and salamander predators showed that active foraging often characterises cave-adapted species, but field studies demonstrating the advantages of active foraging for growth and survival are lacking. In this study, we assessed how predators displaying a sit-and-wait strategy can cope with the variable costs of foraging under different ecological contexts, such as cave and surface environments.

We performed a cross environment experiment that was repeated during three distinct years by rearing salamander larvae from caves and surface streams in cages placed in both surface and subterranean environments. We measured larval growth (weight and total length) repeatedly every 10-20 days, from March to July, and assessed water temperature variation, prey availability and metamorphosis achievement in the rearing sites.

Larvae in stream cages increased their size more than larvae in subterranean cages, which even showed a negative growth. Our results suggest that in subterranean environments, the sit-and-wait strategy does not allow for the collection of enough prey for development, irrespective of the origin of the larvae. In food deprived environments, wide active foraging is necessary to collect the energy required for the basic functions of organisms exploiting them.

GUIDELINES FOR EFFECTIVE COMMUNICATION PROJECTS ON AN ENDANGERED ALPINE SALAMANDER

SARA LEFOSSE[1,*]

[1]Studio Naturalistico Hyla SRL, via Baroncino 11, 06069 Tuoro sul Trasimeno (PG)

[*]Correspondence: selfsdue@gmail.com

KEYWORDS: flag species, *Salamandra atra aurorae*, old-growth forests.

Increasing awareness of the importance of natural heritage among people is pivotal for achieving biodiversity conservation. This is especially important in Italy, where environmental issues have received little attention, and false information has often been exploited for political gain. Furthermore, plants and animals serve as useful flag species to promote the protection of ecosystems. However, flag species are more commonly large vertebrates, even though almost every species could be a flag species.

As part of my master's thesis on Natural Capital and Protected Areas at Università di Roma La Sapienza, I developed a communication project focused on Aurora's salamander (*Salamandra atra aurorae*), a micro-endemic subspecies that inhabits a restricted area of the Altopiano dei Sette Comuni in northeastern Italian Prealps. This subspecies was recently assessed as Endangered according to the IUCN Red List criteria. The main threat to the conservation of *S. a. aurorae* is the deterioration of its habitat, which consists of forest soils under old mixed stands of *Abies alba* and *Fagus sylvatica* with some *Picea abies*. In most of the Altopiano dei Sette Comuni, the original tree community has been replaced by pure *Picea abies* forests over the last century due to forest management and economic reasons. Additionally, in recent years, a windstorm named "tempesta Vaia" has destroyed about 20-25% of the most important forests in *S. a. aurorae*'s geographic range.

I developed a communication project aimed at making this rare alpine salamander a flag species and promoting the conservation of its declining habitat. The objective was to define effective communication strategies that are linked to cultural aspects and/or daily life, in order to engage people effectively. To achieve this, I focused on four main topics: iconography and myth; history and cultural connection between the citizens of the Altopiano dei Sette Comuni and the "resource wood"; scientific aspects about the salamander's micro-habitat and the complexity of the ecosystem. For each topic, I formulated a *claim* and summarized the contents, debunking some misconceptions and analyzing the salamander's symbolic representation ("iconography, symbolism and myth"). Additionally, I analyzed the historical connection with wood, emphasizing the differences between various types of ecosystems ("there is wood and wood"), and addressed crucial scientific aspects to illustrate the interconnectedness of ecosystems ("soil and micro-habitat" and "the fragile balance of ecosystems: good or bad animals?!"). For instance, the unusual habits of Aurora's salamanders and the complexity of the "soil ecosystem" were synthesized by the claim "Salamanders live upside down in a condominium much like a Gruyère cheese". These guidelines serve as a valuable tool for creating communication projects tailored to specific target audiences, communication objectives and communication tools.

POPULATION DENSITY AND SEX-RATIO IN TWO POPULATIONS OF *SALAMANDRA ATRA* OF OROBIE ALPS IN PROVINCE OF SONDRIO (LOMBARDY)

VINCENZO FERRI[1,*], CHRISTIANA SOCCINI[1]

[1]Centro Studi Naturalistici "Arcadia", via Valverde 4, Tarquinia, Viterbo, Italia

[*]Correspondence: drvincenzoferri@gmail.com

KEYWORDS: *Salamandra atra*, ecology, monitoring, conservation, Orobie Alps, Lombardy.

From 2008 to 2015, the authors scientifically coordinated the "Salamandra nera" project of the Orobie Valtellinesi Regional Park, promoted to deepen the knowledge of the ecology, behavior and distribution of alpine black salamander, *Salamandra atra* Laurenti, 1768 in the westernmost sector of the Italian range. The research subsequently continued as part of the herpetological monitoring promoted by LIFE14 IPE/IT000018 GESTIRE 2020. A total of 64 visits have been made in different areas, each one lasting a minimum of 120 minutes per person, for a grand total of 624 hours of actual research and 1890 hours of high-altitude travel for the research group involved.

We found more than 450 individuals in 9 distinct locations (for three of these sites it was the first report for the species). Some salamanders have been sampled for genetic analyses, through a mouth swab, in collaboration with the Department of Molecular Biology, Faculty of Natural Sciences of the University of Salzburg (Salzburg Austria). Since 2009, some adults have been marked with a Visible Implant Elastomer (V.I.E.) for a population study following the "capture-mark-recapture" method.

We report results on population density and sex-ratio from *Salamandra atra* populations present at the extreme altitudes of the study area: between 1000-1100 m a.s.l. of Albaredo Inferiore (Site 1) and 1800-2000 m a.s.l. of Alta Val Gerola (Site 2).

Density, analyzed on data collected with the same field effort and comparable environmental and climatic conditions, was significantly different between the two sites, ranging from 2 to 28 ind./ha in Site 1 compared to 65-235 ind./ha in Site 2. Sex ratio [expressed as: males/(males+females)] ranged from 0,64 to 0,75. These information, are of fundamental importance for planning medium and long-term conservation strategies which could mitigate the foreseeable negative consequences of "Global Warming" for this alpine and stenoecia species.

Based on our study, the Albaredo site was proposed by the authors as an Area of Herpetological Relevance (ARER ITA155LOM038) and was requested to the Lombardy Region the redefinition of the boundaries of the Special Area of Conservation IT2040028 "Valle del Bitto di Albaredo" for the inclusion in it of the *Salamandra atra* area of presence.

The study was authorized by the Italian Ministry of Environment (authorization: MATTM-DPN-2008-0018923 del 01-08-2008; MATTM DPN-2016-0021487 del 11-10-2016; PNM-U.0001725.31-01-2020) and supported by the Orobie Valtellinesi Regional Park.

ACTIONS FOR *IN SITU* AND *NON-SITU* CONSERVATION OF *TRITURUS CARNIFEX* POPULATIONS OF THE LOWER PLAIN IN LOMBARDY

VINCENZO FERRI[1,*], MASSIMILIANO LA ROSA[2], ANDREA LONGO[2], CHRISTIANA SOCCINI[1], ANDREA AGAPITO LUDOVICI[3]

[1]Centro Studi Naturalistici "Arcadia", via Valverde 4, Tarquinia, Viterbo, Italia
[2]Bosco WWF di Vanzago, via delle Tre Campane 21, Vanzago, Milano, Italia
[3]Fondazione WWF Italia, via Po 25/c, Roma, Italia

[*]Correspondence: drvincenzoferri@gmail.com

KEYWORDS: *Triturus carnifex*, conservation, Po Plane, Lombardy.

Conservation Status of the Italian crested newt (*Triturus carnifex*) across Po Plain in Lombardy is poor and calls for urgent management actions. Last ten years of research have shown that this species is extremely localized in the Po Valley between Pavia and Mantua and small populations survive in artificial sites and in context of strong anthropization, but in areas without allochthonous predators or where these have not yet been introduced.

Since 2017 in the "Bosco WWF di Vanzago" Nature Reserve (ZSP and ZSC IT2050006) a generalized increase program of aquatic habitats favorable to amphibians, reptiles, freshwater invertebrates and hydrophytes has been underway to try to keep viable populations of threatened species in the territory. All in a context of almost complete absence of allochthonous fishes and freshwater crayfishes, regulation and maintenance of the waters for the biological needs of the various species and with protective interventions to guarantee reproductive success (anti-bird nets; lateral anti-intrusion barriers of terrestrial fauna; shelters, etc.).

Changes in abundance of adult newts in the breeding sites were followed throughout the breeding seasons of 2017-2023 with a long term monitoring by means of night counts by torch. Such counts may be affected only by changes in the ease with which individuals can be seen because of fluctuations in turbidity and density of water plants. We present results that prove the success of these interventions and the particular increase in the population of *Triturus carnifex*, which has gone from a few localized individuals to a general dispersion with a number currently estimated at 2000-5000 adult individuals.

Hence the activation of a *Triturus* Project which through own funds of "Bosco WWF di Vanzago" management structure or through regional funding (LIFE Gestire 2020), has led to the launch of dedicated protected reproductive points, to an *ex situ* laboratory with controlled tanks to favor deposition and better hatching of eggs and for the subsequent rearing of larvae till 10 weeks of developmental stage, the activation of an authorization procedure (feasibility study in completion) to start restocking programs for *Triturus carnifex* populations of the Lombard Po Valley.

Starting from "Vanzago" source population, the first localities to receive attention and which have already implemented the indispensable interventions of habitat management and predators-control will be the PLIS "Collina di San Colombano al Lambro" (MI), "Monticchie" Nature Reserve (Somaglia, LO) and "Bodrio Oasi delle Margherite" (San Daniele Po, CR). In

synergy with these interventions, those concerning relict but important populations of *Triturus carnifex* in the Brescia plain and in particular those within the Area of National Herpetological Relevance "Valle di Mompiano" (Parco delle Colline di Brescia, Brescia), where the main problems are the persistence and availability of water.

ONLY WE HAVE IT. HISTORICAL, ECOLOGICAL, AND DISTRIBUTION COMPENDIUM ON THE *SALAMANDRINA* GENUS

ANTONIO ROMANO[1,*]

[1]Consiglio Nazionale delle Ricerche - Istituto per la BioEconomia, Via dei Taurini 19, 00100 Roma (RM), Italy

[*]Correspondence: antonio.romano71@gmail.com

KEYWORDS: Spectacled salamander, *Salamandrina terdigitata*, *Salamandrina perspicillata*, endemism, amphibians, Italy.

Italy is the only European country to possess an endemic genus of vertebrate, the *Salamandrina* genus, the Spectacled salamander. In this contribute, the history of this genus will be retraced, from the first description by Ferrante Imperato in 1599, where it was generically referred to as "*another species of salamander rarely seen*", to its formalization by Lacépedè in 1788 who used an incorrect specific epithet in the morphological description (troi doigts = with three fingers), to the subsequent formalization according to the criteria established by Linnaeus and by the International Code of Zoological Nomenclature as *Salamandrina terdigitata* (Bonnaterre 1789). Will be described the first work entirely dedicated to the natural history of the *Salamandrina* by Giovanni Ramorino in 1853, up to the discovery in 2005 of the existence of two species within the genus, and finally, the recent research that has elucidated various aspects of its natural history.

