






Towards evidence-based conservation of subterranean ecosystems

Stefano Mammola^{1,2†*} , Melissa B. Meierhofer^{3†} , Paulo A.V. Borges⁴,
Raquel Colado⁵, David C. Culver⁶, Louis Deharveng⁷, Teo Delić⁸, Tiziana Di Lorenzo⁹,
Tvrтко Dražina^{10,11}, Rodrigo L. Ferreira¹², Barbara Fiasca¹³, Gene Fišer⁸,
Diana M. P. Galassi¹³, Laura Garzoli², Vasilis Gerovasileiou^{14,15}, Christian Griebler¹⁶,
Stuart Halse¹⁷, Francis G. Howarth¹⁸, Marco Isaia¹⁹, Joseph S. Johnson²⁰,
Ana Komerički¹¹, Alejandro Martínez², Filippo Milano¹⁹, Oana T. Moldovan^{21,22},
Veronica Nanni¹⁹, Giuseppe Nicolosi¹⁹, Matthew L. Niemiller²³, Susana Pallarés²⁴,
Martina Pavlek^{11,25} , Elena Piano¹⁹, Tanja Pipan^{26,27}, David Sanchez-Fernandez⁵,
Andrea Santangeli²⁸, Susanne I. Schmidt^{29,30}, J. Judson Wynne³¹ , Maja Zagmajster⁸,
Valerija Zakšek⁸ and Pedro Cardoso^{1,4} 

¹Laboratory for Integrative Biodiversity Research (LIBRe), Finnish Museum of Natural History (LUOMUS), University of Helsinki, Pohjoinen Rautatiekatu 13, Helsinki, 00100, Finland

²Molecular Ecology Group (dark-MEG), Water Research Institute (IRSA), National Research Council (CNR), Largo Tonolli, 50, Verbania-Pallanza, 28922, Italy

³BatLab Finland, Finnish Museum of Natural History Luomus (LUOMUS), University of Helsinki, Pohjoinen Rautatiekatu 13, Helsinki, 00100, Finland

⁴cE3c—Centre for Ecology, Evolution and Environmental Changes / Azorean Biodiversity Group / CHANGE – Global Change and Sustainability Institute, University of Azores, Faculty of Agrarian Sciences and Environment (FCAA), Rua Capitão João d'Ávila, Pico da Urze, 9700-042 Angra do Heroísmo, Azores, Portugal

⁵Departament of Ecology and Hidrology, University of Murcia, Murcia, 30100, Spain

⁶Department of Environmental Science, American University, 4400 Massachusetts Avenue, N.W, Washington, DC, 20016, U.S.A.

⁷Institut de Systématique, Evolution, Biodiversité (ISYEB), CNRS UMR 7205, MNHN, UPMC, EPHE, Museum National d'Histoire Naturelle, Sorbonne Université, Paris, France

⁸SubBio Lab, Department of Biology, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, Ljubljana, 1000, Slovenia

⁹Research Institute on Terrestrial Ecosystems (IRET-CNR), National Research Council, Via Madonna del Piano 10, 50019 Sesto Fiorentino, Florence, Italy

¹⁰Division of Zoology, Department of Biology, Faculty of Science, University of Zagreb, Rooseveltov Trg 6, Zagreb, 10000, Croatia

¹¹Croatian Biospeleological Society, Rooseveltov Trg 6, Zagreb, 10000, Croatia

¹²Center of Studies in Subterranean Biology, Biology Department, Federal University of Lavras, Campus universitário s/n, Aquenta Sol, Lavras, MG, 37200-900, Brazil

¹³Department of Life, Health and Environmental Sciences, University of L'Aquila, Via Vetoio 1, Coppito, L'Aquila, 67100, Italy

¹⁴Department of Environment, Faculty of Environment, Ionian University, M. Minotou-Giannopoulou str, Panagoula, Zakynthos, 29100, Greece

¹⁵Hellenic Centre for Marine Research (HCMR), Institute of Marine Biology, Biotechnology and Aquaculture (IMBBC), Thalassocosmos, Gournes, Crete, 71500, Greece

¹⁶Department of Functional and Evolutionary Ecology, Division of Limnology, University of Vienna, Djerassiplatz 1, Vienna, 1030, Austria

¹⁷Bennelongia Environmental Consultants, 5 Bishop Street, Jolimont, WA, 6014, Australia

¹⁸Hawaii Biological Survey, Bishop Museum, Honolulu, Hawaii, U.S.A.

¹⁹Department of Life Sciences and Systems Biology, University of Turin, Via Accademia Albertina, 13, Torino, I-10123, Italy

²⁰Department of Biological Sciences, Ohio University, 57 Oxbow Trail, Athens, OH, 45701, U.S.A.

* Address for correspondence (Tel: +39 0323 518363; E-mail: stefano.mammola@helsinki.fi; stefano.mammola@cnr.it)

†Equal first authors.

²¹ Emil Racovita Institute of Speleology, Clinicilor 5, Cluj-Napoca, 400006, Romania

²² Romanian Institute of Science and Technology, Saturn 24-26, Cluj-Napoca, 400504, Romania

²³ Department of Biological Sciences, The University of Alabama in Huntsville, 301 Sparkman Drive NW, Huntsville, AL, 35899, U.S.A.

²⁴ Departamento de Biogeografía y Cambio Global, Museo Nacional de Ciencias Naturales, CSIC, Calle de José Gutiérrez Abascal 2, Madrid, 28006, Spain

²⁵ Ruđer Bošković Institute, Bijenička cesta 54, Zagreb, 10000, Croatia

²⁶ ZRC SAZU, Karst Research Institute, Novi trg 2, Ljubljana, 1000, Slovenia

²⁷ UNESCO Chair on Karst Education, University of Nova Gorica, Glavni trg 8, Vipava, 5271, Slovenia

²⁸ Research Centre for Ecological Change, Organismal and Evolutionary Biology Research Programme, University of Helsinki, Vukinkaaari 1, Helsinki, 00014, Finland

²⁹ Institute of Hydrobiology, Biology Centre CAS, Na Sádkách 702/7, České Budějovice, 370 05, Czech Republic

³⁰ Department of Lake Research, Helmholtz Centre for Environmental Research, Brückstraße 3a, Magdeburg, 39114, Germany

³¹ Department of Biological Sciences, Center for Adaptable Western Landscapes, Box 5640, Northern Arizona University, Flagstaff, AZ, 86011, U.S.A.

ABSTRACT

Subterranean ecosystems are among the most widespread environments on Earth, yet we still have poor knowledge of their biodiversity. To raise awareness of subterranean ecosystems, the essential services they provide, and their unique conservation challenges, 2021 and 2022 were designated International Years of Caves and Karst. As these ecosystems have traditionally been overlooked in global conservation agendas and multilateral agreements, a quantitative assessment of solution-based approaches to safeguard subterranean biota and associated habitats is timely. This assessment allows researchers and practitioners to understand the progress made and research needs in subterranean ecology and management. We conducted a systematic review of peer-reviewed and grey literature focused on subterranean ecosystems globally (terrestrial, freshwater, and saltwater systems), to quantify the available evidence-base for the effectiveness of conservation interventions. We selected 708 publications from the years 1964 to 2021 that discussed, recommended, or implemented 1,954 conservation interventions in subterranean ecosystems. We noted a steep increase in the number of studies from the 2000s while, surprisingly, the proportion of studies quantifying the impact of conservation interventions has steadily and significantly decreased in recent years. The effectiveness of 31% of conservation interventions has been tested statistically. We further highlight that 64% of the reported research occurred in the Palearctic and Nearctic biogeographic regions. Assessments of the effectiveness of conservation interventions were heavily biased towards indirect measures (monitoring and risk assessment), a limited sample of organisms (mostly arthropods and bats), and more accessible systems (terrestrial caves). Our results indicate that most conservation science in the field of subterranean biology does not apply a rigorous quantitative approach, resulting in sparse evidence for the effectiveness of interventions. This raises the important question of how to make conservation efforts more feasible to implement, cost-effective, and long-lasting. Although there is no single remedy, we propose a suite of potential solutions to focus our efforts better towards increasing statistical testing and stress the importance of standardising study reporting to facilitate meta-analytical exercises. We also provide a database summarising the available literature, which will help to build quantitative knowledge about interventions likely to yield the greatest impacts depending upon the subterranean species and habitats of interest. We view this as a starting point to shift away from the widespread tendency of recommending conservation interventions based on anecdotal and expert-based information rather than scientific evidence, without quantitatively testing their effectiveness.

Key words: biospeleology, cave, climate change, conservation biology, ecosystem management, extinction risk, groundwater, legislation, pollution, subterranean biology

CONTENTS

I. Introduction	1478
(1) General overview	1478
(2) Definition of subterranean habitats used in this review	1479
II. Materials and methods	1479
(1) Systematic literature search	1479
(2) Additional literature, cross-validation, and caveats	1481

(3) Metadata extraction	1481
(4) Data visualisation and statistical analyses	1482
(5) To meta-analyse or not to meta-analyse?	1482
III. Overview of quantitative results	1482
(1) General summary of the literature	1482
(2) Temporal trends	1483
IV. Current knowledge and research trajectories for conservation interventions	1483
(1) Assessment	1484
(2) Education	1487
(3) Monitoring	1487
(4) Protection	1490
(5) Regulation	1490
(6) Restoration	1490
V. Future directions	1491
(a) Do not reinvent the wheel	1491
(b) Be meticulous with study design and reporting of statistics	1491
(c) Embrace ignorance	1492
(d) Look beyond your backyard	1492
(e) Focus on the gaps	1492
(f) Be aware of constraints	1492
(g) Dialogue with decision-makers and stakeholders	1492
VI. Conclusions	1492
VII. Acknowledgements	1493
VIII. Author contributions	1493
IX. Data accessibility	1493
X. References	1493
XI. Supporting information	1510

I. INTRODUCTION

(1) General overview

Modern conservation science benefits from an increasing use of data to support evidence-based conservation interventions (Sutherland *et al.*, 2004, 2019, 2020; Salafsky *et al.*, 2019; Downey *et al.*, 2021) and recognition of biases in terms of where these efforts are placed (Buxton *et al.*, 2021; Fonseca *et al.*, 2021). First, we are collectively building upon a quantitative understanding of what constitutes effective conservation interventions to ensure the protection and recovery of biodiversity and ecosystems (Sutherland *et al.*, 2019). Second, we now appreciate that, given limited resources available for conservation, we need to maximise their effective allocation – for example by redirecting part of the funding devoted to monitoring and inventories towards direct and cost-effective conservation interventions (Lindenmayer, Piggott & Wintle, 2013; Buxton *et al.*, 2020). Third, we have now identified how cognitive biases have permeated conservation investments and efforts in the past – for example more attention given to charismatic organisms (Mammola *et al.*, 2020b; Adamo *et al.*, 2021; Delso, Fajardo & Muñoz, 2021) and visibly appealing landscapes (Watson *et al.*, 2014). By openly discussing these issues, we are setting the stage for a more effective allocation of conservation efforts and funding in the years ahead (Buxton *et al.*, 2021).

Following recent trends, it is clear there should be a substantial shift of focus towards the species and ecosystems

traditionally overlooked in most global conservation agendas, such as caves and other subterranean ecosystems (Sánchez-Fernández *et al.*, 2021; Wynne *et al.*, 2021; see definition in Section I.2). Due to the intrinsic inaccessibility of subterranean ecosystems (Ficetola, Canedoli & Stoch, 2019) and many impediments to research (Mammola *et al.*, 2021a), we currently know too little about subterranean biota to be able to routinely implement cost-effective conservation interventions. To date, conservation of subterranean ecosystems has been dominated by problem-based studies focused on identifying the main drivers associated with subterranean biodiversity decline (Mammola *et al.*, 2019a; Gerovasileiou & Bianchi, 2021). For example, we have elucidated the ecological impacts of polluted surface waters percolating underground (Di Lorenzo *et al.*, 2015, 2021; Manenti *et al.*, 2021), the long-term consequences of climate change on specialised subterranean organisms adapted to thermally stable conditions (Mammola *et al.*, 2019c; Pallarés *et al.*, 2020a,b; Colado *et al.*, 2022), and some of the negative impacts that pathogens and alien species can cause to subterranean ecosystems (Howarth *et al.*, 2007; Wynne *et al.*, 2014; Howarth & Stone, 2020; Hoyt, Kilpatrick & Langwig, 2021).

However, problem diagnosis alone is notoriously insufficient for implementing conservation (Williams, Balmford & Wilcove, 2020). It is vital to start exploring solution-based approaches, namely proposing and implementing conservation interventions and then monitoring their efficacy. There are examples of habitat manipulation to increase bat survivability

under pathogenic stress (Turner *et al.*, 2021), cave habitat restoration for invertebrate populations (Humphreys, 1991; Mantenti *et al.*, 2019), and several studies synthesising quantitative knowledge on conservation interventions for managing bat populations, including species roosting or hibernating in caves (e.g. Tobin & Chambers, 2017; Berthinussen, Richardson & Altringham, 2021; Sutherland *et al.*, 2021). More often, however, conservation interventions are indirect and/or not assessed quantitatively. We are frequently guilty of concluding our research papers with lofty, often abstract recommendations such as “We should monitor the population...”, “Management of the [habitat/species/population] is strongly advised...”, and “It would be important to protect the site...”. Although the intentions are good, this can contribute to an information overload that may complicate, or even misguide, conservation and management efforts (Landhuis, 2016; Jeschke *et al.*, 2019).

Two questions naturally follow concerning conservation and management of the subterranean biome: (i) how often have conservation interventions been quantified and statistically tested in relation to various anthropogenic threats; and (ii) how has the frequency of the different conservation interventions, whether proposed or tested, changed over time? To approach these questions, we undertook a systematic literature review across a breadth of publications focused on conservation interventions for subterranean ecosystems (Fig. 1). Our efforts were designed to build a quantitative understanding of the number of interventions that have (or have not) been tested, as well as to target threats, organisms, systems, and types of conservation interventions lacking research. Finally, we build upon positive cases of successful conservation to provide examples of robust study designs that monitor the effectiveness of conservation interventions.

(2) Definition of subterranean habitats used in this review

We used the term ‘subterranean habitat/ecosystem’ in a broad sense to encompass all lightless subterranean spaces, dry or filled with water, generally representing buffered climatic conditions, and where organisms do not encounter surface habitats in all three dimensions. The latter condition excludes soil habitats. For the purpose of this analysis, we divide subterranean habitats into six artificial categories: (i) caves – cavities of different origins [karst, volcanic, tectonic, glacier caves, and other voids formed by solution or erosion] that are directly accessible to humans; (ii) show caves – caves made accessible to the general public for tourism, managed by a government or commercial organisation; (iii) artificial – all subterranean spaces of man-made origin, such as mines, bunkers, blockhouses, and water conduits; (iv) groundwater – aquatic subterranean habitats such as aquifers, springs, cenotes, and subterranean rivers; (v) fissural systems – all fissures and pore spaces whose size prevents human entry, with similar habitats occurring close to the surface usually listed under the umbrella term *shallow subterranean habitats* (Culver & Pipan, 2014); these habitats are only accessible *via* indirect

means, for example using subterranean sampling devices (Mammola *et al.*, 2016); and (vi) marine/anchialine – saline groundwater habitats represented through the ecotone that extends from the coast to fresh groundwater. Marine subterranean ecosystems (e.g. submarine caves) are those subject to direct marine influence, whereas ‘anchialine’ is generally used for subterranean or semi-subterranean water bodies with a marine origin that has penetrated inland and remains isolated from the ocean (Sket, 1996).

II. MATERIALS AND METHODS

We conducted a systematic literature review to amass an extensive list of publications that discussed and/or tested conservation interventions for subterranean species or habitats – including terrestrial, freshwater, and marine/anchialine subterranean systems (see Section I.2 for definitions). The PRISMA workflow (Moher *et al.*, 2009; Page *et al.*, 2021) and a summary of this review is provided in Fig. 1A. Throughout the text, we use the term ‘intervention’ in a broad sense, namely any direct or indirect action associated with the conservation of the species/system (see Section II.3 for further details).

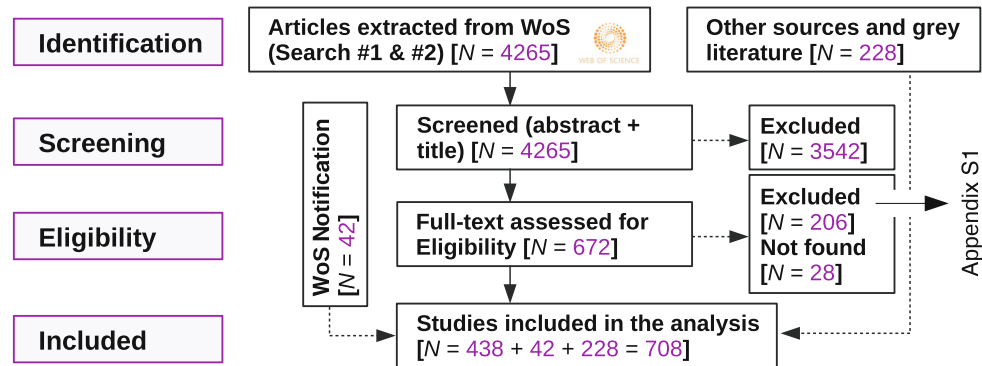
(1) Systematic literature search

On 03 February 2021, we performed standardised literature searches in the *Web of Science*. Different search terms were initially trialed by S.M. and M.B.M. in a scoping exercise to refine the procedure, that is running a search and considering the relevance of the first 200 references. Based upon this exploratory trial, we refined search terms to minimise the number of irrelevant references. We found that using overly broad search terms (e.g. ‘subterranean habitat’, ‘groundwater’) resulted in an overwhelming number of articles. For example, a search with the term ‘groundwater’ yielded >37,000 papers, most of which were irrelevant because they referred to (hydro)geological aspects. At the same time, more specific subterranean biology terms such as ‘caves’ captured several archaeological, palaeontological, and medical papers – for example the term ‘cave’ is used in Osteology. The final search string that maximised both specificity and sensitivity was (Search #1):

TS = (“cave” OR “subterranean biology”) AND
 TS = (“conserv*” OR “managem*” OR “restorat*” OR
 “preserv*” OR “policy” OR “policies” OR “politic*” OR
 “protect*” OR “reintroduc*” OR “regulat*” OR “legislat*”
 OR “IUCN” OR “CITES” OR “sustainabil*”) NOT
 TS = (“surgery” OR “surgical” OR “medicine” OR “Neanderthal” OR “osteology” OR “bones” OR “anthropology” OR “Homo” OR “therapy” OR “art” OR “cranial” OR “paleontolog*”).

This search yielded 3,269 papers. In parallel, we conducted a second search for groundwater and anchialine systems (Search #2) using the search string:

(A) Systematic literature search: PRISMA diagram



(B) Meta-data extraction

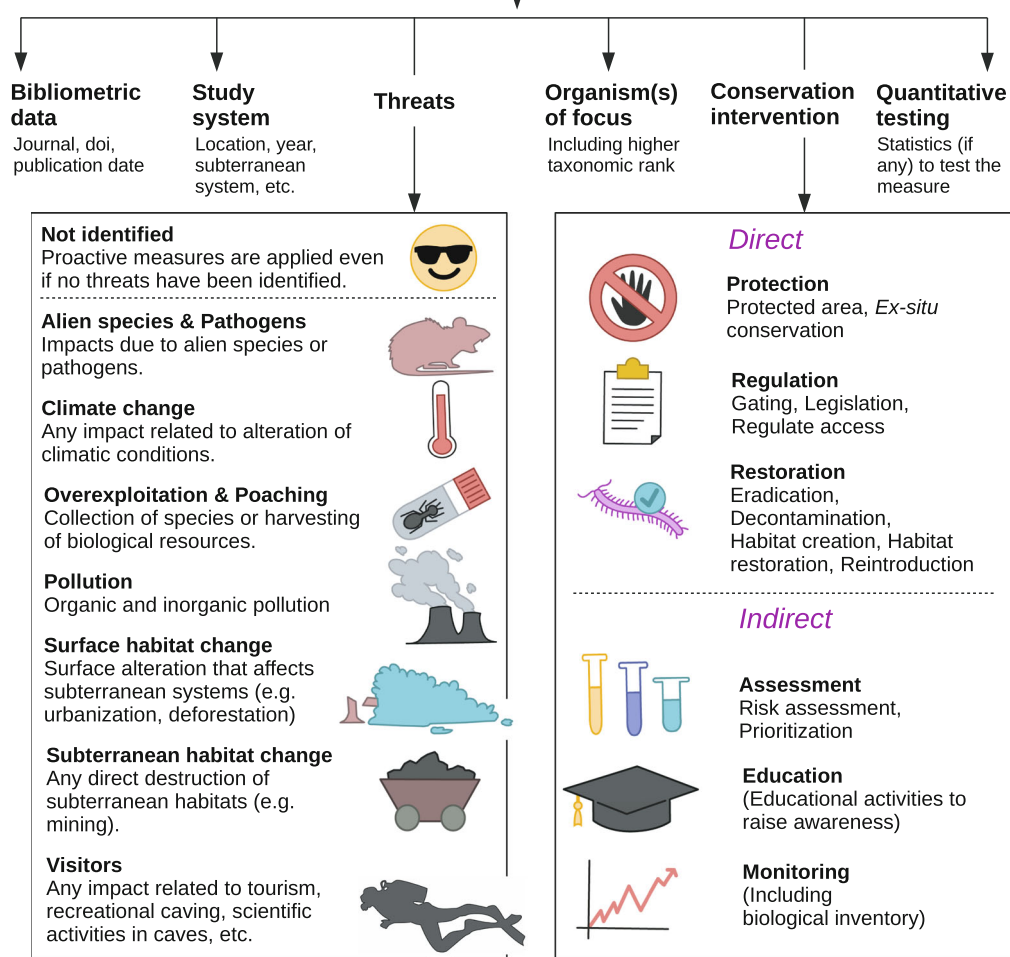


Fig. 1. Summary of the sampled literature and extracted metadata. (A) PRISMA diagram depicting the flow of information through the different phases of the systematic literature review. For the list of studies extracted from the *Web of Science*, including excluded studies with reasons for exclusion, see Appendix S1. (B) Summary of the metadata collected for the database. For the link to the data repository see Section VII. Original silhouettes by Irene Frigo.

TS = (“groundwater” OR “anchialine”) AND TS
= (“fauna” OR “stygob*” OR “organism*”) AND
TS = (“conserv*” OR “managem*” OR “restorat*” OR

“preserv*” OR “policy” OR “policies” OR “politic*” OR
“protect*” OR “reintroduc*” OR “regulat*” OR “legislat*”
OR “IUCN” OR “CITES” OR “sustainabil*”).

This search yielded an additional 998 papers, with less than 100 papers overlapping with Search #1. All papers originating from these two searches ($N = 4,265$) were screened for inclusion in the review based on an agreed set of criteria (Appendix S1). We included studies that: (i) statistically tested the effectiveness of conservation interventions (e.g. gating to prevent access to caves), based on quantitative variables describing the status of species or ecosystems (e.g. population or range trends) (hereafter ‘testing’); (ii) discussed or recommended conservation interventions without testing their effectiveness; (iii) discussed research priorities for conservation of subterranean biodiversity and/or performed risk assessments; and (iv) focused on surface management/protection measures that affect subterranean ecosystems. Studies were excluded that either: (i) focused on non-subterranean habitats (see Section 1.2) or (ii) did not focus on the biological component of the target subterranean ecosystem (e.g. studies examining methods to restore cave-wall paintings at archaeological sites).

We carried out the initial screening by making independent selections based on titles and abstracts. To test the consistency of selection criteria, S.M. and M.B.M. independently classified the first 100 papers and calculated inter-rater agreement using Cohen’s kappa. The value of kappa was 0.7, well above the standard threshold of acceptable inter-rater agreement of 0.4 (Cohen, 1960). Given this result, we used these criteria to screen the remaining papers based on their titles and abstracts. If it was evident that a given study did not address our key research questions, we discarded it. Subsequently, we examined the full text of the references taken forward from this screening ($N = 708$) to determine if they addressed our research questions (Appendix S1).

For both *Web of Science* searches, we set up an alert for relevant references when they entered the *Web of Science* database from February to October 2021, which generated an additional 42 references.

(2) Additional literature, cross-validation, and caveats

To ensure a better coverage of the current conservation literature (Gusenbauer & Haddaway, 2020; Sutherland *et al.*, 2020), we cross-checked the final database with the list of papers focusing on subterranean ecosystems included within the Conservation Evidence database ($N = 15$, of which 11 were also available in the *Web of Science*; online database accessed on 03 February 2021 using the query “Habitat = Rocky Habitats & Caves” and manually extracting relevant entries; Sutherland *et al.*, 2019). We further cross-checked the final database with the lists of papers analysed in three ongoing systematic literature surveys focusing on the environmental impacts related to the exploitation of caves for tourism (E. Piano, G. Nicolosi, S. Mammola, B. Baroni, E. Cumino, N. Muzzulini, V. Balestra, R. Bellopede & M. Isaia, unpublished), on alien species in subterranean ecosystems (G. Nicolosi, L. Verbrugge, M. Isaia & S. Mammola, unpublished), on conservation of cave-dwelling bats (M.B. Meierhofer, J.S. Johnson, J. Perez-Jimenez, F. Ito, P.W. Webela,

S. Wiantoro, E. Bernard, K.C. Tanalgo, A. Hughes, P. Cardoso, T. Lilley, S. Mammola, unpublished), plus a recent synthesis of current knowledge regarding marine caves (Gerovasileiou & Bianchi, 2021). These cross-checks yielded 37 additional papers that were missed from our initial searches, which we also included. Finally, we conducted an unstandardised search for grey literature (Haddaway *et al.*, 2020), including articles not in English (Nuñez & Amano, 2021). All these additional sources ($N = 228$) were labelled as ‘Others’ within the database.

Given that our analysis is based on a single literature database plus unstandardised grey literature searches, we acknowledge that it is not a fully comprehensive coverage of the literature (Gusenbauer & Haddaway, 2020). For example, through our initial search, we captured 9 out of 11 of the papers in Conservation Evidence focusing on bat conservation available in the *Web of Science*. As a result, our estimation of the volume of the literature should be taken as an approximation of the real number of studies. We operated under the reasonable assumption that the biases were homogeneously distributed across conservation interventions and taxa, allowing us to draw meaningful inferences using proportional data. Nevertheless, any comparison of absolute numbers of studies should be taken with caution.

(3) Metadata extraction

For all relevant references included in the final database, we extracted detailed metadata and information (Fig. 1B). We recorded the geographic and taxonomic scope, type of threat, and conservation intervention applied, as well as a list of all tests used to analyse the conservation intervention, the test statistic, the degrees of freedom, number of observations, whether the measure was significant, and the direction of the effect.

We determined the main threats to subterranean ecosystems based on recent syntheses (Mammola *et al.*, 2019a, 2020a; Wynne *et al.*, 2021) complemented by our expert opinion. We grouped threats into the following eight categories: (i) Alien species & Pathogens (impacts due to alien species or pathogens); (ii) Climate change (impacts related to the alteration of climatic conditions); (iii) Overexploitation & Poaching (indiscriminate collection of species or overexploitation of biological resources); (iv) Pollution (organic and inorganic pollution events); (v) Surface habitat change (habitat alteration at the surface that affect subterranean systems; e.g. urbanisation); (vi) Subterranean habitat change (direct destruction of subterranean habitat; e.g. mining); (vii) Visitors (disturbance related to tourism exploitation of caves, recreational caving, etc.); and (viii) Not identified (when proactive conservation interventions are applied or suggested even if no threats were identified) (Fig. 1B).

Likewise, we determined the main conservation interventions based on general conservation science literature (Sutherland *et al.*, 2019) and our knowledge and expertise regarding subterranean ecosystems (Mammola *et al.*, 2019a,

2020a; Wynne *et al.*, 2021). We classified conservation measures as ‘indirect’ or ‘direct’ (Fig. 1B).

Indirect interventions (Fig. 1B) are activities that increase knowledge useful for implementing practical conservation. Such interventions that indirectly enhance the protection of subterranean ecosystems were classified into: (i) Education (dissemination or education program to raise awareness of the subterranean biome); (ii) Monitoring (biological inventories and short- or long-term monitoring programs of the quality/status of a species, habitat or ecosystem); or (iii) Assessment [with two categories: Prioritisation (interventions to prioritise species/habitat/ecosystem for conservation, for example identifying hotspots of biodiversity to be protected, identifying cost-effective interventions, or fundamental questions to be answered to achieve better protection); and Risk assessment (assessments of the status of conservation/extinction risk of a species/habitat/ecosystem)].

Direct interventions (Fig. 1B) have clear relevance for practical conservation of subterranean fauna and habitats, and are classified into: (i) Protection [with two categories: Protected area (interventions to establish legal protection for the site); and *Ex-situ* conservation (interventions focused on species outside natural habitats; for example captive breeding programs established to rear and reintroduce an imperiled species)], (ii) Regulation [with three categories: Gating (install and maintain gates/fences at the entrance to or inside caves, or any other action to restrict human access); Legislation (legal actions to protect biodiversity); and Regulate access (regulation of access to the site; for example restricting recreational users in winter months and regulating visits to show caves)]; and (iii) Restoration [with five categories: Eradication (interventions for controlling the spread of alien species); Decontamination (practices for removal or hindering the spread of pathogens); Habitat creation (interventions to create new, previously non-existing habitat; for example excavating an artificial refuge for bats); Habitat restoration (interventions to restore habitat; for example bioremediation of pollutants, removal of abandoned pitfall traps); and Reintroduction (species reintroductions)].

(4) Data visualisation and statistical analyses

We conducted all analyses in R version 4.1.0 (R Core Team, 2021), using the packages ‘ggplot2’ version 3.3.4 (Wickham, 2016) and ‘circlize’ version 0.4.13 (Gu *et al.*, 2014) for data visualisation. For all analyses and figures, we record an individual mention of a conservation intervention as the minimum measurement unit; there may be multiple measurements/tests per study (mean \pm S.E. recommended interventions per paper = 2.76 ± 0.15).

We used binomial generalised linear models to predict the annual changes in the relative proportion of conservation interventions and threats, as well as the number of interventions being tested in each year. In all models, we used the total number of interventions or threats in each year as a benchmark to standardise values and obtain proportional values. Considering the limited sample size before the year

2000, we restricted all temporal analyses to the period 2000–2021 (note that data for 2021 extend only to the end of October). We validated models with the *check_model* function in the R package ‘performance’ version 0.7.2 (Lüdtke *et al.*, 2020).

(5) To meta-analyse or not to meta-analyse?

For articles that statistically tested conservation interventions, we also collected associated statistical measures (if any) to generate a data baseline for performing future meta-analyses regarding the most effective interventions for the long-term preservation of subterranean species and habitats. However, given the low rate of statistical testing for conservation measures across the data set, we did not perform a meta-analysis. We believe the field has not yet matured sufficiently to support such an analysis because: (i) the number of quantitative studies regarding most conservation interventions was below a threshold of five independent studies, which we considered to be a minimum for deriving meaningful estimates; and (ii) even for the most intensively tested interventions (e.g. risk assessment, gating), we could not extract basic information for several studies due to inadequate reporting of results (e.g. studies reporting only *p*-values, not mentioning sample size, or omitting confidence intervals). The number of estimates potentially usable for future meta-analyses is given in Table 1.

III. OVERVIEW OF QUANTITATIVE RESULTS

(1) General summary of the literature

We identified 4,265 studies in the two initial *Web of Science* literature searches, of which 672 were deemed relevant for full-text inspection based on the screening of titles and abstracts. Of these, 438 studies satisfied our inclusion criteria. Additionally, we included a further 228 papers based on literature known to us and through cross-referencing with other literature data sets, and 42 papers through *Web of Science* email alerts. In total, 708 studies met our criteria for inclusion (Fig. 1A; Appendix S1). These papers entailed 1,954 unique conservation interventions.

Predictably, the majority of conservation interventions occurred in the Palearctic (42%) and Nearctic (22%) biogeographic regions, with few studies originating in the Afrotropical and Indomalayan regions (both 5%; Fig. 2A). The terrestrial environment – caves, show caves, and artificial systems – was the focus of most conservation interventions (59%), followed by groundwater habitats (27%) and marine cave/anchialine systems (8%); difficult-to-access fissure systems were the least studied in conservation science (1%; Fig. 2B). Arthropods (32%) and cave-roosting bats (33%) were the most studied organisms, with plants and microorganisms (bacteria, archaea, unicellular fungi, and viruses) the least studied (both 2%; Fig. 2C). Over one-third of conservation interventions for arthropods and bats were tested.

Table 1. Usable data for meta-analyses based on the sampled literature. Out of the total number of unique interventions, this table reports the percentage (%) that have been tested, the number of quantitative estimates, and the number of studies. Potential number of standardised estimates indicate the number of estimates that could be converted to Pearson's r using standard conversion formulae (Lajeunesse, 2013)

Intervention	Total number of estimates (% tested)	Number of quantitative estimates (number of studies)	Potential number of standardised estimates (% of total studies)
Protected area	183 (0%)	1 (1)	1 (100%)
<i>Ex-situ</i> conservation	10 (0%)	0 (0)	–
Gating	174 (72%)	125 (16)	71 (57%)
Legislation	95 (0%)	0 (0)	–
Regulate access	127 (43%)	55 (6)	44 (80%)
Eradication	15 (27%)	4 (1)	0 (0%)
Decontamination	54 (35%)	19 (6)	2 (11%)
Habitat creation	13 (38%)	5 (1)	4 (80%)
Habitat restoration	115 (14%)	16 (3)	15 (94%)
Reintroduction	5 (0%)	0 (0)	–
Risk assessment	465 (63%)	295 (37)	208 (71%)
Prioritisation	213 (21%)	44 (12)	10 (23%)
Education	105 (0%)	0 (0)	–
Monitoring	399 (11%)	45 (14)	20 (44%)

Pollution (24%) and visitors (19%) were the most frequently addressed, whereas climate change (2%) and overexploitation & poaching (2%) were the least studied and tested (Fig. 2D). Of all conservation interventions, protected areas (9%) and gating (9%) were the most mentioned direct interventions, while risk assessment (24%) and monitoring (20%) were the most considered indirect interventions (Fig. 2E). The frequency of different conservation interventions, whether proposed or tested, varied among the identified threats. For example, monitoring and education were suggested more or less equally in relation to all threats, regulation was mostly recommended in response to visitors, assessments were largely proposed to target pollution, and restoration interventions were mostly suggested in response to alien species & pathogens and subterranean habitat change (Fig. 3).

(2) Temporal trends

Perhaps one of the clearest findings was that only 609 out of 1,954 conservation interventions (31%) were tested using statistical techniques, despite the rapid increase in the number of publications from 2000 to October 2021 (Fig. 4A). This result implies that most of the conservation science in subterranean biology, and the resulting interventions, were not developed using quantitative evidence – the exceptions were gating and risk assessments, where 72 and 63% of cases were quantified and/or tested, respectively (Fig. 2E).

Of the conservation interventions and threats, one intervention and five threats exhibited notable temporal trends (Table 2, Fig. 4B, C). Monitoring actions were increasingly mentioned in the literature since the year 2000 (Fig. 4C). Studies focusing on alien species & pathogens have increased significantly since the year 2000 (Fig. 4B), mostly due to a recent surge in research on white-nose

syndrome in North American bat populations (Blehert *et al.*, 2009). Although the effects of climate change are at the forefront of conversation regarding surface environments (Arneith *et al.*, 2020), only a relatively shallow increase in such studies was observed for subterranean environments (Fig. 4B). Indeed, discussion on the impacts of anthropogenic climate change on subterranean ecosystems has begun only recently (Mammola *et al.*, 2019b; Howarth, 2021). Finally, the three most mentioned threats in earlier research – visitors, pollution, and subterranean habitat change – all displayed a significant decrease over time. This may be due to more balanced attention applied across multiple threats or a shift in research interest in recent years (Fig. 4B).

IV. CURRENT KNOWLEDGE AND RESEARCH TRAJECTORIES FOR CONSERVATION INTERVENTIONS

As illustrated in this review, the field of subterranean conservation is still in its infancy regarding the testing of conservation interventions and their practical implementation. Despite the growing literature concerning the subterranean biome and the breadth of potential threats, reports of conservation interventions have been largely descriptive (Table 1). In this section, we provide a qualitative assessment of past and current conservation interventions and discuss potential future research trajectories. We use the six broad categories for conservation interventions defined in Section II.3 (see Fig. 1B). In Table 3, we provide examples of potential research areas and study designs that can be applied to diverse subterranean species and/or ecosystems to test conservation interventions effectively.