Compared to other amphibians occurring in Italy, the Spectacled salamander has been a little-studied entity in the 19th and 20th centuries, partly due to our inability to distinguish the sexes in the field until 2009. However, since the early 21st century, among researchers there has been a growing and sudden interest, clarifying ecology, genetics, diet, behavior, courtship rituals, sex ratio, distribution of the two species, morphological and pigmentary characteristics. Lastly, the still unknown aspects of this genus will be illustrated, providing a comprehensive contribution and an overview of the knowledge about this endemic taxon of the Italian peninsula, as well as encouraging further research.

CLIMATE CHANGE AND *SALAMANDRA LANZAI*: WHAT DOES THE FUTURE HOLD?

DAVIDE GIULIANO[1,*], DANIELE SEGLIE[2], PAOLO EUSEBIO BERGÒ[2], RICCARDO CAVALCANTE[2], MARCO FAVELLI[2], BRUNO AIMONE GIGIO[1], ALAIN BLOC[3], ANNA GAGGINO[4], MATTEO MASSARA[5], ALESSANDRA PUCCI[6], MARCO RASTELLI[4], CLAUDE MIAUD[7], BARBARA RIZZIOLI[1,5]

[1]Ente di Gestione delle Aree Protette delle Alpi Cozie; Via Fransuà Fontan 1, 10050 Salbertrand (TO), Italy.
[2]ELEADE Società Cooperativa a.r.l.; C.le Montresco 1, 10010 Chiaverano (TO), Italy
[3]Parc Naturel Régional du Queyras - Réserve Naturelle Nationale de Ristolas Mont Viso; 3 580 Route de l'Izoard, 05350 Arvieux (05), France
[4]Ente di Gestione delle Aree Protette del Monviso; Via Griselda 8, 12037 Saluzzo (CN), Italy
[5]Regione Piemonte, Settore Sviluppo Sostenibile, Biodiversità e Aree Naturali; Via Principe Amedeo 17, 10123 Torino, Italy
[6]Città Metropolitana di Torino, Direzione Sistemi Naturali; C.so Inghilterra 7, 10138 Torino, Italy
[7]CEFE, Univ Montpellier, CNRS, EPHE-PSL University, IRD, 1919 route de Mende, 34293 Montpellier, France

[*]Correspondence: giuliano@alpicozie.eu

KEYWORDS: ensemble models, environmental suitability, bioclimatic suitability, future projections, endemic species, conservation.

Climate change is threatening several montane species across the world, including a large number of endemics, needing the development of forward-looking conservation strategies to foster their future survival. In this context, Species Distribution Models (SDMs) represent a useful method to forecast changes in species' habitat suitability under different scenarios of global warming, often advising conservation frameworks with valuable information. In this research, we estimated the environmental and bioclimatic suitability in the Western European Alps for the endemic alpine urodele *Salamandra lanzai* (Lanza's alpine salamander) through an SDM approach, considering both current and future scenarios, in order to address short- and long-term management and conservation actions, and to update the current IUCN extinction risk assessment (*Critically Endangered*).

The total solar radiation in June, the minimum temperature of the coldest month of the year, the total amount of precipitations, the Normalized Difference Vegetation Index in July, the precipitation seasonality, and the mean temperature of the driest quarter of the year were identified as the main parameters correlated with the current distribution of the Lanza's alpine salamander, which covers less than 300 Km^2 in the Cottian Alps, between Italy and France. Concerning the future, the ensemble models predict a dramatic decline of the climatically suitable area for *S. lanzai*, together with a considerable upslope shift, already in the next 20-40 years, even considering an optimistic CO_2 emissions scenario, leading to a theoretical extinction of this species in 2100 in case the worst global warming prediction will be actualized. Increasing temperatures and future alterations in precipitation regimes appear as the main drivers of the reduced bioclimatic suitability for the Lanza's alpine salamander towards the end of the century.

Although based only on surface-related bioclimatic parameters, these results underline the urgent need of up-to-date conservation and management strategies to ensure a successful mitigation of climate change effects on *S. lanzai*, especially by adapting and improving the

network of protected areas (currently covering less than 50% of the suitable area), by immediately removing additional threats (e.g. roadkill mortality), and by identifying possible management actions able to increase fine-scale habitat suitability and connectivity among populations. In addition, a significant range contraction in the future has to be considered when assessing the extinction risk for this species, possibly exacerbating the effect of other threatening factors, such as the spread of lethal pathogens (e.g., *Batrachochytrium salamandrivorans*).

MONITORING SUPRAMONTE CAVE SALAMANDER (*SPELEOMANTES SUPRAMONTIS*) IN THE SCI SUPRAMONTE DI OLIENA, ORGOSOLO E URZULEI – SU SERCONE

ROBERTO COGONI[1,*], TIZIANA SABA[2], MARIO PAPPACODA[3]

[1]Via Segni, 76, Selargius
[2]Regione Autonoma della Sardegna-Servizio Tutela della Natura e Politiche Forestali
[3]Via Barbagia, 7, Quartu S. Elena

[*]Correspondence: roberto.cogoni@tin.it

KEYWORDS: monitoring, Sardinia, *Speleomantes supramontis*, Supramonte.

We here present the results obtained through a monitoring activity that aimed to estimate the abundance of *Speleomantes* populations in Sardinia, in order to contribute in improving the knowledge on this genus and to better plan conservation actions. The Autonomous Region of Sardegna (RAS) funded a monitoring program that include all the Sardinian *Speleomantes* species occurring within Nature 2000 sites. Specifically, we report the results of activities focused on the Supramonte cave salamander, *S. supramontis*, performed on the Supramonte di Oliena, Orgosolo e Urzulei – Su Sercone SCI-SAC (ITB022212) and carried out by Urzulei municipality. The species is distributed over 6 cells of 10x10km in the site. The activities were performed during the period May-June 2022, when *Speleomantes* are particularly active in subterranean environments. Following the guidelines provided by the "Manuale per il monitoraggio di specie e habitat di interesse comunitario (Direttiva 92/43/CEE) in Italia"we selected and monitored 10 hypogean sites (8 within SAC and 2 outside) in which the presence of the species was previously assessed. Information and location of sampling sites were retrieved from bibliography, from the cartographic database of RAS, and from the Regional Speleological Cadaster built up by the Federazione Speleologica Sarda. Each site was surveyed three times within 30 days; during each survey the operator performed standardized counts of the individuals encountered, without any manipulation. In six sites, we were able to observe individuals of *S. supramontis*, while for the other four we did not observe any individual during the three surveys. The lack of observations in these four sites is probably due to the unfavorable microclimatic conditions rather than a local extinction of the species. Within the other sites, we were able to observe individuals during each survey. Populations' estimates, obtained by means of *N*-mixture models, varied from 12 to 130 individuals. We are evaluating the possibility to extend the existing SAC, and to create a new SCI, to cover the sites in which *Speleomantes* abundances were the highest.

REGIONALIZED KNOWLEDGE AND IDENTIFICATION BIASES INFLUENCE OUR PERCEPTION OF THE BIOGEOGRAPHIC HISTORY OF URODELES

LOREDANA MACALUSO[1,*], SARA MONTI[2], ROBERTO ROZZI[1,3,4], MASSIMO DELFINO[2]

[1]Natural Sciences Collections - Martin Luther University Halle-Wittenberg, Domplatz 4, 06108 Halle (Saale), Germany
[2]Dipartimento di Scienze della Terra - Università degli Studi di Torino, Via Valperga Caluso 35, 10125 Torino, Italy
[3]Museum für Naturkunde, Leibniz-Institut für Evolutions- und Biodiversitätsforschung, 10115 Berlin, Germany
[4]German Centre for Integrative Biodiversity Research (iDiv) Halle - Jena - Leipzig, Puschstraße 4, 04103 Leipzig, Germany

[*]Correspondence: loredana.macaluso@zns.uni-halle.de

KEYWORDS: palaeobiogeography, Palaearctic, Cryptobranchidae, Proteidae, anatomy.

Nearly all of the present-day diversity of urodeles is concentrated in the Northern hemisphere, with only a small number of species living in South America. This distribution largely reflects the evolutionary history of a group that first appeared and diversified in the northern part (Laurasia) of the supercontinent Pangea at the height of its Mesozoic fragmentation. Thus, the group seemingly had little time to colonize its southern counterpart, Gondwana, prior to its separation. Interestingly, four families out of ten nowadays show a disjunct geographical range spanning North America and Eurasia (i.e. Cryptobranchidae, Plethodontidae, Proteidae and Salamandridae). These distributional patterns point to a complex evolutionary and biogeographic history that cannot be disentangled by only considering the present-day distribution of urodelan biodiversity, which represents only a temporal snapshot that has been overprinted by extirpations and anthropogenic disturbances. Many taxa that now inhabit just limited geographic ranges had close relatives living in other continents in the past. However, from the XVIII century up to the ’80 of the last century, the difficult access to the fossil remains and to the data from the other continents, as well as the limited knowledge about extant and extinct groups coming from different geographic areas caused a “virtual regionalisation” of extinct taxa. The first renowned case of this “regional identification” bias can be considered the one of the first specimens of the giant salamander *Andrias*. These salamanders currently live in east Asia, but in the past also occurred in Europe, where they have been found in Germany in 1726 and described as *Homo diluvii testis*. More recently, the genus *Mioproteus* is considered an extinct proteid lineage but, when compared with other extinct North American lineages (e.g. the early-branching Sirenidae), the resemblance in the morphology is striking. Moreover, our knowledge of the European fossil record is strongly biased towards complete specimens that are definitely rare in the fossil record, whereas disarticulated elements are commonly found but left aside, dispersed in the scientific collections and only rarely published. This is due to the lack of publications describing the full osteology of extant species, but also of researchers specialized in this group. The few phylogenies based on morphological characters are at the scale of single continents and problematic when it comes to understanding the biogeographic history of the group itself. This project aims from one side to understand the European assemblages of disarticulated urodeles currently scattered in

different collections and from the other side to compare the Palearctic and the North American records in order to have a clear overview of the evolution of salamanders of the world.

BATRACHOCHYTRIUM SALAMANDRIVORANS AND ITALIAN URODELES: EPIDEMIOLOGY AND PRACTICE

STEFANO CANESSA[1,*]

[1]Division of Conservation Biology, University of Bern, Switzerland

[*]Correspondence: stefano.canessa@unibe.ch

KEYWORDS: chytridiomycosis, conservation, detection, management, monitoring.

The invasive pathogenic fungus *Batrachochytrium salamandrivorans* (*Bsal*) is spreading throughout Europe and has been detected in captive collections throughout the continent. It poses a particular threat to urodele species in Italy, given their high level of endemism and high proven or hypothesized susceptibility. Academics usually highlight this threat and recommend monitoring and early reactions. In this contribution, I will argue action might be possible even under scientific uncertainty, but the real obstacle are practical challenges and inadequate management structures and resources.

Ecological theory and experimental data suggest *Bsal* outbreaks could be contained and even eradicated, given early detection, rapid response and considerable efforts. However, in reality detection remains largely opportunistic and a well-structured surveillance and early warning network would require much greater awareness and resources than likely to ever be available. Communication is necessary for any action, but it will mostly depend on goodwill and existing networks. Competences and decision responsibilities should be clarified well in advance of any real emergency, but they are likely to be complicated by bureaucracy, slow response times and unclear or inadequate legislation. Finally – and possibly most important – although "early action" is often mentioned, there is too little practical discussion of what that action would or should look like, and the few interventions that have been attempted in practice remain unique examples from which scarce lessons have been drawn to date. Given these difficulties, there is little room for optimism in the face of the inevitable arrival of *Bsal* in Italy.