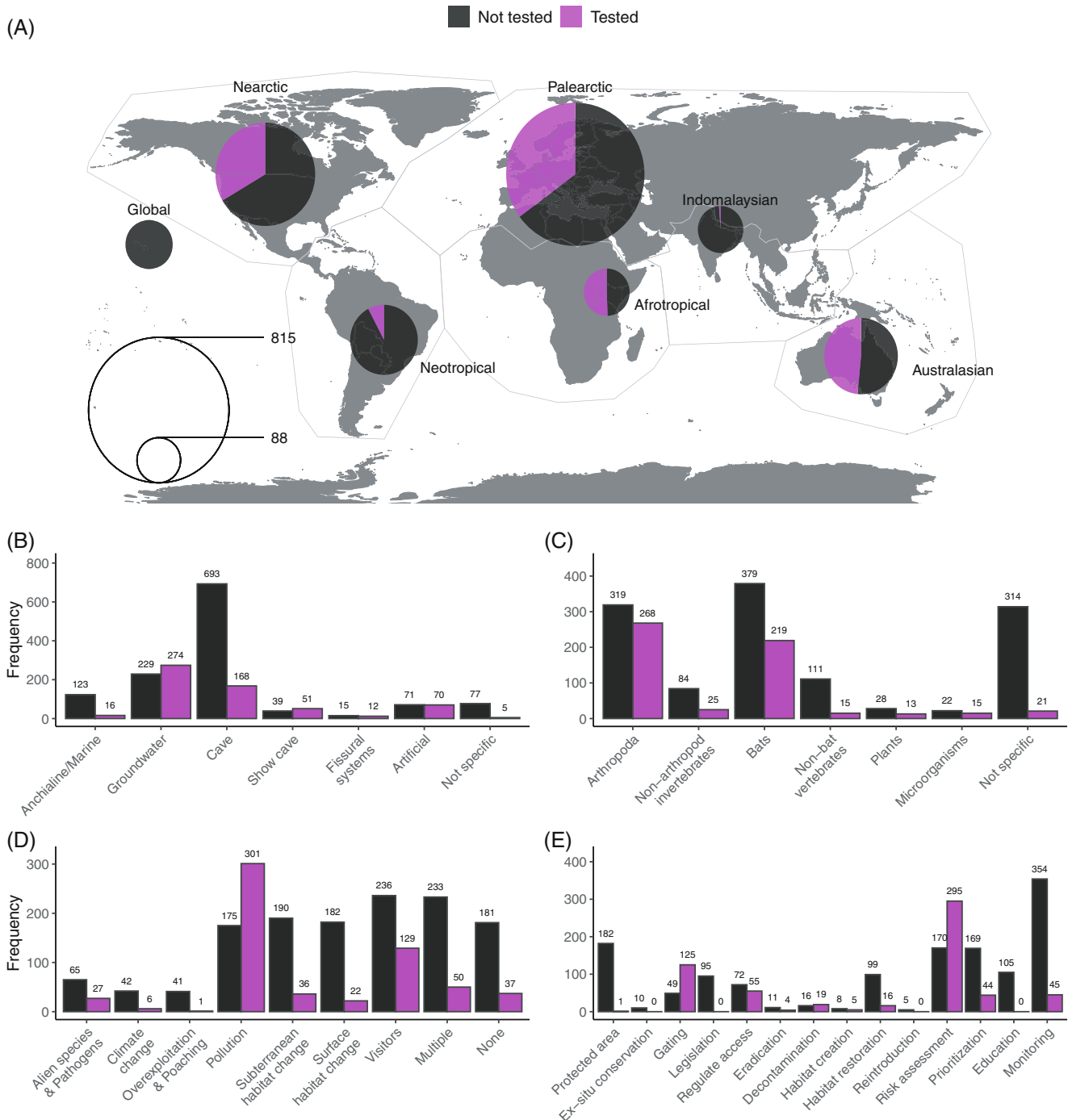


Fig. 2. Summary of the surveyed literature. Proportion of conservation interventions tested across our data set by biogeographic region (A), habitat (B), taxon (C), threat (D), and conservation intervention (E). Size of the circle in A indicates the number of conservation interventions. For definitions of subterranean habitat types used in B see Section I.2. In B and C, ‘Not specific’ means that the study did not refer to a specific subterranean species/system. In D, ‘Multiple’ means that three or more threat groups were considered. Note that total numbers in each panel within the figure may differ slightly from the overall total number of interventions (1,954), because: (i) data were missing for some entries in the database (i.e. we could not derive some information); (ii) some studies focused on multiple biogeographic regions, taxa, or habitats.

(1) Assessment

Assessment of subterranean species or ecosystems comprises two components: prioritisation and risk assessment (Fig. 1B).

These actions combined represented 35% of all suggested conservation interventions (Fig. 2E), despite their effects being indirect. Prioritisation involves the identification of criteria

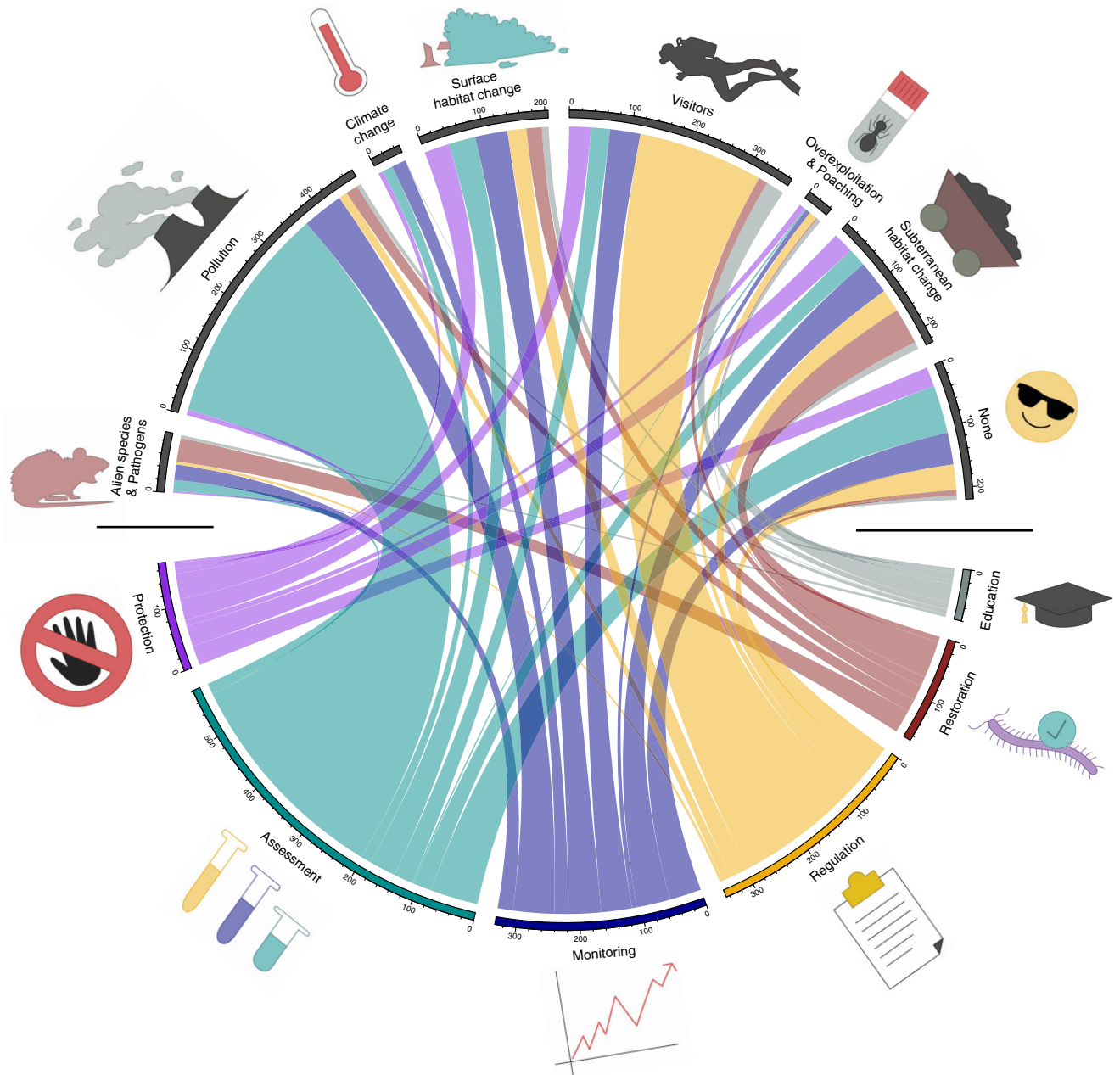


Fig. 3. Chord diagram showing interrelationships among conservation interventions and threats across our data set. Threats are listed in the upper portion of the diagram and conservation interventions in the lower portion. Original silhouettes by Irene Frigo.

for cost-effective conservation interventions and resource allocation. Most studies developed indices to prioritise subterranean sites for spatial conservation planning, although the proposed indices have rarely been implemented. These prioritisation exercises are often based on criteria such as the richness of specialised subterranean species, rare species, and/or the degree of endemism (Michel *et al.*, 2009; Borges *et al.*, 2012; Nitzu *et al.*, 2018; Rabelo, Souza-Silva & Ferreira, 2018; Pipan, Deharveng & Culver, 2020), but can be controversial (Moldovan & Brad, 2019; Nitzu, Meleg &

Giurginca, 2019). The effectiveness of conservation planning has been tested indirectly in most cases, for example by comparing the performance of different prioritisation methods (Rabelo, Souza-Silva & Ferreira, 2018; Cardoso, Ferreira & Souza-Silva, 2021) or by conducting complementarity analyses (Michel *et al.*, 2009; Borges *et al.*, 2012). Furthermore, with a few recent exceptions (e.g. Fattorini *et al.*, 2020; Iannella *et al.*, 2021; Tanalgo, Oliveira & Hughes, 2021), prioritisation attempts have focused solely on taxonomic diversity measures. However, it is increasingly recognised that similar exercises

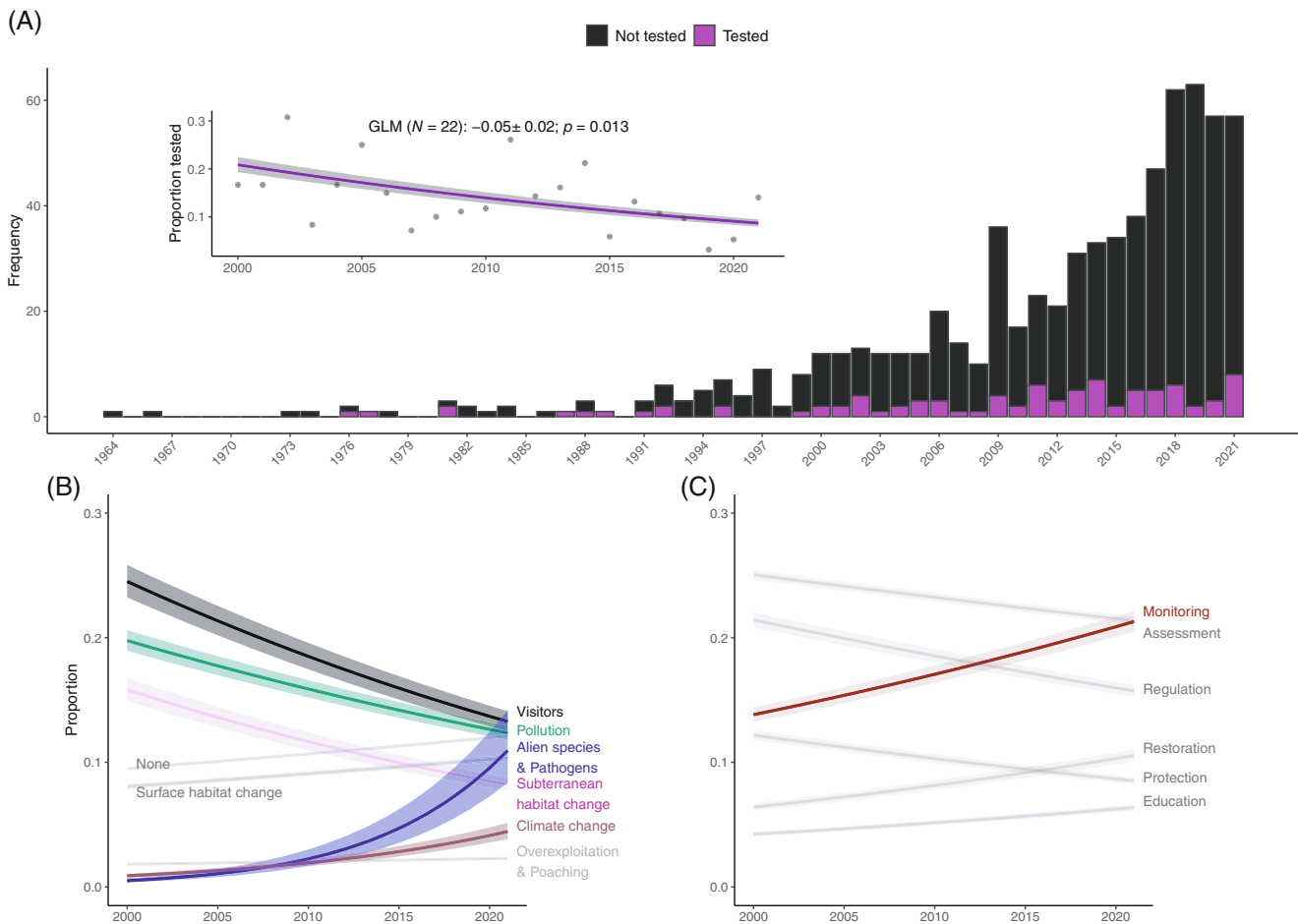


Fig. 4. Temporal trends in research on conservation measures and threats in subterranean ecosystems. (A) Proportion of conservation interventions tested across our data set by year. Inset scatterplot is the proportion of conservation interventions tested per year between 2000 and 2021 (partial data up to October for 2021), with the line fitted using a binomial generalised linear model. (B, C) Annual changes in the relative proportions of studies reporting different threats (B) and conservation interventions (C), with lines fitted using individual binomial generalised linear models. Solid lines are fitted values (slope) and shaded surfaces indicate the associated 95% confidence intervals. Bright colours highlight significant trends. Estimated regression parameters are given in Table 2.

should seek to achieve a delicate balance among multiple facets of diversity [taxonomic, phylogenetic, and functional diversity (Pollock, Thuiller & Jetz, 2017; Mazel *et al.*, 2018; Owen *et al.*, 2019b)] and other features including ecosystem services (Zhang *et al.*, 2015; Girardello *et al.*, 2019), natural resources (e.g. water; Jung *et al.*, 2021), threats (Wilson *et al.*, 2005), and species climatic niches (Hanson *et al.*, 2020). Testing multifaceted conservation planning is much needed to expand the coverage of subterranean protected areas globally (Sánchez-Fernández *et al.*, 2021), although it often remains unclear how to implement these conservation plans in practice (see Pollock *et al.*, 2020).

Risk assessment involves analyses aimed at identifying risks to species and habitats due to anthropogenic threats. Most studies in our database focused on assessing species extinction risk against International Union for Conservation of Nature (IUCN) *Red List* criteria or using other indices for assessing species imperilment (e.g. national or regional evaluations).

Currently, the use of IUCN criteria can be problematic for assessing the extinction risk of most invertebrates and for specific habitats such as caves (Cardoso *et al.*, 2011). However, IUCN assessments represent one of the best measures available to evaluate extinction risks objectively and comparably across different subterranean taxa (Borges *et al.*, 2019), but the effectiveness of these assessments remains largely untested.

Finally, a large body of literature has evaluated the likelihood of harmful effects to subterranean ecosystems resulting from exposure to environmental stressors. Most assessments were conducted in groundwater systems. The main problem is that guideline-based risk scenarios for groundwater are often unrealistic because surface species (e.g. *Daphnia* spp.) are used as proxies for the sensitivity of subterranean species to pollutants (Kolar & Finizio, 2017). Proxies are used because of the shortage of ecotoxicological data concerning subterranean animals (Castaño-Sánchez, Hose & Reboleira, 2020), and

Table 2. Regression parameters for modelled temporal trends in research on conservation interventions and threats in subterranean biology shown in Fig. 4, estimated using binomial generalised linear models. For each model, sample size is equal to 22 (one observation/year between 2000 and 2021). S.E. = standard error. C.I. = 95% confidence interval

Variable	Estimated slope \pm S.E.	C.I.	z	p -value	R^2
<i>Conservation interventions</i>					
Assessment	$-9.87e^{-03} \pm 8.79e^{-03}$	[-0.03, 0.01]	-1.12	0.26	0.07
Education	0.02 ± 0.02	[-0.01, 0.06]	1.11	0.27	0.04
Monitoring	0.02 ± 0.01	[0.01, 0.05]	2.45	0.01	0.04
Protection	-0.02 ± 0.01	[-0.04, 0.01]	-1.49	0.14	0.01
Regulation	$-0.02 \pm 9.73e^{-03}$	[-0.04, 0.01]	-1.85	0.06	0.03
Restoration	0.03 ± 0.01	[-0.01, 0.06]	1.75	0.08	0.01
<i>Threats</i>					
None	0.01 ± 0.01	[-0.01, 0.04]	1.01	0.31	0.06
Alien species & Pathogens	0.15 ± 0.03	[0.10, 0.21]	5.43	<0.001	0.29
Climate change	0.08 ± 0.03	[0.02, 0.14]	2.55	0.01	0.50
Overexploitation & Poaching	0.01 ± 0.03	[-0.05, 0.07]	0.38	0.71	0.58
Pollution	-0.03 ± 0.01	[-0.05, -0.01]	-2.54	0.01	0.01
Surface habitat change	0.01 ± 0.01	[-0.01, 0.04]	0.95	0.34	0.10
Subterranean habitat change	-0.04 ± 0.01	[-0.06, -0.01]	-2.92	0.004	0.07
Visitors	$-0.04 \pm 9.75e^{-03}$	[-0.05, -0.02]	-3.67	<0.001	0.01

the lack of a standard protocol to perform these trials (Di Lorenzo *et al.*, 2019). Although there have been numerous pleas for adaptation of the guidelines and for fine-tuning regulatory limits related to pollutants in subterranean environments (Di Lorenzo *et al.*, 2014, 2018, 2021; Di Marzio *et al.*, 2018), these recommendations have not been incorporated into legislation.

(2) Education

Environmental education encompasses all programs aimed at fostering environmentally related attitudes and developing awareness of biological conservation (Ardoin, Bowers & Gaillard, 2020). Moreover, education increases the success of other actions, such as citizen science-aided data collection in groundwater systems (Alther *et al.*, 2021) and reporting of poaching events in caves (Simičević, 2017). While studies have emphasised the importance of these activities to enhance the long-term preservation of subterranean biota and associated habitats, discussions on educational activities were often vague and lacked plans for practical implementation. Importantly, the effectiveness of subterranean environmental education remains untested in all cases (Fig. 2E).

Examples of concrete interventions proposed include promoting awareness through artistic representations of caves and their biota (Danielopol, 1998), the use of simple narratives to engage children in the conservation of subterranean fauna (Mammola, Frigo & Cardoso, 2022), briefings to increase visitors' awareness about sensitive taxa [e.g. for divers in marine caves (Di Franco *et al.*, 2009b; Guarnieri *et al.*, 2012)], personal contact with target audiences (Alther *et al.*, 2021), and the use of guided tours of caves to deliver an environmental education message (North & van Beynen, 2016). The latter example has received the most attention insofar as show caves represent unique windows

for the general public to experience an inaccessible secluded world. Given that cave tourism can have significant ecological impacts, there remains debate as to whether we should maintain active show caves or establish new ones to achieve broad-ranging educational goals (e.g. Tičar *et al.*, 2018). The most objective way to address this sensitive topic would be to test the effectiveness of educational interventions and their long-term benefits (Table 3).

(3) Monitoring

Monitoring subterranean ecosystems entails the acquisition of knowledge used in the protection of subterranean biota (e.g. new species descriptions, cryptic species identification, natural history studies, and biological inventories) or assessing populations and ecosystems across space and time. Monitoring is often based on simple survey methods (e.g. visual census, emergence count, mark-recapture studies, trapping), the use of indirect monitoring technologies (e.g. environmental DNA, acoustic monitoring, trail cameras with infrared sensors) (Mammola *et al.*, 2021a; Saccò *et al.*, 2022), and, most recently, subterranean citizen science (Alther *et al.*, 2021). Monitoring was by far the most recommended intervention in our database (Figs 2E, 4C) despite its effects being indirect – a pattern that is not exclusive to subterranean conservation (Buxton *et al.*, 2020, 2021). This likely relates to a deficit of knowledge about subterranean ecosystems, which are notoriously difficult to explore, study, understand, and ultimately to protect (Ficetola, Canedoli & Stoch, 2019; Mammola *et al.*, 2019a, 2021a; Gerovasileiou & Bianchi, 2021). Despite their perceived importance, only 11% of the proposed monitoring plans and methods were tested. Examples include comparing the effectiveness of different sampling methods in cave systems (Wynne *et al.*, 2018, 2019) or assessing the detection probability of a given method across diverse environmental conditions (Dole-Olivier

Table 3. Examples of potential research areas and study designs that could be applied to diverse subterranean species and/or ecosystems to test conservation interventions effectively. We report examples of study designs for the effective testing of conservation interventions and anticipated timing for such tests. An expected spatial and temporal scale of the impact of the conservation intervention is also provided. We provide example references from the subterranean ecosystems literature; when not available, we provide references from the general conservation science literature

Intervention	Example of study design	Timing of testing	Expected impact	Reference
Protected areas	(1) Compare outcomes of subterranean species/ecosystems in protected sites over time <i>versus</i> control areas. (2) Monitor habitat degradation in protected <i>versus</i> non-protected areas over time. (3) Compare the status of populations of affected species in protected <i>versus</i> non-protected areas.	(1) Instantaneous (2) Years to decades (3) Years to decades	Local to regional scale. Decades.	(1) Measey, Armstrong & Hanekom (2009) (2) Moldovan <i>et al.</i> (2020a) (3) Pacheco <i>et al.</i> (2021) (1–3) Pressey <i>et al.</i> (2021)
<i>Ex-situ</i> conservation	(1) Check the health status of target species in captivity. (2) Test effectiveness of protocols for treating symptomatic individuals kept in captivity against controls.	(1, 2) Days to years, depending on species longevity and reproductive phenology	Local scale. Years to centuries.	(1) Gredar, Prša & Bizjak Mali (2018) (2) Lukač, Cizelj & Mutschmann (2019)
Gating	(1) Compare abundance/behaviour of animals before/after gate installation. (2) Compare community-level indicators or other abiotic parameters when installing different types of gates and fences. (3) Compare community composition of caves with and without gates within a given region, while correcting for site-level confounding factors.	(1, 2) Years to decades (3) Instantaneous	Local scale. Years to decades.	(1) Voûte & Lina (1986); Caraka <i>et al.</i> (2018) (2) Richter <i>et al.</i> (1993); Pugh & Altringham (2005) (3) Furey & Racey (2016); Phelps <i>et al.</i> (2018) (1–3) Tobin & Chambers (2017)
Legislation	(1) Compare people's behaviour before/after the enforcement of a law/conservation program. (2) Assess whether the regulations are suitable for the intended purpose by examining their success against the criteria: effectiveness, efficiency, coherence, relevance and added value.	(1–2) Years to decades	Local to regional scale. Years to decades.	(1) Infield & Namara (2001)
Regulate access	(1) Monitor species abundances/community composition before/after regulation. (2) Monitor species abundances during reproduction/wintering events for caves with seasonal closures. (3) Monitor species abundances/community composition in managed <i>versus</i> unmanaged areas.	(1) Days to years (2) Years to decades (3) Instantaneous	Local scale. Years.	(1) Moldovan, Racovitza & Rajka (2003) (2) Trevelin <i>et al.</i> (2021) (3) Moldovan, Racovitza & Rajka (2003); Nicolosi <i>et al.</i> (2021); Pacheco <i>et al.</i> (2021)
Eradication	(1) Monitor the potential return(s) of alien species after eradication treatment. (2) Compare the status of native communities before/after eradication treatment.	(1) Years to decades (2) Days to years	Local to regional scale. Years to decades.	(1) Mouser <i>et al.</i> (2019) (2) Maezono & Miyashita (2004); Bergstrom <i>et al.</i> (2009)
Decontamination	(1) Quantify pathogen presence/load before and after intervention.	(1) Days to years (2) Years	Local. Years.	(1) Gabriel <i>et al.</i> (2018); Barton (2020) (2) Hoyt <i>et al.</i> (2019)

(Continues)

Table 3. (Cont.)

Intervention	Example of study design	Timing of testing	Expected impact	Reference
Habitat creation	(2) Monitor the status of species/community before/after the treatment of pathogens. (1) Monitor arrival/long-term survival of organisms in a newly created habitat.	(1) Days to years	Local scale. Years to centuries.	(1) Turner <i>et al.</i> (2021)
Habitat restoration	(1) Monitor for potential return(s) of extirpated/extinct species after restoration event(s). (2) Compare the biological community before/after the restoration event (e.g. removal of trash, closing of artificial entrances, removal of pollutants).	(1) Years to decades (2) Days to years	Local to regional scale. Years.	(1) Manenti <i>et al.</i> (2019) (2) Tobin & Chambers (2017)
Reintroduction	(1) Monitor long-term survival of organisms after reintroduction. (2) Monitor reproduction events among the introduced individuals.	(1) Years to decades (2) One to several generations	Local scale. Years to centuries.	(1) Zhang <i>et al.</i> (2016) (2) Skalski & Word (1994)
Risk assessment	(1) Compare long-term conservation status of species that have been assessed or not against IUCN (or other local) criteria. (2) Test effectiveness of thresholds using physiological experiments. (3) Check if the response of a proposed indicator species for a given threat correlates with the response of other, non/indicator species, within the same community.	(1) Instantaneous to decades, depending on when the assessments were first performed (2, 3) Days to months	Local to regional scale. Years to decades.	(1) Betts <i>et al.</i> (2020) (2) Di Lorenzo <i>et al.</i> (2019); Pallarés <i>et al.</i> (2020b) (3) Korbel & Hose (2017); Strona <i>et al.</i> (2019); Di Lorenzo <i>et al.</i> (2020); Fattorini <i>et al.</i> (2020)
Prioritisation	(1) Compare the fraction of subterranean biodiversity captured by different prioritisation plans to identify the most optimal strategy. (2) Use optimisation algorithms to resolve/simulate different prioritisation scenarios.	(1, 2) Instantaneous	Regional scale. Years to decades.	(1) Abellán <i>et al.</i> (2005); Phelps <i>et al.</i> (2016); Rabelo, Souza-Silva & Ferreira (2018); Tanalgo & Hughes (2019); Linke <i>et al.</i> (2019) (2) Cardoso, Ferreira & Souza-Silva (2021)
Education	(1) Use questionnaires to evaluate public attitudes towards subterranean life in different countries/regions with different educational programs (e.g. guided tours, educational materials/panels) on caves and karst. (2) Use questionnaires to evaluate students' attitudes toward subterranean life before/after being exposed to an educational program.	(1) Instantaneous (2) Days	Local to regional scale. Decades to centuries.	(1) Lopez-Maldonado & Berkes (2017) (1, 2) Ardoin, Bowers & Gaillard (2020)
Monitoring	(1) Estimate detection probability achieved by different monitoring methods and/or indices. (2) Identify trigger points to activate management intervention commensurate with the observed population/habitat change. (3) Test performance and ability to detect change of different monitoring technologies and/or protocols.	(1, 3) Instantaneous to years (2) Years to decades	Local scale. Years to decades.	(1) Mouser <i>et al.</i> (2021) (3) Moldovan & Levei (2015) Trevelin <i>et al.</i> (2021) (2, 3) Lindenmayer, Piggott & Wintle (2013)

et al., 2009; Pellegrini *et al.*, 2016; Korbel *et al.*, 2017; Mouser *et al.*, 2021; Trevelin *et al.*, 2021). Given that monitoring is applied to test the effectiveness of most other conservation interventions (Table 3), we need to ensure that the performance of monitoring technologies and the reliability of monitoring protocols are comprehensively tested.

(4) Protection

While protection (protected areas or *ex-situ* conservation; Fig. 1B) was frequently recommended as a conservation intervention, virtually no studies tested its effectiveness (Fig. 2E). Currently, only 6.9% of known subterranean ecosystems overlap with protected areas globally (Sánchez-Fernández *et al.*, 2021). Importantly, most of these subterranean sites are protected simply because they occur within a protected area established for surface species or ecosystems. Given that surface-focused protected areas are rarely designed to account for the vertical dimension of subterranean ecosystems (Linke *et al.*, 2019; Sánchez-Fernández *et al.*, 2021), including soils (Guerra *et al.*, 2020), it is important to understand and test the extent to which protected areas on the surface benefit the ecosystems underneath (Canedoli *et al.*, 2022).

A special case of protection is *ex-situ* conservation, that is the conservation of species outside their natural habitat. Off-site conservation is still in its infancy in subterranean biology. According to our literature survey, the only existing *ex-situ* breeding program is focused on the European olm, *Proteus anguinus* Laurenti (Amphibia: Proteidae). This emblematic subterranean salamander is often washed out of its groundwater habitats during flood events. The Tular Cave Laboratory (Kranj, Slovenia) has established an *ex-situ* breeding program for washed-out or injured olms. These individuals are rehabilitated and eventually reintroduced back to their natural habitats (Aljančič, Aljančič & Golob, 2016). One important issue associated with *ex-situ* conservation and reintroduction is that breeding should be sustainable. The health and well-being of animals kept in captivity is of vital importance both for rearing and to prevent reintroduced animals from becoming vectors of pathogens to wild populations. In the case of the European olm, there are diagnostic tools to monitor haematological parameters of animals in captivity (Gredar, Prša & Bizjak Mali, 2018) and protocols have been developed to treat symptomatic individuals (Lukač, Cizelj & Mutschmann, 2019).

(5) Regulation

Regulation encompasses all activities that aim to manage access to subterranean ecosystems and resources. These include legislation, limiting the number of visitors or seasonal closures, gating of cave entrances, and other such measures (Fig. 1B). Despite the fact that legislative actions for subterranean environments have been taken at both national and international levels (Niemiller, Taylor & Bichuette, 2018), their effectiveness in terms of implementation and enforcement has not been rigorously evaluated. Whereas at the

regional and national levels many subterranean organisms enjoy protection under endangered species designation, most international legislation and multilateral agreements overlook or only allude to subterranean environments (Wynne *et al.*, 2021). Policies for groundwater protection, for instance, have been implemented to protect effectively and use sustainably this resource at regional levels; however, explicit language on groundwater ecosystems is still needed to ensure such sustainability (Elshall *et al.*, 2020). To our knowledge, the only multilateral agreement that explicitly considers subterranean habitats and species is the European Union's Habitats Directive (92/43/EEC); however, only a few specialised subterranean species are listed in its appendices, with *Congeria kusceri* (Bole) (Mollusca: Bivalvia), *Leptodirus hochenwartii* Schmidt (Coleoptera: Leiodidae), and *Proteus anguinus* being the most notable examples.

Of the regulation interventions identified in this review, gating of cave entrances was the most tested. These steel structures are often erected to protect cave resources by preventing human access while allowing air, water, and wildlife to pass in and out freely. However, testing the effectiveness of gating has primarily focused on the effects of the gate and its structure on the presence, abundance, and behaviour of bats and has yielded mixed results (Tobin & Chambers, 2017). Only a handful of studies tested for effects of cave gating on other ecosystem components, such as microclimate (e.g. King, 2005; Martin *et al.*, 2006), and no studies have examined effects on the abundance and/or behaviour of organisms other than bats.

Regulating human access concerns interventions to mitigate the effects of all human visitors – primarily tourists, but also recreational cavers, divers, and scientists – on cave ecosystems. Understanding the impacts of regulating access could be accomplished in most situations, however only 43% of such studies tested the effectiveness of this regulatory intervention. Most of these tests were conducted in show caves because these sites allow ideal experimental designs due to the presence of a 'tourist' section of the cave, and more pristine areas not accessible to visitors that can be used as a control.

(6) Restoration

Restoration of subterranean ecosystems comprises all interventions aimed at improving and/or recovering species and ecosystems due to human-induced perturbations. These encompass habitat restoration, eradication of alien species, decontamination, reintroduction of species, and the creation of artificial habitats. There were only scattered examples of such interventions in our database, with about 14% of studies testing for effectiveness (Fig. 2E). Encouragingly, the frequency of restoration interventions has been increasing in recent years (Fig. 4C), broadly aligning with the Aichi Convention on Biological Diversity Target 15 of restoring at least 15% of degraded ecosystems by 2020.

Given that restoration is perhaps the most direct intervention, with potentially the greatest impact but generally also

the most expensive, such interventions should be carefully planned, tested, and monitored. As pre-intervention pilot studies are typically performed either in the laboratory (Gabriel *et al.*, 2018; Barton, 2020) or through modelling/simulation exercises, translation of their findings into practical management actions is not always straightforward. Post-intervention monitoring should include the target species and other components of the ecosystem (including temperature, relative humidity, and nutrient inputs), other relevant taxa (e.g. predators, prey and competitors), and the geological integrity of the site (Meierhofer *et al.*, 2022). The few studies that quantified the effectiveness of restoration were focused solely on the target species of the intervention, disregarding the subterranean community as a whole. For example, studies examining the impact of *Pseudogymnascus destructans* (the fungus that causes white-nose syndrome) only looked at bat species recovery post-intervention (Hoyt *et al.*, 2019; Turner *et al.*, 2021). Additionally, mitigation strategies for lampenflora (i.e. autotrophic organisms proliferating in the proximity of artificial light sources in show caves) rarely examined feedback effects on other biotic components (Meyer *et al.*, 2017; Pfendler *et al.*, 2018). It is possible that the creation of suitable conditions for target species may lead to the decline of populations of other taxa, as different species have disparate habitat requirements (Meierhofer *et al.*, 2022). Furthermore, efforts to manage or protect biodiversity can negatively affect other resources, including damaging sensitive areas that contain archaeological, palaeontological, or geological resources.

V. FUTURE DIRECTIONS

Despite the combined effects of multiple anthropogenic stressors threatening subterranean species and ecosystems throughout the world (Mammola *et al.*, 2019a; Li *et al.*, 2020; Cardoso *et al.*, 2020b; Jasechko & Perrone, 2021), there are reasons for optimism. 2021 was nominated the International Year of Caves and Karst (<http://iyck2021.org/>; later extended to 2022), to promote collective global efforts to raise awareness on subterranean ecosystems, the ecosystem services they provide, and their unique conservation challenges (Veni, 2021). Indeed, we saw several calls for action, often published in general and high-impact journals (e.g. Gladstone *et al.*, 2021; Raghavan, Britz & Dahanukar, 2021; Sánchez-Fernández *et al.*, 2021; Wynne *et al.*, 2021; Oliveira *et al.*, 2022). The International Year of Caves and Karst is thus a perfect milestone to pause and reflect on the current status of protection of subterranean ecosystems, confronting an important question: how can we make conservation efforts in subterranean biology more practical, effective, and long-lasting? Although there is no simple answer, we believe that key points include better focusing of our intellectual and funding investments by strategically identifying conservation objectives (Buxton *et al.*, 2021), implementing robust study designs and increasing statistical testing (Christie *et al.*, 2020), building upon current knowledge

(Sutherland *et al.*, 2020), and emphasising positive achievements (Balmford, 2017; Akçakaya *et al.*, 2018). Here, we have built upon the current literature to provide practical recommendations to test the effectiveness of conservation interventions in subterranean ecosystems (Table 3). We view this as a starting point from which we can shift the current negative trajectory (inset in Fig. 4A), going forth with brighter lights into the darkness. Seven important points emerged from this synthesis to guide decision-makers and researchers towards evidence-based conservation of subterranean ecosystems.

(a) Do not reinvent the wheel

Modern conservation science emphasises the importance of grounding conservation practice with evidence (e.g. the Conservation Evidence database). Likewise, researchers in the field of subterranean biology should be aware of advances in conservation science not necessarily focused on subterranean ecosystems, to identify solutions and generate new ideas for subterranean issues. Under this paradigm, high-quality literature synthesis will be key to avoid repeating studies on what is already known and, most importantly, will allow us to learn from past experiences to improve current and future practice (McMahan & McFarland, 2021). We view the database associated with this publication as a baseline for building a centralised and curated corpus of literature on the effectiveness of conservation interventions for subterranean ecosystems. Further development of this database could follow the framework recently implemented by Conservation Evidence (Sutherland *et al.*, 2019), whereby information is presented according to an effectiveness score for the intervention, the certainty of the evidence underlying it, and a quantification of potential harmful effects.

(b) Be meticulous with study design and reporting of statistics

The application of robust study designs for testing conservation interventions is sparse, even for well-studied taxa like birds and amphibians (Christie *et al.*, 2020). Designing rigorous studies both to test conservation interventions effectively, and to allow thorough reporting of the findings is critically important in subterranean biology – a field in a constant shortage of both personnel and financial resources to conduct robust conservation studies and monitoring projects. An appropriate study design is a key factor determining the strength of the evidence resulting from applied conservation research (Salafsky *et al.*, 2019). For example, non-experimental (i.e. correlational) studies produce evidence that is less robust than quasi-experimental (control–impact, or before–after control–impact) and experimental designs (randomised controlled trial). Equally important, we found that the metrics used by studies to measure effectiveness included a multitude of different variables, corroborating previous conclusions (Christie *et al.*, 2020). Furthermore, the paucity of quantitative studies and the often-incomplete presentation of their results (Table 1) illustrates the need for more thorough reporting (Cichoń, 2020). Correctly reporting statistical methods, model parameters, sample sizes, and outcomes

provides a foundation for other scientists to benefit from the testing of conservation interventions (e.g. using meta-analysis; Gerstner *et al.*, 2017), while ensuring reproducibility.

(c) *Embrace ignorance*

A lack of detailed information on subterranean biota should not stall practical conservation activities (Wilson *et al.*, 2007). As for epidemiology or medicine, conservation science is a ‘crisis discipline’ (Soulé, 1985; Kareiva & Marvier, 2012), often requiring us to make decisions without having all of the information (Cook, Hockings & Carter, 2010). A solid body of literature on tested actions (Sutherland *et al.*, 2019, 2020), complemented with expert opinion (Branco & Cardoso, 2020; Miličić *et al.*, 2021), will often be the best information available to make informed decisions about the most effective conservation intervention(s) for a given subterranean species, community, or ecosystem.

(d) *Look beyond your backyard*

We tend to view subterranean ecosystems as isolated systems. In reality, their ecology is highly dependent upon the surface, soil, and/or open-water ecosystems with which they interact (Culver & Pipan, 2014, 2019; Fišer, Pipan & Culver, 2014; Mammola, 2019). In Europe, for example, the effects of contaminated groundwater on groundwater-dependent surface ecosystems were acknowledged and incorporated into the groundwater directive (2006/118/EC). This currently unidirectional view could be elaborated upon with complementary actions to monitor how anthropogenic disturbances on the surface affect subterranean ecosystems. Specifically, it has been shown that laws that subdivide an interconnected resource can often have negative long-term implications that linger long after policy makers begin dismantling the artificial divide (Montesino Pouzols *et al.*, 2014; Arrondo *et al.*, 2018; Owen *et al.*, 2019a). Ideally, then, the best way to promote effective conservation of subterranean environments in a holistic manner is to establish dialogue with surface conservation practitioners, and to use what is known and available (Mammola *et al.*, 2019a; Wynne *et al.*, 2021). This will entail benefiting from conservation strategies and international agreements focused on habitats interconnected with subterranean environments, such as soils (Guerra *et al.*, 2021), karst mountain systems (e.g. GEO Mountains – Mountain Research Initiative), and various groundwater-dependent ecosystems (Cantonati *et al.*, 2020b).

(e) *Focus on the gaps*

Conservation interventions appear unevenly distributed across biogeographic regions, taxa, systems, and threats (Fig. 2). Such biases are not unique to the subterranean conservation literature (Troudet *et al.*, 2017; Christie *et al.*, 2020). Further efforts are needed to examine neglected regions properly (Wynne *et al.*, 2021), especially in the Afrotropical, Neotropical, and Indomalayan regions, to fill significant

information gaps [see Asase *et al.*, 2021 for suggestions]. Taxa such as microbes and viruses play a critical role in the functioning of subterranean ecosystems (Griebler & Lueders, 2009; Griebler, Malard & Lefebure, 2014; Sánchez-Fernández *et al.*, 2021), and yet they are poorly studied. Furthermore, fissure systems, marine caves, and anchialine systems remain particularly unexplored and under-protected (Mammola *et al.*, 2016; Gerovasileiou & Bianchi, 2021). Finally, emerging global threats such as climate change require redoubled efforts to predict and prevent negative consequences to the subterranean environment (Mammola *et al.*, 2019b).

(f) *Be aware of constraints*

While there is an ideal goal of protecting all species and ecosystems, we are working in a deficit of funding, time, and personnel. There will be occasions when the cost of management and the likelihood of achieving conservation goals does not compare favourably with management expenditures allocated for subterranean ecosystems. Therefore, we must define conservation priorities clearly and prioritise efforts to those interventions whose cost-effectiveness has been tested and supported quantitatively.

(g) *Dialogue with decision-makers and stakeholders*

Protection is only effective when moving from the scientific to the societal and political arenas (Balmford *et al.*, 2021; Kadykalo *et al.*, 2021). Engaging with the public, non-governmental organisations, government conservation and environmental protection agencies, and other decision-makers is necessary but often overlooked by academics (Knight *et al.*, 2008; Arlettaz *et al.*, 2010). Furthermore, conservation recommendations that appear in the most prestigious journals often do not reach their intended targets (the decision makers). This entails establishing a dialogue with regional, national, and international initiatives, or organisations such as the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services and the IUCN. Scientists should strive to foster local initiatives for the development of conservation or recovery plans with relevant authorities, even if it requires stepping down from the academic ivory tower (Arlettaz *et al.*, 2010). Only in this way will we ensure that the visibility of the surface environments does not lead to conservation programs that fail to recognise both the scientific importance and ecosystem services provided by subterranean ecosystems.

VI. CONCLUSIONS

- (1) Subterranean ecosystems are some of the most understudied ecosystems on Earth, and contain a high diversity of specialised organisms accounting for a unique fraction of the global taxonomic, phylogenetic, and

functional diversity. This biodiversity is exposed to escalating anthropogenic threats. A scientifically informed protection of subterranean biodiversity is thus a matter of the highest importance.

- (2) We provide the first quantitative global assessment on subterranean ecosystem conservation, by synthesising 708 publications (1964–2021) that discussed, recommended, or implemented 1,945 conservation interventions.
- (3) We documented a consistent increase in the number of studies from the 2000s; yet, the proportion of studies quantifying the impact of conservation interventions has significantly decreased in the last 20 years. Overall, the effectiveness of 31% of conservation interventions was tested statistically, although this proportion varied substantially by type of intervention, taxon, and subterranean system.
- (4) There were important trends in the data that can guide future research. Most studied threats were pollution, disturbance due to tourism, and habitat change, whereas limited research was devoted to understanding climate change effects, alien species, pathogens, and overexploitation. Assessments of the effectiveness of conservation interventions were heavily biased towards indirect measures (monitoring and risk assessment), a limited sample of organisms (mostly arthropods and bats), more accessible systems (terrestrial caves), and temperate regions (Europe and North America).
- (5) We provide practical suggestions for developing study designs able to test quantitatively the effectiveness of conservation interventions in subterranean ecosystems (Table 3). Our recommendations mostly build upon current literature on subterranean ecosystems, but we also draw upon ideas from research carried out on the surface.
- (6) Our synthesis establishes baseline data that can be expanded in the future, enabling, for example, the ability to perform meta-analyses aimed at quantifying the effectiveness of conservation interventions. This will help generate quantitative knowledge about interventions likely to yield the greatest impacts depending upon the subterranean species and habitats of interest.

VII. ACKNOWLEDGEMENTS

Special thanks are due to Irene Frigo for preparing the silhouettes. We are grateful to two anonymous referees for excellent suggestions and to Dr Alison Cooper for carefully editing our text. This study is funded by the European Commission *via* the Marie Skłodowska-Curie Individual Fellowships program (H2020-MSCA-IF-2019; project number 882221), awarded to S.M. Additional support is provided by the PRIN SHOWCAVE “A multidisciplinary research project to study, classify and mitigate the environmental impact in tourist caves” (project number 2017HTXT2R; funded by the Italian Ministry of Education, University and Research). M.B.M. acknowledges support from

the Kone Foundation (project number 202007611). T.D., C.F., V.Z., and M.Z. were supported by the Slovenian Research Agency, through core programme P1-0184 and P6-0119. O.T.M. was supported by a grant of the Romanian Ministry of Research, Innovation and Digitization, CNCS/CCCDI—UEFISCDI, project number 2/2019 (DARKFOOD), within PNCDI III. S.I.S. acknowledges funding by MEMOBIC (EU Operational Programme Research, Development and Education No. CZ.02.2.69/0.0/ 0.0/16_027/0008357), and by the Ministry of Education, Youth and Sports of the Czech Republic (grant number CZ.02.1.01/0.0/0.0/16_025/0007417). E.P. is supported by the PON “Research and Innovation” Programme (Axis IV “Education and Research for recovery” – Action IV.6 “Research contracts on Green themes”).

VIII. AUTHOR CONTRIBUTIONS

S.M. conceived the idea. S.M., M.B.M., and P.C. designed the methodology. All authors (except for A.S., L.D., and M.I.) extracted data from the literature. S.M. and M.B.M. analysed data and wrote the first draft. S.M. prepared the figures. All authors contributed to the writing with suggestions and critical comments.

IX. DATA ACCESSIBILITY

The curated literature database supporting this study is available in Zenodo (doi: 10.5281/zenodo.6088818). R code to reproduce the analyses is also available on GitHub (https://github.com/StefanoMammola/Analysis_Practical-Subterranean-Conservation.git).

X. REFERENCES

- References used in the analysis are identified with an asterisk (*). *AALBU, R. L. & ANDREWS, F. G. (1992). Revision of the spider beetle genus *Niptus* in North America, including new cave and phloecophile species (Coleoptera: Ptinidae). *Pan-Pacific Entomologist* **68**, 73–96.
- ABELLÁN, P., SÁNCHEZ-FERNÁNDEZ, D., VELASCO, J. & MILLÁN, A. (2005). Conservation of freshwater biodiversity: a comparison of different area selection methods. *Biodiversity and Conservation* **14**, 3457–3474.
- *AGHURRA, A. & RODRIGUEZ, P. (2008). Biodiversity of groundwater oligochaetes from a karst unit in northern Iberian Peninsula: ranking subterranean sites for conservation management. *Hydrobiologia* **605**, 159–171.
- *ACOSTA, L. E. (2019). A relictual troglomorphic harvestman discovered in a volcanic cave of western Argentina: *Otilioleptes marcelae*, new genus, new species, and Otilioleptidae, new family (Arachnida, Opiliones, Gonyleptoidea). *PLoS One* **14**, e0223828.
- ADAMO, M., CHIHALVA, M., CALEVO, J., BERTONI, F., DIXON, K. & MAMMOLA, S. (2021). Plant scientists’ research attention is skewed towards colourful, conspicuous and broadly distributed flowers. *Nature Plants* **7**, 574–578.
- *AGOSTA, S. J. (2002). Habitat use, diet and roost selection by the big brown bat (*Eptesicus fuscus*) in North America: a case for conserving an abundant species. *Mammal Review* **32**, 179–198.
- *AIELLO, D., BASSO, A., SPENA, M. T., D’AGOSTINO, G., MONTEODORO, U., GALIZIA, M., GRASSO, R. & SANTAGATI, C. (2019). The virtual Batcave: a project for the safeguard of a Unesco WHL fragile ecosystem. *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences* **42**, 17–24.
- AKÇAKAYA, H. R., BENNETT, E. L., BROOKS, T. M., GRACE, M. K., HEATH, A., HEDGES, S., HILTON-TAYLOR, C., HOFFMANN, M., KEITH, D. A., LONG, B.,

- MALLON, D. P., MEIJAARD, E., MILNER-GULLAND, E. J., RODRIGUES, A. S. L., RODRIGUEZ, J. P., et al. (2018). Quantifying species recovery and conservation success to develop an IUCN Green list of species. *Conservation Biology* **32**, 1128–1138.
- *ALJANČIĆ, G., ALJANČIĆ, M. & GOLOB, Z. (2016). Salvaging the washed-out *Proteus*. *Natura Sloveniae* **18**, 65–66.
- *ALTHEER, R., BONGNI, N., BORKO, Š., FIŠER, C. & ALTERMATT, F. (2021). Citizen science approach reveals groundwater fauna in Switzerland and a new species of *Niphargus* (Amphipoda, Niphargidae). *Subterranean Biology* **25**, 1–31.
- *ALVARENGA, P., MOURINHA, C., FARTO, M., PALMA, P., SENGO, J., MORAIS, M. C. & CUNHA-QUEDA, C. (2016). Ecotoxicological assessment of the potential impact on soil porewater, surface and groundwater from the use of organic wastes as soil amendments. *Ecotoxicology and Environmental Safety* **126**, 102–110.
- *ALONGI, G., CORMACI, M., FURNARI, G. & CATRA, M. (2012). Floristic macroalgal diversity in selected submarine caves located within two marine protected areas off Lampedusa Island and Sicily (Italy). *Botanica Marina* **55**, 387–397.
- *ANDERSON, A. P., LIGHT, J. E., TAKANO, O. M. & MORRISON, M. L. (2018). Population structure of the Townsend's big-eared bat (*Corynorhinus townsendii townsendii*) in California. *Journal of Mammalogy* **99**, 646–658.
- *ANDO, K. (2019). The study of amphipods in rimstone pools of Akiyoshi-do cave, Japan. *Subterranean Biology* **32**, 81.
- *APE, F., ARIGO, C., GRISTINA, M., GENOVESE, L., DI FRANCO, A., DI LORENZO, M., BALATA, P., AGLIERI, G., MILISENDA, G. & MIRTO, S. (2016). Meiofaunal diversity and nematode assemblages in two submarine caves of a mediterranean marine protected area. *Mediterranean Marine Science* **17**, 202–215.
- ARDOIN, N. M., BOWERS, A. W. & GAILLARD, E. (2020). Environmental education outcomes for conservation: a systematic review. *Biological Conservation* **241**, 108224.
- *ARITA, H. T. (1993). Conservation biology of the cave bats of Mexico. *Journal of Mammalogy* **74**, 693–702.
- *ARITA, H. T. (1996). The conservation of cave-roosting bats in Yucatan, Mexico. *Biological Conservation* **76**, 177–185.
- *ARITA, H. T. & VARGAS, J. A. (1995). Natural history, interspecific association, and incidence of the cave bats of Yucatan, Mexico. *The Southwestern Naturalist* **40**, 29–37.
- ARLETTAZ, R., SCHAUB, M., FOURNIER, J., REICHLIN, T. S., SIERRA, A., WATSON, J. E. M. & BRAUNISCH, V. (2010). From publications to public actions: when conservation biologists bridge the gap between research and implementation. *Bioscience* **60**, 835–842.
- *ARMAS, L. D., DÍAZ, R. B. & BARRERO, A. A. (2017). Redescription of the monotypic genus *Cubacanthozomus* (Schizomida: Hubbardiidae) and conservation status of its type-species. *Zootaxa* **4323**, 534–546.
- *ARMSTRONG, K. (2011). The current status of bats in Western Australia. In *The Biology and Conservation of Australasian Bats* (eds B. LAW, P. EBY, D. LUNNEY and L. LUMSDEN), pp. 257–269. Royal Zoological Society of New South Wales, Sydney.
- ARNETH, A., SHIN, Y.-J., LEADLEY, P., RONDININI, C., BUKVAREVA, E., KOLB, M., MIDDLEY, G. F., OBERDORFF, T., PALOMO, I. & SAITO, O. (2020). Post-2020 biodiversity targets need to embrace climate change. *Proceedings of the National Academy of Sciences* **117**, 30882–30891.
- ARRONDO, E., MOLEÓN, M., CORTÉS-AVIZANDA, A., JIMÉNEZ, J., BEJA, P., SÁNCHEZ-ZAPATA, J. A. & DONÁZAR, J. A. (2018). Invisible barriers: differential sanitary regulations constrain vulture movements across country borders. *Biological Conservation* **219**, 46–52.
- ASASE, A., MZUMARA-GAWA, T. I., OWINO, J. O., PETERSON, A. T. & SAUPE, E. (2021). Replacing “parachute science” with “global science” in ecology and conservation biology. *Conservation Science and Practice* **4**, e517.
- *ASMYYR, M. G., LINKE, S., HOSE, G. & NIPPERESS, D. A. (2014). Systematic conservation planning for groundwater ecosystems using phylogenetic diversity. *PLoS One* **9**, e115132.
- *AUGUSTEYN, J., HUGHES, J., ARMSTRONG, G., REAL, K. & PACIONI, C. (2017). Tracking and tracing Central Queensland's macroderma—determining the size of the Mount Etma ghost bat population and potential threats. *Australian Mammalogy* **40**, 243–253.
- *AUL, B., BATES, P. J. J., HARRISON, D. L. & MARIMUTHU, G. (2014). Diversity, distribution and status of bats on the Andaman and Nicobar Islands, India. *Oryx* **48**, 204–212.
- *AULER, A. S., SOUZA, T. A., SÉ, D. C. & SOARES, G. A. (2018). A review and statistical assessment of the criteria for determining cave significance. *Geological Society, London, Special Publications* **466**, 443–459.
- *AVRAMOV, M., SCHMIDT, S. I. & GRIEBLER, C. (2013). A new bioassay for the ecotoxicological testing of VOCs on groundwater invertebrates and the effects of toluene on *Niphargus inopinatus*. *Aquatic Toxicology* **130**, 1–8.
- *BAGHERI, M., GOUDARZI, F., ZALAGHI, A. H. & SAVABIEASFHANI, M. (2016). Habitat characteristics and population size of *Iranocypris typhlops*, the Iran cave barb. *Environmental Biology of Fishes* **99**, 179–185.
- *BAKER, G. M. (2015). Quantifying wildlife use of cave entrances using remote camera traps. *Journal of Cave and Karst Studies* **77**, 200–210.
- *BAKRAN-PETRICIOLI, T. & PETRICIOLI, D. (2008). Habitats in submerged karst of eastern Adriatic coast—Croatian natural heritage. *Croatian Medical Journal* **49**, 455–458.
- *BALÁZS, G., VÖRÖS, J., LEWARNE, B. & HERCZEG, G. (2020). A new non-invasive in situ underwater DNA sampling method for estimating genetic diversity. *Evolutionary Ecology* **34**, 633–644.
- BALMFORD, A. (2017). On positive shifting baselines and the importance of optimism. *Oryx* **51**, 191–192.
- BALMFORD, A., BRADBURY, R. B., BAUER, J. M., BROAD, S., BURGESS, G., BURGMAN, M., BYERLY, H., CLAYTON, S., ESPELOSIN, D., FERRARO, P. J., FISHER, B., GARNETT, E. E., JONES, J. P. G., MARTEAU, T. M., OTTIENO, M., et al. (2021). Making more effective use of human behavioural science in conservation interventions. *Biological Conservation* **261**, 109256.
- *BAMBINI, L., KOFOKY, A., MBOHOAHY, T., RALISATA, M., MANJOAZY, T., HOSKEN, D. J. & JENKINS, R. K. (2010). Do bats need trees? Habitat use of two Malagasy hipposiderid bats *Trienops furculus* and *T. menamena* in the dry southwest. *Hystrix, The Italian Journal of Mammalogy* **22**, 81–92.
- *BÁNCLÁ, R. I., PRADEL, R., CHOQUET, R., PLĂIAȘU, R. & GIMENEZ, O. (2018). Using temporary emigration to inform movement behaviour of cave-dwelling invertebrates: a case study of a cave harvestman species. *Ecological Entomology* **43**, 551–559.
- *BARLAS, E. & YAMAÇ, E. (2019). Cave dwelling bat species and their cave preferences in northwest of Central Anatolia. *Pakistan Journal of Zoology* **51**, 2141.
- *BARNES, J. K., SLAY, M. E. & TAYLOR, S. J. (2009). Adult Diptera from Ozark caves. *Proceedings of the Entomological Society of Washington* **111**, 335–353.
- *BARR, T. C. (1976). *Ecological Effects of Water Pollutants in Mammoth Cave: Final Technical Report to the National Park Service*. University of Kentucky, Lexington.
- *BARROS, J. D. S., BERNARD, E. & FERREIRA, R. L. (2020). Ecological preferences of neotropical cave bats in roost site selection and their implications for conservation. *Basic and Applied Ecology* **45**, 31–41.
- *BARROS, J. D. S., BERNARD, E. & FERREIRA, R. L. (2021). An exceptionally high bat species richness in a cave conservation hotspot in Central Brazil. *Acta Chiropterologica* **23**, 233–245.
- *BARTON, H. A. (2020). Safe and effective disinfection of show cave infrastructure in a time of COVID-19. *International Journal of Speleology* **49**, 137–147.
- *BAUDINETTE, R. V., WELLS, R. T., SANDERSON, K. J. & CLARK, B. (1994). Microclimatic conditions in maternity caves of the bent-wing bat, *Miniopterus schreibersii*: an attempted restoration of a former maternity site. *Wildlife Research* **21**, 607–619.
- *BEDEK, J., GOTTSTEIN, S. & TAFTI, S. (2019). A new species of *Alpioniscus* (*Illyronethes*) from the Dinaric karst (isopoda, Oniscidea, Trichoniscidae). *Subterranean Biology* **32**, 33–42.
- *BENTO, D. M., SOUZA-SILVA, M., VASCONCELOS, A., BELLINI, B. C., PROUS, X. & FERREIRA, R. L. (2021). Subterranean “oasis” in the Brazilian semiarid region: neglected sources of biodiversity. *Biodiversity and Conservation* **30**, 3837–3857.
- *BERCEA, S., NĂSTASE-BUCUR, R., MIREA, I. C., MĂNTOIU, D. S., KENESZ, M., PETCULESCU, A., BARICZ, A., ANDREI, A. S., BANCUI, H. L., PAPP, B. & CONSTANTIN, S. (2018). Novel approach to microbiological air monitoring in show caves. *Aerobiologia* **34**, 445–468.
- *BERCEA, S., NĂSTASE-BUCUR, R., MOLDOVAN, O. T., KENESZ, M. & CONSTANTIN, S. (2019). Yearly microbial cycle of human exposed surfaces in show caves. *Subterranean Biology* **31**, 1–14.
- BERGSTROM, D. M., LUCIEER, A., KIEFER, K., WASLEY, J., BELBIN, L., PEDERSEN, T. K. & CHOWN, S. L. (2009). Indirect effects of invasive species removal devastate world Heritage Island. *Journal of Applied Ecology* **46**, 73–81.
- *BERNARD, R. F., EVANS, J., FULLER, N. W., REICHAARD, J. D., COLEMAN, J. T., KOECER, C. J. & CAMPBELL GRANT, E. H. (2019). Different management strategies are optimal for combating disease in East Texas cave versus culvert hibernating bat populations. *Conservation Science and Practice* **1**, e106.
- *BERNARD, E. C., SOTO-ADAMES, F. N. & WYNNE, J. J. (2015). Collembola of Rapa Nui (Easter Island) with descriptions of five endemic cave-restricted species. *Zootaxa* **3949**, 239–267.
- BERTHINUSSEN, A., RICHARDSON, O. C. & ALTRINGHAM, J. D. (2021). *Bat Conservation: Global Evidence for the Effects of Interventions*. University of Cambridge, Cambridge.
- *BETTS, B. J. (1997). Microclimate in Hell's canyon mines used by maternity colonies of *Myotis yumanensis*. *Journal of Mammalogy* **78**, 1240–1250.
- BETTS, J., YOUNG, R. P., HILTON-TAYLOR, C., HOFFMANN, M., RODRÍGUEZ, J. P., STUART, S. N. & MILNER-GULLAND, E. J. (2020). A framework for evaluating the impact of the IUCN red list of threatened species. *Conservation Biology* **34**, 632–643.
- *BEUNEUX, G. (2004). Morphometrics and ecology of *Myotis cf. punicus* (Chiroptera, Vespertilionidae) in Corsica. *Mammalia* **68**, 269–273.
- *BEYNEIN, P. E. V. & BEYNEIN, K. M. V. (2011). Human disturbance of karst environments. In *Karst management* (ed. P. E. VAN BEYNEIN), pp. 379–397. Springer, Dordrecht.
- *BICHUETTE, M. E., CAVALLARI, D. C., SALVADOR, R. S., SANTOS, F. & CUNHA, C. M. (2021). Brazilian troglotic snails begin to emerge—and are already in danger. *Tentacle* **29**, 32–34.
- *BICHUETTE, M. E., GIMENEZ, E. A., ARNONE, I. S. & TRAJANO, E. (2018). An important site for conservation of bats in Brazil: Passa Três cave, São Domingos karst area, with an updated checklist for Distrito Federal (DF) and Goiás state. *Subterranean Biology* **28**, 39.

- *BICHUETTE, M. E. & RIZZATO, P. P. (2012). A new species of cave catfish from Brazil, *Trichomycterus rubbioli* sp. n., from Serra do Ramalho karstic area, São Francisco River basin, Bahia state (Siluriformes: Trichomycteridae). *Zootaxa* **3480**, 48–66.
- *BICHUETTE, M. E., SIMÕES, L. B., ZEPON, T., SCHIMONSKY, D. M. & GALLÃO, J. E. (2019). Richness and taxonomic distinctness of cave invertebrates from the northeastern state of Goiás, Central Brazil: a vulnerable and singular area. *Subterranean Biology* **29**, 1–33.
- *BICHUETTE, M. E. & TRAJANO, E. (2015). Population density and habitat of an endangered cave fish *Eigenmannia vicentespelaea* Triques, 1996 (Ostariophysi: Gymnotiformes) from a karst area in Central Brazil. *Neotropical Ichthyology* **13**, 113–122.
- *BILGIN, İ. R. (2012). The conservation genetics of three cave-dwelling bat species in southeastern Europe and Anatolia. *Turkish Journal of Zoology* **36**, 275–282.
- *BISWAS, S. & BANAFAR, A. S. (2017). Bildwar Gufa: a derelict cave on the way of natural rehabilitation Centre for microchiropteran (bats). *Ambient Science* **4**, 42–43.
- BLEHERT, D. S., HICKS, A. C., BEHR, M., METEYER, C. U., BERLOWSKI-ZIER, B. M., BUCKLES, E. L., COLEMAN, J. T. H., DARLING, S. R., GARGAS, A., NIVER, R., OKONIEWSKI, J. C., RUDD, R. J. & STONE, W. B. (2009). Bat white-nose syndrome: an emerging fungal pathogen? *Science* **323**, 227.
- *BOCKMANN, F. A. & CASTRO, R. (2010). The blind catfish from the caves of Chapada Diamantina, Bahia, Brazil (Siluriformes: Heptapteridae): description, anatomy, phylogenetic relationships, natural history, and biogeography. *Neotropical Ichthyology* **8**, 673–706.
- *BOGAN, M. A. (2000). Western bats and mining. In Proceedings of Bat Conservation and Mining: A Technical Interactive Forum Held November, pp. 14–16. Airport Hilton, St. Louis, Missouri. U.S. Department of the Interior, Office of Surface Mining, and Coal Research Center, Southern Illinois University, Carbondale, IL.
- *BORGES, P. A. V., CARDOSO, P., AMORIM, I. R., PEREIRA, F., CONSTÂNCIA, J. P., NUNES, J. C., BARCELOS, P., COSTA, P., GABRIEL, R. & DAPKEVICIUS, M. D. L. (2012). Volcanic caves: priorities for conserving the Azorean endemic troglobiont species. *International Journal of Speleology* **41**, 101–112.
- *BORGES, P. A. V., CRESPO, L. C. & CARDOSO, P. (2016). Species conservation profile of the cave spider *Turinyphia cavernicola* (Araneae, Linyphiidae) from Terceira Island, Azores, Portugal. *Biodiversity Data Journal* **4**, e10274.
- *BORGES, P. A. V., LAMELAS-LOPEZ, L., AMORIM, I. R., DANIELCZAK, A., BOIEIRO, M., REGO, C., WALLON, S., NUNES, R., CARDOSO, P. & HOCHKIRCH, A. (2019). Species conservation profiles of cave-dwelling arthropods from Azores, Portugal. *Biodiversity Data Journal* **24**, e32530.
- *BORGES, P. A., OROMI, P., SERRANO, A. R., AMORIM, I. R. & PEREIRA, F. (2007). Biodiversity patterns of cavernicolous ground-beetles and their conservation status in the Azores, with the description of a new species: *Trechus isabelae* n. sp. (Coleoptera: Carabidae: Trechinae). *Zootaxa* **1478**, 21–31.
- *BORCHARDT, D., BOSENIUS, U., DÖRR, R.-D., EWENS, H.-P., FRIEDL, C., IRMER, U., JEKEL, H., KEPNER, L., MO-HAUPT, V., NAUMANN, S., RECHENBERG, B., RECHENBERG, J., RICHTER, S. A., RICHTER, S., ROHRMOSER, R., et al. (2005). *Environmental Policy. Water Frame-Work Directive—Summary of River Basin District Analysis 2004 in Germany*. Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Berlin.
- *BORDERIE, F., ALAOU-SEHMER, L., BOUSTA, F., ALAOU-SOSSÉ, B. & ALEYA, L. (2014a). Cellular and molecular damage caused by high UV-C irradiation of the cave-harvested green alga *Chlorella minutissima*: implications for cave management. *International Biodeterioration & Biodegradation* **93**, 118–130.
- *BORDERIE, F., TÊTE, N., CAILHOL, D., ALAOU-SEHMER, L., BOUSTA, F., RIEFFEL, D., ALEYA, L. & ALAOU-SOSSÉ, B. (2014b). Factors driving epilithic algal colonization in show caves and new insights into combating biofilm development with UV-C treatments. *Science of the Total Environment* **484**, 43–52.
- *BORZĘCKA, J., PIECUCH, A., KOKUREWICZ, T., LAVOIE, K. H. & OGÓREK, R. (2021). Greater mouse-eared bats (*Myotis myotis*) hibernating in the Nietoperek bat Reserve (Poland) as a vector of airborne culturable fungi. *Biology* **10**, 593.
- *BOSNAK, A. D. & MORGAN, E. L. (1981a). Acute toxicity of cadmium, zinc, and total residual chlorine to epigeal and hypogean isopods (Asellidae). *The NSS Bulletin* **43**, 12–18.
- *BOSNAK, A. D. & MORGAN, E. L. (1981b). Comparison of acute toxicity for cd, Cr and cu between two distinct populations of aquatic hypogean isopods. *Proceedings of the 8th International Congress of Speleology* **1**, 72–74.
- *BOUGHROUS, A. A., YACOUBI KHEBIZA, M., BOULANOUAR, M., BOUTIN, C. & MESSANA, G. (2007). Groundwater quality in two arid areas of Morocco: impact of pollution on biodiversity and paleogeographic implications. *Environmental Technology* **28**, 1299–1315.
- *BOULTON, A. J. (2020). Conservation of groundwaters and their dependent ecosystems: integrating molecular taxonomy, systematic reserve planning and cultural values. *Aquatic Conservation: Marine and Freshwater Ecosystems* **30**, 1–7.
- *BOULTON, A. J., DATRY, T., KASAHARA, T., MUTZ, M. & STANFORD, J. A. (2010). Ecology and management of the hyporheic zone: stream–groundwater interactions of running waters and their floodplains. *Journal of the North American Benthological Society* **29**, 26–40.
- *BOULTON, A. J., HUMPHREYS, W. F. & EBERHARD, S. M. (2003). Imperilled subsurface waters in Australia: biodiversity, threatening processes and conservation. *Aquatic Ecosystem Health & Management* **6**, 41–54.
- *BOULTON, A. J., SCARSBROOK, M. R., QUINN, J. M. & BURRELL, G. P. (1997). Land-use effects on the hyporheic ecology of five small streams near Hamilton, New Zealand. *New Zealand Journal of Marine and Freshwater Research* **31**, 609–622.
- *BOUTIN, C. (1984). Sensibilité à la pollution et répartition de quelques espèces de Crustacés phréatobies à Marrakech (Maroc occidental). *Mémoires de Biospéologie* **11**, 55–64.
- *BOUTIN, C., BOULANOUAR, M. & YACOUBI-KHEBIZA, M. (1995). Un test biologique simple pour apprécier la toxicité de l'eau et des sédiments d'un puits. Toxicité comparée, in vitro, de quelques métaux lourds et de l'ammonium, vis-à-vis de trois genres de crustacés de la zoocénose des puits. *Hydroécologie appliquée* **7**, 91–109.
- *BOYD, S. H., NIEMILLER, K. D. K., DOOLEY, K. E., NIX, J. & NIEMILLER, M. L. (2020). Using environmental DNA methods to survey for rare groundwater fauna: detection of an endangered endemic cave crayfish in northern Alabama. *PLoS One* **15**, e0242741.
- *BOYLES, J. G. (2017). Benefits of knowing the costs of disturbance to hibernating bats. *Wildlife Society Bulletin* **41**, 388–392.
- BRANCO, V. V. & CARDOSO, P. (2020). An expert-based assessment of global threats and conservation measures for spiders. *Global Ecology and Conservation* **24**, e01290.
- *BRIBIESCA-CONTRERAS, G., SOLÍS-MARÍN, F. A., LAGUARDA-FIGUERAS, A. & ZALDÍVAR-RIVERÓN, A. (2013). Identification of echinoderms (Echinodermata) from an anchialine cave in Cozumel Island, Mexico, using DNA barcodes. *Molecular Ecology Resources* **13**, 1137–1145.
- *BRITZKE, E. R., LOEB, S. C., ROMANEK, C. S., HOBSON, K. A. & VONHOF, M. J. (2012). Variation in catchment areas of Indiana bat (*Myotis sodalis*) hibernacula inferred from stable hydrogen ($\delta^2\text{H}$) isotope analysis. *Canadian Journal of Zoology* **90**, 1243–1250.
- *BRKIĆ, Ž., KUHTA, M., LARVA, O. & GOTTSTEIN, S. (2019). Groundwater and connected ecosystems: an overview of groundwater body status assessment in Croatia. *Environmental Sciences Europe* **31**, 1–20.
- *BROWNSEY, P. J. & LANGE, P. D. (1997). *Asplenium cimmeriorum*, a new fern species from New Zealand. *New Zealand Journal of Botany* **35**, 283–292.
- *BU, Y., WANG, Y., ZHANG, C., LIU, W., ZHOU, H., YU, Y. & NIU, H. (2015). Geographical distribution, roost selection, and conservation state of cave-dwelling bats in China. *Mammalia* **79**, 409–417.
- *BUHAY, J. E. & CRANDALL, K. A. (2005). Subterranean phylogeography of freshwater crayfishes shows extensive gene flow and surprisingly large population sizes. *Molecular Ecology* **14**, 4259–4273.
- *BUHAY, J. E. & CRANDALL, K. A. (2008). Taxonomic revision of cave crayfishes in the genus *Orconectes*, subgenus *Orconectes* (Decapoda: Cambaridae) along the Cumberland plateau, including a description of a new species, *Orconectes barri*. *Journal of Crustacean Biology* **28**, 57–67.
- *BUHAY, J. E. & CRANDALL, K. A. (2009). Taxonomic revision of cave crayfish in the genus *Cambarus*, subgenus *Aviticambarus* (Decapoda: Cambaridae) with descriptions of two new species, *C. speleocoopi* and *C. laconensis*, endemic to Alabama, USA. *Journal of Crustacean Biology* **29**, 121–134.
- *BUSSOTTI, S., DI FRANCO, A., BIANCHI, C. N., CHEVALDONNÉ, P., EGEA, L., FANELLI, E., LEJEUNE, C., MUSCO, L., NAVARRO-BARRANCO, C., PEY, A., PLANES, S., VIEUX-INGRASSIA, J. V. & GUIDETTI, P. (2018). Fish mitigate trophic depletion in marine cave ecosystems. *Scientific Reports* **8**, 1–11.
- *BUSSOTTI, S., DI FRANCO, A., FRANCOUR, P. & GUIDETTI, P. (2015). Fish assemblages of Mediterranean marine caves. *PLoS One* **10**, e0122632.
- *BUSSOTTI, S. & GUIDETTI, P. (2009). Do Mediterranean fish assemblages associated with marine caves and rocky cliffs differ? *Estuarine, Coastal and Shelf Science* **81**, 65–73.
- *BUSSOTTI, S., TERLIZZI, A., FRASCHETTI, S., BELMONTE, G. & BOERO, F. (2006). Spatial and temporal variability of sessile benthos in shallow Mediterranean marine caves. *Marine Ecology Progress Series* **325**, 109–119.
- BUXTON, R. T., AVERY-GOMM, S., LIN, H.-Y., SMITH, P. A., COOKE, S. J. & BENNETT, J. R. (2020). Half of resources in threatened species conservation plans are allocated to research and monitoring. *Nature Communications* **11**, 4668.
- BUXTON, R. T., NYBOER, E. A., PIGEON, K. E., RABY, G. D., RYTWINSKI, T., GALLAGHER, A. J., SCHUSTER, R., LIN, H.-Y., FAHRIG, L., BENNETT, J. R., COOKE, S. J. & ROCHE, D. G. (2021). Avoiding wasted research resources in conservation science. *Conservation Science and Practice* **3**, e329.
- *CABEZAS, P., ALDA, F., MACPHERSON, E. & MACHORDOM, A. (2012). Genetic characterization of the endangered and endemic anchialine squat lobster *Munidopsis polymorpha* from Lanzarote (Canary Islands): management implications. *ICES Journal of Marine Science* **69**, 1030–1037.
- *CABLE, A. B., O'KEEFE, J. M., DEPPE, J. L., HOHOFF, T. C., TAYLOR, S. J. & DAVIS, M. A. (2021). Habitat suitability and connectivity modeling reveal priority areas for Indiana bat (*Myotis sodalis*) conservation in a complex habitat mosaic. *Landscape Ecology* **36**, 119–137.
- *CAI, Y. & LI, S. (1997). *Caridina demenica*, a new species of troglobitic shrimp (Crustacea: Decapoda: Atyidae) from Guizhou, China. *Raffles Bulletin of Zoology* **45**, 315–318.