THE AMPHIBIA CAUDATA OF PRATOMAGNO (VALDARNO SIDE) (CENTRAL-NORTHERN TUSCANY)

NICOLÒ PELLECCHIA[1*], RICCARDO MOSCHI[1], ROSSANO PAPI[1], PIERANGELO CRUCITTI[1]

[1]Società Romana di Scienze Naturali (SRSN), Campus di "Villa Esmeralda" Via Fratelli Maristi 43 00137 Roma (RM) Italia

[*]Correspondence: *info@srsn.it*

Keywords: Amphibia Caudata, Pratomagno massif, checklist, citizen science.

We present the results of the distribution of Caudata on the Valdarno side of the Pratomagno massif (AR). This research is part of a larger census project, of the whole herpetofauna of the massif. Data collection started in summer 2020 and is still ongoing. The study area covers a total of 142 km² and is included in the municipalities of Castelfranco-Piandiscò (55 km²) and Loro Ciuffenna (87 km²). Inside this territory are included two protected areas: the Oasis of Pratomagno, and the ANPIL "Le Balze". This area is characterized by the abundance of running waters. Aquatic lentic environments are scarce, and mostly are of anthropic origin. For the purposes of a program of capture, manipulation and *in situ* release of species of herpetofauna of the Pratomagno district, the relative authorization was requested by the SRSN, issued by the Italian Ministry of Environment (MASE). The use of *citizen science* activities has proved to be of considerable importance for our research, particularly the realization of a project on iNaturalist, "Anfibi e Rettili del Pratomagno", as well as the involvement of the local people. Our searches allowed to find the presence of five species of Amphibia Caudata: *Lissotriton vulgaris meridionalis* (Boulenger, 1882), *Salamandra salamandra gigliolii* (Eiselt & Lanza,1954), *Salamandrina perspicillata* Savi, 1821, *Speleomantes italicus* (Dunn, 1923), *Triturus carnifex* (Laurenti, 1768). This note describes some qualitative aspects observed in the field, such as site description, egg/larvae deposition period and altitude range of each species.

DIVERSITY, DISTRIBUTION AND HABITAT PREFERENCES OF URODELES IN THE "CILENTO, VALLO DI DIANO E ALBURNI" NATIONAL PARK (CAMPANIA, SOUTHERN ITALY)

ANTONIO ROMANO[1,*], DINO BIANCOLINI[1]

[1]CNR-IBE, Consiglio Nazionale delle Ricerche - Istituto per la BioEconomia, Via dei Taurini, 19 00100 Roma (RM) – Italy

[*]Correspondence: antonioromano71@gmail.com

KEYWORDS*:* diversity, ecology, habitat, distribution, Cilento.

Urodeles are critical ecological indicators of ecosystem health and play important ecological roles. However, due to factors such as climate and land-use change, their populations are declining globally. It is critical to study the distribution of these species in protected areas to effectively manage them. In the "Cilento, Vallo di Diano e Alburni" (CVDA) National Park (Southern Italy) two newt and two salamander species occur. Here we present new information on the distribution and ecology of these Urodeles in the Park. We used a large dataset of 325 records from fieldwork, citizen science, and literature to assess species rarity and habitat preferences. We aimed to know if differences in species richness across habitat types and elevations were caused by species selection for different environmental conditions. We calculated the probability of observing a species in various habitat types and estimated the significance of species-habitat associations. Geographic range, population abundance, and habitat breadth were used to determine species' rarity. When compared to published data, collected data significantly improved understanding of the distribution of numerous species. Our findings are generally consistent with the species' ecological information available in Italy, but we also discovered some peculiar ecological aspects of some species that were previously unknown. *Triturus carnifex* and *Salamandra salamandra* are the most stenoecious species because they are strictly associated with only one habitat type (wells and streams, respectively) avoiding all other aquatic habitat types. While this is consistent with the knowledge of the Fire salamander on the national territory, it does not hold true for the Italian crested newt. The CVDA National Park emerges as an effective protected area that ensures good conservation status of Urodeles, including species with national population and range declines.

WETLAND RESTORATION INTERVENTIONS TARGETING *TRITURUS CARNIFEX* AND *LISSOTRITON VULGARIS* IN THE BEIGUA NATURAL PARK (GENOA - SAVONA; LIGURIA)

ANTONIO ALUIGI[1,*], SERGIO G. FASANO[1]

Ente Parco del Beigua - Piazza Beato Jacopo 1 e 3 - 17019 Varazze (SV), Italia

[*]Correspondence: biodiv@parcobeigua.it

KEYWORDS: newts, management, Beigua Natural Park.

In 2015, the Integrated Plan of the Beigua Natural Park (Genoa - Savona; Liguria) highlighted how the main conservation emergencies of the protected area were attributable to some target species linked to wetlands. From the point of view of the state of conservation, the element that aroused the greatest concern was represented by *Triturus carnifex*, which could be considered at risk of extinction at local scale, while for *Anagallis tenella*, *Spiranthes aestivalis*, *Lissotriton vulgaris* was unfavourable - inadequate. In the study area, the main risk factors are represented by silting of ponds and ageing processes of wetlands due to the evolution of the herbaceous-shrub component and the expansion of the forest.

The opportunity to carry out the appropriate management actions materialized in 2017, thanks to funding from WWF Switzerland with the support of Blue Planet - Virginia Böger Stiftung X.X., which made possible to implement the project "Actions to improve the state of conservation and restore ecological connectivity of wetland".

During 2018, the preparatory activities for the implementation of the project were carried out, which led to the identification of seven intervention sites. The interventions were therefore carried out between 2019 and 2020. In the following years, monitoring of the sites was carried out.

The results have been remarkable, one of the intervention sites was colonized by *Triturus carnifex* already in 2022, and another by *Lissotriton vulgaris* in 2023, which are located respectively at about 1150 and 620 metres from the closest known presence sites. The preparatory investigations for updating the Management Plan of the SAC IT1331402 "Beigua - Monte Dente - Gargassa – Pavaglione" (currently being drafted) indicate in fact, both for *Triturus carnifex* and for *Lissotriton vulgaris*, a substantially favourable state of conservation, achieved thanks to the actions previously described and to what emerged during other monitoring activities.

PRELIMINARY DATA ON THE COMPARATIVE OSTEOLOGY OF DENTIGEROUS ELEMENTS OF THE ITALIAN URODELES

SARA MONTI[1,*], LOREDANA MACALUSO[2], MASSIMO DELFINO[1,3]

[1] Dipartimento di Scienze della Terra, Università degli Studi di Torino, Via Valperga Caluso 35, 10125 Turin, Italy
[2] Natural Sciences Collections - Martin Luther University Halle-Wittenberg, Domplatz 4, 06108 Halle (Saale), Germany
[3] Institut Català de Paleontologia Miquel Crusafont, Edifici ICTA-ICP, c/ Columnes, s/n, Campus de la UAB, 08193 Cerdanyola del Vallès, Barcelona, Spain

[*]Correspondence: sara.monti957@edu.unito.it

KEYWORDS: osteology, Salamandridae, dentary, maxilla, premaxilla, vomer.

The scarcity of articulated skeletons in the fossil record of urodeles constitutes a problem for determining the taxonomic identity of specimens, as well as for understanding the phylogenetic relationships of extinct taxa known from isolated skeletal remains (which forms the 87% of the fossil record). The record of the isolated remains is strongly biased towards the most robust elements, with vertebrae being the most commonly found skeletal element, followed by limb elements and some elements of the skull. Among these, the otic-occipitum complexes and the dentigerous elements are the proportionally thickest ones and therefore more frequently preserved as fossil. With the comparative osteology of vertebrae and otic-occipitum complexes of European urodeles recently published, this project aims to create a comparative atlas of the dentigerous elements (dentary, premaxillae, maxillae, vomers) of the skull for the Italian Urodela. For this purpose, 61 specimens have been studied, with four specimens for the genus *Speleomantes*, three for the genus *Euproctus*, 18 for the genus *Salamandra*, 12 for the genus *Salamandrina*, 11 for the genus *Triturus*, three for the genus *Ichthyosaura* and 14 for the genus *Lissotriton*, taking into account a total of 70% of the Italian species. Remarkable is the absence of any representative of *Proteus anguinus*, whose disarticulated skeletons were not available for study.

The analyses are still ongoing, but preliminary results show the possibility to reach an identification at different taxonomic levels for the different elements. The most diagnostic elements are premaxillae and vomers, that allow taxonomic identification at the genus level and in few cases at species level (e.g., premaxillae of *Salamandra salamandra*). As far as premaxillae are, the most diagnostic characters are the degree of fusion, the number of teeth, the expansions on the alary process and the number of foramina. For the vomer, it is useful to observe the shape of the dentigerous ridge, the expansions and cavities of the margo intervomeropalatinum and orbitoshpenoideum.

Based on the current dataset, dentaries and maxillae show a more conservative morphology within the Salamandridae family and the distinction of the different genera is more challenging.

However, the ornamentation, the shape of the processus maxillaris anterior and the position and percentage of coverage of teeth are good diagnostic characters for the maxillae,

whereas for the dentary one should observe the degree of fusion of the dorsal and ventral margins, the teeth shape, the thickness of the process articularis and the shape of the symphysis.

The future direction of this project will be to assess whether the phylogenetic characters based on these skeletal elements can provide a reliable phylogenetic signal, both by conducting analyses using a matrix based on the morphology of these skeletal elements only and by incorporating new characters into existing morphological matrices.

EFFECTS OF PREDATION IN *PROTEUS ANGUINUS*: A COMPARISON OF MALFORMITIES AND INJURES BETWEEN CAVES AND SPRINGS

THOMAS CREANZA[1,*], GIORGIO GRASSI[1], RAOUL MANENTI[1], BENEDETTA BARZAGHI[1]

[1]Department of Environmental Science and Policy, Università degli Studi di Milano, Via Celoria 26, 20133 Milano, Italy

[*]Correspondence: thomas.creanza99@gmail.com

KEYWORDS: olm, malformation, predation, camparison, caves, springs.

Proteus anguinus is an iconic stygobiont salamander which can be found also in surface aquatic environments such as springs.

P. anguinus is a top predator underground, but in epigean environments we can hypothesize that it may be subject to predation by different species. If the risk of predation is higher in springs than in caves, we expect to encounter a higher number of *P. anguinus* individuals with injuries and malformations in epigean environments.

To assess the variation of injuries/malformities occurring between the two different types of environments, we sampled Italian populations of *P. anguinus* in 2 caves and 5 springs of the provinces of Monfalcone and Trieste from September 2022. We collected and analyzed data on the number of individuals with possible signs of predation, such as absent limbs or deformed body parts. The individuals were collected from both environments using a net and photographed in standard conditions with graph paper, and then released at the capture site. 5 individuals out of 19 sampled in caves and 13 individuals out of 47 found in springs showed malformities/injuries. The commonest malformations in caves were atrophied gills, but absent fingers were also found, while in springs were absence of limbs. The differences between caves and springs were only slightly significant (percentage of malformed individuals in caves = 26,32% and in springs = 27,66%).

Consequently, we can assume that predation on the surface may not have as significant an impact as expected and injuries/malformities can occur also in caves. In the future we will investigate what other factors (e.g., pollution) may cause all the reported malformations.

LONG-TERM TRENDS OF CAVE SALAMANDERS (*SPELEOMANTES STRINATII*) IN LIGURIA AND PIEDMONT

GENTILE FRANCESCO FICETOLA[1,*], ENRICO LUNGHI[2], MATTIA FALASCHI[1], BENEDETTA BARZAGHI[1], SAMUELE ROMAGNOLI[1], ELIA LO PARRINO[1], ANDREA MELOTTO[1], SILVIO MARTA[1], VALENTINA BALESTRA[3,4], RAOUL MANENTI[1]

[1]Department of Environmental Science and Policy, Università degli Studi di Milano, Via Celoria 10, Milano
[2]Department of Life, Health and Environmental Sciences, Università degli Studi dell'Aquila
[3]Department of Environment, Land and Infrastructure Engineering, Politecnico di Torino, Corso Duca degli Abruzzi 24, Torino, Italy
[4]Biologia Sotterranea Piemonte - Gruppo di Ricerca, % Bossea Cave, Frabosa Soprana (CN), Italy

*Correspondence: francesco.ficetola@gmail.com

KEYWORDS: occupancy, forest cover, cave, biospeleology, land-use change.

Documenting amphibian declines and extinctions is pivotal to identify drivers and conservation priorities. However, ascertaining population trends is difficult, and requires long term monitoring programs. Unfortunately, such programs often are jeopardized by funding constraints and rarely cover broad areas of species ranges. The cave salamander, *Speleomantes strinatii*, is listed as endangered by the IUCN redlist, which suggests a declining population trend and a high risk of extinction in the next years, but its actual status is highly debated. Despite time series exist on the abundance of some populations, very limited information is so far available on the overall trend of this species over a broad scale. However, published surveys by cave biologists are available and report the occurrence of *S. strinatii* in a large number of cavities of Liguria and Piedmont for the period 1950-1985. From 2011 to 2023, we conducted visual encounter surveys in 111 cavities in Central and Western Liguria, and in Southern Piedmont. We re-surveyed cavities for which historical data on the occurrence of *S. strinatii* were available. We then used occupancy modeling to 1) relate present-day occupancy to recorded microhabitat features (temperature, humidity, incident light), and 2) compare present-day occupancy with historical data. We also used historical and present-day information on land cover to identify potential drivers of occupancy changes. Our surveys confirmed that *Speleomantes strinatii* is widespread in the study area. Its occupancy was significantly associated with microhabitats characterized by low temperature, high humidity and limited incident light. Overall, salamanders were detected in most of cavities with suitable microhabitat. Our surveys confirmed salamander occurrence in most of cavities with historical records. We did not detect evidence of decline. Present-day levels of occupancy and abundance are apparently higher than values reported in historical records. Nevertheless, uncertainty on the sampling efforts during historical records is high, thus it is unclear whether differences correspond to actual expansion of the species, or are simply the effect of a higher sampling intensity. Our analysis highlights the importance of long-term data to ascertain the actual conservation status of species, and can be used as reference to understand the fate of *S. strinatii* under the threat of emerging infectious diseases.

ESTIMATION OF NEWT POPULTAION TRENDS: ABUNDANCE VS OCCUPANCY DATA

MATTIA FALASCHI[1,*], ELIA LO PARRINO[1], RAOUL MANENTI[1], GENTILE FRANCESCO FICETOLA[1,2]

[1]Department of Environmental Science and Policy, Università degli Studi di Milano, Via Celoria 10, 20133 Milan, Italy
[2]Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, LECA, Laboratoire d'Écologie Alpine, F-38000 Grenoble, France

*Correspondence: matt_fala@hotmail.it

KEYWORDS: N-mixture models, occupancy models, population decline.

Assessing temporal trends of animal populations is the first fundamental step to identify the underlying drivers of change and to understand how to halt and reverse declines. The data used to estimate temporal trends can be ascribed to two categories: presence/absence or abundance. Abundance is the most straightforward way to assess population trends because it gives a direct indication of how the size of a population varies over time. However, accurate abundance measures can be difficult to obtain because individuals of a species can be hard to detect, or because effort-demanding techniques (e.g., capture-mark-recapture) are needed. Conversely, species presence data are easier to obtain because of the higher detectability of the species compared to detectability of individuals. However, we can expect that in species suffering declines, first a decline in abundance occurs and only later the species' presence over an area will shrink. For this reason, trend estimation based on presence/absence data might underestimate population declines. Here, we estimated temporal trends of two newt species (*Triturus carnifex* and *Lissotriton vulgaris*) in Northern Italy, using both occupancy models, based on detection/non-detection data, and abundance models based on counts of adult individuals. Abundance and occupancy of both species showed significant declines; however, as hypothesized, population declines were detected earlier for abundance, while occupancy showed a more linear decline over time. While abundance data may be more effort-demanding to collect, our work suggests that they are fundamental to rapidly track population changes, should we want to apply prompt conservation measures.

PRIORITIZING REGIONAL LAND COVER DATA FOR MODELING THE DISTRIBUTION OF MICRO-ENDEMIC SPECIES, A CASE STUDY ON *SALAMANDRA ATRA AURORAE*

SIMONE GIACHELLO[1,2,*], SARA LEFOSSE[3], LUCIO BONATO[4, 5]

[1]Department of Environmental Science and Policy - Università degli Studi di Milano, Via Celoria 10, Milano
[2]University School for Advanced Studies IUSS Pavia. Piazza della Vittoria 15, Pavia
[3]Studio Naturalistico Hyla SRL, via Baroncino 11, 06069 Tuoro sul Trasimeno (PG)
[4]Department of Biology - Università di Padova, Via U.Bassi 58b, Padova
[5]National Biodiversity Future Center, Piazza Marina 61, Palermo

[*]Correspondence: simone.giachello@unimi.it

KEYWORDS: species distribution model, micro-endemic species, land cover, environmental predictors, habitat suitability, *Salamandra atra aurorae*.

Micro-endemic species are more susceptible to extinction due to their limited distribution. Identifying the key environmental features driving their occurrence is crucial to put in place effective conservation strategies. Species distribution models (SDMs) are popular and effective tools that link species occurrence records with environmental information to infer habitat suitability. Satellite remote-sensing has provided land-cover (LC) datasets at a continental scale that are commonly employed for modeling species distribution. However, their habitat categorization and precision may be inadequate to detect habitat features that are critical to micro-endemic species, resulting in inaccurate estimates of habitat suitability.

In this study, we compared performance and accuracy of two widely used LC datasets versus LC maps produced at a regional scale. The last include more precise LC categories derived by satellite interpretation integrated with field surveys and local knowledge of the area. We modelled the distribution of the endangered *Salamandra atra aurorae*, a distinct lineage of alpine salamander with a known area of occupancy of only 33 km^2. Previous studies in restricted areas indicate that this salamander occurs mainly in mature mixed forests with silver fir, beech and Norway spruce whereas avoids monospecific plantations of Norway spruce. We performed three SDMs using a resolution of 100x100 m, with the same topographic and microclimatic variables but different LC datasets to represent various type of vegetation. Specifically, we tested, i) the European Corine Land Cover (CLC); ii) the Sentinel 2 Global Land Cover (S2GLC); iii) a composition of regional LC maps.

All models showed high and similar performance, with the S2GLC model being the most powerful. The CLC model identified microclimate and elevation as major drivers of habitat suitability, the S2GLC model attributed more importance to the kind of vegetation (indicating coniferous forests as more suitable than other major categories of forests), and the regional LC model showed that the presence of *Abies alba* is associated with a higher suitability. The S2GLC model estimated a slightly broader suitable area than the CLC model and much higher than the regional LC model. Therefore, despite the strong performance, the CLC model failed in identifying LC as a crucial predictor for the occurrence of the salamanders, while the forest categories of S2GLC were not precise enough to adequately model the habitat suitability of such a

micro-endemic lineage. Furthermore, both CLC and S2GLC models overestimated the suitable area compared to the regional LC model.

These findings highlight the limitations of two widely used land cover datasets in accurately estimating habitat suitability for the micro-endemic *Salamandra atra aurorae*. Furthermore, our study emphasizes the critical role of more detailed regional data in designing appropriate conservation management plans.

OBSERVED MALFORMATIONS ON THREE ITALIAN PLETHODONTID SPECIES

LUCA COPPARI[1,*], MIRKO ENEA[1], ROBERTO COGONI[2], ENRICO LUNGHI[3]

[1]S.H.I. Sezione interregionale Umbria – Marche, Perugia, Italy
[2]Unione Speleologica Cagliaritana, Quartu Sant'Elena, Cagliari, Italy
[3]Dipartimento di Medicina clinica, sanità pubblica, scienze della vita e dell'ambiente (MeSVA), Università degli Studi dell'Aquila, L'Aquila, Italy

[*]Correspondence: luca.coppari@yahoo.it

KEYWORDS: malformations, *Speleomantes*, mutations.

Body malformations in wild animals usually reduce the fitness and survivorship of afflicted individuals, which have potential negative effects on the overall population when their frequency is high. Among amphibians, most of the reported deformities were mainly induced by chemical contaminants, ultraviolet radiation (UV), stress events (i.e. predatory interactions), parasites and genetics. Most of these studies were focused on anurans and urodeles (mostly salamandrids), while there is very little knowledge on plethodontid salamanders. Here we report a list of several malformations observed in multiple populations (usually one case per population/visit) belonging to three Italian plethodontid species (*Speleomantes flavus*, *S. imperialis* and *S. italicus*). Our observations report: four cases of forked tail, three cases of malformations on one eye, and two individuals with deformities concerning their mental gland. All the observed individuals showed good health condition, even with evident deformities. During our fieldworks, we also observed an incomplete regrowth of the limb, bone malformation that included the backbone and the jaw. Finally, we also report the case of a juvenile of *S. flavus* with a swollen body, probably an indication of a potential bacterial infection. The malformations we observed can be caused by many post-traumatic factors in general, such as injuries, infections, predations but also by environmental and genetic factors like pollution, inheritance and mutations. We recommend further research on the malformations of the European plethodontids in order to better understand their causes and the mechanisms that drive the regenerative processes.

HOW DID IT GET THERE? DISCOVERY OF A GEOGRAPHICALLY ISOLATED POPULATION OF CAVE SALAMANDERS IN TUSCANY

GIACOMO BRUNI[1,*], ANDREA BATTAGLINI[2], GABRIELE CANANZI[3], IRENE TATINI[3], LEANDRO GAMMUTO[3], GIULIO PETRONI[3]

[1]Viale Palmiro Togliatti, 50019 Sesto Fiorentino, Italy
[2]Via del Bandino, 50126 Firenze, Italy
[3]Department of Biology, University of Pisa, 56126 Pisa, Italy

[*]Correspondence: giacomobruni90@gmail.com

KEYWORDS: *Speleomantes italicus*, distribution, isolated population, mtDNA, Tuscany.