- *CAJAIBA, R. L., PERICO, E., DA SILVA, W. B., VIEIRA, T. B., DOS SANTOS, F. M. B. & SANTOS, M. (2021). Are neotropical cave-bats good landscape integrity indicators? Some clues when exploring the cross-scale interactions between underground and above-ground ecosystems. *Ecological Indicators* **122**, 107258.
- *CALDERÓN-GUTIÉRREZ, F., SÁNCHEZ-ORTIZ, C. A. & HUATO-SOBERANIS, L. (2018). Ecological patterns in anchialine caves. *PLoS One* **13**, e0202909.
- *CAMPBELL, L. (1995). *Endangered and Threatened Animals of Texas: Their Life History and Management*. Texas Parks and Wildlife, Resource Protection Division, Endangered Resources Branch, Campbell.
- *CAMPBELL, S. (2011). Ecological specialisation and conservation of Australia's largest-fled myotis: a review of trawling bat behaviour. In *The Biology and Conservation of Australasian Bats* (eds B. LAW, P. EBY, D. LUNNEY and L. F. LUMSDEN), pp. 72–85. Royal Zoological Society of NSW, Mosman.
- CANEDOLI, C., FICETOLA, G. F., CORENGIA, D., TOGNINI, P., FERRARIO, A. & PADOA-SCHIOPPA, E. (2022). Integrating landscape ecology and the assessment of ecosystem services in the study of karst areas. *Landscape Ecology* **37**, 347–365.
- *CANIVET, V. & GIBERT, J. (2002). Sensitivity of epigeic and hypogean freshwater macroinvertebrates to complex mixtures. Part I: laboratory experiments. *Chemosphere* **46**, 999–1009.
- *CANIVET, V., CHAMBON, P. & GIBERT, J. (2001). Toxicity and bioaccumulation of arsenic and chromium in epigeic and hypogean freshwater macroinvertebrates. *Archives of Environmental Contamination and Toxicology* **40**, 345–354.
- *CANTONATI, M., POIKANE, S., PRINGLE, C. M., STEVENS, L. E., TURAK, E., HEINO, J., RICHARDSON, J. S., BOLPAGNI, R., BORRINI, A., CID, N., ČTVRTLÍKOVÁ, M., GALASSI, D. M. P., HÁJEK, M., HAWES, I., LEVKOV, Z., et al. (2020a). Characteristics, main impacts, and stewardship of natural and artificial freshwater environments: consequences for biodiversity conservation. *Water* **12**, 260.
- *CANTONATI, M., SEGADDELLI, S., OGATA, K., TRAN, H., SANDERS, D., GERECKE, R., ROTT, E., FILIPPINI, M., GARGINI, A. & CELICO, F. (2016). A global review on ambient limestone-Precipitating Springs (LPS): hydrogeological setting, ecology, and conservation. *Science of the Total Environment* **568**, 624–637.
- *CANTONATI, M., STEVENS, L. E., SEGADDELLI, S., SPRINGER, A. E., GOLDSCHIEDER, N., CELICO, F., FILIPPINI, M., OGATA, K. & GARGINI, A. (2020b). Ecohydrogeology: the interdisciplinary convergence needed to improve the study and stewardship of springs and other groundwater-dependent habitats, biota, and ecosystems. *Ecological Indicators* **110**, 105803.
- CARAKA, R. E., SHOHAIMI, S., KURNIAWAN, I. D., HERLIANSYAH, R., BUDIARTO, A., SARI, S. P. & PARDAMEAN, B. (2018). Ecological show cave and wild cave: negative binomial Gllvm's arthropod community modelling. *Procedia Computer Science* **135**, 377–384.
- *CARDIFF, S. G., RATRIMOMANARIVO, F. H. & GOODMAN, S. M. (2012). The effect of tourist visits on the behavior of *Rousettus madagascariensis* (Chiroptera: Pteropodidae) in the caves of Ankarana, northern Madagascar. *Acta Chiropterologica* **14**, 479–490.
- *CARDIFF, S. G., RATRIMOMANARIVO, F. H., REMBERT, G. & GOODMAN, S. M. (2009). Hunting, disturbance and roost persistence of bats in caves at Ankarana, northern Madagascar. *African Journal of Ecology* **47**, 640–649.
- *CARDOSO, G. M., BASTOS-PEREIRA, R., SOUZA, L. A. & FERREIRA, R. L. (2020a). New troglobitic species of Xanagoniscus (isopoda: Styoloniscidae) from Brazil, with notes on their habitats and threats. *Zootaxa* **4819**(1), zootaxa-4819.
- *CARDOSO, P. (2012). Diversity and community assembly patterns of epigeic vs. troglobitic spiders in the Iberian Peninsula. *International Journal of Speleology* **41**, 83–94.
- CARDOSO, P., BARTON, P. S., BIRKHOFFER, K., CHICHORRO, F., DEACON, C., FARTMANN, T., FUKUSHIMA, C. S., GAIGHER, R., HABEL, J. C., HALLMANN, C. A., HILL, M. J., HOCHKIRCH, A., KWAK, M. L., MAMMOLA, S., ARI NORIEGA, J., et al. (2020b). Scientists' warning to humanity on insect extinctions. *Biological Conservation* **242**, 108426.
- CARDOSO, P., BORGES, P. A. V., TRIANTIS, K. A., FERRANDEZ, M. A. & MARTIN, J. L. (2011). Adapting the IUCN red list criteria for invertebrates. *Biological Conservation* **144**, 2432–2440.
- *CARDOSO, P., CRESPO, L. C., SILVA, I., BORGES, P. A. & BOIEIRO, M. (2017). Species conservation profiles of endemic spiders (Araneae) from Madeira and Selvagens archipelagos, Portugal. *Biodiversity Data Journal* **5**, e20810.
- *CARDOSO, R. C., FERREIRA, R. L. & SOUZA-SILVA, M. (2021). Priorities for cave fauna conservation in the lúíú karst landscape, northeastern Brazil: a threatened spot of troglobitic species diversity. *Biodiversity and Conservation* **30**, 1433–1455.
- *CARTER, T. C. & STEFFEN, B. J. (2010). Converting abandoned mines to suitable hibernacula for endangered Indiana bats. In *Protecting Threatened Bats at Coal Mines: A Technical Interactive Forum* (eds K. C. VORIES, A. H. CASWELL and T. M. PRICE), pp. 205–213. Department of Interior, Office of Surface Mining, Coal Research Center, Southern Illinois University, Carbondale.
- *CARVER, L. M., PERLAKY, P., CRESSLER, A. & ZIGLER, K. S. (2016). Reproductive seasonality in *Nesticus* (Araneae: Nesticidae) cave spiders. *PLoS One* **11**, e0156751.
- CASTAÑO-SÁNCHEZ, A., HOSE, G. C. & REBOLEIRA, A. S. P. S. (2020). Ecotoxicological effects of anthropogenic stressors in subterranean organisms: a review. *Chemosphere* **244**, 125422.
- *CASTAÑO-SÁNCHEZ, A., MALARD, F., KALČÍKOVÁ, G. & REBOLEIRA, A. S. P. S. (2021). Novel protocol for acute in situ ecotoxicity test using native crustaceans applied to groundwater ecosystems. *Water* **13**, 1132.
- *CASTELLARINI, F., DOLE-OLIVIER, M. J. M. & GIBERT, J. (2007). Using habitat heterogeneity to assess stygobiotic species richness in the French Jura region with a conservation perspective. *Fundamental and Applied Limnology* **169**, 69–78.
- *CASTELLARINI, F., MALARD, F., DOLE-OLIVIER, M. J. & GIBERT, J. (2007). Modelling the distribution of stygobionts in the Jura Mountains (eastern France). Implications for the protection of ground waters. *Diversity and Distributions* **13**, 213–224.
- *CASTELLO, M. (2014). Species diversity of bryophytes and ferns of lampenflora in Grotta Gigante (NE Italy). *Acta Carsologica* **43**, 185–193.
- *CHAGAS-JR, A. & BICHUETTE, M. E. (2018). A synopsis of centipedes in Brazilian caves: hidden species diversity that needs conservation (Myriapoda, Chilopoda). *ZooKeys* **737**, 13–56.
- *CHEVALDONNÉ, P. & LEJEUSNE, C. (2003). Regional warming-induced species shift in north-West Mediterranean marine caves. *Ecology Letters* **6**, 371–379.
- *CHEVALDONNÉ, P., PÉREZ, T., CROUZET, J. M., BAY-NOUAILHAT, W., BAY-NOUAILHAT, A., FORT, M., ALMÓN, B., PÉREZ, J., AGUILAR, R. & VACELET, J. (2015). Unexpected records of 'deep-sea carnivorous sponges *Asbestopluma hypogea* in the shallow NE Atlantic shed light on new conservation issues. *Marine Ecology* **36**, 475–484.
- *CHIPPINDALE, P. T. & PRICE, A. H. (2005). Conservation of Texas spring and cave salamanders (Eurycea). In *Amphibian Declines: The Conservation Status of United States Species* (ed. M. LANNON), pp. 193–197. University of California Press, Los Angeles.
- CHRISTIE, A. P., AMANO, T., MARTIN, P. A., PETROVAN, S. O., SHACKELFORD, G. E., SIMMONS, B. I., SMITH, R. K., WILLIAMS, D. R., WORDLEY, C. F. R. & SUTHERLAND, W. J. (2020). Poor availability of context-specific evidence hampers decision-making in conservation. *Biological Conservation* **248**, 108666.
- CICHON, M. (2020). Reporting statistical methods and outcome of statistical analyses in research articles. *Pharmacological Reports* **72**, 481–485.
- *CLARKE, A. K. (1997). Management Prescriptions for Tasmania's Cave Fauna. Report to Tasmanian RFA Environment and Heritage Technical Committee, Tasmanian Parks and Wildlife Service, Tasmania. 167 pp.
- *CLAWSON, R. L. (2000). Implementation of a recovery plan for the endangered Indiana bat. In *Proceedings of Bat Conservation and Mining: A Technical Interactive Forum* (eds K. C. VORIES and D. THROGMORTON), pp. 14–16. US Department of Interior, Office of Surface Mining, Alton and Coal Research Center, Southern Illinois University, Carbondale.
- COHEN, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement* **20**, 37–46.
- COLADO, R., PALLARÉS, S., FRESNEDA, J., MAMMOLA, S., RIZZO, V. & SÁNCHEZ-FERNÁNDEZ, D. (2022). Climatic stability, not average habitat temperature, determines thermal tolerance of subterranean beetles. *Ecology* e3629.
- *CONSTANTIN, S., MIREA, I. C., PETCULESCU, A., ARGHIR, R. A., MĂNTOIU, D. Ș., KENESZ, M., ROBU, M. & MOLDOVAN, O. T. (2021). Monitoring human impact in show caves. A study of four Romanian caves. *Sustainability* **13**, 1619.
- COOK, C. N., HOCKINGS, M. & CARTER, R. W. (2010). Conservation in the dark? The information used to support management decisions. *Frontiers in Ecology and the Environment* **8**, 181–186.
- *COOPER-BOHANNON, R., REBELO, H., JONES, G., COTTERILL, F., MONADJEM, A., SCHOEMAN, M. C., TAYLOR, P. & PARK, K. (2016). Predicting bat distributions and diversity hotspots in southern Africa. *Hystrix, the Italian Journal of Mammalogy* **27**, 1–11.
- *COSTA, G., BETTI, F., NEPOTE, E., CATTANEO-VIETTI, R., PANSINI, M., BAVESTRELLO, G. & BERTOLINO, M. (2018). Sponge community variations within two semi-submerged caves of the Ligurian Sea (Mediterranean Sea) over a half-century time span. *The European Zoological Journal* **85**, 381–391.
- *CRAMER, V. A., ARMSTRONG, K. N., BULLEN, R. D., ELLIS, R., GIBSON, L. A., MCKENZIE, N. L., O'CONNELL, M., SPATE, A. & VAN LEEUWEN, S. (2016). Research priorities for the Pilbara leaf-nosed bat (*Rhinonicteris aurantia* Pilbara form). *Australian Mammalogy* **38**, 149–157.
- *CREUZÉ DES CHÂTELLIERS, M., DOLEDEC, S., LAFONT, M., DOLE-OLIVIER, M. J., KONECNY, L. & MARMONIER, P. (2021). Are hyporheic oligochaetes efficient indicators of hydrological exchanges in river bed sediment? A test in a semi-natural and a regulated river. *River Research and Applications* **37**, 399–407.
- *CRIMMINS, S. M., MCKANN, P. C., SZYMANSKI, J. A. & THOGMARTIN, W. E. (2014). Effects of cave gating on population trends at individual hibernacula of the Indiana bat (*Myotis sodalis*). *Acta Chiropterologica* **16**, 129–137.
- *CULVER, D. C., JONES, W. K. & HOLSINGER, J. R. (1992). Biological and hydrological investigation of the cedars, Lee County, Virginia, an ecologically significant and threatened karst area. In *Proceedings of the 1st International Conference on*

- Ground Water Ecology* (eds J. A. STANFORD and J. J. SIMONS), pp. 281–290. American Water Resources Association, Bethesda.
- *CULVER, D. C., MASTER, L. L., CHRISTMAN, M. C. & HOBBS, H. H. III (2000). Obligate cave fauna of the 48 contiguous United States. *Conservation Biology* **14**, 386–401.
- CULVER, D. C. & PIPAN, T. (2014). *Shallow Subterranean Habitats: Ecology, Evolution, and Conservation*. Oxford University Press, Oxford.
- CULVER, D. C. & PIPAN, T. (2019). *The Biology of Caves and Other Subterranean Habitats*, Second Edition (Second Edition). Oxford University Press, Oxford.
- *CURRIE, R. R. (2000a). Federally listed threatened and endangered species of importance to mining. In *Proceedings of Bat Conservation and Mining: A Technical Interactive Forum* (eds K. C. VORIES and D. THROGMORTON), pp. 51–56. US Department of Interior, Office of Surface Mining, Alton and Coal Research Center, Southern Illinois University, Carbondale.
- *CURRIE, R. R. (2000b). An overview of the response of bats to protection efforts. In *Proceedings of Bat Conservation and Mining: A Technical Interactive Forum* (eds K. C. VORIES and D. THROGMORTON), pp. 173–186. US Department of Interior, Office of Surface Mining, Alton and Coal Research Center, Southern Illinois University, Carbondale.
- *DALHOUMI, R., AISSA, P., BEYREM, H. & AULAGNIER, S. (2019). Annual cycle of bats in a cave of Jebel Ertwa, a sub-desert zone of Central Tunisia. *Tropical Zoology* **32**, 155–165.
- *DANIELOPOL, D. (1983). Bekämpfungsmöglichkeiten der Grundwasserassel Proasellus strouhali Karaman im Trinkwasserversorgungsnetz der Stadt Linz. pp. 1–26. Internal Report, Limnological Institute Mondsee, ÖAW, unpublished.
- DANIELOPOL, D. L. (1998). Conservation and protection of the biota of karst: assimilation of scientific ideas through artistic perception. *Journal of Cave and Karst Studies* **60**, 67.
- *DANIELOPOL, D. L., ARTHEAU, M. & MARMONIER, P. (2009). Site prioritisation for the protection of rare subterranean species—the cases of two ostracods from South-Western France. *Freshwater Biology* **54**, 877–884.
- *DANIELOPOL, D. L., GIBERT, J., GRIEBLER, C., GUNATILAKA, A., HAHN, H. J., MESSANA, G., NOTENBOOM, J. & SKET, B. (2004). Incorporating ecological perspectives in European groundwater management policy. *Environmental Conservation* **31**, 185–189.
- *DANIELOPOL, D. L. & POSPISIL, P. (2001). Hidden biodiversity in the groundwater of the Danube flood plain national park (Austria). *Biodiversity and Conservation* **10**, 1711–1721.
- *DANKS, H. V. & WILLIAMS, D. D. (1991). Arthropods of springs, with particular reference to Canada: synthesis and needs for research. *The Memoirs of the Entomological Society of Canada* **123**, 203–217.
- *DÁVALOS, L. M. (2005). Molecular phylogeny of funnel-eared bats (Chiroptera: Natalidae), with notes on biogeography and conservation. *Molecular Phylogenetics and Evolution* **37**, 91–103.
- *DAVIS, J., MUNKSGAARD, N., HODGETTS, J. & LAMBRINIDIS, D. (2021). Identifying groundwater-fed climate refugia in remote arid regions with citizen science and isotope hydrology. *Freshwater Biology* **66**, 35–43.
- *DAY, K. M. & TOMASI, T. E. (2014). Winter energetics of female Indiana bats *Myotis sodalis*. *Physiological and Biochemical Zoology* **87**, 56–64.
- *DEBATA, S. (2021). Bats in a cave tourism and pilgrimage site in eastern India: conservation challenges. *Oryx* **55**, 684–691.
- *DEHARVENG, L., STOCH, F., GIBERT, J., BEDOS, A., GALASSI, D., ZAGMAJSTER, M., BRANCELJ, A., CAMACHO, A., FIERS, F., MARTIN, P. & GIANI, N. (2009). Groundwater biodiversity in Europe. *Freshwater Biology* **54**, 709–726.
- *DELEVA, S. & CHAVERRI, G. (2018). Diversity and conservation of cave-dwelling bats in the Brunca region of Costa Rica. *Diversity* **10**, 43.
- *DELGADO-JARAMILLO, M., BARBIER, E. & BERNARD, E. (2018). New records, potential distribution, and conservation of the Near threatened cave bat *Natalus macrourus* in Brazil. *Oryx* **52**, 579–586.
- DELSO, Á., FAJARDO, J. & MUÑOZ, J. (2021). Protected area networks do not represent unseen biodiversity. *Scientific Reports* **11**, 12275.
- *DERKARABETIAN, S., STEINMANN, D. B. & HEDIN, M. (2010). Repeated and time-correlated morphological convergence in cave-dwelling harvestmen (Opiliones, Laniatores) from montane western North America. *PLoS One* **5**, e10388.
- *DERUSSEAU, S. N. & HUNTLY, N. J. (2012). Effects of gates on the nighttime use of mines by bats in northern Idaho. *Northwestern Naturalist* **93**, 60–66.
- *DELTSHEV, C., BLAGOEV, G. & HUBENOV, Z. (1998). Conservation priorities on biodiversity of invertebrates (non-Insecta) in Bulgarian Mountains. *Ambio* **27**, 330–334.
- *DEVITT, T. J., WRIGHT, A. M., CANNATELLA, D. C. & HILLIS, D. M. (2019). Species delimitation in endangered groundwater salamanders: implications for aquifer management and biodiversity conservation. *Proceedings of the National Academy of Sciences* **116**, 2624–2633.
- *DIAMOND, G. F. & DIAMOND, J. M. (2014). Bats and mines: evaluating Townsend's big-eared bat (*Corynorhinus townsendii*) maternity colony behavioral response to gating. *Western North American Naturalist* **74**, 416–426.
- *DI CICCIO, M., DI LORENZO, T., IANNELLA, M., VACCARELLI, I., GALASSI, D. M. P. & FIASCA, B. (2021). Linking hydrogeology and ecology in karst landscapes: the response of Epigeic and obligate groundwater copepods (Crustacea: Copepoda). *Water* **13**, 2106.
- *DIELS, L. & LOOKMAN, R. (2007). Microbial systems for in-situ soil and groundwater remediation. In *Advanced Science and Technology for Biological Decontamination of Sites Affected by Chemical and Radiological Nuclear Agents* (eds N. MARMIROLI, B. SAMOTOKIN and M. MARMIROLI), pp. 61–77. Springer, Dordrecht.
- *DI FRANCO, A., FERRUZZA, G., BAIATA, P., CHEMELLO, R. & MILAZZO, M. (2010). Can recreational scuba divers alter natural gross sedimentation rate? A case study from a Mediterranean deep cave. *ICES Journal of Marine Science* **67**, 871–874.
- *DI FRANCO, A., MARCHINI, A., BAIATA, P., MILAZZO, M. & CHEMELLO, R. (2009a). Developing a scuba trail vulnerability index (STVI): a case study from a Mediterranean MPA. *Biodiversity and Conservation* **18**, 1201–1217.
- *DI FRANCO, A., MILAZZO, M., BAIATA, P., TOMASELLO, A. & CHEMELLO, R. (2009b). Scuba diver behaviour and its effects on the biota of a Mediterranean marine protected area. *Environmental Conservation* **36**, 32–40.
- DI LORENZO, T., CIFONI, M., FIASCA, B., DI CICCIO, A. & GALASSI, D. M. P. (2018). Ecological risk assessment of pesticide mixtures in the alluvial aquifers of Central Italy: toward more realistic scenarios for risk mitigation. *Science of the Total Environment* **644**, 161–172.
- *DI LORENZO, T., CIFONI, M., LOMBARDO, P., FIASCA, B. & GALASSI, D. M. P. (2015). Ammonium threshold values for groundwater quality in the EU may not protect groundwater fauna: evidence from an alluvial aquifer in Italy. *Hydrobiologia* **743**, 139–150.
- *DI LORENZO, T., FIASCA, B., DI CAMILLO TABILIO, A., MUROLO, A., DI CICCIO, M. & GALASSI, D. M. P. (2020). The weighted groundwater health index (wGHI) by Korbelt and Hose (2017) in European groundwater bodies in nitrate vulnerable zones. *Ecological Indicators* **116**, 106525.
- DI LORENZO, T., FIASCA, B., DI CICCIO, M. & GALASSI, D. M. P. (2021). The impact of nitrate on the groundwater assemblages of European unconsolidated aquifers is likely less severe than expected. *Environmental Science and Pollution Research* **28**, 11518–11527.
- DI LORENZO, T., DI MARZIO, W. D., FIASCA, B., GALASSI, D. M. P., KORBEL, K., IEPURE, S., PEREIRA, J. L., REBOLEIRA, A. S. P. S., SCHMIDT, S. I. & HOSE, G. C. (2019). Recommendations for ecotoxicity testing with stygobiotic species in the framework of groundwater environmental risk assessment. *Science of the Total Environment* **681**, 292–304.
- *DI LORENZO, T., DI MARZIO, W. D., SÁENZ, M. E., BARATTI, M., DEDONNO, A. A., IANNUCCI, A., CANNICCI, S., MESSANA, G. & GALASSI, D. M. P. (2014). Sensitivity of hypogean and epigeic freshwater copepods to agricultural pollutants. *Environmental Science and Pollution Research* **21**, 4643–4655.
- *DI MAGGIO, C., MADONIA, G., PARISE, M. & VATTANO, M. (2012). Karst of Sicily and its conservation. *Journal of Cave and Karst Studies* **74**, 157–172.
- *DIMARCHOPOULOU, D., GEROVASILEIOU, V. & VOULTSIADOU, E. (2018). Spatial variability of sessile benthos in a semi-submerged marine cave of a remote Aegean Island (eastern Mediterranean Sea). *Regional Studies in Marine Science* **17**, 102–111.
- *DI MARZIO, W. D., CASTALDO, D., PANTANI, C., DI CICCIO, A., DI LORENZO, T., SÁENZ, M. E. & GALASSI, D. M. P. (2009). Relative sensitivity of hyporheic copepods to chemicals. *Bulletin of Environmental Contamination and Toxicology* **82**, 488–491.
- *DI MARZIO, W. D., CIFONI, M., SÁENZ, M. E., GALASSI, D. M. P. & DI LORENZO, T. (2018). The ecotoxicity of binary mixtures of Imazamox and ionized ammonia on freshwater copepods: implications for environmental risk assessment in groundwater bodies. *Ecotoxicology and Environmental Safety* **149**, 72–79.
- *DI STEFANO, R. J., ASHLEY, D., BREWER, S. K., MOUSER, J. B. & NIEMILLER, M. (2020). Preliminary investigation of the critically imperiled Caney Mountain cave crayfish *Orconectes stygocaneyi* Hobbs III, 2001 (Decapoda: Cambaridae) in Missouri, USA. *Freshwater Crayfish* **25**, 47–57.
- *DIXON, J. W. (2011). The role of small caves as bat hibernacula in Iowa. *Journal of Cave and Karst Studies* **73**, 21–27.
- *DIXON, G. B. & ZIGLER, K. S. (2011). Cave-obligate biodiversity on the campus of Sewanee: the University of the South, Franklin County, Tennessee. *Southeastern Naturalist* **10**, 251–266.
- *DOBKIN, D. S., GETTINGER, R. D. & GERDES, M. G. (1995). Springtime movements, roost use, and foraging activity of Townsend's big-eared bat (*Plecotus townsendii*) in Central Oregon. *The Great Basin Naturalist* **55**, 315–321.
- DOLE-OLIVIER, M. J., CASTELLARINI, F., COINEAU, N., GALASSI, D. M. P., MARTIN, P., MORI, N., VALDECASAS, A. & GIBERT, J. (2009). Towards an optimal sampling strategy to assess groundwater biodiversity: comparison across six European regions. *Freshwater Biology* **54**, 777–796.
- *DO MONTE, B. G. O., GALLÃO, J. E., VON SCHIMONSKY, D. M. & BICHUETTE, M. E. (2015). New records of two endemic troglottic and threatened arachnids (Amblypygi and Opiliones) from limestone caves of Minas Gerais state, Southeast Brazil. *Biodiversity Data Journal* **3**, e5260.
- *DORAN, N. E., EBERHARD, S. M., RICHARDSON, A. M. M. & SWAIN, R. (1997). Invertebrate biodiversity and conservation in Tasmanian caves. *Memoirs of Museum of Victoria* **56**, 649–653.

- *DORAN, N. E., KIERNAN, K., SWAIN, R. & RICHARDSON, A. M. M. (1999). *Hickmania troglodytes*, the Tasmanian cave spider, and its potential role in cave management. *Journal of Insect Conservation* **3**, 257–262.
- DOWNY, H., AMANO, T., CADOTTE, M., COOK, C. N., COOKE, S. J., HADDAWAY, N. R., JONES, J. P. G., LITTLEWOOD, N., WALSH, J. C., ABRAHAMS, M. I., ADUM, G., AKASAKA, M., ALVES, J. A., ANTWS, R. E., ARELLANO, E. C., et al. (2021). Training future generations to deliver evidence-based conservation and ecosystem management. *Ecological Solutions and Evidence* **2**, e12032.
- *DRAGU, A. (2009). Species structure of the bat community hibernating in Muierilor cave (southern Carpathians, Romania). *North-Western Journal of Zoology* **5**, 281–289.
- *DRIESSEN, M. M. (2010). Enhancing conservation of the Tasmanian glow-worm, *Arachnocampa tasmaniensis* Ferguson (Diptera: Keroplatidae) by monitoring seasonal changes in light displays and life stages. *Journal of Insect Conservation* **14**, 65–75.
- *EBERHARD, S. & HAMILTON-SMITH, E. (1996). Conservation of cave fauna in Australia. Australas. *Journal of the Australasian Cave and Karst Management Association* **23**, 4–14.
- *EBERHARD, S. M., SMITH, G. B., GIBIAN, M., SMITH, H. M. & GRAY, M. R. (2014). Invertebrate cave fauna of Jenolan. *Proceedings of the Linnean Society of New South Wales* **136**, 35–68.
- *EL ADNANI, M., AIT BOUGHROUS, A., KHEBIZA, M. Y., EL GHARMALI, A., SBAI, M. L., ERROUANE, A. S., IDRIS, L. & NEJMEDDINE, A. (2007). Impact of mining wastes on the physicochemical and biological characteristics of groundwater in a mining area in Marrakech (Morocco). *Environmental Technology* **28**, 71–82.
- *ELLIOTT, W. R. (2006). *Cave Gating Criteria*. Missouri Department of Conservation, Jefferson City.
- ELSHALL, A. S., ARIK, A. D., EL-KADI, A. I., PIERCE, S., YE, M., BURNETT, K. M., WADA, C. A., BREMER, L. L. & CHUN, G. (2020). Groundwater sustainability: a review of the interactions between science and policy. *Environmental Research Letters* **15**, 93004.
- *ENVIRONMENTAL PROTECTION AGENCY TIMIS. (2013). LIFE Preserving of the Habitat 8310 from the Site Natura 2000 Cheile Nerei Beusnita. LIFE13 NAT/RO/001488. Timisoara.
- *ERCOLI, F., LEFEBVRE, F., DELANGLE, M., GODÉ, N., CAILLON, M., RAIMOND, R. & SOUTY-GROSSET, C. (2019). Differing trophic niches of three French stygobionts and their implications for conservation of endemic stygofauna. *Aquatic Conservation: Marine and Freshwater Ecosystems* **29**, 2193–2203.
- *FAILLE, A., BOURDEAU, C. & DEHARVENG, L. (2015). Weak impact of tourism activities on biodiversity in a subterranean hotspot of endemism and its implications for the conservation of cave fauna. *Insect Conservation and Diversity* **8**, 205–215.
- *FARNWORTH, B., INNES, J., KELLY, C., LITTLER, R. & WAAS, J. R. (2018). Photons and foraging: artificial light at night generates avoidance behaviour in male, but not female, New Zealand weta. *Environmental Pollution* **236**, 82–90.
- *FATTORINI, S., FIASCA, B., DI LORENZO, T., DI CICCO, M. & GALASSI, D. M. P. (2020). A new protocol for assessing the conservation priority of groundwater-dependent ecosystems. *Aquatic Conservation: Marine and Freshwater Ecosystems* **30**, 1483–1504.
- *FEIJÓ, A., WANG, Y., SUN, J., LI, F., WEN, Z., GE, D., XIA, L. & YANG, Q. (2019). Research trends on bats in China: a twenty-first century review. *Mammalian Biology* **98**, 163–172.
- *FENG, S., CHEN, Q. H. & GUO, Z. L. (2021). Integrative taxonomy uncovers a new stygobiotic *Caridina* species (Decapoda, Caridea, Atyidae) from Guizhou Province, China. *ZooKeys* **1028**, 29–47.
- *FENG, Z., WYNNE, J. J. & ZHANG, F. (2020). Cave-dwelling pseudoscorpions of China with descriptions of four new hypogean species of *Parobisium* (Pseudoscorpiones, Neobisiidae) from Guizhou Province. *Subterranean Biology* **34**, 61–98.
- *FENTON, M. B., TAYLOR, P. J., JACOBS, D. S., RICHARDSON, E. J., BERNARD, E., BOUCHARD, S., DEBAEREMAEKER, K. R., TER HOFSTEDE, H., HOLLIS, L., LAUSEN, C. L., LISTER, J. S., RAMBALDINI, D., RATCLIFFE, J. M. & REDDY, E. (2002). Researching little-known species: the African bat *Otomops martiensseni* (Chiroptera: Molossidae). *Biodiversity and Conservation* **11**, 1583–1606.
- *FERNANDES, C. S., BATALHA, M. A. & BICHUETTE, M. E. (2016). Does the cave environment reduce functional diversity? *PLoS One* **11**, e0151958.
- *FERNANDES, C. S., BATALHA, M. A. & BICHUETTE, M. E. (2019). Dark diversity in the dark: a new approach to subterranean conservation. *Subterranean Biology* **32**, 69–80.
- *FERNÁNDEZ-LLAMAZARES, Á., LÓPEZ-BAUCELLS, A., ROCHA, R., ANDRIAMI TANDRINA, S. F., ANDRIATAFIKA, Z. E., BURGAS, D., TEMBA, E. M., TORRENT, L. & CABEZA, M. (2018). Are sacred caves still safe havens for the endemic bats of Madagascar? *Oryx* **52**, 271–275.
- *FERNHOLZ, J. (2018). *Influence of Pit Tags on Growth and Survival of Banded Sculpin (Cottus caroliniae): Implications for Endangered Grotto Sculpin (Cottus Specus)*. Doctoral Dissertation, Southeast Missouri State University, Cape Girardeau.
- *FERRARO, F. (2009). *Effects and Impacts on Groundwater Ecosystems: Review and Experiments*. Master Thesis, Institute of Environmental Engineering, ETH Zurich, Zurich.
- *FERREIRA, R. L., BERNARDI, L. F. O. & SOUZA-SILVA, M. (2009). Caracterização dos ecossistemas das Grutas Aroê Jari, Kiogo Brado e Lago Azul (Chapada dos Guimarães, MT): subsídios para o turismo nestas cavidades. *Revista de Biologia e Ciências da Terra* **9**, 41–58.
- *FERREIRA, R. L., GIRIBET, G., DU PREEZ, G., VENTOURAS, O., JANION, C. & SILVA, M. S. (2020). The Wynberg cave system, the most important site for cave fauna in South Africa at risk. *Subterranean Biology* **36**, 73–81.
- *FERREIRA, R. L. & HORTA, L. C. S. (2001). Natural and human impacts on invertebrate communities in Brazilian caves. *Revista Brasileira de Biologia* **61**, 7–17.
- *FERREIRA, D., MALARD, F., DOLE-OLIVIER, M. J. & GIBERT, J. (2007). Obligate groundwater fauna of France: diversity patterns and conservation implications. *Biodiversity and Conservation* **16**, 567–596.
- *FERREIRA, R. L., PROUS, X., DE OLIVEIRA BERNARDI, L. F. & SOUZA-SILVA, M. (2010). Fauna subterrânea do estado do Rio Grande do Norte: caracterização e impactos. *Revista Brasileira de Espeleologia* **1**, 25–51.
- FICETOLA, G. F., CANEDOLI, C. & STOCH, F. (2019). The Racovitzan impediment and the hidden biodiversity of unexplored environments. *Conservation Biology* **33**, 214–216.
- *FILLINGER, L., HUG, K., TRIMBACH, A. M., WANG, H., KELLERMANN, C., MEYER, A., BENDINGER, B. & GRIEBLER, C. (2019). The DA-(C) index: a practical approach towards the microbiological-ecological monitoring of groundwater ecosystems. *Water Research* **163**, 114902.
- *FINSTON, T. L., LUKEHURST, S. S. & FITZPATRICK, G. L. (2010). Characterisation of microsatellite loci in the groundwater amphipod *Chlydaekata* sp. (malacostraca: Paramelitidae). *Conservation Genetics Resources* **2**, 237–239.
- FIŠER, C., PIPAN, T. & CULVER, D. C. (2014). The vertical extent of groundwater metazoans: an ecological and evolutionary perspective. *Bioscience* **64**, 971–979.
- *FIŠER, C., ZAGMAJSTER, M. & DETHIER, M. (2018). Overview of Niphargidae (Crustacea: Amphipoda) in Belgium: distribution, taxonomic notes and conservation issues. *Zootaxa* **4387**, 47–74.
- *FONG, D. W. (2011). Management of subterranean fauna in karst. In *Karst management* (ed. P. E. VAN BEYENEN), pp. 201–224. Springer, Dordrecht.
- FONSECA, C. R., PATERNO, G. B., GUADAGNIN, D. L., VENTIGINQUE, E. M., OVERBECK, G. E., GANADE, G., METZGER, J. P., KOLLMANN, J., SAUER, J., CARDOSO, M. Z., LOPES, P. F. M., OLIVEIRA, R. S., PILLAR, V. D. & WEISSER, W. W. (2021). Conservation biology: four decades of problem- and solution-based research. *Perspectives in Ecology and Conservation* **19**, 121–130.
- *FRANZ, R., BAUER, J. & MORRIS, T. (1994). Review of biologically significant caves and their faunas in Florida and South Georgia. *Brimleyana* **20**, 1–109.
- *FRICK, W. F., CHENG, T. L., LANGWIG, K. E., HOYT, J. R., JANICKI, A. F., PARISE, K. L., FOSTER, J. T. & KILPATRICK, A. M. (2017). Pathogen dynamics during invasion and establishment of white-nose syndrome explain mechanisms of host persistence. *Ecology* **98**, 624–631.
- *FRICK, W. F., KINGSTON, T. & FLANDERS, J. (2020). A review of the major threats and challenges to global bat conservation. *Annals of the New York Academy of Sciences* **1469**, 5–25.
- *FU, L. F., MONRO, A. K., HUANG, S. L., WEN, F. & WEI, Y. G. (2017). *Elatostema tiechangense* (Urticaceae), a new cave-dwelling species from Yunnan, China. *Phytotaxa* **292**, 85–90.
- *FUREY, N. M., MACKIE, I. J. & RACEY, P. A. (2011). Reproductive phenology of bat assemblages in Vietnamese karst and its conservation implications. *Acta Chiropterologica* **13**, 341–354.
- FUREY, N. M. & RACEY, P. A. (2016). Conservation ecology of cave bats. In *Bats in the Anthropocene: Conservation of Bats in a Changing World* (eds C. C. VOIGT and T. KINGSTON), pp. 463–500. Springer International Publishing, Cham.
- *FUREY, N. M., RACEY, P. A., ITH, S., TOUCH, V. & CAPPELLE, J. (2018). Reproductive ecology of wrinkle-lipped free-tailed bats *Chaerephon plicatus* (Buchanan, 1800) in relation to guano production in Cambodia. *Diversity* **10**, 91.
- *FURMAN, A. & ÖZGÜL, A. (2002). Distribution of cave-dwelling bats and conservation status of underground habitats in the Istanbul area. *Ecological Research* **17**, 69–77.
- *FURMAN, A. & ÖZGÜL, A. (2004). The distribution of cave-dwelling bats and conservation status of underground habitats in northwestern Turkey. *Biological Conservation* **120**, 243–248.
- GABRIEL, K. T., KARTFOROSH, L., CROW, S. A. J. & CORNELISON, C. T. (2018). Antimicrobial activity of essential oils against the fungal pathogens *Ascosphaera apis* and *Pseudogymnosascus destructans*. *Mycopathologia* **183**, 921–934.
- *GABRIEL, R., PEREIRA, F. E., BORGES, P. A. & CONSTÂNCIA, J. P. (2008). Indicators of conservation value of Azorean caves based on its bryophyte flora at cave entrances. *AMCS Bulletin* **19**, 114–118.
- *GAISLER, J. & CHYTI, J. (2002). Mark-recapture results and changes in bat abundance at the cave of Na Turoldu, Czech Republic. *Folia Zoologica* **51**, 1–10.
- *GALASSI, D. M., HUYS, R. & REID, J. W. (2009). Diversity, ecology and evolution of groundwater copepods. *Freshwater Biology* **54**, 691–708.
- *GALLI, B. S. & GOREN, M. (2019). Rosh-Hanikra grottoes, Israel—a refuge for the critically endangered and for opportunistic invasives. Marine caves of the eastern