European cave salamanders (genus *Speleomantes*) are fully terrestrial amphibians which distribution is mainly shaped by geological features and geographical barriers. Among the latter, big rivers have isolated population in the past (e. g. origin of the subspecies of *S. ambrosii* separed by the Magra River) and still represent obstacles to their expansion. This is the case of *S. italicus*, the species with the widest range in its genus, which southern limit coincide with the course of the Pescara River. Specifically, *S. italicus* is distributed along northern and central Apennines, in areas in orographic continuity, and its expansion toward north-east is limited by secondary contacts with *S. ambrosii* and *S. strinatii*. In Florence province, *S. italicus* distribution is affected by the Arno River. In this study we report the unexpected discovery of *S. italicus* in an area detached from the rest of the species range by this river course. After a first observation by A. B., fieldwork sessions were conducted between November 2022 and January 2023 at night after rainy days, searching mainly along the road in suitable habitats to find individuals in surface activity. The species was detected in 4 out of 38 investigated sites in Bagno a Ripoli, Greve in Chianti, Scandicci and Lastra a Signa municipalities, in a total area of about 150 km^2. In the study area, *S. italicus* appears localized in the northern portion of a mountainous relief in Bagno a Ripoli municipality, with an approximate distribution of less than 2 km^2. The shortest distance between the presence sites and the Arno River shore is about 4 km. The species was found between 205 and 596 m asl in habitats characterised by *Castanea sativa* woods. The new localities appear even more isolated considering geological features, since they are restricted to a sandstone formation which is not present in the rest of the study area. Tissue samples for genetic analysis were collected from 8 individuals to be compared with *S. italicus* populations from closest localities (areas of Montalbano mountain chain, Fiesole and Pratomagno massif) and Apuan Alps. Cytochrome c oxidase I (COI) and Cytochrome b (Cytb) mtDNA markers were used in preliminary analysis to investigate the relationship and the isolation processes between populations. Moreover, it is worth mentioning that the only sequence containing the COI fragment available online, came from an individual of *S. ambrosii* collected near La Spezia, and incorrectly attributed to *S. italicus*. Preliminary genetic results ascribed the new localities to *S. italicus* and do not highlight relevant differences with the closest populations, but further sampling could success in tracking the historical dispersion process of these populations to this new area. The presence of the species in different localities and in a specific geological formation suggests a relict

distribution which implies the possibility of crossing the Arno River course in the past. The implementation of habitat conservation measures is necessary to preserve this isolated population, since the occurrence localities are not included in protected areas.

BACK TO THE PAST: CLIMATE- AND LAND USE-CHANGES THREATEN THE ITALIAN ALPINE NEWT

MARTINO FLEGO[1], DARIO OTTONELLO[2], FABRIZIO ONETO[3], RENATO COTTALASSO[4], GIACOMO FERRARO[4], ROBERTO SACCHI[1], MARCO MANGIACOTTI[1,*]

[1]Department of Earth and Environmental Sciences – University of Pavia, via Taramelli 24, Pavia
[2]ARPAL, Via Bombrini 8, Genova
[3]CesBIN S.r.l., Via San Vincenzo 2, Genova
[4]Il Piviere S.r.l., Via Cavalieri di Vittorio Veneto 23, Gavi (Alessandria)

[*]Correspondence: marco.mangiacotti@unipv.it

KEYWORDS: climate warming, land use change, *Ichthyosaura alpestris apuana*, habitat suitability models, decline.

Human-mediated changes in land cover can accelerate the negative effects of climate change on amphibian populations, whose life cycle typically needs a specific habitat combination. This may become dramatically true where a species occupies restricted areas or cannot move to track the climatic shift and/or habitat loss.

The Italian alpine newt is a subspecies distributed in the northern Apennine, mainly in hilly and mountainous environments, where it often occupies secondary wet habitats (drinking troughs, basins, fountains) typical of rural contexts. Since the availability and maintenance of such artificial sites may play a pivotal role in providing suitable habitats for this prevalently aquatic newt, we may predict that a change in land use management (e.g., land abandonment) should have a detrimental effect on alpine newt populations, which sum up to that of climatic change. Our aim is therefore evaluating if and how the combined changes in climate and land-use have translated into a variation of habitat suitability for the Italian alpine newt, possibly quantifying the relative importance of both driving factors.

We collected 331 Italian alpine newt occurrences for three provinces (La Spezia, Genova, Alessandria), over the last 20 years (2006-2023). We used this dataset to model species habitat suitability (HS) for the study area (the minimum convex polygon of all the observations plus a 10 km buffer). As suitability predictors, we used three groups of environmental layers: topography, climate, and land cover. We picked climate and land cover variables over two time-frames: current (2001-2020) and past (1981-2000). We modelled HS with Maxent using current values for predictors to set the reference link between environmental features and newt occurrence. We evaluated the impact of climate and land use by partitioning HS variation of the model, and comparing current HS with those predicted for three past scenarios accounting for both climate-, and land-use-changes.

HS model performed well, with favourable conditions characterized by flat, humid patches, with fresh and rainy climate, balanced wood/crops proportion, and low urbanization. Topography, climate, and land cover accounted for 43, 34, and 8% of variation, respectively, with climate and land cover explaining a further 16%, not-exclusively allocatable, variation. Current average suitability (0.241 ± 0.004; on a 0-1 score scale) showed a significant decline compared with back-projections on the three scenarios from the past: past climate and past land cover (0.342 ± 0.004); past climate, current land cover (0.335 ± 0.004); current climate, past land cover (0.245

± 0.004). The negative effect of land use change, despite significant, was twenty times lower than that of climate change. In other words, the variable on which humans might directly and locally act (i.e., land cover) will probably translate in less than 5% HS change over 20 years: not much, but better than nothing.

NEW KNOWLEDGE ON THE DISTRIBUTION OF THE URODELES IN MARCHE REGION

MIRKO ENEA[1,*], LUCA COPPARI[1], DAVID FIACCHINI[1]

[1]S.H.I. Sezione interregionale Umbria-Marche, Perugia, Italy

*Correspondence: eneamirko27@gmail.com

KEYWORDS: distribution, Marche region, Caudata.

Marche region has a diversified batracofauna with fifteen species of amphibians, seven of which are urodeles. Hitherto, not many investigations have been undertaken on the distribution of urodeles and an overall regional atlas is still missing. Some provincial atlases are still absent, such as those of the Provinces of Macerata, Fermo and Ascoli Piceno. Nevertheless, there exists the provincial atlas of Ancona, published in 2003, and the recently published provincial atlas of Pesaro Urbino. The presence of some urodeles species represents a considerable case, since they find their latitudinal limits in the regional territory, such as the *Lissotriton italicus* which in Marche reaches its northern limit and *Ichthyosaura alpestris apuana*, which is only present with an isolated population, resulting as one of the southernmost populations on the Italian peninsula. We provide here new data on the presence of urodeles species on the regional territory, relating to the period 2021-2023, therefore not included in the new National Atlas produced by SHI "in press". The collected data derive from fieldworks (conducted by the authors) and from citizen science. For each species, the new presence quadrants with respect to those used in the UTM 10x10 grid of the national atlas are indicated. This study demonstrates that the distribution of the batracofauna on the regional territory of Marche is still partly unknown and that further field investigations must be undertaken. Furthermore, we highlighted the threat conditions for some species of urodeles on the regional territory, such as *Salamandra salamandra* and *Ichthyosaura alpestris apuana*, whose populations are extremely isolated and limited to restricted areas. Especially for these taxa, our new reports represent starting points for future field research, which can be integrated by monitoring, demographic census, and conservation plans.

THE ITALIAN POPULATIONS OF *SALAMANDRA*: AN UNPDATED OVERVIEW OF THEIR EVOLUTIONARY HISTORY IN THE LIGHT OF NEW GENOMIC ANALYSES

LUCIO BONATO[1,*]

[1]Dipartimento di Biologia, Università di Padova; National Biodiversity Future Center

[*]Correspondence: lucio.bonato@unipd.it

KEYWORDS: *Salamandra salamandra*, *Salamandra lanzai*, *Salamandra atra*, Italy, genomics.

Populations of the genus *Salamandra* living in the Italian territory belong to three species: *S. salamandra* along the Southern Alps and the Apennines, *S. lanzai* in the Cottian Alps, and *S. atra* in the Central and Eastern Alps and Prealps.

A subspecies-level differentiation has been established over the years, mainly based on geographic variation in coloration and a few molecular markers: within *S. salamandra*, the Apennine populations are distinguished as the endemic subspecies *S. s. gigliolii*, while the Alpine populations are assigned to *S. s. salamandra*, which is widespread in Central-Eastern Europe; within *S. atra*, the yellow-patched populations of the Pasubio massif and the Sette Comuni plateau are distinguished as the micro-endemic subspecies *S. a. pasubiensis* and *S. a. aurorae*, respectively, while all other Italian invariantly melanic populations are traditionally assigned to *S. a. atra*, despite preliminary evidence of substantial genetic differentiation.

New insights on the evolutionary differentiation of the Italian populations of *Salamandra* and on their biogeographical history are emerging from the first genomic data recently obtained, partly published and partly still under analysis, within a broader project on the genus *Salamandra* throughout its entire distribution range, through the collaboration of many herpetologists coordinated by M. Vences.

Preliminary analyses of genomic differentiation, genetic population structure and phylogenomics suggest that *S. s. gigliolii* and *S. s. salamandra* are deeply differentiated: the former is more strictly related to the populations inhabiting the Pyrenees and probably originated from a colonization from the West. *S. lanzai* is confirmed as a distinct lineage, more strictly related to *S. corsica* and *S. atra* than to *S. salamandra*. Within *S. atra*, *S. a. pasubiensis* and *S. a. aurorae* are confirmed strictly related.The first genomic data from the invariantly melanic populations from the Orobic mountains and the Dolomites, suggest that they are more strictly related to the other populations inhabiting the Southern Alps and the Dinaric Alps, rather than to the other populations of *S. a. atra* inhabiting the Northern Alps.

DIVERSITY, DISTRIBUTION AND HABITAT PREFERENCES OF URODELES IN THE LATIUM REGION (CENTRAL ITALY).

DINO BIANCOLINI[1,2,3,*], ANTONIO ROMANO[2], PIERLUIGI BOMBI[1,4], RICCARDO NOVAGA[1,3], LEONARDO VIGNOLI[1,5], GIANPAOLO MONTINARO[1,6], DANIELE SALVI[1,7], ERNESTO FILIPPI[1], DANIELE MARINI[1,8], CHRISTIANA SOCCINI[1], VINCENZO FERRI[1]

[1]Societas Herpetologica Italica - Sezione Lazio
[2]CNR-IBE, Consiglio Nazionale delle Ricerche - Istituto per la BioEconomia, Via dei Taurini 19, 00100 Roma (RM) - Italy
[3]La Giovane Ecologia, Via Emilia SNC – 04010 Sezze Scalo (LT) - Italy
[4]CNR-IRET, Consiglio Nazionale delle Ricerche - Istituto di Ricerca sugli Ecosistemi Terrestri, Via Salaria, km 29.300, 00015 Monterotondo (RM) - Italy
[5]Dipartimento di Scienze, Università degli Studi Roma Tre, Viale G. Marconi 446, 00146 Roma (RM) - Italy
[6]Rifcon GmbH, Golbeckstrasse 26, 69493 Hirschberg - Germany
[7]Department of Health, Life and Environmental Sciences, University of L'Aquila, 67100 L'Aquila (AQ) – Italy
[8]Associazione Naturalistica Valle dell'Aniene - ANVA, Via delle Ginestre 30, 00012 Guidonia Montecelio (RM) - Italy

*Correspondence: dinobiancolini@gmail.com

KEYWORDS: diversity, ecology, habitat, distribution, atlas, Latium.