- Mediterranean Sea biodiversity, threats and conservation. *Turkish Marine Research Foundation (TUDAV) Publication* **53**, 159–164.
- *GALLÃO, J. E. & BICHUETTE, M. E. (2015). Taxonomic distinctness and conservation of a new high biodiversity subterranean area in Brazil. *Anais da Academia Brasileira de Ciências* **87**, 209–217.
- *GALLÃO, J. E. & BICHUETTE, M. E. (2018). Brazilian obligatory subterranean fauna and threats to the hypogean environment. *ZooKeys* **746**, 1–23.
- *GANNON, W. L., ALTENBACH, J. S. & STRICKLAN, D. (2000). Roost fidelity of Townsend's big-eared bat in Utah and Nevada. *Transactions of the Western Section of the Wildlife Society* **36**, 15–20.
- *GAO, Z., WYNNE, J. J. & ZHANG, F. (2018). Two new species of cave-adapted pseudoscorpions (Pseudoscorpiones: Neobisiidae, Chthoniidae) from Guangxi, China. *The Journal of Arachnology* **46**, 345–354.
- *GARRABOU, J., PEREZ, T., SARTORETTO, S. & HARMELIN, J. G. (2001). Mass mortality event in red coral *Corallium rubrum* populations in the Provence region (France, NW Mediterranean). *Marine Ecology Progress Series* **217**, 263–272.
- *GARRABOU, J., SALA, E., LINARES, C., LEDOUX, J. B., MONTERO-SERRA, I., DOMINICI, J. M., KIPSON, S., TEIXIDÓ, N., CEBRIAN, E., KERSTING, D. K. & HARMELIN, J. G. (2017). Re-shifting the ecological baseline for the overexploited Mediterranean red coral. *Scientific Reports* **7**, 1–6.
- *GAUSSET, Q. (2004). Chronicle of a foreseeable tragedy: birds' nests management in the Niah caves (Sarawak). *Human Ecology* **32**, 487–507.
- *GERLACH, J. & TAYLOR, M. (2006). Habitat use, roost characteristics and diet of the Seychelles sheath-tailed bat *Coleura seychellensis*. *Acta Chiropterologica* **8**, 129–139.
- GEROVASILEIOU, V. & BIANCHI, C. N. (2021). Mediterranean marine caves: a synthesis of current knowledge. *Oceanography and Marine Biology: An Annual Review* **59**, 1–88.
- *GEROVASILEIOU, V., GHINTIROGLOU, C., VAFIDIS, D., KOUTSOUBAS, D., SINI, M., DAILIANIS, T., ISSARIS, Y., AKRITPOULOU, E., DIMARCHOPOULOU, D. & VOULTSIADOU, E. (2015). Census of biodiversity in marine caves of the eastern Mediterranean Sea. *Mediterranean Marine Science* **16**, 245–265.
- *GEROVASILEIOU, V., DIMITRIADIS, C., ARVANITIDIS, C. & VOULTSIADOU, E. (2017). Taxonomic and functional surrogates of sessile benthic diversity in Mediterranean marine caves. *PLoS One* **12**, e0183707.
- *GEROVASILEIOU, V., MARTÍNEZ, A., ÁLVAREZ, F., BOXSHALL, G., HUMPHREYS, W. F., JAUME, D., BECKING, L., MURICY, G., VAN HENGSTUM, P., DEKEYZER, S., DECOCK, W., VANHOORNE, B., VANDEPITTE, L., BAILLY, N. & ILIFFE, T. M. (2016a). World register of marine cave species (WoRCS): a new thematic species database for marine and anchialine cave biodiversity. *Research Ideas and Outcomes* **2**, e10451.
- *GEROVASILEIOU, V. & VOULTSIADOU, E. (2012). Marine caves of the Mediterranean Sea: a sponge biodiversity reservoir within a biodiversity hotspot. *PLoS One* **7**, e39873.
- *GEROVASILEIOU, V. & VOULTSIADOU, E. (2016). Sponge diversity gradients in marine caves of the eastern Mediterranean. *Journal of the Marine Biological Association of the United Kingdom* **96**, 407–416.
- *GEROVASILEIOU, V., VOULTSIADOU, E., ISSARIS, Y. & ZENETOS, A. (2016b). Alien biodiversity in Mediterranean marine caves. *Marine Ecology* **37**, 239–256.
- GERSTNER, K., MORENO-MATEOS, D., GUREVITCH, J., BECKMANN, M., KAMBACH, S., JONES, H. P. & SEPPELT, R. (2017). Will your paper be used in a meta-analysis? Make the reach of your research broader and longer lasting. *Methods in Ecology and Evolution* **8**, 777–784.
- *GIAKOUMI, S., SINI, M., GEROVASILEIOU, V., MAZOR, T., BEHER, J., POSSINGHAM, H. P., ABDULLA, A., ÇINAR, M. E., DENDRINOS, P., GUCU, A. C., KARAMANLIDIS, A. A., RODIC, P., PANAYOTIDIS, P., TASKIN, E., JAKLIN, A., et al. (2013). Ecoregion-based conservation planning in the Mediterranean: dealing with large-scale heterogeneity. *PLoS One* **8**, e76449.
- *GIAVI, S., GLAIZOT, O. & CHRISTE, P. (2020). Sex and age variation in the phenology of a common pipistrelle bat (*Pipistrellus pipistrellus*) population in front of a hibernaculum. *Acta Chiropterologica* **22**, 113–120.
- *GIBSON, L., HUMPHREYS, W. F., HARVEY, M., HYDER, B. & WINZER, A. (2019). Shedding light on the hidden world of subterranean fauna: a transdisciplinary research approach. *Science of the Total Environment* **684**, 381–389.
- *GIBSON, R., HUTCHINS, B. T., KREJČA, J. K., DIAZ, P. H. & SPROUSE, P. S. (2021). *Stygobromus bakeri*, a new species of groundwater amphipod (Amphipoda, Crangonyctidae) associated with the trinity and Edwards aquifers of Central Texas, USA. *Subterranean Biology* **38**, 19–45.
- *GILLIESON, D. S. (2011). Management of caves. In *Karst management* (ed. P. E. VAN BEYEN), pp. 141–158. Springer, Dordrecht.
- *GILLIES, K. E., MURPHY, P. J. & MATOCCO, M. D. (2014). Hibernacula characteristics of Townsend's big-eared bats in southeastern Idaho. *Natural Areas Journal* **34**, 24–30.
- *GIBERT, J., CULVER, D. C., DOLE-OLIVER, M. J., MALARD, F., CHRISTMAN, M. C. & DEHARVENG, L. (2009). Assessing and conserving groundwater biodiversity: synthesis and perspectives. *Freshwater Biology* **54**, 930–941.
- GIRARDELLO, M., SANTANGELI, A., MORI, E., CHAPMAN, A., FATTORINI, S., NAIDOO, R., BERTOLINO, S. & SVENNING, J.-C. (2019). Global synergies and trade-offs between multiple dimensions of biodiversity and ecosystem services. *Scientific Reports* **9**, 5636.
- *GLADSTONE, N. S., CARTER, E. T., MCKINNEY, M. L. & NIEMILLER, M. L. (2018). Status and distribution of the cave-obligate land snails in the Appalachians and interior low plateau of the eastern United States. *American Malacological Bulletin* **36**, 62–78.
- *GLADSTONE, N. S., NIEMILLER, M. L., HUTCHINS, B., SCHWARTZ, B., CZAJA, A., SLAY, M. E. & WHELAN, N. V. (2021). Subterranean freshwater gastropod biodiversity and conservation in the United States and Mexico. *Conservation Biology* **36**(1), e13722.
- *GLASSPOOL, A. (2014). *Management Plan for Bermuda's Critically Endangered Cave Fauna*. Government of Bermuda, Department of Conservation Services, Bermuda.
- *GOLDSCHIEDER, N. (2019). A holistic approach to groundwater protection and ecosystem services in karst terrains. *Carbonates and Evaporites* **34**, 1241–1249.
- *GOMES, F. T. D. M. C., FERREIRA, R. L. & JACOBI, C. M. (2001). Comunidade de artrópodes de uma caverna calcária em área de mineração: composição e estrutura. *Revista Brasileira de Zootecia* **3**, 77–96.
- *GOMES, M., FERREIRA, R. L. & RUCHKYS, Ú. D. A. (2019). Landscape evolution in ferruginous geosystems of the iron quadrangle, Brazil: a speleological approach in a biodiversity hotspot. *SN Applied Sciences* **1**, 1–13.
- *GOMEZ, P. & CALDERÓN-GUTIÉRREZ, F. (2020). Anchialine cave-dwelling sponge fauna (Porifera) from La Quebrada, Mexico, with the description of the first Mexican stygobiont sponges. *Zootaxa* **4803**(1), zootaxa-4803.
- *GOODMAN, S. M., ANDRIAFIDISON, D., ANDRIANAIVOARIVELO, R., CARDIFF, S. G., IFTIGENE, E., JENKINS, R. K., KOFOKY, A., MBOHOAHY, T., RAKOTONDRAVONY, D., RANIVO, J., RATRIMOMANARIVO, F., RAZAFIMANAHAKA, J. & RACEY, P. A. (2006). The distribution and conservation of bats in the dry regions of Madagascar. *Animal Conservation* **8**, 153–165.
- *GONSALVES, L., POTTER, T., COLMAN, N. & LAW, B. (2021). Long-term effects of grating derelict mines on bat emergence activity, abundance and behaviour. *Australian Journal of Zoology* **68**, 320–331.
- *GORE, J. A., LAZURE, L. & LUDLOW, M. E. (2012). Decline in the winter population of gray bats (*Myotis grisescens*) in Florida. *Southeastern Naturalist* **11**, 89–98.
- *GORIČKI, Š., STANKOVIĆ, D., SNOJ, A., KUNTNER, M., JEFFERY, W. R., TRONTELJ, P., PAVIČEVIĆ, M., GRIZELJ, Z., NĀPĀRUŠ-ALJANČIČ, M. & ALJANČIČ, G. (2017). Environmental DNA in subterranean biology: range extension and taxonomic implications for Proteus. *Scientific Reports* **7**, 1–11.
- *GOTTFRIED, I. (2009). Use of underground hibernacula by the barbastelle (*Barbastella barbastellus*) outside the hibernation season. *Acta Chiropterologica* **11**, 363–373.
- *GRAENING, G. O. & BROWN, A. V. (2003). Ecosystem dynamics and pollution effects in an Ozark cave stream. *Journal of the American Water Resources Association* **39**, 1497–1507.
- *GRAENING, G. O., FENOLIO, D. B., HOBBS, H. H.III, JONES, S., SLAY, M. E., MCGINNIS, S. R. & STOUT, J. F. (2006a). Range extension and status update for the Oklahoma cave crayfish, *Cambarus tartarus* (Decapoda: Cambaridae). *The Southwestern Naturalist* **51**, 94–99.
- *GRAENING, G. O., FENOLIO, D. B., NIEMILLER, M. L., BROWN, A. V. & BEARD, J. B. (2010). The 30-year recovery effort for the Ozark cavefish (*Amblyopsis rosae*): analysis of current distribution, population trends, and conservation status of this threatened species. *Environmental Biology of Fishes* **87**, 55–88.
- *GRAENING, G. O., HOBBS, H. H.III, SLAY, M. E., ELLIOTT, W. R. & BROWN, A. V. (2006b). Status update for bristly cave crayfish, *Cambarus setosus* (Decapoda: Cambaridae), and range extension into Arkansas. *The Southwestern Naturalist* **51**, 382–392.
- *GRAENING, G. O., SHCHERBANYUK, Y. & ARGHANDIWAL, M. (2014). Annotated checklist of the Diplura (Hexapoda: Entognatha) of California. *Zootaxa* **3780**, 297–322.
- *GRAENING, G. O., SLAY, M. & BITTING, C. (2006c). Cave fauna of the buffalo National River. *Journal of Cave and Karst Studies* **68**, 153–163.
- *GRAENING, G. O., SLAY, M. E., BROWN, A. V. & KOPPELMAN, J. B. (2006c). Status and distribution of the endangered Benton cave crayfish, *Cambarus aculabrum* (Decapoda: Cambaridae). *The Southwestern Naturalist* **51**, 376–381.
- GREDDAR, T., PRŠA, P. & BIZJAK MALI, L. (2018). Comparative analysis of hematological parameters in wild and captive *Proteus anguinus*. *Natura Sloveniae* **20**, 57–59.
- GRIEBLER, C. & LUEDERS, T. (2009). Microbial biodiversity in groundwater ecosystems. *Freshwater Biology* **54**, 649–677.
- GRIEBLER, C., MALARD, F. & LEFÉBURE, T. (2014). Current developments in groundwater ecology—from biodiversity to ecosystem function and services. *Current Opinion in Biotechnology* **27**, 159–167.
- *GRIEBLER, C., STEIN, H., KELLERMANN, C., BERKHOFF, S., BRIELMANN, H., SCHMIDT, S., SELESI, D., STEUBE, C., FUCHS, A. & HAHN, H. J. (2010). Ecological assessment of groundwater ecosystems—vision or illusion? *Ecological Engineering* **36**, 1174–1190.
- *GRIFFITHS, S. R., DONATO, D. B., LUMSDEN, L. F. & COULSON, G. (2014). Hypersalinity reduces the risk of cyanide toxicosis to insectivorous bats interacting with wastewater impoundments at gold mines. *Ecotoxicology and Environmental Safety* **99**, 28–34.

- *GRISMER, L. L., WOOD, P. L. JR., NGO, V. T. & MURDOCH, M. L. (2015). The systematics and independent evolution of cave ecomorphology in distantly related clades of bent-toed geckos (genus *Cyrtodactylus* Gray, 1827) from the Mekong Delta and islands in the Gulf of Thailand. *Zootaxa* **3980**, 106–126.
- GU, Z., GU, L., EILS, R., SCHLESNER, M. & BRORS, B. (2014). Circize: implements and enhances circular visualization in R. *Bioinformatics* **30**, 2811–2812.
- *GUARNIERI, G., TERLIZZI, A., BEVILACQUA, S. & FRASCHETTI, S. (2012). Increasing heterogeneity of sensitive assemblages as a consequence of human impact in submarine caves. *Marine Biology* **159**, 1155–1164.
- GUERRA, C. A., BARDGETT, R. D., CAON, L., CROWTHER, T. W., DELGADO-BAQUERIZO, M., MONTANARELLA, L., NAVARRO, L. M., ORGIAZZI, A., SINGH, B. K., TEDERSON, L., VARGAS-ROJAS, R., BRIONES, M. J. I., BUSCOT, F., CAMERON, E. K., CESARZ, S., et al. (2021). Tracking, targeting, and conserving soil biodiversity. *Science* **371**, 239–241.
- GUERRA, C. A., HEINTZ-BUSCHART, A., SIKORSKI, J., CHATZINOTAS, A., GUERRERO-RAMÍREZ, N., CESARZ, S., BEAUMELLE, L., RILLIG, M. C., MAESTRE, F. T., DELGADO-BAQUERIZO, M., BUSCOT, F., OVERMANN, J., PATOINE, G., PHILLIPS, H. R. P., WINTER, M., et al. (2020). Blind spots in global soil biodiversity and ecosystem function research. *Nature Communications* **11**, 3870.
- *GUEVARA-CHUMACERO, L. M., LÓPEZ-WILCHIS, R., JUSTE, J., IBÁÑEZ, C., MARTÍNEZ-MÉNDEZ, L. A. & BARRIGA-SOSA, I. D. (2013). Conservation units of *Pteronotus davyi* (Chiroptera: Mormoopidae) in Mexico based on phylogeographical analysis. *Acta Chiropterologica* **15**, 353–363.
- *GULICKX, M. M. C., BEECROFT, R. C. & GREEN, A. C. (2007). Creating a bat hibernaculum at kingfishers bridge, Cambridgeshire, England. *Conservation Evidence* **4**, 41–42.
- *GURJARPADHYE, P., KAWALKAR, D., SINGH, R. P. & MANCHI, S. (2021). Stay or shift: does breeding success influence the decision in a cave-dwelling swiftlet? *Journal of Ornithology* **162**, 369–379.
- GUSENBAUER, M. & HADDADWAY, N. R. (2020). Which academic search systems are suitable for systematic reviews or meta-analyses? Evaluating retrieval qualities of Google scholar, PubMed, and 26 other resources. *Research Synthesis Methods* **11**, 181–217.
- *HAARMA, A. J., LINA, P. H., VOÛTE, A. M. & SIEPEL, H. (2019). Male long-distance migrant turned sedentary; the west European pond bat (*Myotis dasycneme*) alters their migration and hibernation behaviour. *PLoS One* **14**, e0217810.
- HADDADWAY, N. R., BETHEL, A., DICKS, L. V., KORICHEVA, J., MACURA, B., PETROKOFKY, G., PULLIN, A. S., SAVILAAKSO, S. & STEWART, G. B. (2020). Eight problems with literature reviews and how to fix them. *Nature Ecology & Evolution* **4**, 1582–1589.
- *HADJISTERKOTIS, E. (2006). The destruction and conservation of the Egyptian fruit bat *Rousettus aegyptiacus* in Cyprus: a historic review. *European Journal of Wildlife Research* **52**, 282–287.
- *HAHN, H. J. (2002). Grundwasser: Leben in ewiger Dunkelheit: Der vergessene Lebensraum. *Biologie in unserer Zeit* **32**, 110–117.
- *HAHN, H. J. (2004). Grundwasser, ein bisher verkannter Lebensraum. In *Biodiversität im Biosphärenreservat Pfälzerwald* (ed. J. OTT), pp. 66–78. Bund für Umwelt und Naturschutz Deutschland (BUND), Landesverband Rheinland-Pfalz e.V., Mainz.
- *HAHN, H. J. (2006). The GW-Fauna-index: a first approach to a quantitative ecological assessment of groundwater habitats. *Limnologia* **36**, 119–137.
- *HAHN, H. J. (2015). Biotop- und Artenschutz im Grundwasser/Rechtliche Stellung der Grundwasserökosysteme - eine persönliche Einschätzung. In *Grundwasser-geprägte Lebensräume. Limnologie aktuell* (eds H. BRENDLEBERGER, P. MARTIN, M. BRUNKE and H. J. HAHN), pp. 40–42. Schweizerbart, Stuttgart.
- *HAHN, H. J., SCHWEER, C. & GRIEBLER, C. (2018). Are groundwater ecosystem rights being preserved? A critical evaluation of the legal background of groundwater ecosystems. *Grundwasser* **23**, 209–218.
- *HAMMATT, H. H., HOWARTH, F. G., MIURA, M. T. & TOMONARI-TUGGLE, M. J. (1978). *Archaeological and Biological Survey of the Proposed Kāhuna Golf Village Area: Kōloa, Kōna*. Archaeological Research Center Hawaii, Kaua'i Island.
- *HANCOCK, P. J. & BOULTON, A. J. (2008). Stygofauna biodiversity and endemism in four alluvial aquifers in eastern Australia. *Invertebrate Systematics* **22**, 117–126.
- HANSON, J. O., RHODES, J. R., BUTCHART, S. H. M., BUCHANAN, G. M., RONDININI, C., FICETOLA, G. F. & FULLER, R. A. (2020). Global conservation of species' niches. *Nature* **580**, 232–234.
- *HARRIS, L. S., MORRISON, M. L., SZEWCZAK, J. M. & OSBORN, S. D. (2019). Assessment of the status of the Townsend's big-eared bat in California. *California Fish and Game* **105**, 101–119.
- *HARVEY, M. S., RIX, M. G., FRAMENAU, V. W., HAMILTON, Z. R., JOHNSON, M. S., TEALE, R. J., HUMPHREYS, G. & HUMPHREYS, W. F. (2011). Protecting the innocent: studying short-range endemic taxa enhances conservation outcomes. *Invertebrate Systematics* **25**, 1–10.
- *HARVEY, M. S., RIX, M. G., HILLYER, M. J. & HUEY, J. A. (2020). The systematics and phylogenetic position of the troglitic Australian spider genus *Trogloidiplura* (Araneae: Mygalomorphae), with a new classification for Anamidae. *Invertebrate Systematics* **34**, 799–822.
- *HARVEY, M. S. & WYNNE, J. J. (2014). Troglomorphic pseudoscorpions (Arachnida: Pseudoscorpiones) of northern Arizona, with the description of two new short-range endemic species. *The Journal of Arachnology* **42**, 205–219.
- *HAYES, M. A. & ADAMS, R. A. (2015). Maternity roost selection by fringed myotis in Colorado. *Western North American Naturalist* **75**, 460–473.
- *HAYES, M. A., SCHORR, R. A. & NAVO, K. W. (2011). Hibernacula selection by Townsend's big-eared bat in southwestern Colorado. *The Journal of Wildlife Management* **75**, 137–143.
- *HE, H. & ZHANG, L. B. (2011). *Polystichum cavernicola*, sp. nov. (sect. Haplopolystichum, Dryopteridaceae) from a karst cave in Guizhou, China and its phylogenetic affinities. *Botanical Studies* **52**, 121–127.
- *HEDIN, M. & DELLINGER, B. (2005). Descriptions of a new species and previously unknown males of *Nesticus* (Araneae: Nesticidae) from caves in eastern North America, with comments on species rarity. *Zootaxa* **904**, 1–19.
- *HEDIN, M., DERKARABETIAN, S., BLAIR, J. & PAQUIN, P. (2018). Sequence capture phylogenomics of eyeless *Cicarina* spiders from Texas caves, with emphasis on US federally-endangered species from Bexar County (Araneae, Hahniidae). *ZooKeys* **769**, 49–76.
- *HERNÁNDEZ-ORDÓÑEZ, O., CERVANTES-LÓPEZ, M. D. J., GONZÁLEZ-HERNÁNDEZ, A., ANDRESEN, E. & REYNOSO, V. H. (2017). First record of the limestone rainfrog *Craugastor psephosypharus* (Amphibia: Anura: Craugastoridae) in Mexico. *Revista Mexicana de Biodiversidad* **88**, 260–264.
- *HOBSON, C. S. & HOLLAND, J. N. (1995). Post-hibernation movement and foraging habitat of a male Indiana bat, *Myotis sodalis* (Chiroptera: Vespertilionidae), in western Virginia. *Brimleyana* **23**, 95–100.
- *HOLLAND, E. & PAPIS, R. (1993). Abercrombie Caves Plan of Management. 41 pp.
- *HOLSINGER, J. R. (1966). A preliminary study on the effects of organic pollution of the banners corner cave, Virginia. *International Journal of Speleology* **2**, 75–89.
- *HOLTZE, S., LUKAČ, M., CIZELJ, I., MUTSCHMANN, F., SZENTIKS, C. A., JELIČ, D., HERMES, R., GÖRITZ, F., BRAUDE, S. & HILDEBRANDT, T. B. (2017). Monitoring health and reproductive status of olms (*Proteus anguinus*) by ultrasound. *PLoS One* **12**, e0182209.
- *HOLZ, P., HUFSCHEMID, J., BOARDMAN, W. S., CASSEY, P., FIRESTONE, S., LUMSDEN, L. F., PROWSE, T. A. A., REARDON, T. & STEVENSON, M. (2019). Does the fungus causing white-nose syndrome pose a significant risk to Australian bats? *Wildlife Research* **46**, 657–668.
- *HOSE, G. C. (2005). Assessing the need for groundwater quality guidelines for pesticides using the species sensitivity distribution approach. *Human and Ecological Risk Assessment* **11**, 951–966.
- *HOSE, G. C., ASMYHR, M. G., COOPER, S. J. & HUMPHREYS, W. F. (2015). Down under down under: austral groundwater life. In *Austral Ark: The State of Wildlife in Australia and New Zealand* (eds A. STOW, N. MACLEAN and G. I. HOLWELL), pp. 512–536. Cambridge University Press, Cambridge.
- *HOSE, G. C., SYMINGTON, K., LOTT, M. J. & LATEGAN, M. J. (2016). The toxicity of arsenic (III), chromium (VI) and zinc to groundwater copepods. *Environmental Science and Pollution Research* **23**, 18704–18713.
- *HOWARTH, F. G. (1983). Ecology of cave arthropods. *Annual Review of Entomology* **28**, 365–389.
- *HOWARTH, F. G. (1982). Bioclimatic and geologic factors governing the evolution and distribution of Hawaiian cave insects. *Entomologia generalis* **8**, 17–26.
- *HOWARTH, F. G. (2021). Glacier caves: a globally threatened subterranean biome. *Journal of Cave and Karst Studies* **83**, 66–70.
- *HOWARTH, F. G., JAMES, S. A., McDOWELL, W., PRESTON, D. J. & IMADA, C. T. (2007). Identification of roots in lava tube caves using molecular techniques: implications for conservation of cave arthropod faunas. *Journal of Insect Conservation* **11**, 251–261.
- *HOWARTH, F. G., McDOWELL, W. & DOCKALL, J. (2003). *An Assessment of the Biological Importance and Recommendations for Management of Caves within the Kūkū'ula Property, Kōloa, Kauai*, p. 22. Prepared for Kūkū'ula Development Company (Hawaii), LLC, Kōloa.
- *HOWARTH, F. G. & STONE, F. D. (2020). Impacts of invasive rats on Hawaiian cave resources. *International Journal of Speleology* **49**, 35–42.
- HOYT, J. R., KILPATRICK, A. M. & LANGWIG, K. E. (2021). Ecology and impacts of white-nose syndrome on bats. *Nature Reviews Microbiology* **19**, 196–210.
- HOYT, J. R., LANGWIG, K. E., WHITE, J. P., KAARAKKA, H. M., REDELL, J. A., PARISE, K. L., FRICK, W. F., FOSTER, J. T. & KILPATRICK, A. M. (2019). Field trial of a probiotic bacteria to protect bats from white-nose syndrome. *Scientific Reports* **9**, 9158.
- *HSU, M. J. (1997). Population status and conservation of bats (Chiroptera) in Kenting National Park, Taiwan. *Oryx* **31**, 295–301.
- *HUMPHREYS, W. F. (1991). Experimental re-establishment of pulse-driven populations in a terrestrial troglobite community. *Journal of Animal Ecology* **60**, 609–623.
- *HUMPHREYS, W. F. (2006). Aquifers: the ultimate groundwater-dependent ecosystems. *Australian Journal of Botany* **54**, 115–132.
- *HUSMANN, S. (1964). Studien zur Ökologie und Verbreitung der Gattung *Chappuisius* Kieffer, 1938 (Copepoda, Harpacticoida); Mitteilung über Neufunde aus den Grundwasserströmen von Lahn, Niederrhein, Ruhr, Leine und Unterweser. *Crustaceana* **6**, 179–194.
- *HUSMANN, S. (1975). Versuche zur Erfassung der vertikalen Verteilung von Organismen und chemischen Substanzen im Grundwasser von Talaun und Terrassen; Methoden und erste Befunde. *International Journal of Speleology* **6**, 271–302.

- *HUSMANN, S. & MARXSEN, J. (1988). Besiedlung und Milieufaktoren im Grundwasser der Weserterrasse und der Fuldaaue. In *Bedeutung biologischer Vorgänge für die Beschaffenheit des Grundwassers*, pp. 246–255. DVVW, Parey, Hamburg, Berlin.
- *HUTCHINS, B. T. (2018). The conservation status of Texas groundwater invertebrates. *Biodiversity and Conservation* **27**, 475–501.
- *HUTCHINS, B., FONG, D. W. & CARLINI, D. B. (2010). Genetic population structure of the Madison cave isopod, *Antrolana lira* (Cymothoidea: Cirolanidae) in the Shenandoah Valley of the eastern United States. *Journal of Crustacean Biology* **30**, 312–322.
- *IANNELLA, M., FIASCA, B., DI LORENZO, T., DI CICCIO, M., BIONDI, M., MAMMOLA, S. & GALASSI, D. M. P. (2021). Getting the ‘Most out of the hotspot’ for practical conservation of groundwater biodiversity. *Global Ecology and Conservation* **31**, e01844.
- *IDREES, M. O., PRADHAN, B., BÜCHROITHNER, M. F., SHAFRI, H. Z. & BEJO, S. K. (2016). Assessing the transferability of a hybrid Taguchi-objective function method to optimize image segmentation for detecting and counting cave roosting birds using terrestrial laser scanning data. *Journal of Applied Remote Sensing* **10**, 035023.
- INFIELD, M. & NAMARA, A. (2001). Community attitudes and behaviour towards conservation: an assessment of a community conservation programme around Lake Mburo National Park, Uganda. *Oryx* **35**, 48–60.
- *INIESTA, L. F. M. & FERREIRA, R. L. (2013). The first troglolitic *Pseudonannolene* from Brazilian iron ore caves (Spirostreptida: Pseudonannolenidae). *Zootaxa* **3669**, 85–95.
- *INIESTA, L. F. & FERREIRA, R. L. (2013). Two new species of *Pseudonannolene* Silvestri, 1895 from Brazilian limestone caves (Spirostreptida: Pseudonannolenidae): synotypy of a troglolitic and a troglolitic species. *Zootaxa* **3702**, 357–369.
- *ISAIA, M., GIACHINO, P. M., SAPINO, E., CASALE, A. & BADINO, G. (2011). Conservation value of artificial subterranean systems: a case study in an abandoned mine in Italy. *Journal for Nature Conservation* **19**, 24–33.
- *IVANOVA, S. (2017). Influence of tourists on the summer bat colonies in the Devetashka cave, Bulgaria. *Acta Zoologica Bulgarica* **8**, 211–216.
- *JAFFÉ, R., PROUS, X., CALUX, A., GASTAUER, M., NIGACIO, G., ZAMPAULO, R., SOUZA-FILHO, P. W., OLIVEIRA, G., BRANDI, I. V. & SIQUEIRA, J. O. (2018). Conserving relics from ancient underground worlds: assessing the influence of cave and landscape features on obligate iron cave dwellers from the eastern Amazon. *PeerJ* **6**, e4531.
- *JAFFÉ, R., PROUS, X., ZAMPAULO, R., GIANNINI, T. C., IMPERATRIZ-FONSECA, V. L., MAURITY, C., OLIVEIRA, G., BRANDI, I. V. & SIQUEIRA, J. O. (2016). Reconciling mining with the conservation of cave biodiversity: a quantitative baseline to help establish conservation priorities. *PLoS One* **11**, e0168348.
- *JÄHNIG, S. C., ADRIAN, R., GROSSART, H.-P., FREYHOF, J., STOCK, M., HOLKER, F., JESCHKE, J. M., ARLINGHAUS, R., GESSNER, M., PUSH, M., HAASE, P., DUTZ, J., JURGENS, K., KREMP, A., KUBE, S., et al. (2019). *Lebendiges Wasser: Forschungsagenda zur biologischen Vielfalt*, Edition (Volume 13). Leibniz-Institut für Gewässerökologie und Binnenfischerei (IGB) im Forschungsverbund Berlin e. V., Berlin.
- *JANSKY, K., SCHUBERT, B. W. & WALLACE, S. C. (2016). Geometric morphometrics of dentaries in *Myotis*: species identification and its implications for conservation and the fossil record. *Northeastern Naturalist* **23**, 184–194.
- JASECHKO, S. & PERRONE, D. (2021). Global groundwater wells at risk of running dry. *Science* **372**, 418–421.
- JESCHKE, J. M., LOKATIS, S., BARTRAM, I. & TOCKNER, K. (2019). Knowledge in the dark: scientific challenges and ways forward. *FACETS* **4**, 423–441.
- *JIMENEZ, C., ACHILLEOS, K., PETROU, A., HADJOANNOU, L., GUIDO, A., ROSSO, A., GEROVASILEIOU, V., ALBANO, P. G., DI FRANCO, D., ANDREOU, V. & ABU ALHAIJA, R. (2019). A dream within a dream: Kakoskali cave, a unique marine ecosystem in Cyprus (Levantine Sea). *Marine caves of the eastern Mediterranean Sea. Biodiversity, Threats and Conservation* **53**, 91–110.
- *JOCHUM, A., SLAPNIK, R., KAMPSCHULTE, M., MARTELS, G., HENEKA, M. & PÁLL-GERGELY, B. (2014). A review of the microgastropod genus *Systemostoma* Bavay & Dautzenberg, 1908 and a new subterranean species from China (Gastropoda, Pulmonata, Hypsclomatidae). *Zoologica* **410**, 23–40.
- *JOHNSON, W. M. & LAVIGNE, D. M. (1999). Mass tourism and the Mediterranean monk seal. *The Monachus Guardian* **2**, 1–30.
- *JOHNSON, J. B., WOOD, P. B. & EDWARDS, J. W. (2006). Are external mine entrance characteristics related to bat use? *Wildlife Society Bulletin* **34**, 1368–1375.
- JUNG, M., ARNELL, A., DE LAMO, X., GARCÍA-RANGEL, S., LEWIS, M., MARK, J., MEROW, C., MILES, L., ONDO, I., PIRONON, S., RAVILIOUS, C., RIVERS, M., SCHEPASHENKO, D., TALLOWIN, O., VAN SOESBERGEN, A., et al. (2021). Areas of global importance for conserving terrestrial biodiversity, carbon and water. *Nature Ecology & Evolution* **5**, 1499–1509.
- KADYKALO, A. N., BUXTON, R. T., MORRISON, P., ANDERSON, C. M., BICKERTON, H., FRANCIS, C. M., SMITH, A. C. & FAHRIG, L. (2021). Bridging research and practice in conservation. *Conservation Biology* **35**, 1725–1737.
- *KARANOVIC, T., EBERHARD, S., COOPER, S. J. & GUZIK, M. T. (2015). Morphological and molecular study of the genus *Nitokra* (Crustacea, Copepoda, Harpacticoida) in a small palaeochannel in Western Australia. *Organisms Diversity & Evolution* **15**, 65–99.
- KAREIVA, P. & MARVIER, M. (2012). What is conservation science? *Bioscience* **62**, 962–969.
- *KATH, J. A. (2000). A Midwestern case study to secure an underground mine for bat habitat: the Unimin magazine mine in Alexander County, Illinois. In *Proceedings of Bat Conservation and Mining: A Technical Interactive Forum*, pp. 169–172. US Department of Interior, Office of Surface Mining and Coal Research Center, Southern Illinois University, Carbondale.
- *KATSANEVAKIS, S., TSIRINTANIS, K., SINI, M., GEROVASILEIOU, V. & KOUKOUROUVLI, N. (2020). Aliens in the Aegean—A Sea under siege (ALAS). *Research Ideas and Outcomes* **6**, e53057.
- *KARANOVIC, T., EBERHARD, S. M., PERINA, G. & CALLAN, S. (2013). Two new subterranean ameiriids (Crustacea: Copepoda: Harpacticoida) expose weaknesses in the conservation of short-range endemics threatened by mining developments in Western Australia. *Invertebrate Systematics* **27**, 540–566.
- *KARUNARATHNA, S., BAUER, A. M., DE SILVA, A., SURASINGHE, T., SOMARATNA, L., MADAWALA, M., GABADAGE, D., BOTEJUE, M., HENKANATHHEGEDARA, S. & UKUWELA, K. D. (2019). Description of a new species of the genus *Cnemaspis* Strauch, 1887 (Reptilia: Squamata: Gekkonidae) from the Nilgala Savannah forest, Uva Province of Sri Lanka. *Zootaxa* **4545**, 389–407.
- *KEARNEY, T. C., KEITH, M. & SEAMARK, E. C. (2017). New records of bat species using Gatkop cave in the maternal season. *Mammalia* **81**, 41–48.
- *KIBICHI, S., FEELEY, H. B., BAARS, J. R. & KELLY-QUINN, M. (2015). The influence of water quality on hyporheic invertebrate communities in agricultural catchments. *Marine and Freshwater Research* **66**, 805–814.
- KING, R. H. (2005). Microclimate Effects from Closing Abandoned Mines with Culvert Bat Gates. Technical Note 416, Golden, 15 pp.
- *KINGSTON, T. (2010). Research priorities for bat conservation in Southeast Asia: a consensus approach. *Biodiversity and Conservation* **19**, 471–484.
- *KLEIN, L. & PÄRTEL, L. (2017). Improving the Pond Bat (*Myotis dasycneme*) habitats in Estonia. Electronic file available at <https://elfond.org/bats/the-project> Accessed 23.2.2021.
- *KULHAVY, V. (1982). Einfluß der Desinfektion auf die chemischen und biologischen Eigenschaften von Grundwasser. *Polski Archiwum Hydrobiologii* **29**, 519–526.
- KNIGHT, A. T., COWLING, R. M., ROUGET, M., BALMFORD, A., LOMBARD, A. T. & CAMPBELL, B. M. (2008). Knowing but not doing: selecting priority conservation areas and the research–implementation gap. *Conservation Biology* **22**, 610–617.
- *KOFOKY, A., ANDRIAFIDISON, D., RATRIMOMANARIVO, F., RAZAFIMANAHAKA, H. J., RAKOTONDRAVONY, D., RACEY, P. A. & JENKINS, R. K. (2006). Habitat use, roost selection and conservation of bats in Tsingy de Bemaraha National Park, Madagascar. In *Vertebrate Conservation and Biodiversity* (eds D. L. HAWKSWORTH and A. T. BULL), pp. 213–227. Springer, Dordrecht.
- KOLAR, B. & FINIZIO, A. (2017). Assessment of environmental risks to groundwater ecosystems related to use of veterinary medicinal products. *Regulatory Toxicology and Pharmacology* **88**, 303–309.
- *KOLUPAEVA, V. N., BELIK, A. A., KOKOREVA, A. A. & ASTAIKINA, A. A. (2019). Risk assessment of pesticide leaching into groundwater based on the results of a lysimetric experiment. *IOP Conference Series: Earth and Environmental Science* **368**, 012023.
- *KOPPELMAN, J. B. & FIGG, D. E. (1995). Genetic estimates of variability and relatedness for conservation of an Ozark cave crayfish species complex. *Conservation Biology* **9**, 1288–1294.
- KORBEL, K., CHARITON, A., STEPHENSON, S., GREENFIELD, P. & HOSE, G. C. (2017). Wells provide a distorted view of life in the aquifer: implications for sampling, monitoring and assessment of groundwater ecosystems. *Scientific Reports* **7**, 40702.
- *KORBEL, K. L. & HOSE, G. C. (2011). A tiered framework for assessing groundwater ecosystem health. *Hydrobiologia* **661**, 329–349.
- *KORBEL, K. L. & HOSE, G. C. (2017). The weighted groundwater health index: improving the monitoring and management of groundwater resources. *Ecological Indicators* **75**, 164–181.
- *KOSTANJŠEK, R., DIDERICHSEN, B., RECKNAGEL, H., GUNDE-CIMERMAN, N., GOSTINČAR, C., FAN, G., KORDIŠ, D., TRONTELJ, P., JIANG, H., BOLUND, L. & LUO, Y. (2022). Toward the massive genome of *Proteus anguinus*—illuminating longevity, regeneration, convergent evolution, and metabolic disorders. *Annals of the New York Academy of Sciences* **1507**, 5–11.
- *KOZEL, P., PIPAN, T., ŠAJNA, N., POLAK, S. & NOVAK, T. (2017). Mitigating the conflict between pitfall-trap sampling and conservation of terrestrial subterranean communities in caves. *International Journal of Speleology* **46**, 359–368.
- *KREILING, A. K., OLAFSSON, J. S., PÁLSSON, S. & KRISTJANSSON, B. K. (2018). Chironomidae fauna of springs in Iceland: assessing the ecological relevance behind Tuxen’s spring classification. *Journal of Limnology* **77**, 145–154.
- *KRETMANN, J. (2000). New Mexico experience with bat grates at abandoned mines. In *Proceedings of Bat Conservation and Mining: A Technical Interactive Forum* (eds K. C. VORIES and

- D. THROGMORTON), pp. 145–153. US Department of Interior, Office of Surface Mining, Alton and Coal Research Center, Southern Illinois University, Carbondale.
- *KRSTUFEK, B. (2008). Bat hibernacula in a cave-rich landscape of the northern Dinaric karst, Slovenia. *Hystrix-The Italian Journal of Mammalogy* **18**, 195–204.
- *KUHAJDA, B. R. & MAYDEN, R. L. (2001). Status of the federally endangered Alabama cavefish, *Speoplatyrhinus poulsoni* (Amblyopsidae), in key cave and surrounding caves, Alabama. *Environmental Biology of Fishes* **62**, 215–222.
- *LADLE, R. J., FIRMINO, J. V., MALHADO, A. C. & RODRÍGUEZ-DURÁN, A. (2012). Unexplored diversity and conservation potential of Neotropical hot caves. *Conservation Biology* **26**, 978–982.
- *LAGNIKA, M., IBIKOUNLE, M. & BOUTIN, C. (2016). Groundwater biodiversity and water quality of wells in the southern region of Benin. *Comptes Rendus Chimie* **19**, 798–806.
- LAJEUNESSE, M. J. (2013). Recovering missing or partial data from studies: a survey of conversions and imputations for meta-analysis. In *Handbook of Meta-Analysis in Ecology and Evolution* (eds J. KORICHEVA, J. GUREVITCH and K. MENGENSEN), pp. 195–206. Princeton University Press, Princeton.
- *LAM, K., MORTON, B. & HODGSON, P. (2008). Ahermatypic corals (Scleractinia: Dendrophylliidae, Oculinidae and Rhizangiidae) recorded from submarine caves in Hong Kong. *Journal of Natural History* **42**, 729–747.
- LANDHUIS, E. (2016). Scientific literature: information overload. *Nature* **535**, 457–458.
- *LATEGAN, M. J. & HOSE, G. C. (2014). Development of a groundwater fungal strain as a tool for toxicity assessment. *Environmental Toxicology and Chemistry* **33**, 2826–2834.
- *LATEGAN, M. J., KLARE, W., KIDD, S., HOSE, G. C. & NEVALAINEN, H. (2016). The unicellular fungal tool RhoTox for risk assessments in groundwater systems. *Ecotoxicology and Environmental Safety* **132**, 18–25.
- *LEAL, E. S. B. & BERNARD, E. (2021). Mobility of bats between caves: ecological aspects and implications for conservation and environmental licensing activities in Brazil. *Studies on Neotropical Fauna and Environment* **2021**, 1–11.
- *LEAL-ZANCHET, A. M. & MARQUES, A. D. (2018). Coming out in a harsh environment: a new genus and species for a land flatworm (Platyhelminthes: Tricladida) occurring in a ferruginous cave from the Brazilian savanna. *Pearl* **6**, e6007.
- *LEDESMA, E., JIMÉNEZ-VALVERDE, A., BAQUERO, E., JORDANA, R., DE CASTRO, A. & ORTUÑO, V. M. (2020). Arthropod biodiversity patterns point to the Mesovoid shallow substratum (MSS) as a climate refugium. *Zoology* **141**, 125771.
- *LEE, D. N., STARK, R. C., PUCKETT, W. L., HAMILTON, M. J., LESLIE, D. M. JR. & VAN DEN BUSSCHE, R. A. (2015). Population connectivity of endangered Ozark big-eared bats (*Corynorhinus townsendii ingens*). *Journal of Mammalogy* **96**, 522–530.
- *LEHNERT, L. S., KRAMER-SCHADT, S., TEIGE, T., HOFFMEISTER, U., POPALISSEANU, A., BONTADINA, F., CIECHANOWSKI, M., DECHMANN, D. K. N., KRAVCHENKO, K., PRESETNIK, P., STARRACH, M., STRAUBE, M., ZOEPHEL, U. & VOIGT, C. C. (2018). Variability and repeatability of noctule bat migration in Central Europe: evidence for partial and differential migration. *Proceedings of the Royal Society B* **285**, 20182174.
- *LERA, T. (2009). The Virginia cave protection act: a review (1966–2009). *Journal of Cave and Karst Studies* **71**, 204–209.
- *LESIŃSKI, G., KOWALSKI, M., DOMAŃSKI, J., DZIĘCIOŁOWSKI, R., LASKOWSKA-DZIĘCIOŁOWSKA, K. & DZIĘGIELEWSKA, M. (2004). The importance of small cellars to bat hibernation in Poland. *Mammalia* **68**, 345–352.
- *LEWANDOWSKI, J., ARNON, S., BANKS, E., BATELAAN, O., BETTERLE, A., BROECKER, T., COLL, C., DRUMMOND, J. D., GAONA GARCIA, J., GALLOWAY, J. & GOMEZ-VELEZ, J. (2019). Is the hyporheic zone relevant beyond the scientific community? *Water* **11**, 2230.
- *LEWIS, J. J., MOSS, P., TECIC, D. & NELSON, M. E. (2003). A conservation focused inventory of subterranean invertebrates of the southwestern Illinois karst. *Journal of Cave and Karst Studies* **65**, 9–21.
- *LLAVEN-MACÍAS, V., RUIZ-MONTOYA, L., LÓPEZ-GONZÁLEZ, C., RICO, Y. & NARANJO, E. J. (2021). Monthly fluctuation of colony size and composition of the free-tailed bat *Tadarida brasiliensis* in the southernmost roost of Mexico. *Mammal Research* **66**, 339–348.
- LI, C., GAO, X., LI, S. & BUNDSCHUH, J. (2020). A review of the distribution, sources, genesis, and environmental concerns of salinity in groundwater. *Environmental Science and Pollution Research* **27**, 41157–41174.
- *LIANG, Z. Q., ZHANG, S. H., WANG, C. R., WEI, Q. & WU, Y. (2013). Present situation of natural resources and protection recommendations of *Andrias davidianus*. *Freshwater Fisheries* **43**, 13–17.
- *LIM, T., CAPPELLE, J., HOEM, T. & FUREY, N. (2018). Insectivorous bat reproduction and human cave visitation in Cambodia: a perfect conservation storm? *PLoS One* **13**, e0196554.
- LINDENMAYER, D. B., PIGGOTT, M. P. & WINTLE, B. A. (2013). Counting the books while the library burns: why conservation monitoring programs need a plan for action. *Frontiers in Ecology and the Environment* **11**, 549–555.
- *LINKE, S., TURAK, E., ASMYHR, M. G. & HOSE, G. (2019). 3D conservation planning: including aquifer protection in freshwater plans refines priorities without much additional effort. *Aquatic Conservation: Marine and Freshwater Ecosystems* **29**, 1063–1072.
- *LISÓN, F., PALAZÓN, J. A. & CALVO, J. F. (2013). Effectiveness of the Natura 2000 network for the conservation of cave-dwelling bats in a Mediterranean region. *Animal Conservation* **16**, 528–537.
- *LIU, W. & WYNNE, J. J. (2019). Cave millipede diversity with the description of six new species from Guangxi, China. *Subterranean Biology* **30**, 57–94.
- *LONGING, S. D. & HAGGARD, B. E. (2009). New distribution records of an endemic diving beetle, *Heterostemuta sulphuria* (Coleoptera: Dytiscidae: Hydroproinae), in Arkansas with comments on habitat and conservation. *The Southwestern Naturalist* **54**, 357–361.
- *LÓPEZ-BAUCELLS, A., ROCHA, R. & FERNÁNDEZ-LLAMAZARES, Á. (2018). When bats go viral: negative framings in virological research imperil bat conservation. *Mammal Review* **48**, 62–66.
- *LÓPEZ-GONZÁLEZ, C. & TORRES-MORALES, L. (2004). Use of abandoned mines by long-eared bats, genus *Corynorhinus* (Chiroptera: Vespertilionidae) in Durango, Mexico. *Journal of Mammalogy* **85**, 989–994.
- LOPEZ-MALDONADO, Y. & BERKES, F. (2017). Restoring the environment, revitalizing the culture: cenote conservation in Yucatan, Mexico. *Ecology and Society* **22**, 7.
- *LLORET, J., MARÍN, A., MARÍN-GUIRAO, L. & FRANCISCA CARREÑO, M. (2006). An alternative approach for managing scuba diving in small marine protected areas. *Aquatic Conservation: Marine and Freshwater Ecosystems* **16**, 579–591.
- LÜDECKE, D., BEN-SHACHAR, M. S., PATIL, I., WAGGONER, P. & MAKOWSKI, D. (2020). Performance: an R package for assessment, comparison and testing of statistical models. *The Journal of Open Source Software* **6**, 3139.
- *LUDLOW, M. E. & GORE, J. A. (2000). Effects of a cave gate on emergence patterns of colonial bats. *Wildlife Society Bulletin* **28**, 191–196.
- LUKAČ, M., CIZELJ, I. & MUTSCHMANN, F. (2019). Health research and ex situ keeping of *Proteus anguinus*. In *Proteus* (eds K. ŠARIĆ, D. JELIĆ, P. KONRAD and B. JALŽIĆ), pp. 219–232. Udruga Hyla, Zagreb.
- *LUNGI, E., CORTI, C., MULARGIA, M., ZHAO, Y., MANENTI, R., FICETOLA, G. F. & VEITH, M. (2020a). Cave morphology, microclimate and abundance of five cave predators from the Monte Albo (Sardinia, Italy). *Biodiversity Data Journal* **8**, e48623.
- *LUNGI, E., GIACHELLO, S., MANENTI, R., ZHAO, Y., CORTI, C., FICETOLA, G. F. & BRADLEY, J. G. (2020b). The post hoc measurement as a safe and reliable method to age and size plethodontid salamanders. *Ecology and Evolution* **10**, 11111–11116.
- *LUNGI, E., GIACHELLO, S., ZHAO, Y., CORTI, C., FICETOLA, G. F. & MANENTI, R. (2020c). Photographic database of the European cave salamanders, genus *Hydromantes*. *Scientific Data* **7**, 1–6.
- *LUO, J., JIANG, T., LU, G., WANG, L., WANG, J. & FENG, J. (2013). Bat conservation in China: should protection of subterranean habitats be a priority? *Oryx* **47**, 526–531.
- *LUO, J., LU, G. & FENG, J. (2012). Diurnal capture reduces the colony size of *Hipposideros armiger* (Chiroptera: Hipposideridae). *Mammalia* **76**, 447–449.
- *LUO, S., YANG, Y. & CHUI, T. F. M. (2020). Tidal responses of groundwater level and salinity in a silty mangrove swamp of different topographic characteristics. *Journal of Hydrology* **591**, 125598.
- *MAAZOUZI, C., COUREAU, C., PISCART, C., SAPLAIROLES, M., BARAN, N. & MARMONIER, P. (2016). Individual and joint toxicity of the herbicide S-metolachlor and a metabolite, deethylazine on aquatic crustaceans: difference between ecological groups. *Chemosphere* **165**, 118–125.
- *MACHADO, M. C., MONSALVE, M. A., CASTELLÓ, A., ALMENAR, D., ALCOCER, A. & MONRÓS, J. S. (2017). Population trends of cave-dwelling bats in the eastern Iberian Peninsula and the effect of protecting their roosts. *Acta Chiropterologica* **19**, 107–118.
- *MAČIĆ, V., ĐORĐEVIĆ, N., PETOVIĆ, S., MALOVRAZIĆ, N. & BAJKOVIĆ, M. (2018). Typology of marine litter in Papuča “(slipper)” cave (Montenegro, South Adriatic Sea). *Studia Marina* **31**, 38–43.
- *MAČIĆ, V., PANOU, A., BUNDONE, L., VARDA, D. & PAVIČEVIĆ, M. (2019). First inventory of the semi-submerged marine caves in south Dinarides karst (Adriatic coast) and preliminary list of species. *Turkish Journal of Fisheries and Aquatic Sciences* **19**, 765–774.
- MAEZONO, Y. & MIYASHITA, T. (2004). Impact of exotic fish removal on native communities in farm ponds. *Ecological Research* **19**, 263–267.
- *MAKORI, B. (2015). *Survey and Conservation of Cave-Dwelling Bats in Coastal Kenya*, p. 15. Karatina University, School of Natural Resources and Environmental Studies, Karatina.
- *MALARD, F. (2001). Groundwater contamination and ecological monitoring in a Mediterranean karst ecosystem in southern France. In *Groundwater Ecology. A Tool for Management of Water Resources* (eds C. GRIEBLER, D. L. DANIELOPOL, J. GIBERT, H. P. NACHTNEBEL and J. NOTENBOOM), pp. 183–194. Environment and Climate Programme European Commission, Luxembourg.
- *MALARD, F., REYGROBELLET, J. L. & LAURENT, R. (1998). Spatial distribution of hypogean invertebrates in an alluvial aquifer polluted by iron and manganese, Rhone River, France. *Internationale Vereinigung für theoretische und angewandte Limnologie: Verhandlungen* **26**, 1590–1594.

- *MALARD, F., MATHIEU, J., REYGROBELLET, J. L. & LAFONT, M. (1996). Biomonitoring groundwater contamination: application to a karst area in southern France. *Aquatic Sciences* **58**, 158–187.
- *MALARD, F., REYGROBELLET, J. L., MATHIEU, J. & LAFONT, M. (1994). The use of invertebrate communities to describe groundwater flow and contaminant transport in a fractured rock aquifer. *Archiv für Hydrobiologie* **131**, 93–110.
- MAMMOLA, S. (2019). Finding answers in the dark: caves as models in ecology fifty years after Poulson and White. *Ecography* **42**, 1331–1351.
- *MAMMOLA, S., AMORIM, I. R., BICHUETTE, M. E., BORGES, P. A. V., CHEEPHAM, N., COOPER, S. J. B., CULVER, D. C., DEHARVING, L., EME, D., FERREIRA, R. L., FIŠER, C., FIŠER, Ž., FONG, D. W., GRIEBLER, C., JEFFERY, W. R., et al. (2020a). Fundamental research questions in subterranean ecology. *Biological Reviews* **95**, 1855–1872.
- *MAMMOLA, S., CARDOSO, P., CULVER, D. C., DEHARVING, L., FERREIRA, R. L., FIŠER, C., GALASSI, D. M. P., GRIEBLER, C., HALSE, S., HUMPHREYS, W. F., ISAIA, M., MALARD, F., MARTINEZ, A., MOLDOVAN, O. T., NIEMILLER, M. L., et al. (2019a). Scientists' warning on the conservation of subterranean ecosystems. *Bioscience* **69**, 641–650.
- *MAMMOLA, S., FRIGO, I. & CARDOSO, P. (2022). Life in the darkness of caves. *Frontiers for Young Minds*.
- MAMMOLA, S., GIACHINO, P. M., PIANO, E., JONES, A., BARBERIS, M., BADINO, G. & ISAIA, M. (2016). Ecology and sampling techniques of an understudied subterranean habitat: the *milieu Souterrain Superficiel* (MSS). *The Science of Nature* **103**, 88.
- *MAMMOLA, S., GOODACRE, S. L. & ISAIA, M. (2018). Climate change may drive cave spiders to extinction. *Ecography* **41**, 233–243.
- *MAMMOLA, S., HORMIGA, G. & ISAIA, M. (2017). Species conservation profile of the stenoendemic cave spider *Pimoida delphinica* (Araneae, Pimoidae) from the Varaita valley (NW-Italy). *Biodiversity Data Journal* **5**, e11509.
- *MAMMOLA, S. & ISAIA, M. (2017). Spiders in caves. *Proceedings of the Royal Society B: Biological Sciences* **284**, 20170193.
- *MAMMOLA, S. & LEROY, B. (2018). Applying species distribution models to caves and other subterranean habitats. *Ecography* **41**, 1194–1208.
- MAMMOLA, S., LUNGI, E., BILANDŽIJA, H., CARDOSO, P., GRIMM, V., SCHMIDT, S. I., HESSELBERG, T. & MARTINEZ, A. (2021a). Collecting eco-evolutionary data in the dark: impediments to subterranean research and how to overcome them. *Ecology and Evolution* **11**, 5911–5926.
- *MAMMOLA, S., MILANO, F. & ISAIA, M. (2019). Taxonomy, ecology and conservation of the cave-dwelling spider *Histopona palaeolithica*, with the description of *H. petrovi* sp. nov. (Araneae: Agelenidae). *The Journal of Arachnology* **47**, 317–325.
- *MAMMOLA, S., PIANO, E., CARDOSO, P., VERNON, P., DOMÍNGUEZ-VILLAR, D., CULVER, D. C. D. C., PIPAN, T. & ISAIA, M. (2019b). Climate change going deep: the effects of global climatic alterations on cave ecosystems. *The Anthropocene Review* **6**, 98–116.
- MAMMOLA, S., PIANO, E., MALARD, F., VERNON, P. & ISAIA, M. (2019c). Extending Janzen's hypothesis to temperate regions: a test using subterranean ecosystems. *Functional Ecology* **33**, 1638–1650.
- MAMMOLA, S., RICCARDI, N., PRIÉ, V., CORREIA, R., CARDOSO, P., LOPES-LIMA, M. & SOUSA, R. (2020b). Towards a taxonomically unbiased European Union biodiversity strategy for 2030. *Proceedings of the Royal Society B: Biological Sciences* **287**, 20202166.
- *MAMMOLA, S., SOUZA, M. F. V. R., ISAIA, M. & FERREIRA, R. L. (2021b). Global distribution of microwhip scorpions (Arachnida: Palpigradi). *Journal of Biogeography* **48**(6), 1518–1529.
- *MANGINA, C., ECHENIQUE-DIAZ, L., TEJEDOR, A., GARCÍA, L., DANIEL-ALVAREZ, A. & ORTEGA-HUERTA, M. (2007). Endemics under threat: an assessment of the conservation status of Cuban bats. *Hystrix, The Italian Journal of Mammalogy* **18**, 3–15.
- *MANCONI, R. & SERUSI, A. (2008). Rare sponges from marine caves: discovery of *Neophrissospongia nana* nov. sp. (Demospongiae, Corallistidae) from Sardinia with an annotated checklist of Mediterranean lithistids. *ZooKeys* **4**, 71–87.
- *MANCONI, R., LEDDA, F. D., SERUSI, A., CORSO, G. & STOCCHINO, G. A. (2009). Sponges of marine caves: notes on the status of the Mediterranean palaeoendemic *Petrobiona massiliana* (Porifera: Calcarea: Lithonida) with new records from Sardinia. *Italian Journal of Zoology* **76**, 306–315.
- *MANENTI, R., BARZAGHI, B., TONNI, G., FICETOLA, G. F. & MELOTTO, A. (2019). Even worms matter: cave habitat restoration for a planarian species increased environmental suitability but not abundance. *Oryx* **53**, 216–221.
- *MANENTI, R., FICETOLA, G. F., MARIENI, A. & DE BERNARDI, F. (2011). Caves as breeding sites for *Salamandra salamandra*: habitat selection, larval development and conservation issues. *North-Western Journal of Zoology* **7**, 304–309.
- MANENTI, R., PIAZZA, B., ZHAO, Y., PADOA SCHIOPPA, E. & LUNGI, E. (2021). Conservation studies on groundwaters' pollution: challenges and perspectives for stygofauna communities. *Sustainability* **13**, 7030.
- *MANN, S. L., STEIDL, R. J. & DALTON, V. M. (2002). Effects of cave tours on breeding *Myotis velifer*. *The Journal of Wildlife Management* **66**, 618–624.
- *MARMONIER, P., DES CHÂTELLIERS, M. C., DOLE-OLIVIER, M. J., RADAKOVITCH, O., MAYER, A., CHAPUIS, H., GRAILLOT, D., RE-BAHUAUD, J., JOHANNET, A. & CADILHAC, L. (2020). Are surface water characteristics efficient to locate hyporheic biodiversity hotspots? *Science of the Total Environment* **738**, 139930.
- *MARMONIER, P., MAZOUZI, C., BARAN, N., BLANCHET, S., RITTER, A., SAPLAIROLES, M., DOLE-OLIVIER, M. J., GALASSI, D. M., EME, D., DOLÉDEC, S. & PISCART, C. (2018). Ecology-based evaluation of groundwater ecosystems under intensive agriculture: a combination of community analysis and sentinel exposure. *Science of the Total Environment* **613**, 1353–1366.
- *MARMONIER, P., MAZOUZI, C., FOULQUIER, A., NAVEL, S., FRANÇOIS, C., HERVANT, F., MERMILLOD-BLONDIN, F., VIENEY, A., BARRAUD, S., TOGOLA, A. & PISCART, C. (2013). The use of crustaceans as sentinel organisms to evaluate groundwater ecological quality. *Ecological Engineering* **57**, 118–132.
- *MARNELL, F. & P. PRESETNIK (2010). Protection of Overground Roosts for Bats (Particularly Roosts in Buildings of Cultural Heritage Importance). EUROBATs Publication Series No. 4 (English Version). UNEP / EUROBATs Secretariat, Bonn, Germany. 57 pp.
- *MARRACK, L., BEAVERS, S. & O'GRADY, P. (2015). The relative importance of introduced fishes, habitat characteristics, and land use for endemic shrimp occurrence in brackish anchialine pool ecosystems. *Hydrobiologia* **758**, 107–122.
- *MARTIN, K. W., LESLIE, D. M.JR., PAYTON, M. E., PUCKETTE, W. L. & HENSLEY, S. L. (2003). Internal cave gating for protection of colonies of the endangered gray bat (*Myotis grisescens*). *Acta Chiropterologica* **5**, 143–150.
- *MARTIN, K. W., LESLIE, D. M.JR., PAYTON, M. E., PUCKETTE, W. L. & HENSLEY, S. L. (2006). Impacts of passage manipulation on cave climate: conservation implications for cave-dwelling bats. *Wildlife Society Bulletin* **34**, 137–143.
- *MARTIN-SANCHEZ, P. M., NOVÁKOVÁ, A., BASTIAN, F., ALABOUVETTE, C. & SAIZ-JIMENEZ, C. (2012). Use of biocides for the control of fungal outbreaks in subterranean environments: the case of the Lascaux cave in France. *Environmental Science & Technology* **46**, 3762–3770.
- *MARXSEN, J., RÜTZ, N. K. & SCHMIDT, S. I. (2021). Organic carbon and nutrients drive prokaryote and metazoan communities in a floodplain aquifer. *Basic and Applied Ecology* **51**, 43–58.
- *MASCIOPIANTO, C., SEMERARO, F., LA MANTIA, R., INGUSCIO, S. & ROSSI, E. (2006). Stygofauna abundance and distribution in the fissures and caves of the Nardo (southern Italy) fractured aquifer subject to reclaimed water injections. *Geomicrobiology Journal* **23**, 267–278.
- *MATHES, R. C., BOSNAK, A. D., TENNANT, D. S. & MORGAN, E. L. (1977). Mortality curves of blind cave crayfish (*Oreocetes australis australis*) exposed to chlorinated stream water. *Hydrobiologia* **53**, 107–111.
- *MATZKE, D., HAHN, H. J., RAMSTÖCK, A. & ROTHER, K. (2005). Bewertung von Altlasten im Grundwasser anhand der Meiofaunagemeinschaften—erste Ergebnisse. *Grundwasser* **10**, 25–34.
- *MAYEROVA-SMRZOVA, E. (1976). *Pusobeni Sagenu na Komplex Organismu Tvoricich Potravni Retezci*. Diploma Thesis, Faculty of Natural Sciences of the Charles University, Prague.
- *MAZEBEDI, R. & HESSELBERG, T. (2020). A preliminary survey of the abundance, diversity and distribution of terrestrial macroinvertebrates of Gwihaba cave, Northwest Botswana. *Subterranean Biology* **35**, 49–63.
- MAZEL, F., PENNELL, M. W., CADOTTE, M. W., DIAZ, S., DALLA RIVA, G. V., GRENYER, R., LEPRIEUR, F., MOOERS, A. O., MOULLOT, D., TUCKER, C. M. & PEARSE, W. D. (2018). Prioritizing phylogenetic diversity captures functional diversity unreliably. *Nature Communications* **9**, 2888.
- *MCANEY, K. (1999). Mines as roosting sites for bats: their potential and protection. In *Biology and Environment: Proceedings of the Royal Irish Academy* **99**, 63–65.
- *MCIVER, W. R., CARTER, H. R., HARVEY, A. L., MAZURKIEWICZ, D. M., HOWARD, J. A., MARTIN, P. L. & MASON, J. W. (2018). Avian and skunk predation of ash storm-petrels at Santa Cruz Island, California. *Western North American Naturalist* **78**, 421–440.
- MCMAHAN, P. & MCFARLAND, D. A. (2021). Creative destruction: the structural consequences of scientific curation. *American Sociological Review* **86**, 341–376.
- *MEANS, M. L. & JOHNSON, J. E. (1995). Movement of threatened Ozark cavefish in Logan cave national wildlife refuge, Arkansas. *The Southwestern Naturalist* **40**, 308–313.
- MEASEY, G. J., ARMSTRONG, A. J. & HANEKOM, C. (2009). Subterranean herpetofauna show a decline after 34 years in Ndumu game reserve, South Africa. *Oryx* **43**, 284–287.
- *MEDELLIN, R. A., WIEDERHOLT, R. & LOPEZ-HOFFMAN, L. (2017). Conservation relevance of bat caves for biodiversity and ecosystem services. *Biological Conservation* **211**, 45–50.
- MEIERHOFER, M. B., CARDOSO, P., LILLEY, T. M. & MAMMOLA, S. (2022). The promise and perils of engineering cave climates. *Conservation Biology*.
- *MEIERHOFER, M. B., JOHNSON, J. S., LEIVERS, S. J., PIERCE, B. L., EVANS, J. E. & MORRISON, M. L. (2019). Winter habitats of bats in Texas. *PLoS One* **14**, e0220839.
- *MEIERHOFER, M. B., LILLEY, T. M., RUOKOLAINEN, L., JOHNSON, J. S., PARRATT, S. R., MORRISON, M. L., PIERCE, B. L., EVANS, J. W. & ANTILLA, J. (2021). Ten-year projection of white-nose syndrome disease dynamics at the

- southern leading-edge of infection in North America. *Proceedings of the Royal Society B* **288**, 20210719.
- *MEINEL, W. & KRAUSE, R. (1988). Zur Korrelation zwischen Zink und verschiedenen pH-Werten in ihrer toxischen Wirkung auf einige Grundwasser-Organismen. *Zeitschrift für angewandte Zoologie* **75**, 159–182.
- *MEINEL, W., KRAUSE, R. & MUSKO, J. (1989). Experimente zur pH-Wert-abhängigen Toxizität von Kadmium bei einigen Grundwasserorganismen. *Zeitschrift für angewandte Zoologie* **76**, 101–125.
- *MENDES RABELO, L., SOUZA-SILVA, M. & LOPES FERREIRA, R. (2021). Epigeic and hypogean drivers of Neotropical subterranean communities. *Journal of Biogeography* **48**, 662–675.
- *MERCADO-SALAS, N. F., MORALES-VÉLA, B., SUÁREZ-MORALES, E. & ILIFFE, T. M. (2013). Conservation status of the inland aquatic crustaceans in the Yucatan peninsula, Mexico: shortcomings of a protection strategy. *Aquatic Conservation: Marine and Freshwater Ecosystems* **23**, 939–951.
- *MERRITT, D. J. & CLARKE, A. K. (2013). The impact of cave lighting on the bioluminescent display of the Tasmanian glow-worm *Arachnocampa tasmaniensis*. *Journal of Insect Conservation* **17**, 147–153.
- *MESSANA, G. & ARGANO, R. (2019). A new stygobiotic *Stenasellus* Dollfus, 1897 (Asellota: Stenasellidae) from Socotra Island, Yemen. *Zootaxa* **4683**, zootaxa-4683.
- *MEŠTROV, M. & LATTINGER-PENKO, R. (1981). Investigation of the mutual influence between a polluted river and its hyporheic. *International Journal of Speleology* **11**, 159–171.
- *MEYER, A., AVRAMOV, M., FILLINGER, L., HUG, K., SPENGLER, C., HAHN, H. J. & GRIEBLER, C. (2020). Das Grundwasser unter die Lupe nehmen: Lebensgemeinschaften als Anzeiger der Grundwasserqualität. *ANLiegen.Natur* **42**, 173–182.
- *MEYER, E., SEALE, L. D., PERMAR, B. & McCLARY, A. (2017). The effect of chemical treatments on lampenflora and a Collembola indicator species at a popular tour cave in California, USA. *Environmental Management* **59**, 1034–1042.
- *MICHEL, G., MALARD, F., DEHARVENG, L., DI LORENZO, T., SKET, B. & DE BROYER, C. (2009). Reserve selection for conserving groundwater biodiversity. *Freshwater Biology* **54**, 861–876.
- *MILANOVIC, P. (2002). The environmental impacts of human activities and engineering constructions in karst regions. *Episodes* **25**, 13–21.
- *MILAZZO, M., CHEMELLO, R., BADALAMENTI, F., CAMARDA, R. & RIGGIO, S. (2002). The impact of human recreational activities in marine protected areas: what lessons should be learnt in the Mediterranean Sea? *Marine Ecology* **23**, 280–290.
- MILIČIĆ, M., POPOV, S., BRANCO, V. V. & CARDOSO, P. (2021). Insect threats and conservation through the lens of global experts. *Conservation Letters* **14**, e12814.
- *MILNE, D. J. & PAVEY, C. R. (2011). The status and conservation of bats in the Northern Territory. In *The Biology and Conservation of Australasian Bats* (eds B. LAW, P. EBY, D. LUNNEY and L. LUMSDEN), pp. 208–225. Royal Zoological Society of New South Wales, Mosman.
- MOHER, D., LIBERATI, A., TETZLAFF, J. & ALTMAN, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ* **339**, b2535.
- *MOLDOVAN, O. T. (2019). Cave protection in Romania. In *Cave and Karst Systems of Romania* (eds G. M. L. PONTA and B. P. ONAC), pp. 537–541. Springer, Cham.
- *MOLDOVAN, O. T., BERCEA, S., NĂSTASE-BUCUR, R., CONSTANTIN, S., KENESZ, M., MIREA, I. C., PETCULESCU, A., ROBU, M. & ARGHIR, R. A. (2020a). Management of water bodies in show caves—a microbial approach. *Tourism Management* **78**, 104037.
- *MOLDOVAN, O. T. & BRAD, T. (2019). Comment on “assessing preservation priorities of caves and karst areas using the frequency of endemic cave-dwelling species” by Nitzu et al. (2018), *Int. J. Speleol.*, 47 (1): 43–52. *International Journal of Speleology* **48**, 107–109.
- *MOLDOVAN, O. T., CONSTANTIN, S. & CHEVAL, S. (2018). Drip heterogeneity and the impact of decreased flow rates on the vadose zone fauna in Ciur-Izbuc cave, NW Romania. *Ecology* **11**, e2028.
- MOLDOVAN, O. T. & LEVEI, E. (2015). Temporal variability of fauna and the importance of sampling frequency in the hyporheic zone. *Hydrobiologia* **755**, 27–38.
- *MOLDOVAN, O. T., MELEG, I. N., LEVEI, E. & TERENCE, M. (2013). A simple method for assessing biotic indicators and predicting biodiversity in the hyporheic zone of a river polluted with metals. *Ecological Indicators* **24**, 412–420.
- MOLDOVAN, O., RACOVITZA, G. & RAJKA, G. (2003). The impact of tourism in Romanian show caves: the example of the beetle populations in the Ursilor cave of Chişcau (Transylvania, Romania). *Subterranean Biology* **1**, 73–78.
- *MOLDOVAN, O. T., SANDA IEPURE, T. B., KENESZ, M., MIREA, I. C. & NĂSTASE-BUCUR, R. (2020b). Database of Romanian cave invertebrates with a red list of cave species and a list of hotspot/coldspot caves. *Biodiversity Data Journal* **8**, e53571.
- *MONRO, A. K., BYSTRIKOVA, N., FU, L., WEN, F. & WEI, Y. (2018). Discovery of a diverse cave flora in China. *PLoS One* **13**, e0190801.
- *MONTEFALCONE, M., DE FALCO, G., NEPOTE, E., CANESSA, M., BERTOLINO, M., BAVESTRELLO, G., MORRI, C. & BIANCHI, C. N. (2018). Thirty year ecosystem trajectories in a submerged marine cave under changing pressure regime. *Marine Environmental Research* **137**, 98–110.
- MONTESINO POUZOLS, F., TOIVONEN, T., DI MININ, E., KUKKALA, A. S., KULLBERG, P., KUUSTERÄ, J., LEHTOMÄKI, J., TENKANEN, H., VERBURG, P. H. & MOILANEN, A. (2014). Global protected area expansion is compromised by projected land-use and parochialism. *Nature* **516**, 383–386.
- *MOORE, G. I., HUMPHREYS, W. F. & FOSTER, R. (2018). New populations of the rare subterranean blind cave eel *Ophistemon candidum* (Synbranchidae) reveal recent historical connections throughout North-Western Australia. *Marine and Freshwater Research* **69**, 1517–1524.
- *MOORE, P. R., RISCH, T. S., MORRIS, D. K. & ROLLAND, V. (2017). Habitat use of female gray bats assessed using aerial telemetry. *The Journal of Wildlife Management* **81**, 1242–1253.
- *MORAIS, A. L., BICHUETTE, M. E., CHAGAS-JÚNIOR, A. & LEAL-ZANCHET, A. (2021). Under threat: two new troglotic species of *Givardia* (Platyhelminthes: Tricladida) from sandstone and limestone caves in Brazil. *Zoologischer Anzeiger* **293**, 292–302.
- *MOREHOUSE, R. L. & TOBLER, M. (2013). Crayfishes (Decapoda: Cambaridae) of Oklahoma: identification, distributions, and natural history. *Zootaxa* **3717**, 101–157.
- *MORENO-VALDEZ, A., HONEYCUTT, R. L. & GRANT, W. E. (2004). Colony dynamics of *Leptonycteris nivalis* (Mexican long-nosed bat) related to flowering agave in northern Mexico. *Journal of Mammalogy* **85**, 453–459.
- *MÖSSLACHER, F. (2000). Sensitivity of groundwater and surface water crustaceans to chemical pollutants and hypoxia: implications for pollution management. *Archiv für Hydrobiologie* **149**, 51–66.
- *MÖSSLACHER, F. & NOTENBOOM, J. (1999). Groundwater biomonitoring. Biomonitoring of polluted waters. *Environmental Science Forum* **96**, 119–140.
- *MÖSSLACHER, F., GRIEBLER, C. & NOTENBOOM, J. (2001). Biomonitoring of groundwater systems: methods, applications and possible indicators among the groundwater biota. In *Groundwater Ecology: A Tool for Management of Water Resources* (eds C. GRIEBLER, D. L. DANIELOPOLI, J. GIBERT, H. P. NACHTNEBEL and J. NOTENBOOM), pp. 132–170. Office for Official Publications of the European Communities, Luxembourg.
- *MOUSER, J., ASHLEY, D. C., ALEY, T. & BREWER, S. K. (2019). Subterranean invasion by gapped ringed crayfish: effectiveness of a removal effort and barrier installation. *Diversity* **11**, 3.
- *MOUSER, J. B., BREWER, S. K., NIEMILLER, M. L., MOLLENHAUER, R. & VAN DEN BUSSCHE, R. A. (2021). Refining sampling protocols for cavefishes and cave crayfishes to account for environmental variation. *Subterranean Biology* **39**, 79–105.
- *MULEC, J. (2014). Human impact on underground cultural and natural heritage sites, biological parameters of monitoring and remediation actions for insensitive surfaces: case of Slovenian show caves. *Journal for Nature Conservation* **22**, 132–141.
- *MUSA, J. Y. (1994). The Sisia cave bats of Bamenda, Cameroon. *Environmental Conservation* **21**, 275.
- *MUTHERSBAUGH, M. S., FORD, W. M., SILVIS, A. & POWERS, K. E. (2019). Activity patterns of cave-dwelling bat species during pre-hibernation swarming and post-hibernation emergence in the Central Appalachians. *Diversity* **11**, 159.
- *NAE, I. & BĂNCILĂ, R. I. (2017). Mesovoid shallow substratum as a biodiversity hotspot for conservation priorities: analysis of oribatid mite (Acari: Oribatida) fauna. *Acarologia* **57**, 855–868.
- *NAGY, Z. L. & POSTAWA, T. (2011). Seasonal and geographical distribution of cave-dwelling bats in Romania: implications for conservation. *Animal Conservation* **14**, 74–86.
- *NAVARRO-BARRANCO, C., GUERRA-GARCÍA, J. M., SÁNCHEZ-TOCINO, L., ROS, M., FLORIDO, M. & GARCÍA-GÓMEZ, J. C. (2015). Colonization and successional patterns of the mobile epifaunal community along an environmental gradient in a marine cave. *Marine Ecology Progress Series* **521**, 105–115.
- *NAVO, K. W. & INGERSOLL, T. E. (2000). A Colorado case study to secure underground mines for bat habitat. In *Proceedings of Bat Conservation and Mining: A Technical Interactive Forum*, pp. 14–16. Washington, DC: Office of Surface Mining Reclamation and Enforcement.
- *NEMOY, P., SPANIER, E., KASHTAN, N., ISRAEL, A. & ANGEL, D. L. (2018). Plasticity of marine sponge habitat preferences with regard to light and water motion: the example of *Batzella inops* (Topsent, 1891) in submerged caves. *Marine and Freshwater Research* **69**, 1784–1789.
- *NEPOTE, E., BIANCHI, C. N., MORRI, C., FERRARI, M. & MONTEFALCONE, M. (2017). Impact of a harbour construction on the benthic community of two shallow marine caves. *Marine Pollution Bulletin* **114**, 35–45.
- *NEUBAUM, D. J., NAVO, K. W. & SIEMERS, J. L. (2017). Guidelines for defining biologically important bat roosts: a case study from Colorado. *Journal of Fish and Wildlife Management* **8**, 272–282.
- *NICO, L. G., ENGLUND, R. A. & JELKS, H. L. (2015). Evaluating the piscicide rotenone as an option for eradication of invasive Mozambique tilapia in a Hawaiian brackish-water wetland complex. *Management of Biological Invasions* **6**, 83–104.
- *NICOLOSI, G., MAMMOLA, S., COSTANZO, S., SABELLA, G., CIRINCIONE, R., SIGNORELLO, G. & ISAJA, M. (2021). Microhabitat selection of a Sicilian subterranean woodlouse and its implications for cave management. *International Journal of Speleology* **50**, 53–63.