The Latium region is home to a significant number of urodeles, consisting of six Salamandridae species and one Plethodontidae species. However, these species are currently facing substantial threats from habitat destruction, the introduction of non-native species, and climate change. In 2019, the Latium regional branch of the Societas Herpetologica Italica initiated the Atlas of Amphibians and Reptiles of Latium project to update species distribution and to identify the notable changes that have occurred since the publication of the first Atlas (in 2000). In this study, we present new findings regarding the distribution of the seven urodeles species found in the region. Our data compilation involved gathering information from various sources, including institutions, private entities, and citizen science initiatives, which were then consolidated into a single comprehensive database. To collect field data, we employed a systematic sampling design that aimed to cover the entire region, with particular attention given to areas with limited existing records. The Atlas project activities are still ongoing and have contributed to the development of a regional database encompassing over 2915 occurrences of urodeles between 1954 and 2023, up until June 10, 2023. Using this extensive database, we analyzed how species richness and the likelihood of observing a species can vary across different habitat types. Additionally, we assessed the strength of the associations between species and their respective habitats. Furthermore, we evaluated the rarity of species based on factors such as geographic range, a proxy of population abundance, and habitat breadth. Our findings generally align with the existing ecological information available for these species in Italy and identified possible local extinctions for some species. Overall, Latium emerges as a highly diverse region where the conservation of urodeles is attainable through the implementation of appropriate management measures.

OPPOSITE EFFECTS OF CLIMATE AND LAND-USE CHANGE ON SALAMANDRIDS OF THE CILENTO NATIONAL PARK AND CONNECTED NATURA 2000 SITES (CAMPANIA, SOUTHERN ITALY)

DINO BIANCOLINI[1,*], ANTONIO ROMANO[1]

[1]CNR-IBE, Consiglio Nazionale delle Ricerche - Istituto per la BioEconomia, Via dei Taurini, 19 - 00100 Roma (RM) – Italy.

[*]Correspondence: dinobiancolini@gmail.com

KEYWORDS: climate change, land-use change, habitat, distribution, Cilento.

Climate change and natural land conversion are altering species distribution dramatically. Salamandrids, ectothermic animals with limited dispersal ability, and Mediterranean mountain ranges, which host numerous taxa adapted to local conditions, are particularly vulnerable to these threats. This is the case of Cilento, a biodiverse but understudied region of southern Italy protected by a National Park and by 30 Natura 2000 (N2000) sites. Using bioclimatic envelopes and Area of Habitat (AOH) models, we assessed the potential combined impact of climate and land-use change on four Salamandridae species found in the Park and in the connected N2000 sites: *Lissotriton italicus, Salamandra salamandra, Salamandrina terdigitata and Triturus carnifex*. Bioclimatic envelopes calculate species' climatic suitability (CS) by correlating species presence with climatic characteristics, whereas the AOH models categorize land-use types based on species-habitat relationships. We calculated CS and AOH for the current conditions as well as two climate and land-use change scenarios: one of sustainability (SSP1-2.6) and one of fossil-fueled development (SSP5-8.5). In both scenarios, all species lost significant amounts of CS, with the greatest declines estimated for SSP5-8.5. Highland species such as *Salamandra salamandra* and *Triturus carnifex* appear to be particularly vulnerable. Because renaturalization of agricultural land is widespread in both scenarios, there were no significant decreases in AOH as a result of land-use change. However, in both scenarios, significant shifts in CS are projected for all species, posing a critical challenge to their survival. Our findings could help guide climate mitigation efforts to ensure the long-term protection of Salamandrids within Cilento's protected areas.

STUDY OF *PROTEUS ANGUINUS* THROUGH CAPTURE-MARK-RECAPTURE TECHNIQUE IN HYPOGEAN AND EPIGEAN ENVIRONMENTS

GIORGIO GRASSI[1,*], THOMAS CREANZA[1], GENTILE FRANCESCO FICETOLA[1], RAOUL MANENTI[1], BENEDETTA BARZAGHI[1]

[1]Department of Environmental Science and Policy, Università degli Studi di Milano, Via Celoria 26, 20133 Milano, Italy

[*]Correspondence: giorgio1499@hotmail.it

KEYWORDS: *Proteus anguinus*, collection, individual recognition, habitat, subterranean, caves

Proteus anguinus is considered a strictly troglobiotic animal, possessing adaptive characteristics for the hypogean environment, such as reduced pigmentation and degenerated eyes from the larval to adult stage. *P. anguinus* can also be sighted in epigean environments in springs connected to the underground aquifer. In order to understand if this occurrence is merely accidental, occurring only when underground water currents push out the salamanders to the surface, from September 2022 we performed multiple surveys on spring and caves in Trieste and Gorizia districts and used capture-mark-recapture method with Visible Implant Elastomers. In addition to marking, for each captured proteus, weight, sex, length, presence/absence of eyes, and environmental parameters were recorded.

The data collected suggest that *P. anguinus* seems inclined to visit springs, with higher encounter rates during night. A total of 60 individuals were collected and marked. 6 individuals were recaptured at least one time. Maximum recapture rate was 3 times for 1 individual. In springs we marked 42 individuals, recapturing 5 of them at the same capture site. Comparing individuals of *P. anguinus* captured in caves with those in springs, it appears that, at equal length, the latter are heavier than those in caves.

These results lead us to hypothesize a certain fidelity to the site and support our hypothesis regarding the non-random presence of *P. anguinus* in epigean environments. Weight data suggest that the behaviour of visiting springs is related to the greater abundance of trophic resources that an interface environment can provide compared to a resource-poor environment like caves.

VARIABILITY OF SEASONAL TROPHIC NICHE IN TWO SYMPATRIC SALAMANDERS, THE ITALIAN CAVE SALAMANDER AND THE FIRE SALAMANDER

FABIO CIANFERONI[1,2], MILOS DI GREGORIO[3,*], CLAUDIA CORTI[2], ENRICO LUNGHI[4]

[1]Istituto di Ricerca sugli Ecosistemi Terrestri (IRET), Consiglio Nazionale delle Ricerche (CNR), Firenze, Italy
[2]Museo di Storia Naturale dell'Università degli Studi di Firenze, "La Specola", Firenze, Italy
[3]Corso Buenos Aires 66, 20124, Milano, Italy
[4]Dipartimento di Medicina Clinica, Sanità Pubblica, Scienze della Vita e dell'Ambiente (MeSVA), Università degli Studi dell'Aquila, L'Aquila, Italy

[*]Correspondence: milosdigre@gmail.com

KEYWORDS: diet, competition, Plethodontidae, Salamandridae, *Speleomantes*, *Salamandra*.

The trophic niche is one of the most important ecological traits for any species, as it provides information about trophic position in a food web, preference on foraging sites, intra- and interspecific interactions. In this study we examined seasonal variations in the diet composition of two sympatric salamanders from central Italy, the Italian cave salamander (*Speleomantes italicus*) and the Fire salamander (*Salamandra salamandra*). Adults of these two species are generalist predators which mostly feed on terrestrial invertebrates. The diet of both species has been previously studied under allopatric conditions; only one study, performed in spring, aimed to assess their diet when the two species are in sympatry. In this follow-up study we surveyed the same sympatric population in autumn, performing two night surveys in rainy weather. Our study aimed to evaluate the species' autumn diet and compare it with data obtained in spring, to assess potential seasonal variations in their trophic niche. Captured salamanders of both species were measured (SVL) and we inspected the residuals of their last foraging activity through stomach flushing. Overall, we sampled 75 *S. italicus* and 34 *S. salamandra*, from which we recognized more than 1200 prey items belonging to 31 prey categories. Similarly to what has been observed in spring, there is a significant divergence in the diet composition of both species during autumn. Compared to spring, *S. italicus* reduced by 20% the diversity of consumed prey, while *S. salamandra* increased it by 13%. In spring, the Fire salamander consumed more slugs, larvae of Diptera and anellids, while in autumn it increased the consumption of millipedes. In spring, *S. italicus* consumed more adult insects (Diptera and Coleoptera), spiders, and Entomobryomorpha springtails, while in autumn the majority of consumed prey were Symphypleona springtails and adult Diptera. In both species larger individuals consumed more prey, while we did not find any significant predictor for the diversity of consumed prey. Analysis on individual diet specialization identified a high proportion of generalist individuals in both species, although the results were significant only for *S. italicus*. We conclude that also during autumn the trophic niche of these two sympatric salamanders do not significantly overlap, allowing their coexistence with low (if any) competition for food resources.

NEWTS IN TOWN: DISCRETE PRESENCE OF *LISSOTRITON VULGARIS* AND *TRITURUS CARNIFEX* IN THE URBAN FABRIC OF PISA

SIMONE MARZOCCA[1,*], MARCO MANGIACOTTI[2], ROBERTO SACCHI[2], STEFANO SCALI[3], FEDERICO STORNIOLO[2], MARCO A.L. ZUFFI[1]

[1]Museo di storia naturale dell'Università di Pisa, via Roma 79, 56011 Calci (PI)
[2]Dipartimento di scienze della terra e dell'ambiente, Università di Pavia, viale Torquato Taramelli 24, 27100 Pavia
[3]Museo di storia naturale di Milano, corso Venezia 55, 20121 Milano

[*]Correspondence: si.marzocca@gmail.com

KEYWORDS: amphibians, newts, artificial habitats, urban habitats, morphometry, population ecology.

For a long time, urban areas have not been considered as a reservoir for biodiversity conservation. In the last decades the necessity to integrate urban development and the conservation of local communities has increased. Newts are commonly found in natural or rural damp sites characterized by still waters (pools, drinking troughs, ponds, swamps), from mountain to plain areas. However, records in towns and urban areas are usually uncommon. The city of Pisa is built on an ancient, drained swamp. This causes the presence of suitable sites for newts in artificial and marginal areas inside the urban texture. During 2022, from February to June, we monitored several humid sites in the municipality of Pisa, selecting three ponds in high urbanized areas (site 1, 2, 3), and one at less than 1 km from the northern outskirt (4), in a rural area. A natural pond (C1) in the Migliarino San Rossore Massaciuccoli regional park, was selected as control site. We performed several surveys, ranging from 15 to 29 per site. The sites show various number of surveys due to different desiccation time. We applied capture mark and recapture method (CMR) using floating bottle traps and a fishing net for the capture of the specimens. The traps were positioned a day before the sampling. Biometrical parameters were taken for each specimen (species, sex, total length, body mass, ventral picture), which it was then released. The individuals will be identified by ventral picture. We performed samplings three days/week for each site among five months, during most of the breeding season. We captured 590 *T. carnifex* (site 1: 410; site 3: 2; site 4: 88; site C1: 90) and 1070 *L. vulgaris* (site 1: 1; site 2: 234; site 3: 175; site 4: 9; site C1: 651). The numbers refer to number of captures, not number of individuals. We handled the specimens with sterile gloves and sanitized every tool after use. First results show that the crested newt is present with high frequency in three sites, occasional in one site, absent in one site; the smooth newt is present with high frequency in three sites, occasional in one site. Urban and peripheral sites show an apparent specificity for one or the other species, while in the control site both species are abundant. Population structure estimation, abundance estimations and first capture vs recaptures analysis are under process. Preliminary considerations suggest that the main threats for newt populations are urbanization and the early desiccation of the sites. We are planning safeguard actions for the urban sites. Capture and handling of *T. carnifex* have been authorized by MITE (prot. 0000053/2022 del 26/01/2022).