- *NIEMILLER, M. L., GRAENING, G. O., FENOLIO, D. B., GODWIN, J. C., COOLEY, J. R., PEARSON, W. D., FITZPATRICK, B. M. & NEAR, T. J. (2013). Doomed before they are described? The need for conservation assessments of cryptic species complexes using an amblyopsid cavefish (Amblyopsidae: Typhlichthys) as a case study. *Biodiversity and Conservation* **22**, 1799–1820.
- *NIEMILLER, M. L., HELF, K. & TOOMEY, R. S. (2021). Mammoth cave: a hotspot of subterranean biodiversity in the United States. *Diversity* **13**, 373.
- *NIEMILLER, M. L., INEBNIT, T., HINKLE, A., JONES, B. D., JONES, M., LAMB, J., MANN, N., MILLER, B., PINKLEY, J., PITTS, S. & SAPKOTA, K. N. (2019). Discovery of a new population of the federally endangered Alabama cave shrimp, *Palaemonias alabamiae* Smalley, 1961, in northern Alabama. *Subterranean Biology* **32**, 43–59.
- *NIEMILLER, M. L., OSBOURN, M. S., FENOLIO, D. B., PAULEY, T. K., MILLER, B. T. & HOLSINGER, J. R. (2010). Conservation status and habitat use of the West Virginia spring salamander (*Gyrinophilus subterraneus*) and spring salamander (*G. porphyriticus*) in General Davis cave, greenbrier co., West Virginia. *Herpetological Conservation and Biology* **5**, 32–43.
- *NIEMILLER, M. L., PORTER, M. L., KEANY, J., GILBERT, H., FONG, D. W., CULVER, D. C., HOBSON, C. S., KENDALL, K. D., DAVIS, M. A. & TAYLOR, S. J. (2018). Evaluation of eDNA for groundwater invertebrate detection and monitoring: a case study with endangered *Syngnathus* (Amphipoda: Crangonyctidae). *Conservation Genetics Resources* **10**, 247–257.
- NIEMILLER, M. L., TAYLOR, S. J. & BICHUETTE, M. E. (2018). Conservation of cave Fauna, with an emphasis on Europe and the Americas. In *Cave Ecology* (eds O. T. MOLDOVAN, Ø. KOVÅG and S. HALSE), pp. 451–478. Springer International Publishing, Cham.
- *NIEMILLER, M. L. & ZIGLER, K. S. (2013). Patterns of cave biodiversity and endemism in the Appalachians and interior plateau of Tennessee, USA. *PLoS One* **8**, e64177.
- *NIEMILLER, M. L., ZIGLER, K. S., OBER, K. A., CARTER, E. T., ENGEL, A. S., MONI, G., PHILIPS, T. K. & STEPHEN, C. D. (2017). Rediscovery and conservation status of six short-range endemic *Pseudanophthalmus* cave beetles (Carabidae: Trechini). *Insect Conservation and Diversity* **10**, 495–501.
- *NIEMILLER, M. L., ZIGLER, K. S., STEPHEN, C. D., CARTER, E. T., PATERSON, A. T., TAYLOR, S. J. & ENGEL, A. S. (2016). Vertebrate fauna in caves of eastern Tennessee within the Appalachians karst region, USA. *Journal of Cave and Karst Studies* **78**, 1–24.
- *NITZU, E., NAE, A., BĂNCILĂ, R., POPA, I., GIURGINCA, A. & PLĂIAȘU, R. (2014). Scree habitats: ecological function, species conservation and spatial-temporal variation in the arthropod community. *Systematics and Biodiversity* **12**, 65–75.
- *NITZU, E., VLAICU, M., GIURGINCA, A., MELEG, I. N., POPA, I., NAE, A. & BABA, Ș. (2018). Assessing preservation priorities of caves and karst areas using the frequency of endemic cave-dwelling species. *International Journal of Speleology* **47**, 43–52.
- *NITZU, E. I., MELEG, I. N. & GIURGINCA, A. (2019). A reply to the comment on “assessing preservation priorities of caves and karst areas using the frequency of endemic cave-dwelling species” by Nitzu et al. (2018). *International Journal of Speleology* **47**(1), 43–52. *International Journal of Speleology* **48**, 111–113.
- *NKURUMAH, E. E., BALDWIN, H. J., BADU, E. K., ANTI, P., VALLO, P., KLOSE, S., KALKO, E. K. V., OPPONG, S. K. & TSCHAPKA, M. (2021). Diversity and conservation of cave-roosting bats in Central Ghana. *Tropical Conservation Science* **14**, 1–10.
- NORTH, L. & VAN BEYNEN, P. (2016). All in the training: techniques for enhancing karst landscape education through show cave interpretation. *Applied Environmental Education & Communication* **15**, 279–290.
- *NORTHUP, D. E. (2011). Managing microbial communities in caves. In *Karst Management* (ed. P. E. VAN BEYNEN), pp. 225–240. Springer, Dordrecht.
- *NOTENBOOM, J. (2001). Managing ecological risks of groundwater pollution. In *Groundwater Ecology. A Tool for Management of Water Resources* (eds G. GRIEBLER, D. L. DANIELOPOL, J. GIBERT, H. P. NACHTNEBEL and J. NOTENBOOM), pp. 248–262. Office for Official Publications of the European Communities, Luxembourg.
- *NOTENBOOM, J. & BOESSENKOOL, J. J. (1992). Acute toxicity testing with the groundwater copepod *Parastenocaris germanica* (Crustacea). In *Proceeding First International Conference on Groundwater Ecology, American Water Resources Association* (eds J. A. STANFORD and J. J. SIMONS), American water Resource Association, pp. 301–309. Tampa.
- *NOTENBOOM, J., CRUYS, K., HOEKSTRA, J. & VAN BEELEN, P. (1992). Effect of ambient oxygen concentration upon the acute toxicity of chlorophenols and heavy metals to the groundwater copepod *Parastenocaris germanica* (Crustacea). *Ecotoxicology and Environmental Safety* **24**, 131–143.
- *NOTENBOOM, J., PLÉNÉT, S. & TURQUIN, M. J. (1994). Groundwater contamination and its impact on groundwater animals and ecosystems. In *Groundwater Ecology* (eds J. GIBERT, D. L. DANIELOPOL and J. A. STANFORD), pp. 477–504. Academic Press, San Diego.
- *NOTENBOOM, J., SERRANO, R., MORELL, I. & HERNANDEZ, F. (1995). The phreatic aquifer of the ‘Plana de Castellón’ (Spain): relationships between animal assemblages and groundwater pollution. *Hydrobiologia* **297**, 241–249.
- *NTAKIS, A., KARAOUZAS, I., FIŠER, C. & STOCH, F. (2020). An annotated checklist of the Niphargidae (Crustacea: Amphipoda) of Greece. *Zootaxa* **4772**, 517–544.
- *NUNES, G. A., CHAGAS-JR, A. & BICHUETTE, M. E. (2019). A new centipede *Schendylops* Cook from eastern Brazil: the first trogloditic geophilomorph for South America (Geophilomorpha, Schendylidae). *Zootaxa* **4691**, zootaxa-4691.
- NUÑEZ, M. A. & AMANO, T. (2021). Monolingual searches can limit and bias results in global literature reviews. *Nature Ecology & Evolution* **5**, 264.
- *NÚÑEZ-NOVAS, M. S., LEÓN, Y. M., MATEO, J. & DÁVALOS, L. M. (2016). Records of the cave-dwelling bats (Mammalia: Chiroptera) of Hispaniola with an examination of seasonal variation in diversity. *Acta Chiropterologica* **18**, 269–279.
- *O’DONNELL, C. F. (2002). Variability in numbers of long-tailed bats (*Chalinobius tuberculatus*) roosting in grand canyon cave, New Zealand: implications for monitoring population trends. *New Zealand Journal of Zoology* **29**, 273–284.
- *OKANISHI, M. & FUJITA, Y. (2019). A comprehensive taxonomic list of brittle stars (Echinodermata: Ophiuroidea) from submarine caves of the Ryukyu Islands, southwestern Japan, with a description of a rare species, *Dougalophus echinatus* (Amphiuridae). *Zootaxa* **4571**, 73–98.
- OLIVEIRA, H. F. M., SILVA, D. C., ZANGRANDI, P. L. & DOMINGOS, F. M. C. B. (2022). Brazil opens highly protected caves to mining, risking fauna. *Nature* **602**, 386.
- *OLSON, C. R., HOBSON, D. P. & PYBUS, M. J. (2011). Changes in population size of bats at a hibernaculum in Alberta, Canada, in relation to cave disturbance and access restrictions. *Northwestern Naturalist* **92**, 224–230.
- *ORTUÑO, V. M., GILGADO, J. D., JIMÉNEZ-VALVERDE, A., SENDRA, A., PÉREZ-SUÁREZ, G. & HERRERO-BORGONÓN, J. J. (2013). The “alluvial mesovoid shallow substratum”, a new subterranean habitat. *PLoS One* **8**, e76311.
- *ORTUÑO, V. M., LEDESMA, E., JIMÉNEZ-VALVERDE, A. & PÉREZ-SUÁREZ, G. (2019). Studies of the mesovoid shallow substratum can change the accepted autecology of species: the case of ground beetles (Coleoptera, Carabidae) in the sierra de Guadarrama National Park (Spain). *Animal Biodiversity and Conservation* **42**, 213–226.
- *OSBORNE, R. A. L. (2019). Saving and conserving the caves: reflections on 37 years of listings, disputes, submissions and court cases. *Australian Journal of Earth Sciences* **66**, 767–778.
- *O’SHEA, T. J., CRYAN, P. M., HAYMAN, D. T., PLOWRIGHT, R. K. & STREICKER, D. G. (2016). Multiple mortality events in bats: a global review. *Mammal Review* **46**, 175–190.
- *OTÁLORA-ARDILA, A., TORRES, J. M., BARBIER, E., PIMENTEL, N. T., BARBOSA LEAL, E. S. & BERNARD, E. (2019). Thermally-assisted monitoring of bat abundance in an exceptional cave in Brazil’s Caatinga drylands. *Acta Chiropterologica* **21**, 411–423.
- *OVČINA KOČEVIJE. (2019). Conservation of Natura 2000 sites Koevsko. Final Report. Covering the project activities from 01/09/2014 to 28/02/2019. Kočevje, Slovenia. 70 pp.
- *OWEN, C. L., BRACKEN-GRISSOM, H., STERN, D. & CRANDALL, K. A. (2015). A synthetic phylogeny of freshwater crayfish: insights for conservation. *Philosophical Transactions of the Royal Society B: Biological Sciences* **370**, 20140009.
- OWEN, D., CANTOR, A., NYLEN, N. G., HARTER, T. & KIPARSKY, M. (2019a). California groundwater management, science-policy interfaces, and the legacies of artificial legal distinctions. *Environmental Research Letters* **14**, 045016.
- OWEN, N. R., GUMBS, R., GRAY, C. L. & FAITH, D. P. (2019b). Global conservation of phylogenetic diversity captures more than just functional diversity. *Nature Communications* **10**, 859.
- *ÖZALP, H. B. (2020). Biodiversity of marine caves and cave-like formations around the northern Aegean islands of Turkey (Gökçeada and Bozcaada). In *Marine Caves of the Eastern Mediterranean Sea. Biodiversity, Threats and Conservation* (ed. B. ÖZTURK), pp. 166–185. Turkish Marine Research Foundation (TUDAV) Publication no: 53, Istanbul.
- *PACHECO, G. S. M., DE OLIVEIRA, M. P. A., CANO, E., SOUZA SILVA, M. & FERREIRA, R. L. (2021). Tourism effects on the subterranean fauna in a central American cave. *Insect Conservation and Diversity* **14**, 294–306.
- *PADIGLIA, A., CADEDDU, B., LEDDA, F. D., BERTOLINO, M., COSTA, G., PRONZATO, R. & MANCONI, R. (2018). Biodiversity assessment in Western Mediterranean marine protected areas (MPAs): porifera of *Posidonia oceanica* meadows (Asinara Island MPA) and marine caves (capo Caccia–Isola Piana MPA) of Sardinia. *The European Zoological Journal* **85**, 409–422.
- PAGE, M. J., MCKENZIE, J. E., BOSSUYT, P. M., BOUTRON, I., HOFFMANN, T. C., MULROW, C. D., SHAMSEER, L., TETZLAFF, J. M., AKL, E. A., BRENNAN, S. E., CHOU, R., GLANVILLE, J., GRIMSHAW, J. M., HRÓBJARTSSON, A., LALU, M. M., et al. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* **372**, n71.
- *PAKSUZ, S. & ÖZKAN, B. (2012). The protection of the bat community in the Dupnisa cave system, Turkey, following opening for tourism. *Oryx* **46**, 130–136.
- *PALLARÉS, S., COLADO, R., BOTELLA-CRUZ, M., MONTES, A., BALART-GARCÍA, P., BILTON, D. T., MILLÁN, A., RIBERA, I. & SÁNCHEZ-FERNÁNDEZ, D. (2020a). Loss of heat acclimation capacity could leave subterranean specialists highly sensitive to climate change. *Animal Conservation* **24**, 482–490.

- PALLARÉS, S., SANCHEZ-HERNANDEZ, J. C., COLADO, R., BALART-GARCÍA, P., COMAS, J. & SÁNCHEZ-FERNÁNDEZ, D. (2020b). Beyond survival experiments: using biomarkers of oxidative stress and neurotoxicity to assess vulnerability of subterranean fauna to climate change. *Conservation Physiology* **8**, coaa067.
- *PANNO, S. V., HACKLEY, K. C., KELLY, W. R., HWANG, H. H., WILHELM, F. M., TAYLOR, S. J. & STIFF, B. J. (2006). Potential effects of recurrent low oxygen conditions on the Illinois cave amphipod. *Journal of Cave and Karst Studies* **68**, 55–63.
- *PAPADATOU, E., BUTLIN, R. K., PRADEL, R. & ALTRINGHAM, J. D. (2009). Sex-specific roost movements and population dynamics of the vulnerable long-fingered bat, *Myotis capaccinii*. *Biological Conservation* **142**, 280–289.
- *PAQUIN, P., DUPÉRRÉ, N., COKENDOLPHER, J. C., WHITE, K. & HEDIN, M. (2008). The fundamental importance of taxonomy in conservation biology: the case of the eyeless *Cicurina bandida* (Araneae: Dictynidae) of Central Texas, including new synonyms and the description of the male of the species. *Invertebrate Systematics* **22**, 139–149.
- *PAQUIN, P. & DUPERRÉ, N. (2009). A first step towards the revision of *Cicurina*: redescription of type specimens of 60 troglobitic species of the subgenus *Cicurella* (Araneae: Dictynidae), and a first visual assessment of their distribution. *Zootaxa* **2002**, 1–67.
- *PAQUIN, P. & HEDIN, M. (2004). The power and perils of ‘molecular taxonomy’: a case study of eyeless and endangered *Cicurina* (Araneae: Dictynidae) from Texas caves. *Molecular Ecology* **13**, 3239–3255.
- *PARIZOTTO, D. R., PIRES, A. C., MISE, K. M. & FERREIRA, R. L. (2017). Troglobitic invertebrates: improving the knowledge on the Brazilian subterranean biodiversity through an interactive multi-entry key. *Zootaxa* **4365**, 401–409.
- *PARRAVICINI, V., GUIDETTI, P., MORRI, C., MONTEFALCONE, M., DONATO, M. & BIANCHI, C. N. (2010). Consequences of sea water temperature anomalies on a Mediterranean submarine cave ecosystem. *Estuarine, Coastal and Shelf Science* **86**, 276–282.
- *PARSONS, K. N., JONES, G., DAVIDSON-WATTS, I. & GREENAWAY, F. (2003). Swarming of bats at underground sites in Britain—implications for conservation. *Biological Conservation* **111**, 63–70.
- *PATRIARCA, E., DEBERNARDI, P. & TOFFOLI, R. (2012). *Piano d'azione per i chiroteristi del Piemonte*, p. 231. Regione Piemonte, Bozza pubblicata.
- *PAVLEK, M. & CARLES, R. (2017). *Kryptonesticus delemanae* gen. Et sp. nov. (Araneae, Nesticidae), with notes on the Mediterranean cave species. *European Journal of Taxonomy* **262**, 1–27.
- *PECK, S. B. (2013). *Ptomaphagus parashant* Peck and Wynne, new species (Coleoptera: Leiodidae: Cholevinae: Ptomaphagini): the most troglomorphic cholevine beetle known from western North America. *The Coleopterists Bulletin* **67**, 309–317.
- *PELLEGRINI, T. G. & LOPES FERREIRA, R. (2012). Management in a neotropical show cave: planning for invertebrates conservation. *International Journal of Speleology* **41**, 359–366.
- PELLEGRINI, T. G., SALES, L. P., AGUIAR, P. & FERREIRA, R. L. (2016). Linking spatial scale dependence of land-use descriptors and invertebrate cave community composition. *Subterranean Biology* **18**, 17–38.
- *PÉREZ-MORENO, J. L., ILIFFE, T. M. & BRACKEN-GRISSOM, H. D. (2016). Life in the underworld: Anchialine cave biology in the era of speleogenomics. *International Journal of Speleology* **45**, 149–170.
- *PERRY, R. W. & JORDAN, P. N. (2020). Survival and persistence of tricolored bats hibernating in Arkansas mines. *Journal of Mammalogy* **101**, 535–543.
- *PETTIT, S. (1996). The status of bats on Curaçao. *Biological Conservation* **77**, 27–31.
- *PETTIT, S., ROJER, A. & PORS, L. (2006). Surveying bats for conservation: the status of cave-dwelling bats on Curaçao from 1993 to 2003. *Animal Conservation* **9**, 207–217.
- *PETRICIOLI, D., BUZZACOTT, P., RADOLOVIĆ, M., BAKRAN-PETRICIOLI, T. & GEROVASILEIOU, V. (2015). *Visitation and Conservation of Marine Caves // inside and outside the Mountain - Geology - Karst & Paleontology, Program and Abstracts Book. University of Catania, Karst Research Institute Slovenia*, pp. 29–30. UNESCO Chair for Karst Education Nova Gorica, Custonaci.
- *PETROV, B., ALEXandrova, I., KARADAKOV, V., GEORGIEVA, T., TOSHKOVA, N. & ZHELYAZKOVA, V. (2014). Bats (Mammalia: Chiroptera) in ponor special protection area (Natura 2000), Western Bulgaria: species diversity and distribution. *Acta Zoologica Bulgarica* **65**, 117–128.
- *PFENDLER, S., MUNCH, T., BOUSTA, F., ALAOU-SOSSE, L., ALEYA, L. & ALAOU-SOSSÉ, B. (2018). Bleaching of biofilm-forming algae induced by UV-C treatment: a preliminary study on chlorophyll degradation and its optimization for an application on cultural heritage. *Environmental Science and Pollution Research* **25**, 14097–14105.
- *PHELPS, K., JOSE, R., LABONITE, M. & KINGSTON, T. (2016). Correlates of cave-roosting bat diversity as an effective tool to identify priority caves. *Biological Conservation* **201**, 201–209.
- PHELPS, K., JOSE, R., LABONITE, M. & KINGSTON, T. (2018). Assemblage and species threshold responses to environmental and disturbance gradients shape bat diversity in disturbed cave landscapes. *Diversity* **10**, 55.
- *PIANO, E., BONA, F., FALASCO, E., LA MORGIA, V., BADINO, G. & ISAJA, M. (2015). Environmental drivers of phototrophic biofilms in an alpine show cave (SW-Italian Alps). *Science of the Total Environment* **536**, 1007–1018.
- *PIPAN, T., CULVER, D. C., PAPI, F. & KOZEL, P. (2018). Partitioning diversity in subterranean invertebrates: the epikarst fauna of Slovenia. *PLoS One* **13**, e0195991.
- PIPAN, T., DEHARVENG, L. & CULVER, D. C. (2020). Hotspots of subterranean biodiversity. *Diversity* **12**, 209.
- *PIPAN, T., HOLT, N. & CULVER, D. C. (2010). How to protect a diverse, poorly known, inaccessible fauna: identification and protection of source and sink habitats in the epikarst. *Aquatic Conservation: Marine and Freshwater Ecosystems* **20**, 748–755.
- *PLĂIAȘU, R. & BĂNCILĂ, R. I. (2018). Fluctuating asymmetry as a bio-marker to account for in conservation and management of cave-dwelling species. *Journal of Insect Conservation* **22**, 221–229.
- *PLĂIAȘU, R., ÖZGÜL, A., SCHMIDT, B. R. & BĂNCILĂ, R. I. (2017). Estimation of apparent survival probability of the harvestman *Paranemastoma sillii sillii* (Herman, 1871) from two caves. *Animal Biology* **67**, 165–176.
- *PLÉNET, S. (1999). Metal accumulation by an epigeal and a hypogean freshwater amphipod: considerations for water quality assessment. *Water Environment Research* **71**, 1298–1309.
- *PLÉNET, S., MARMONIER, P., GIBERT, J., STANFORD, J. A., BODERGAT, A. M. & SCHMIDT, C. M. (1992). Groundwater hazard evaluation: a perspective for the use of interstitial and benthic invertebrates as sentinels of aquifer metallic contamination. In *Proceedings of the First International Conference on Groundwater Ecology* (eds J. A. STANFORD and J. J. SIMONS), pp. 319–329. American Water Resources Association, Bethesda.
- POLLOCK, L. J., O'CONNOR, L. M. J., MOKANY, K., ROSAUER, D. F., TALLUTO, M. V. & THUILLER, W. (2020). Protecting biodiversity (in all its complexity): new models and methods. *Trends in Ecology & Evolution* **35**, 1119–1128.
- POLLOCK, L. J., THUILLER, W. & JETZ, W. (2017). Large conservation gains possible for global biodiversity facets. *Nature* **546**, 141–144.
- *POSŁUSZNY, E. T. & BUTCHKOSKI, C. M. (2000). Pennsylvania case studies to secure underground mine workings for bat habitat. In *Bat Conservation and Mining: A Technical Interactive Forum* (eds K. C. VORIES and D. THROGMORTON), pp. 224–234. U.S. Department of Interior, Office of Surface Mining, Alton, Illinois and Coal Research Center, Southern Illinois University, Carbondale.
- PRESSEY, R. L., VISCONTI, P., MCKINNON, M. C., GURNEY, G. G., BARNES, M. D., GLEW, L. & MARON, M. (2021). The mismeasure of conservation. *Trends in Ecology & Evolution* **36**, 808–821.
- *PRIÉ, V. & BICHAIN, J. M. (2009). Phylogenetic relationships and description of a new stygobite species of *Bythinella* (Mollusca, Gastropoda, Caenogastropoda, Amnicolidae) from southern France. *Zoosystema* **31**, 987–1000.
- *PREUSS, G. & SCHMINKE, H. K. (2004). Grundwasser lebt! Ein globales Ökosystem. *Chemie in unserer Zeit* **38**, 340–347.
- *PRINGLE, C. M. (2001). Hydrologic connectivity and the management of biological reserves: a global perspective. *Ecological Applications* **11**, 981–998.
- *PROUDLOVE, G. S. (2001). The conservation status of hypogean fishes. *Environmental Biology of Fishes* **62**, 201–213.
- PUGH, M. & ALTRINGHAM, J. D. (2005). The effect of gates on cave entry by swarming bats. *Acta Chiropterologica* **7**, 293–299.
- *QUIBOD, M. N. R. M., ALVIOLA, P. A., DE GUIA, A. P. O., CUEVAS, V. C., LIT, I. L. JR. & PASION, B. O. (2019). Diversity and threats to cave-dwelling bats in a small island in the southern Philippines. *Journal of Asia-Pacific Biodiversity* **12**, 481–487.
- *RAGKOUSIS, M., DIGENIS, M., KOVAČIĆ, M., KATSANEVAKIS, S. & GEROVASILEIOU, V. (2021). Rarely reported cryptobenthic fish in marine caves of the eastern Mediterranean Sea. *Journal of Marine Science and Engineering* **9**, 557.
- R CORE TEAM (2021). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna.
- *RABELO, L. M., SOUZA-SILVA, M. & FERREIRA, R. L. (2018). Priority caves for biodiversity conservation in a key karst area of Brazil: comparing the applicability of cave conservation indices. *Biodiversity and Conservation* **27**, 2097–2129.
- *RACHWALD, A., KOKUREWICZ, T., ZAPART, A., APOZNAŃSKI, G., SZURLEJ, M., HADDOW, J., ĐUROVIĆ, M. & KEPEL, A. (2019). New records of the western barbastelle *Barbastella barbastellus* (Schreber, 1774) and other rare bat species in Montenegro. *Acta Zoologica Bulgarica* **71**, 519–524.
- *RAEDTS, C. & SMART, C. (2015). Tracking of karst contamination using alternative monitoring technologies: Hidden River cave Kentucky. In LAND, L., DOCTOR, D. H. & STEPHENSON, J. B., eds. *Fourteenth Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst*, pp. 327–336. National Cave and Karst Research Institute, Rochester.
- *RAGHAVAN, R., BRITZ, R. & DAHANUKAR, N. (2021). Poor groundwater governance threatens ancient subterranean fishes. *Trends in Ecology & Evolution* **36**, 875–878.
- *RAHMAN, A., CHOUDHURY, P. & TALUKDAR, N. R. (2019). Assessing essential trace elements in cave nectar bat (*Eonycteris spelaea*): a study in Barak Valley of Assam, India. *Biological Trace Element Research* **188**, 451–460.
- *RAINHO, A. & PALMEIRIM, J. M. (2013). Prioritizing conservation areas around multispecies bat colonies using spatial modeling. *Animal Conservation* **16**, 438–448.
- *RAJASEGARAN, P., SHAZALI, N. & KHAN, F. A. A. (2018). Microclimate and physiological effects in the roosts of cave dwelling bats: implications in roost selection and conservation in Sarawak, Malaysian Borneo. *Zoological Science* **35**, 521–527.