IS IT A MATTER OF PREY OR PREDATORS? STUDY ON THE COLORATION OF *SALAMANDRA LANZAI* USING PONGO MODELS

BENEDETTA BARZAGHI[1,*], RAOUL MANENTI[1], GENTILE FRANCESCO FICETOLA[1], FRANCO ANDREONE[2], SAMUELE ROMAGNOLI[1]

[1]Department of Environmental Science and Policy, Università degli Studi di Milano, Via Celoria 10, 20133 Milan, Italy.
[2]Museo Regionale di Scienze Naturali, Via G. Giolitti, 36, I-10123 Torin, Italy

[*]Correspondence: Benedetta.Barzaghi@unimi.it

KEYWORDS: salamanders, predation, models, yellow, amphibians, prey.

Salamandra lanzai is an amphibian endemic to the Cottian Alps and is classified as critically endangered by the IUCN. Although its range is wide, the largest population of this species is located on the Monviso massif right next to the source of the river Po around 2000 m a.s.l.

The coloration of *Salamandra lanzai* varies from black to dark brown and does not have the typical aposematic colouration of *Salamandra salamandra*.

It is still unknown why *S. lanzai* does not express this aposematic coloration. One of the most accredited hypotheses is the lack of a large number of predators at high altitude. Another hypothesis is that of the scarcity of trophic resources at high elevations where prey availability is low and the salamanders experience a reduced trophic period compared to the fire salamanders that, instead, colonize more hilly areas. In fact, the aposematic coloration is very energy-consuming and the animals need a large number of trophic resources to be able to express it.

To verify this hypothesis, during September 2021, 120 pongo models, similar to salamanders, were placed along 30 transects long 15 m. For each transect biotic parameters were taken, such as vegetative coverage and abiotic parameters as temperature, humidity and exposure of the transept.

60 models were entirely black, the other 60, instead, had yellow spots to emulate the typical aposematic color of the fire salamander. The 120 models were left in place for 4 days and were checked at both dawn and dusk, noting the number of potential predation signs on the pongo. 35% of the models showed signs of predation and the black ones had significantly higher number of evidence of attempted predation than the models with aposematic coloration.

We can therefore assume that the salamander predators are not lacking even in a mountain environment but probably, *Salamandra lanzai* does not have the trophic resources necessary to show an aposematic coloration that is energy demanding to produce.

PREDATION PRESSURE ON THE GOLDEN ALPINE SALAMANDER (*SALAMANDRA ATRA AURORAE*): EFFECT OF APOSEMATISM, DIEL ACTIVITY AND ENVIRONMENTAL FEATURES

DANILO BORGATTI[1,*], GENTILE FRANCESCO FICETOLA[1], RAOUL MANENTI[1], ISABELLA PALEARI[1], VALERIA TREZZI[1], BENEDETTA BARZAGHI[1]

[1]Department of Environmental Science and Policy, Università degli Studi di Milano, Via Celoria 10, 20133 Milan, Italy

[*]Correspondence: danilo.borgatti@gmail.com

KEYWORDS: amphibians, anti-predatory mechanisms, colouration, defensive systems.

Animals have evolved different types of anti-predatory mechanisms to survive in the wild. They can have physical or physiological defences; they can change their behaviour in response to external stimuli. Aposematism, a visual communication system in which bright and contrasted coloured prey warn predators about their unprofitability, is one of these mechanisms.

The Golden Alpine Salamander *Salamandra atra aurorae*, a small terrestrial salamander endemic to "Altopiano dei 7 Comuni" in Italy, has a coloration pattern that resembles the aposematic black-and-yellow coloration of the fire salamander (*Salamandra salamandra*): it has large dorsal yellow spots on a completely black background. Despite this typical aposematic colouration, no one has ever investigated its potential anti-predatory functions.

In this study, we used realistic plasticine replicas to test the aposematic hypothesis in the Golden Alpine Salamander. Through the use of clay models, we also evaluated whether the predation rate differed between the different periods of the day and if the substrate features affect the predation pressure. We also tried to characterize the main potential predators of the Golden Alpine salamander.

We placed inside "Bosco del Dosso", the type locality of the Golden Alpine salamander, a total of 360 couples of models (360 clay models resembling an individual of *S. a. atra*, and the other 360 resembling an individual of *S. a. aurorae).* We also made an environmental characterisation of plasticine replicas' position. From August 2021 to July 2022, we performed 6 study sessions that were divided into 3 passages at dawn and 3 passages at dusk.

Contrary to expectations our experiment did not support the aposematic hypothesis. However, the study revealed that the predation pressure is affected by both the time of the day (the predation pressure is higher during the night: $X^2=116.99$; $P<0.001$) and the type of substrate on which the silhouettes were placed (the predation pressure is higher on the substrate composed of a litter of White Fir and Beech leaves: $X^2=7.61$; $P<0.01$). All preyed silhouettes were hit by mammals, especially rodents.

Our results suggest the necessity to perform further research in the significance of yellow colouration of the Golden Alpine Salamander.

THE TROPHIC ECOLOGY OF THE GOLDEN ALPINE SALAMANDER, *SALAMANDRA ATRA AURORAE*

EMMA CENTOMO[1], LUCA RONER[1,*], MARCO SALVATORI[1,2], PAOLO PEDRINI[1], ANTONIO ROMANO[3,1]

[1]MUSE - Museo delle Scienze, Ufficio Ricerca e Collezioni - Ambito Biologia della Conservazione, Corso del Lavoro e della Scienza 3, I-38122 Trento, Italy
[2]Università di Firenze, Dipartimento di Biologia, via Madonna del piano 6, I-50019 Sesto Fiorentino (FI), Italy
[3]Consiglio Nazionale delle Ricerche—Istituto per la BioEconomia, Via dei Taurini 19, I-00100 Roma, Italy

[*]Correspondence: luca.roner@muse.it, lucaroner@gmail.com

KEYWORDS: feeding ecology, diet, prey selectivity, optimal diet theory, amphibians, endemic taxon.

Amphibians play a crucial role in the movement of nutrients within and between ecosystems. Therefore, knowledge on their trophic ecology is crucial for habitat and species conservation.. We examined the feeding habits of the rare and endemic *Salamandra atra aurorae* in a mixed temperate forest in northern Italy. Our objectives were to determine their actual trophic niche, investigate prey preferences, and explore potential levels of individual specialization. During the summer of 2022, we collected stomach contents from 53 salamanders using stomach flushing techniques, and we assessed prey availability using pitfall traps. To analyze the realized trophic niche we employed the Costello graphical method, and for studying prey selectivity we used the relativized electivity index. Our findings indicate that the Golden Alpine salamander adopts a generalist feeding strategy, displaying a positive selection in relation to trophic availability for specific prey categories such as Myriapoda and Hymenoptera (excluding Formicidae). The salamander's food preferences appear to be influenced by factors like size, movement ability, and chitinization of prey. We observed a significant degree of inter-individual diet variation, along with modularity and clustering patterns, which suggest a Distinct Preference model framework. This study offers valuable insights into the trophic ecology of the Alpine salamander complex, where different subspecies seem to adopt similar feeding strategies.

WHAT HAPPENS WHEN A STORM CHANGES THE MENU'? THE TROPHIC ECOLOGY OF *SALAMANDRA ATRA AURORAE* AFTER THE STORM VAIA

LUCA RONER[1], EMMA CENTOMO[1], MARCO SALVATORI[1,2], PAOLO PEDRINI[1], ANTONIO ROMANO[3,1,*]

[1]MUSE - Museo delle Scienze, Ufficio Ricerca e Collezioni - Ambito Biologia della Conservazione, Corso del Lavoro e della Scienza 3, I-38122 Trento, Italy
[2]Università di Firenze, Dipartimento di Biologia, via Madonna del piano 6, I-50019 Sesto Fiorentino (FI), Italy
[3]Consiglio Nazionale delle Ricerche—Istituto per la BioEconomia, Via dei Taurini 19, I-00100 Roma, Italy

[*]Correspondence: antonioromano71@gmail.com, antonio.romano@ibe.cnr.it

KEYWORDS: foraging ecology, wind, forest ecology, invertebrates, salamanders.

Knowledge on trophic ecology of amphibians is essential to understand their requirements and ecological roles in order to plan proper conservation measures. In October 2018 the VAIA storm caused the fall of millions of trees in North-East Italy, impacting also the range of the Golden Alpine salamander (*Salamandra atra aurorae*), a rare subspecies of alpine salamander of high conservation interest, occurs. Our general aim was to evaluate the effect of the storm on trophic availability of potential prey and on foraging ecology of this salamander. By comparing impacted and non-impacted habitat we evaluated differences in i) salamanders' stomach contents, ii) trophic availability, and iii) trophic niche, prey preferences and individual specialization. We used 10 pitfalls to assess trophic availability for each of three habitat categories: not-impacted, medium-impacted, fully-impacted. During summer 2022 we collected stomach contents from 32 individuals inhabiting non-impacted areas and 21 individuals inhabiting medium-impacted areas, while no salamander was found in fully-impacted habitat. We employed the Costello graphical method and the relativized electivity index, for assessing realized trophic niche and prey selectivity. Finally, we applied network analysis to investigate potential levels of inter-individual specialization and compared the results against null models. Our results show that trophic availability was markedly different between non-impacted and medium-impacted areas and between non-impacted and fully-impacted ones. Golden Alpine salamanders adopted a generalist feeding strategy in both sampled habitats, but presented a higher degree of individual specialization in medium-impacted habitats. Even trophic selectivity reflected differences in impact on the forest stands: in non-impacted habitat salamanders positively selected Myriapoda, Hymenoptera (not Formicidae) and Gasteropoda, whereas in medium-impacted ones salamanders positively selected Myriapoda, Isopoda and Coleoptera (adult and larvae). These findings give insight on the trophic plasticity of an endangered salamander when exposed to an extreme weather event, valuable to predict the resilience of rare amphibians to environmental upheaval driven by ongoing and future climate change.

AN ACTION PLAN FOR THE ENDEMIC CALABRIAN ALPINE NEWT

ILARIA BERNABÒ[1,*], ANTONIO ROMANO[2], VIVIANA CITTADINO[1,3], MATTIA IANNELLA[3], SABINE WIRTZ[4], MICHEL ANSERMET[4], SANDRO TRIPEPI[1], FRANCO ANDREONE[5], ROCCO TIBERTI[1]

[1]Department of Biology, Ecology and Earth Science, University of Calabria, Via P. Bucci 4/B, 87036 Rende, Italy
[2]Consiglio Nazionale delle Ricerche - Istituto per la BioEconomia, Via dei Taurini, 19 - 00100 Roma, Italy
[3]Department of Life, Health & Environmental Sciences, University of L'Aquila, Via Vetoio, Coppito, 67100 L'Aquila, Italy
[4]AQUATIS Aquarium-Vivarium, Route de Berne, 144 -1010 Lausanne, Switzerland
[5]Museo Regionale di Scienze Naturali, Via G. Giolitti 36, 10123 Torino, Italy

[*]Correspondence: ilaria.bernabo@unical.it

KEYWORDS: *Ichthyosaura alpestris inexpectata*, endemism, amphibians, Italy, alien species, conservation.

This project focuses on mitigating the impact on several amphibians caused by the introduction of invasive alien fish in three lakes of the Special Area of Conservation (SAC) "IT9310060 Laghi di Fagnano" located in the north of the Catena Costiera, in the municipality of Fagnano Castello in Calabria. The fish are carp *Cyprinus carpio*, goldfish *Carassius auratus*, and gambusia *Gambusia holbrooki*, all considered among the 100 worst invasive alien species in the world. In particular, *G. holbrooki* is an invasive alien species of Union concern under Regulation (EU) No. 1143/2014.

The presence of these non-native fish species poses a severe threat to the habitats and the protected species inhabiting the lakes, such as the amphibians *Triturus carnifex* and *Lissotriton italicus*, which share their habitat with the endemic Calabrian Alpine newt, *Ichthyosaura alpestris inexpectata*. The Calabrian Alpine newt is a rare subspecies - in terms of very restricted range and population size - of great biogeographic and conservation value. It is threatened by fish introduction and habitat loss due to the direct and indirect effects of climate change in the few sites where it breeds. For this, it is currently assessed as Endangered at regional level by the "Lista Rossa IUCN dei Vertebrati Italiani".

In this context of threat to the populations of *I. a. inexpectata* as well as for other amphibians, it was a priority to set-up a tailored Action Plan to enforce effective *in situ* and *ex situ* conservation actions. The main objective of the actions is to erase or mitigate the impact of alien ichthyofauna on this highly imperilled endemic newt. Another crucial objective is the improvement of the conservation status of the aquatic habitats in the SAC, threatened by the alterations triggered by the presence of alien fish, which produces a degradation of the complex ecological relationships between flora and batrachofauna, with extremely negative consequences. While the actions of eradication and/or control of the alien fish from the invaded lakes will be carried out with a targeted strategy that combines several removal methods for each water basin (each one invaded by one different species), the survival of the Calabrian Alpine newt will be guaranteed through the creation of new artificial breeding sites and the establishment of an *ex situ* population. Thanks to the collaboration with the AQUATIS aquarium-vivarium in Lausanne (Switzerland), with the support of EAZA (European Association of Zoos and Aquaria), the

breeding of this threatened newt outside of its natural environment will be accomplished for future restocking actions. The project benefits from the approval and funding of the “Dipartimento Territorio e Tutela dell’Ambiente” of the Calabria Region and the municipality of Fagnano Castello.

I HAVE SEEN THE LIGHT! COLORED LIGHT PREFERENCE IN THE CALABRIAN ALPINE NEWT TO INCREASE CAPTURE RATE

VIVIANA CITTADINO[1,2], MATTIA IANNELLA[2], ANTONIO ROMANO[3], MAURIZIO BIONDI[2], ILARIA BERNABÒ[1,*]

[1]Department of Biology, Ecology and Earth Science, University of Calabria, Via P. Bucci 4/B, 87036 Rende, Italy
[2]Department of Life, Health & Environmental Sciences, University of L'Aquila, Via Vetoio, Coppito, 67100 L'Aquila, Italy
[3]Consiglio Nazionale delle Ricerche - Istituto per la BioEconomia, Via dei Taurini, 19 - 00100 Roma, Italy

[*]Correspondence: ilaria.bernabo@unical.it

KEYWORDS: *Ichthyosaura alpestris inexpectata*, colour, behaviour, conservation.

Calabrian Alpine newt *Ichthyosaura alpestris inexpectata*, a unique glacial relict, currently has a small and highly localised population in the Catena Costiera of Calabria region. Due to its limited range and vulnerable status, this taxon is classified as "Endangered" in the IUCN Red List of Italian Vertebrates. The survival of this endemic newt in its core range is under substantial threat due to climate-induced habitat loss and, above all, the recent introduction of invasive fish (*Cyprinus carpio*, *Carassius auratus*, and *Gambusia holbrooki*) into three lakes within the Special Area of Conservation named "Laghi di Fagnano".

To address the challenges of preserving a highly threatened taxon is essential to understand its distribution, population size and dynamics. For this aim, efficient sampling techniques are crucial in measuring many auto- and synecological aspects. Fieldwork may present some issues, such as difficulties in sampling every portion of the target habitats, limited human and/or economic resources, and time constraints. It is well known that utilising light cues such as aquatic funnel traps baited with glow sticks is an effective strategy to enhance capture probability. Therefore, to maximise the catching success of the traps and optimise population monitoring of the Calabrian Alpine newt, we tested the effectiveness of different coloured light cues, namely coloured glow sticks, as bait for traps. Earlier experiments proved that *I. alpestris* is positively phototactic and can distinguish colours. It should be mentioned that spectral sensitivities can differ between different species, age groups and perhaps even males and females. Thus, we explored Calabrian Alpine newt colour perception through behavioural tests under experimentally controlled conditions assessing its response to different coloured glow sticks (light green, orange and blue).

Briefly, five males and five females were tested in a dark room in a cross-shaped aquarium; each colour light stimulus illuminated one side of the cross, plus one arm that remained dark (no glow stick). Visual cue placement was reversed during the test, and each newt was subjected to 4 trials (of 3 minutes) for three consecutive days. The apparatus was cleaned between each individual to prevent the influence of scent cues.

Preliminary results of our analyses showed that the green light was the most successful colour stimulus for both sexes, followed by orange (for males) and blue (for females). On the other hand, no influence of the cardinal directions was found as significant in the choice. Taking advantage of this behavioural preference for a certain colour of the Calabrian subspecies, capture

rates can be optimised in future field samplings. Further tests to be carried out in the field could contribute to standardise a future sampling protocol and implement conservation strategies for this endangered newt.

AMPHIBIAN DETECTION THROUGH STANDARD AND MOLECULAR SURVEYS IN SERCHIO RIVER BASIN

GABRIELE CANANZI[1], TIANSHI LI[2], IRENE TATINI[1], ANDREA CHEMELLO[1], FEDERICO RIVA[1], SAMUEL F.A. ALVAREZ[3], ANNA CAPITANI[1], LEANDRO GAMMUTO[1], VALENTINA SERRA[1], JOACHIM LANGENECK[4], GIULIO PETRONI[1,*]

[1]Department of Biology, University of Pisa
[2]Department of Biology, University of Florence
[3]Universidad Complutense de Madrid
[4]Consorzio Nazionale Interuniversitario per le Scienze del Mare (CoNISMa), Lecce (IT)

[*]Correspondence: giulio.petroni@unipi.it

KEYWORDS: monitoring, environmental DNA, metabarcoding, amphibian, Serchio basin.

In the last years, traditional monitoring (i.e., transects, repeated counts and surveys) is often combined with environmental matrices sampling and analyses with molecular protocols. This method, known as environmental DNA (eDNA) metabarcoding is becoming widespread. Amid its advantages, its non-invasiveness, its sensitivity to low concentrations of DNA (and therefore to rare or elusive species) and its wide taxonomic spectrum. Notwithstanding the huge presence of this method in scientific literature, there is still no consensus about its coherence with traditional methods, and the methodologies behind eDNA collection. In this study, we performed field surveys since 2021, and collected environmental DNA from water, river sediment and active carbon-based passive environmental DNA samplers retrieved in literature. The site selected for this study is the basin of the river Serchio, the third longest river in Tuscany, whose basin is covered by 24,7% of protected areas, such as one national and two regional parks. eDNA samples have been collected from secondary and primary tributaries, as well as the main trait of the river, to better understand the spatial resolution of this method. Subsequently, eDNA was amplified trough a 12S rRNA vertebrate-specific metabarcoding primer, retrieved by literature. Through traditional surveys, a large amount of new and updated data was obtained for various amphibian species, including *Salamandra Salamandra*, *Salamandrina perspicillata* and *Speleomantes sp*. At the same time some critical situations emerged, such as the co-occurrence of populations of *S. perspicillata* and individuals of allochthonous fish predators, like *Onchorhyncus mykiss.* Moreover, in the same site, we point out the discharge of materials from a quarry directly nearby the stream. Concerning *S. salamandra*, we detected a huge number (>10) of dead adults on a street connecting Fornovolasco (LU) to Campolemisi (LU), inside the regional park of the Apuan Alps, due to roadkill. We therefore propose the institution of a specific signaling for car-drivers in this area, or/and to build underground passageways specifically for small terrestrial fauna. Trough the analysis of eDNA sequences, performed with the bioinformatic pipelines QIIME2 and DADA2, amphibians such as *Rana temporaria* and *Rana italica*, whose tadpoles are hard to distinguish, and *S. salamandra* and *S. perspicillata* were detected, coherently with traditional surveys but therefore revealing also new distribution spots. eDNA sampling methods showed differences in species obtained, possibly due to different spatial resolution of each collection strategy. eDNA metabarcoding appeared to be a useful method to collect data about presence of amphibian species in river ecosystems. In addition, different eDNA sampling methods revealed

different results, implicating that choosing the right substrate to collect is a crucial step before performing an eDNA survey.

HOME RANGE AND SPACE USE OF *SPELEOMANTES STRINATII* IN CAVE ENVIRONMENT: A FIRST INSIGHT

GIACOMO ROSA[1,2,*], ANDREA COSTA[1], MAURO VALERIO PASTORINO[2], SEBASTIANO SALVIDIO[1,2]

[1]Dipartimento Scienze della Terra dell'Ambiente e della Vita—DISTAV, Università degli Studi di Genova, 16132 Genova, Italy
[2]Gruppo Speleologico "A. Issel", Villa Comunale ex Borsino c.p. 21, 16012 Busalla (GE), Italy

[*]Correspondence: giacomo.rosa@edu.unige.it

KEYWORDS: amphibian, capture-recapture, cave environment, home range, *Speleomantes strinatii*.

Despite the wide employment of capture recapture surveys to monitor herpetofauna, there are few applications of spatial capture recapture (SCR) methods in the herpetological literature, especially for Urodela. We analyzed a multi-year SCR dataset from a cave population of Strinati's cave salamander, *Speleomantes strinatii*, in the Biospeleological Station A. Issel of Besolagno (GE). Spatial capture data were obtained through repeated surveys on a permanent grid. Individuals were identified by the photo-identification of the ventral pattern. Analysis of spatial encounter histories of marked individuals was carried out using Kernel Density Estimation in package "adehabitat" and "secr", allowing an estimation of individual home range size and distances moved. Population home range was 14.44 m^2 (9.93 - 23.78) and females displayed wider home ranges compared to males, but without any significant difference (z=1.4793, p=0.13907). Mean Maximum Distance Moved was 16.25 m (3 - 35.13) and females covered longer distances compared to males, but without any significant difference (z=1.1983, p=0.23081). The application of this protocol allowed us to obtain the first information about home range and space use of *S. strinatii* in cave environments. Future developments will focus on the analysis of these data in order to obtain more detailed information regarding space use, detectability and density, depending on environmental covariates. Furthermore, we are planning to apply the same SCR protocol in epigean environments. This will allow to make comparisons regarding the spatial ecology and behavior of a salamander living in two completely different environments.

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