- *RASTORGUEFF, P. A., BELLAN-SANTINI, D., BIANCHI, C. N., BUSSOTTI, S., CHEVALDONNÉ, P., GUIDETTI, P., HARMELIN, J. G., MONTEFALCONE, M., MORRI, C., PEREZ, T. & RUITTON, S. (2015). An ecosystem-based approach to evaluate the ecological quality of Mediterranean undersea caves. *Ecological Indicators* **54**, 137–152.
- *RAVBAR, N. & ŠEBELA, S. (2015). The effectiveness of protection policies and legislative framework with special regard to karst landscapes: insights from Slovenia. *Environmental Science & Policy* **51**, 106–116.
- *REBOLEIRA, A. S. P., ABRANTES, N., OROMÍ, P. & GONÇALVES, F. (2013). Acute toxicity of copper sulfate and potassium dichromate on stygobiont *Proasellus*: general aspects of groundwater ecotoxicology and future perspectives. *Water, Air, & Soil Pollution* **224**, 1–9.
- *REBOLEIRA, A. S., BORGES, P. A., GONÇALVES, F., SERRANO, A. R. & OROMÍ, P. (2011). The subterranean fauna of a biodiversity hotspot region-Portugal: an overview and its conservation. *International Journal of Speleology* **40**, 23–37.
- *REBOLEIRA, A. S. P. & EUSÉBIO, R. P. (2021). Cave-adapted beetles from continental Portugal. *Biodiversity Data Journal* **9**, e67426.
- *REDDY, Y. R. (2018). An updated checklist of groundwater crustaceans of India. *Crustaceana* **91**, 677–731.
- *REGIONALNA DYREKCYJA OCHRONY ŚRODOWISKA W KATOWICACH. (2012). Carrying out necessary conservation work on a territory of Szachownica Cave designated within Natura 2000 / Wykonanie zabieg w ochronie przyrody na terenie Specjalnego Obszaru Ochrony Siedlisk Natura 2000 Szachownica. LIFE12 NAT/PL/000012. Katowice, Poland Polska.
- *REVILLA-MARTÍN, N., BUDINSKI, I., PUIG-MONTSERRAT, X., FLAQUER, C. & LÓPEZ-BAUCELLS, A. (2021). Monitoring cave-dwelling bats using remote passive acoustic detectors: a new approach for cave monitoring. *Bioacoustics* **30**, 527–542.
- *REYNOLDS, H. T., INGERSOLL, T. & BARTON, H. A. (2015). Modeling the environmental growth of *Pseudogymnoascus destructans* and its impact on the white-nose syndrome epidemic. *Journal of Wildlife Diseases* **51**, 318–331.
- *RICHTER, A. R., HUMPHREY, S. R., COPE, J. B. & BRACK, V. JR. (1993). Modified cave entrances: thermal effect on body mass and resulting decline of endangered Indiana bats (*Myotis sodalis*). *Conservation Biology* **7**, 407–415.
- *RIVERS, N. M., BUTLIN, R. K. & ALTRINGHAM, J. D. (2006). Autumn swarming behaviour of Natterer's bats in the UK: population size, catchment area and dispersal. *Biological Conservation* **127**, 215–226.
- *RIX, M. G. & HARVEY, M. S. (2010). The spider family Micropholcommatidae (Arachnida: Araneae: Araneoidea): a relimitation and revision at the generic level. *ZooKeys* **36**, 1–321.
- *RODHOUSE, T. J., PHILIPPI, T. E., MONAHAN, W. B. & CASTLE, K. T. (2016). A macroecological perspective on strategic bat conservation in the US National Park Service. *Ecosphere* **7**, e01576.
- *ROBERT, G. K., ONYARI, C. N. & MBAKA, J. G. (2021). Development of a water quality assessment index for the Chania River, Kenya. *African Journal of Aquatic Science* **46**, 142–152.
- *ROBERTSON, A. L., SMITH, J. W. N., JOHNS, T. & PROUDLOVE, G. S. (2009). The distribution and diversity of stygobites in Great Britain: an analysis to inform groundwater management. *Quarterly Journal of Engineering Geology and Hydrogeology* **42**, 359–368.
- *ROBERTSON, A. L., PERKINS, D. M., ENGLAND, J. & JOHNS, T. (2021). Invertebrate responses to restoration across benthic and Hyporheic stream compartments. *Water* **13**, 996.
- *ROCHA, A. D. & BICHUETTE, M. E. (2016). Influence of abiotic variables on the bat fauna of a granitic cave and its surroundings in the state of São Paulo. *Brazil. Biota Neotropica* **16**, e20150032.
- *ROMERO, A. (2009). Cave conservation and management. In *Cave Biology: Life in Darkness* (ed. A. ROMERO), pp. 182–208. Cambridge University Press, New York.
- *ROSSINI, R. A., FENSHAM, R. J. & WALTER, G. H. (2020). Different species requirements within a heterogeneous spring complex affects patch occupancy of threatened snails in Australian desert springs. *Water* **12**, 2942.
- *ROSSO, A., SANFILIPPO, R., GUIDO, A., GEROVASILEIOU, V., TADDEI RUGGIERO, E. & BELMONTE, G. (2021). Colonisers of the dark: biotactite-associated metazoans from “lu Lampiùne” submarine cave (Apulia, Mediterranean Sea). *Marine Ecology* **42**, e12634.
- *ROUCH, R. & DANIELOPOL, D. L. (1997). Species richness of microcrustacea in subterranean freshwater habitats. Comparative analysis and approximate evaluation. *Internationale Revue der gesamten Hydrobiologie und Hydrographie* **82**, 121–145.
- *RUSSELL, R. E., TINSLEY, K., ERICKSON, R. A., THOGMARTIN, W. E. & SZYMANSKI, J. (2014). Estimating the spatial distribution of wintering little brown bat populations in the eastern United States. *Ecology and Evolution* **4**, 3746–3754.
- *SACCÒ, M., BLYTH, A. J., HUMPHREYS, W. F., COOPER, S. J., WHITE, N. E., CAMPBELL, M., MOUSAVI-DERAZMAHALLEH, M., HUA, Q., MAZUMDER, D., SMITH, C. & GRIEBLER, C. (2021). Rainfall as a trigger of ecological cascade effects in an Australian groundwater ecosystem. *Scientific Reports* **11**, 1–15.
- SACCÒ, M., GUZIK, M. T., VAN DER HEYDE, M., NEVILL, P., COOPER, S. J., AUSTIN, A. D., COATES, P. J., ALLENTOFT, M. E. & WHITE, N. E. (2022). cDNA in subterranean ecosystems: applications, technical aspects, and future prospects. *Science of the Total Environment* **820**, 153223.
- *SAIKIA, U. & RUEDI, M. (2021). Beauties beneath. *Resonance* **26**, 829–840.
- SALAFSKY, N., BOSHOVEN, J., BURIVALOVA, Z., DUBOIS, N. S., GOMEZ, A., JOHNSON, A., LEE, A., MARGOLUS, R., MORRISON, J., MUIR, M., PRATT, S. C., PULLIN, A. S., SALZER, D., STEWART, A., SUTHERLAND, W. J., et al. (2019). Defining and using evidence in conservation practice. *Conservation Science and Practice* **1**, e27.
- *SANCHEZ, L., MORENO, C. R. & MORA, E. C. (2017). Echolocation calls of *Natalus primus* (Chiroptera: Natalidae): implications for conservation monitoring of this species. *Cogent Biology* **3**, 1355027.
- *SÁNCHEZ-FERNÁNDEZ, D., GALASSI, D. M. P., WYNNE, J. J., CARDOSO, P. & MAMMOLA, S. (2021). Don't forget subterranean ecosystems in climate change agendas. *Nature Climate Change* **11**, 458–459.
- *SANKARAN, R. (2001). The status and conservation of the edible-nest swiftlet (*Collocalia fuciphaga*) in the Andaman and Nicobar Islands. *Biological Conservation* **97**, 283–294.
- *SANTOS, J. C. D. C. V., FERREIRA, R. L., MILLAR, I. & HOCH, H. (2019). Conservation status and complementary description of *Confuga persephone* (Cixiidae): should this species be considered threatened? *New Zealand Journal of Zoology* **46**, 61–73.
- *SANTOS-MORENO, A. & HERNÁNDEZ-AGUILAR, I. (2021). Estimation of bat colony size even with low recapture rates: an example based on the Cormack-jolly-Seber model in Oaxaca, México. *Revista de Biología Tropical* **69**, 231–244.
- *SCANLON, A., PETIT, S. & BOTTROFF, G. (2014). The conservation status of bats in Fiji. *Oryx* **48**, 451–459.
- *SCARSBROOK, M. R. & FENWICK, G. D. (2003). Preliminary assessment of crustacean distribution patterns in New Zealand groundwater aquifers. *Journal of Marine and Freshwater Research* **37**, 405–413.
- *SCHÄFFERS, C., WENZEL, A., LUKOW, T. & SEHR, I. (2001). Ökotoxikologische Prüfung von Pflanzenschutzmitteln hinsichtlich ihres Potenzials zur Grundwassergefährdung. TEXTE, UBA – FB 000239, Federal Environment Agency, Berlin, Germany. 91 pp.
- *SCHMIDT, S. I., HAHN, H. J., HATTON, T. J. & HUMPHREYS, W. F. (2007). Do faunal assemblages reflect the exchange intensity in groundwater zones? *Hydrobiologia* **583**, 1–19.
- *SCHMIDT, C. M., MARMONIER, P., PLÉNÉT, S., CREUZÉ DES CHÂTELLIERS, M. & GIBERT, J. (1991). Bank filtration and interstitial communities. Example of the Rhône River in a polluted sector (downstream of Lyon, grand Gravier, France). *Hydrobiologie* **3**, 217–223.
- *SCHMIDT, S., STEIN, H. & HAHN, H. J. (2013). Ökologische Bewertung des Grundwassers: “Stygoregionen” als biogeographische Referenzen für den Lebensraum Grundwasser. *Korrespondenz Wasserwirtschaft* **6**, 7–10.
- *SCINTO, A., PANTALEO, U., SERLUCA, G., DI CAMILLO, C. G., BETTI, F., BAVESTRELLO, G. & CERRANO, C. (2010). Comparative analysis of different marine cave assemblages characterized by different intensities of diving tourism. *Biologia Marina Mediterranea* **17**, 63–66.
- *SCOTTI, G., CONSOLI, P., ESPOSITO, V., CHEMELLO, R., ROMEO, T. & ANDALORO, F. (2017). Marine caves of the southern Tyrrhenian Sea: a first census of benthic biodiversity. *Journal of Marine Science: Research and Development* **7**, 1–9.
- *SEDLÖCK, J. L., JOSE, R. P., VOGT, J. M., PAGUNTALAN, L. M. J. & CARIÑO, A. B. (2014). A survey of bats in a karst landscape in the Central Philippines. *Acta Chiropterologica* **16**, 197–211.
- *SEWALL, B. J., SCAFINI, M. R., TURNER, G. G., BUTCHKOSKI, C. M., REEDER, D. M. & WHIDDEN, H. P. (2016). Prioritization and management of Pennsylvania's bat hibernacula after pervasive contamination with the fungus causing white-nose syndrome. In *Conservation and Ecology of Pennsylvania's Bats* (eds C. M. BUTCHKOSKI, D. M. REEDER, G. G. TURNER and H. P. WHIDDEN), pp. 181–199. The Pennsylvania Academy of Sciences, East Stroudsburg.
- *SEMPERE-VALVERDE, J., LORENZO, Á. S., ESPINOSA, F., GEROVASILEIOU, V., SÁNCHEZ-TOCINO, L. & NAVARRO-BARRANCO, C. (2019). Taxonomic and morphological descriptors reveal high benthic temporal variability in a Mediterranean marine submerged cave over a decade. *Hydrobiologia* **839**, 177–194.
- *SENDRA, A., NIKOLOUDAKIS, I., GAVALAS, I., SELFA, J. & PARAGAMIAN, K. (2020). A surprising new genus and species of cave-adapted Plusiocampinae *Cycladiacampa irakleiae* (Diplura, Campodeidae) from Irakleia Island, Cyclades Islands in the Aegean archipelago (Greece). *Subterranean Biology* **35**, 15–32.
- *SENDRA, A., YOSHIZAWA, K. & LOPES FERREIRA, R. (2018). New oversize troglitic species of Campodeidae in Japan (Diplura). *Subterranean Biology* **27**, 53–73.
- *SHAIK, S. (2019). A new *Indobathynella* species from an Indian cave: the first cavernicolous Bathynellidae (Syncarida: Bathynellacea) from South-Eastern India. *Zootaxa* **4565**, 345–360.
- *SHAIK, S. & REDDY, Y. R. (2018). On the genus *Habrobathynella* Schminke, 1973 (Crustacea, malacostraca, Bathynellacea), with description of three new species from India. *Zootaxa* **4492**, 1–72.
- *SHAPIRO, H. G., WILLCOX, A. S., ADER, D. R. & WILLCOX, E. V. (2021a). Attitudes towards and relationships with cave-roosting bats in Northwest Cambodia. *Journal of Ethnobiology* **41**, 87–104.

- *SHAPIRO, H. G., WILLCOX, A. S., VERANT, M. L. & WILLCOX, E. V. (2021b). How has White-nose syndrome changed cave Management in National Parks? *Wildlife Society Bulletin* **45**, 422–429.
- *SHAZALI, N., CHEW, T. H., SHAMSIR, M. S., TINGGA, R. C. T., MOHD-RIDWAN, A. R. & KHAN, F. A. A. (2017). Assessing bat roosts using the LiDAR system at wind cave nature reserve in Sarawak, Malaysian Borneo. *Acta Chiropterologica* **19**, 199–210.
- *SHEAR, W. A., TAYLOR, S. J., WYNNE, J. J. & KREJCA, J. K. (2009). Cave millipeds of the United States. VIII. New genera and species of polydesmidan millipeds from caves in the southwestern United States (Diplopoda, Polydesmida, Macrosteronodesmidae). *Zootaxa* **2151**, 47–65.
- *SHUEY, M. M., DREES, K. P., LINDNER, D. L., KEIM, P. & FOSTER, J. T. (2014). Highly sensitive quantitative PCR for the detection and differentiation of *Pseudogymnoascus destructans* and other *Pseudogymnoascus* species. *Applied and Environmental Microbiology* **80**, 1726–1731.
- *SILVA, M. S. & FERREIRA, R. L. (2009). Caracterização ecológica de algumas cavernas do Parque Nacional de Ubajara (Ceará) com considerações sobre o turismo nestas cavidades. *Revista de Biologia e Ciências da Terra* **9**, 59–71.
- *SILVA, M. S., RATTON, P., DE ALMEIDA ZAMPAULO, R. & FERREIRA, R. L. (2017). Is an outstanding environment always preserved? When the most diverse cave in subterranean species becomes one of the most endangered in a landscape. *Revista Brasileira de Espeleologia* **2**, 22–48.
- *SIMIČEVIĆ, V. (2017). Poachers threaten Balkans underground biodiversity. *Science* **358**, 1116–1117.
- *SIMÕES, M. H., SOUZA-SILVA, M. & FERREIRA, R. L. (2014). Cave invertebrates in northwestern Minas Gerais state, Brazil: endemism, threats and conservation priorities. *Acta carsologica* **43**, 159–174.
- *SIMÕES, M. H., SOUZA-SILVA, M. & FERREIRA, R. L. (2013). Species richness and conservation of caves in the Urucua River sub-basin, a tributary of the San Francisco River: a case study in caves of Arinos, Minas Gerais, Brazil. *Revista Brasileira de Espeleologia* **2**, 1–17.
- *SIMON, K. S. & BUIKEMA, A. L. JR. (1997). Effects of organic pollution on an Appalachian cave: changes in macroinvertebrate populations and food supplies. *American Midland Naturalist* **138**, 387–401.
- *SIMONE, L. R. L. (2013). *Habeas*, a new genus of Diplommatinidae from Central Bahia, Brazil (Caenogastropoda), with description of three new species. *Journal of Conchology* **41**, 519–525.
- *SINTON, L. W. (1984). The macroinvertebrates in a sewage-polluted aquifer. *Hydrobiologia* **119**, 161–169.
- *SIRISENA, K. A., DAUGHNEY, C. J., MOREAU-FOURNIER, M., RYAN, K. G. & CHAMBERS, G. K. (2013). National survey of molecular bacterial diversity of New Zealand groundwater: relationships between biodiversity, groundwater chemistry and aquifer characteristics. *FEMS Microbiology Ecology* **86**, 490–504.
- SKALSKI, J. R. & WORD, J. Q. (1994). Detection of contaminated samples using a two-way compositing scheme. *Environmental Toxicology and Chemistry* **13**, 15–19.
- *SKET, B. (1973). Gegenseitige Beeinflussung der Wasserpollution und des Hohlenmilieus. *Proceedings of the 6th International Congress of Speleology* **5**, 253–262.
- SKET, B. (1996). The ecology of anchihaline caves. *Trends in Ecology & Evolution* **11**, 221–225.
- *SKET, B. (1999). The nature of biodiversity in hypogean waters and how it is endangered. *Biodiversity and Conservation* **8**, 1319–1338.
- *SLADE, C. P. & LAW, B. S. (2008). An experimental test of gating derelict mines to conserve bat roost habitat in southeastern Australia. *Acta Chiropterologica* **10**, 367–376.
- *SLANEY, D. P. & WEINSTEIN, P. (1997). Conservation of cave fauna: more than just bats. *Memoirs Museum Victoria* **56**, 591–596.
- *SMITH, L. M., DOONAN, T. J., SYLVIA, A. L. & GORE, J. A. (2021). Characteristics of caves used by wintering bats in a subtropical environment. *Journal of Fish and Wildlife Management* **12**, 139–150.
- *SMITH, B. A., HUNT, B. B. & BEERY, J. (2010). Recharge enhancement and protection of a karst aquifer in Central Texas. In *Advances in Research in Karst Media* (eds B. ANDREO, F. CARRASCO, J. J. DURÁN and J. W. LAMOREAUX), pp. 37–42. Springer, Berlin.
- *SMITH, H. & WOOD, P. J. (2002). Flow permanence and macroinvertebrate community variability in limestone spring systems. *Hydrobiologia* **487**, 45–58.
- *SOLER-ZAMORA, C., GONZÁLEZ-MIGUÉNS, R., GUILLÉN-OTERINO, A. & LARA, E. (2021). Arcellinida testate amoebae as climate miner's canaries in southern Spain. *European Journal of Protistology* **81**, 125828.
- SOULÉ, M. E. (1985). What is conservation biology? *Bioscience* **35**, 727–734.
- *SOUZA, M. F. V. R., ALVARENGA, D. A., SOUZA-SILVA, M. & FERREIRA, R. L. (2021). Do different relevance attributes indicate the same conservation priorities? A case study in caves of southeastern Brazil. *International Journal of Speleology* **50**, 223–238.
- *SOUZA-SILVA, M., CERQUEIRA, R. F. V., PELLEGRINI, T. G. & FERREIRA, R. L. (2021). Habitat selection of cave-restricted fauna in a new hotspot of subterranean biodiversity in Neotropics. *Biodiversity and Conservation* **30**, 4223–4250.
- *SOUZA-SILVA, M., MARTINS, R. P. & FERREIRA, R. L. (2015). Cave conservation priority index to adopt a rapid protection strategy: a case study in Brazilian Atlantic rain forest. *Environmental Management* **55**, 279–295.
- *SOUZA, S., RIUTORT, M., FERREIRA, R. L. & LEAL-ZANCHET, A. (2018). An integrative taxonomic approach reveals the first marine tricolad (Platyhelminthes) trapped in a cave from a semiarid Neotropical environment. *Invertebrate Systematics* **32**, 627–638.
- *SPANJER, G. R. & FENTON, M. B. (2005). Behavioral responses of bats to gates at caves and mines. *Wildlife Society Bulletin* **33**, 1101–1112.
- *SPA/RAC-UN ENVIRONMENT/MAP, OCEANA (2017). Guidelines for inventorying and monitoring of dark habitats in the Mediterranean Sea. In *SPA/RAC - Deep Sea Lebanon Project* (eds V. GEROVASILEIOU, R. AGUILAR and P. MARIN). Lebanon: SPA/RAC - Deep Sea Lebanon, 40 pp. + Annexes.
- *SRITONGCHUAY, T., KREMEN, C. & BUMRUNGSRIS, S. (2016). Effects of forest and cave proximity on fruit set of tree crops in tropical orchards in southern Thailand. *Journal of Tropical Ecology* **32**, 269–279.
- *STABLER, F. & HERDER, M. (2000). The role of the Bureau of Land Management in bat conservation. In *Proceedings of Bat Conservation and Mining: A Technical Interactive Forum*, US Department of Interior, Office of Surface Mining (eds K. C. VORIES and D. THROGMORTON), pp. 101–104. Alton and Coal Research Center, Southern Illinois University, Carbondale.
- *STATE OF NEW SOUTH WALES AND OFFICE OF ENVIRONMENT AND HERITAGE (2019). *Jenolan Karst Conservation Reserve Plan of Management*. Sydney: State of NSW and Office of Environment and Heritage.
- *STEIN, H., KELLERMANN, C., SCHMIDT, S. I., BRIELMANN, H., STEUBE, C., BERKHOFF, S. E., FUCHS, A., HAHN, H. J., THULIN, B. & GRIEBLER, C. (2010). The potential use of fauna and bacteria as ecological indicators for the assessment of groundwater quality. *Journal of Environmental Monitoring* **12**, 242–254.
- *STEUBE, C., RICHTER, S. & GRIEBLER, C. (2009). First attempts towards an integrative concept for the ecological assessment of groundwater ecosystems. *Hydrogeology Journal* **17**, 23–35.
- *STOEVE, P., DELTSHEV, C., BACHVAROVA, D. & DOICHINOV, A. (2014). Cave invertebrates in ponor special protection area (Natura 2000), Western Bulgaria: Faunistic diversity and conservation significance. *Acta Zoologica Bulgarica* **5**, 75–84.
- *STONER, K. E., O-SALAZAR, K. A., FERNÁNDEZ, R. C. & QUESADA, M. (2003). Population dynamics, reproduction, and diet of the lesser long-nosed bat (*Leptonycteris curasoae*) in Jalisco, Mexico: implications for conservation. *Biodiversity and Conservation* **12**, 357–373.
- *STOYCHEVA, S., PAVLOVA, A., RUSSO, D., DELEVA, S. & ATANASSOV, T. (2014). Bats (Mammalia: Chiroptera) in Besaparski Ridove special protection area (Natura 2000), southern Bulgaria: species list, distribution and conservation. *Acta Zoologica Bulgarica* **5**, 213–220.
- *STRONA, G., FATTORINI, S., FIASCA, B., DI LORENZO, T., DI CICCO, M., LORENZETTI, W., BOCCACCI, F. & GALASSI, D. M. P. (2019). Aqualife software: a new tool for a standardized ecological assessment of groundwater dependent ecosystems. *Water* **11**, 2574.
- *STRAKA, T. M., GREIF, S., SCHULTZ, S., GOERLITZ, H. R. & VOIGT, C. C. (2020). The effect of cave illumination on bats. *Global Ecology and Conservation* **21**, e00808.
- *STRONG, E. E., GARGOMINY, O., PONDER, W. F. & BOUCHET, P. (2007). Global diversity of gastropods (Gastropoda; Mollusca) in freshwater. In *Freshwater Animal Diversity Assessment* (ed. H. SEGERS), pp. 149–166. Springer, Dordrecht.
- *STRUEBIG, M. J., KINGSTON, T., ZUBAID, A., LE COMBER, S. C., MOHD-ADNAN, A., TURNER, A., KELLY, J., BOŽEK, M. & ROSSITER, S. J. (2009). Conservation importance of limestone karst outcrops for Palaeotropical bats in a fragmented landscape. *Biological Conservation* **142**, 2089–2096.
- *SUGAYA, K., OGAWA, R. & HARA, Y. (2017). Rediscovery of the “extinct” blind ground beetle (Coleoptera: Carabidae: Trechinae). *Entomological Science* **20**, 159–162.
- *SUN, B. & YU, D. L. (2018). Study on Jinan urban construction planning based on the protection of karst landscape. *Journal of Groundwater Science and Engineering* **6**, 280–292.
- SUTHERLAND, W. J., ALVAREZ-CASTAÑEDA, S. T., AMANO, T., AMBROSINI, R., ATKINSON, P., BAXTER, J. M., BOND, A. L., BOON, P. J., BUCHANAN, K. L., BARLOW, J., BOGLIANI, G., BRAGG, O. M., BURGMAN, M., CADOTTE, M. W., CALVER, M., et al. (2020). Ensuring tests of conservation interventions build on existing literature. *Conservation Biology* **34**, 781–783.
- SUTHERLAND, W. J., DICKS, L. V., PETROVAN, S. O. & SMITH, R. K. (2021). *What Works in Conservation 2021*. Open Book Publishers, Cambridge, UK.
- SUTHERLAND, W. J., PULLIN, A. S., DOLMAN, P. M. & KNIGHT, T. M. (2004). The need for evidence-based conservation. *Trends in Ecology & Evolution* **19**, 305–308.
- SUTHERLAND, W. J., TAYLOR, N. G., MACFARLANE, D., AMANO, T., CHRISTIE, A. P., DICKS, L. V., LEMASSON, A. J., LITTLEWOOD, N. A., MARTIN, P. A., OCKENDON, N., PETROVAN, S. O., ROBERTSON, R. J., ROCHA, R., SHACKELFORD, G. E., SMITH, R. K., et al. (2019). Building a tool to overcome barriers in research-implementation spaces: the conservation evidence database. *Biological Conservation* **238**, 108199.
- *SUWANNAPOOM, C., SUMONTHA, M., TUNPRASERT, J., RUANGSUWAN, T., PAWANGKHANANT, P., KOROST, D. V. & POYARKOV, N. A. (2018). A striking new genus and species of cave-dwelling frog (Amphibia: Anura: Microhylidae: Asterophryinae) from Thailand. *PeerJ* **6**, e4422.

- *SUWANNARONG, K., BALTHIP, K., KANTHAWEE, P., SUWANNARONG, K., KHEWKHERN, S., LANTICAN, C., PONLAPF, T., BUPHAG, N. & AMONSIN, A. (2020). Bats and belief: a sequential qualitative study in Thailand. *Heliyon* **6**, e04208.
- *SUZUKI, Y. & BALLARIN, F. (2020). *Nesticus kosodensis* Yaginuma, 1972 bona species. Molecular and morphological separation from *N. latiscapus* Yaginuma, 1972 with notes on cave scaffold-web spiders subspecies in Japan (Araneae, Nesticidae). *Subterranean Biology* **35**, 79–96.
- *TAITI, S. & WYNNE, J. J. (2015). The terrestrial isopoda (Crustacea, Oniscidea) of Rapa Nui (Easter Island), with descriptions of two new species. *ZooKeys* **515**, 27–49.
- TANALGO, K. C. & HUGHES, A. C. (2019). Priority-setting for Philippine bats using practical approach to guide effective species conservation and policy-making in the Anthropocene. *Hystrix, the Italian Journal of Mammalogy* **30**, 74–83.
- TANALGO, K. C., OLIVEIRA, H. & HUGHES, A. C. (2021). Using bats as surrogates to effectively target global hotspots for subterranean conservation and monitoring. *Research square (preprint version 3)*. <https://doi.org/10.21203/rs.3.rs-492875/v2>.
- *TANG, D. & KNOTT, B. (2009). Freshwater cyclopoids and harpacticoids (Crustacea: Copepoda) from the Gngangara mound region of Western Australia. *Zootaxa* **2029**, 1–70.
- *TAYLOR, D. A. (1995). The North American bats and mines project: a cooperative approach for integrating wildlife, ecosystem management, and mine land reclamation. In *Proceedings of the 23rd Annual British Columbia Mine Reclamation Symposium*, pp. 10–21. The Technical and Research Committee on Reclamation, Kamloops.
- *TAYLOR, E. L. S., RESENE STOIANOFF, M. A. D. & LOPES FERREIRA, R. (2013). Mycological study for a management plan of a neotropical show cave (Brazil). *International Journal of Speleology* **42**, 267–277.
- *TERCAFS, R. (1988). Optimal management of karst sites with cave fauna protection. *Environmental Conservation* **15**, 149–158.
- *TENCATT, L. F. C. & BICHUETTE, M. E. (2017). *Aspidoras mephisto*, new species: the first troglolithic Callichthyidae (Teleostei: Siluriformes) from South America. *PLoS One* **12**, e0171309.
- *THAVRY, H., CAPPELLE, J., BUMRONGSRI, S., THONA, L. & FUREY, N. M. (2017). The diet of the cave nectar bat (*Eonycteris spelaea* Dobson) suggests it pollinates economically and ecologically significant plants in southern Cambodia. *Zoological Studies* **56**, e17.
- TIČAR, J., TOMIĆ, N., BREG VALJAVEC, M., ZORN, M., MARKOVIĆ, S. B. & GAVRILOV, M. B. (2018). Speleotourism in Slovenia: balancing between mass tourism and geoheritage protection. *Open Geosciences* **10**, 344–357.
- *TIMS, A. R. & ALROY, J. (2021). Phylogeny-based conservation priorities for Australian freshwater fishes. *Conservation Biology* in press.
- *TOBIN, A. & CHAMBERS, C. L. (2017). Mixed effects of gating subterranean habitat on bats: a review. *The Journal of Wildlife Management* **81**, 1149–1160.
- *TOBIN, A., CORBETT, R. J. M., WALKER, F. M. & CHAMBERS, C. L. (2018). Acceptance of bats to gates at abandoned mines. *The Journal of Wildlife Management* **82**, 1345–1358.
- *TORRES-FLORES, J. W. & SANTOS-MRENO, A. (2017). Inventory, features, and protection of underground roosts used by bats in Mexico. *Acta Chiropterologica* **19**, 439–454.
- *TRAJANO, E., GALLAO, J. E. & BICHUETTE, M. E. (2016). Spots of high diversity of trogloliths in Brazil: the challenge of measuring subterranean diversity. *Biodiversity and Conservation* **25**, 1805–1828.
- *TRAJANO, E., SECUTTI, S., PEREIRA, E. H. & REIS, R. E. (2008). A cave population of *Isbrueckerichthys alpinis* (Gosline, 1947) in the upper Ribeira karst area, southeastern Brazil (Siluriformes: Loricariidae). *Neotropical Ichthyology* **6**, 679–682.
- *TREVELIN, L. C., GASTAUER, M., PROUS, X., NICÁCIO, G., ZAMPAULO, R., BRANDI, I., OLIVEIRA, G., STQUEIRA, J. O. & JAFFÉ, R. (2019). Biodiversity surrogates in Amazonian iron cave ecosystems. *Ecological Indicators* **101**, 813–820.
- *TREVELIN, L. C., SIMÕES, M. H., PROUS, X., PIETROBON, T., BRANDI, I. V. & JAFFÉ, R. (2021). Optimizing speleological monitoring efforts: insights from long-term data for tropical iron caves. *PeerJ* **9**, e11271.
- *TRONTEJ, P. & ZAKSEK, V. (2016). Genetic monitoring of *Proteus* populations/Genetski monitoring populacij cloveskih ribic. *Natura Sloveniae* **18**, 53–54.
- TROUDET, J., GRANDCOLAS, P., BLIN, A., VIGNES-LEBBE, R. & LEGENDRE, F. (2017). Taxonomic bias in biodiversity data and societal preferences. *Scientific Reports* **7**, 9132.
- *TURAN, C., UYGUR, N., İÇDE, M. & DOĞDU, S. A. (2019). Habitat mapping of underwater bilge Taş cave (wisdom Stone cave) in the northeastern Mediterranean Sea: structure and biodiversity. In *Marine Caves of the Eastern Mediterranean Sea. Biodiversity, Threats and Conservation* (ed. B. ÖZTURK), pp. 195–206. Turkish Marine Research Foundation (TUDAV) Publication no. 53, Istanbul.
- *TUBERVILLE, T., BUHLMANN, K. A., BJORKLAND, R. K. & BOOHER, D. (2005). Ecology of the Jamaican slider turtle (*Trachemys terrapen*), with implications for conservation and management. *Chelonian Conservation and Biology* **4**, 908–915.
- *TURBILL, C. & WELBERGEN, J. A. (2020). Anticipating white-nose syndrome in the southern hemisphere: widespread conditions favourable to *Pseudogymnoascus destructans* pose a serious risk to Australia's bat fauna. *Austral Ecology* **45**, 89–96.
- *TURCIOS-CASCO, M. A., MAZIER, D. I. O., ORELLANA, J. A. S., ÁVILA-PALMA, H. D. & TREJO, E. J. O. (2019). Two caves in western Honduras are important for bat conservation: first checklist of bats in Santa Bárbara. *Subterranean Biology* **30**, 41–55.
- *TURNER, G. G., SEWALL, B. J., SCAFINI, M. R., LILLEY, T. M., BITZ, D. & JOHNSON, J. S. (2021). Cooling of bat hibernacula to mitigate white-nose syndrome. *Conservation Biology* in press.
- *UHEREK, C. B. & PINTO GOUVEIA, F. B. (2014). Biological monitoring using macroinvertebrates as bioindicators of water quality of Maroaga stream in the Maroaga cave system, Presidente Figueiredo, Amazon, Brazil. *International Journal of Ecology* **2014**, 308149.
- *UNEP-MAP-RAC/SPA (2015). Action plan for the conservation of habitats and species associated with seamounts, underwater caves and canyons, aphotic hard beds and chemo-synthetic phenomena in the Mediterranean Sea. *Dark Habitats Action Plan (ed RAC/SPA - Tunis)* 17.
- *UNIVERSITY OF CRETE (2017). *Greek Caves and Bats: Management Actions and Change of Altitude. LIFE17 NAT/GR/000522*. Rethymno, Crete.
- *VALDEZ, E. W., HANTTULA, M. K. & HINCK, J. E. (2021). Seasonal activity and diets of bats at uranium mines and adjacent areas near the grand canyon. *Western North American Naturalist* **81**, 1–18.
- *VAN DER MEIJ, T., VAN STRIEN, A. J., HAYSOM, K. A., DEKKER, J., RUSS, J., BIALA, K., BIHARI, Z., JANSEN, E., LANGTON, S., KURALI, A., LIMPENS, H., MESCHÉDE, A., PETERSONS, G., PRESETNIK, P., PRÜGER, J., REITER, G., RODRIGUES, L., SCHORCHT, W., UHRIN, M. & VINTULIS, V. (2015). Return of the bats? A prototype indicator of trends in European bat populations in underground hibernacula. *Mammalian Biology* **80**, 170–177.
- *VAN SCHAİK, J., JANSSEN, R., BOSCH, T., HAARMSMA, A. J., DEKKER, J. J. & KRANSTAUBER, B. (2015). Bats swarm where they hibernate: compositional similarity between autumn swarming and winter hibernation assemblages at five underground sites. *PLoS One* **10**, e0130850.
- *VARGAS-MENA, J. C., CORDERO-SCHMIDT, E., RODRIGUEZ-HERRERA, B., MEDELLÍN, R. A., BENTO, D. D. M. & VENTICINQUE, E. M. (2020). Inside or out? Cave size and landscape effects on cave-roosting bat assemblages in Brazilian Caatinga caves. *Journal of Mammalogy* **101**, 464–475.
- *VARGOVITSH, R. S. (2017). Two new troglolithic *Pygmarhophilites* species of the *principalis* group (Collembola: Arrhopalitidae) from the West Caucasus. *Zootaxa* **4250**, 23–42.
- *VENARSKY, M. P., ANDERSON, F. E. & WILHELM, F. M. (2009). Population genetic study of the US federally listed Illinois cave amphipod, *Gammarus acherondytes*. *Conservation Genetics* **10**, 915–921.
- *VENARSKY, M. P., WILHELM, F. M. & ANDERSON, F. E. (2007). Conservation strategies supported by non-lethal life history sampling of the US federally listed Illinois cave amphipod, *Gammarus acherondytes*. *Journal of Crustacean Biology* **27**, 202–211.
- *VENI, G. (2003). GIS applications in managing karst groundwater and biological resources. In *Sinkholes and the Engineering and Environmental Impacts of Karst* (eds L. B. YUHR, E. C. ALEXANDER and B. F. BECK), pp. 466–476. American Society of Civil Engineers, Reston.
- VENI, G. (2021). Groundwater and the international year of caves and karst: explore, understand, protect. *Ground Water* **60**(2), 158–159.
- *VICTOR, R. & AL-FARSI, A. A. (2001). Water quality and invertebrate fauna of farm wells in an area affected by salinization in Oman. *Journal of Arid Environments* **48**, 419–428.
- *VINARSKI, M. V. & PALATOV, D. M. (2018). *Ferrisia californica* (Gastropoda: Planorbidae): the first record of a global invader in a cave habitat. *Journal of Natural History* **52**, 1147–1155.
- *VINCENT, S., NEMOZ, M. & AULAGNIER, S. (2011). Activity and foraging habitats of *Miniapterus schreibersii* (Chiroptera, Miniopteridae) in southern France: implications for its conservation. *Hystrix, The Italian Journal of Mammalogy* **22**, 57–72.
- *VOÛTE, A. M. & LINA, P. H. C. (1986). Management effects on bat hibernacula in The Netherlands. *Biological Conservation* **38**, 163–177.
- *VÖRÖS, J., MÁRTON, O., SCHMIDT, B. R., GÁL, J. T. & JELIĆ, D. (2017). Surveying Europe's only cave-dwelling chordate species (*Proteus anguinus*) using environmental DNA. *PLoS One* **12**, e0170945.
- *WALSH, S. J. & CHAKRABARTY, P. (2016). A new genus and species of blind sleeper (Teleostei: Eleotridae) from Oaxaca, Mexico: first obligate cave gobiiform in the Western hemisphere. *Copeia* **104**, 506–517.
- *WANG, Z., HE, L., LU, H., REN, L. & XU, Z. (2016). Network environmental analysis based ecological risk assessment of a naphthalene-contaminated groundwater ecosystem under varying remedial schemes. *Journal of Hydrology* **543**, 612–624.
- *WANG, Z. F., REN, H., LI, Z. C., ZHANG, Q. M., LIANG, K. M., YE, W. H. & WANG, Z. M. (2013). Local genetic structure in the critically endangered, cave-associated perennial herb *Primulina tabacum* (Gesneriaceae). *Biological Journal of the Linnean Society* **109**, 747–756.
- *WANG, J., ZHANG, H., XIE, F., WEI, G. & JIANG, J. (2017). Genetic bottlenecks of the wild Chinese giant salamander in karst caves. *Asian Herpetological Research* **8**, 174–183.
- *WARD, J. V., VOELZ, N. J. & MARMONIER, P. (1992). Groundwater faunas at riverine sites receiving treated sewage effluent. In *Proceedings 1st International Conference on Groundwater Ecology* (eds J. A. STANFORD and J. J. SIMONS), pp. 351–365. American Water Resources Association, Bethesda.

- *WATKINS, F. (2002). An overview: the North American Bats and Mines Project. pp. 240–246 Proceedings of the 26th Annual British Columbia Mine Reclamation Symposium.
- WATSON, J. E. M., DUDLEY, N., SEGAN, D. B. & HOCKINGS, M. (2014). The performance and potential of protected areas. *Nature* **515**, 67–73.
- *WEI, Y. G. & WANG, W. T. (2011). *Elatostema recurvum* (Urticaceae), a new cave-dwelling species from Guangxi, China. *Novon: A Journal for Botanical Nomenclature* **21**, 281–284.
- *WEIL, M., MACKENZIE, K., FOIT, K., KÜHNEL, D., BUSCH, W., BUNDSCHUH, M., SCHULZ, R. & DUIS, K. (2019). Environmental risk or benefit? Comprehensive risk assessment of groundwater treated with nano Fe₀-based carbo-iron[®]. *Science of the Total Environment* **677**, 156–166.
- *WEYANDT, S. E., VAN DEN BUSSCHE, R. A., HAMILTON, M. J. & LESLIE, D. M. (2005). Unraveling the effects of sex and dispersal: Ozark big-eared bat (*Corynorhinus townsendii ingens*) conservation genetics. *Journal of Mammalogy* **86**, 1136–1143.
- *WHITE, N. E., GUZIK, M. T., AUSTIN, A. D., MOORE, G. I., HUMPHREYS, W. F., ALEXANDER, J. & BUNCE, M. (2020). Detection of the rare Australian endemic blind cave eel (*Ophistemon candidum*) with environmental DNA: implications for threatened species management in subterranean environments. *Hydrobiologia* **847**, 3201–3211.
- *WHITE, D. H. & SEGINAK, J. T. (1987). Cave gate designs for use in protecting endangered bats. *Wildlife Society Bulletin* **15**, 445–449.
- *WHITFIELD, P. (2013). Cave conservation: a Canadian Caver's perspective. In CHEEPTAM, N., eds. *Cave Microbiomes: A Novel Resource for Drug Discovery*, pp. 47–67. Springer, New York.
- *WHITING, J. C., DOERING, B., WRIGHT, G., ENGLESTEAD, D. K., FRYE, J. A. & STEFANIC, T. (2018). Bat hibernacula in caves of southern Idaho: implications for monitoring and management. *Western North American Naturalist* **78**, 165–173.
- *WHITTEN, T. (2009). Applying ecology for cave management in China and neighbouring countries. *Journal of Applied Ecology* **46**, 520–523.
- WICKHAM, H. (2016). *ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag, New York.
- WILLIAMS, D. R., BALMFORD, A. & WILCOVE, D. S. (2020). The past and future role of conservation science in saving biodiversity. *Conservation Letters* **13**, e12720.
- *WILLIAMS, K. E., SHERWIN, R. E., VANDALEN, K. K. & PIAGGIO, A. J. (2020). A noninvasive genetic technique using guano for identification of *Corynorhinus townsendii* (Townsend's big-eared bat) maternity roosts. *Western North American Naturalist* **80**, 476–482.
- *WILLOUGHBY, A. R., PHELPS, K. L., OLIVAL, K. J. & PREDICT CONSORTIUM (2017). A comparative analysis of viral richness and viral sharing in cave-roosting bats. *Diversity* **9**, 35.
- *WILSON, G. D. & HUMPHREY, C. L. (2020). The *Eophreatoicus* Nicholls, 1926 species flock from Kakadu and Arnhem Land, with a description of a new genus of Amphispodidae (Crustacea: isopoda: Phreatoicoidea). *Zootaxa* **4854**, zootaxa-4854.
- WILSON, K., PRESSEY, R. L., NEWTON, A., BURGMAN, M., POSSINGHAM, H. & WESTON, C. (2005). Measuring and incorporating vulnerability into conservation planning. *Environmental Management* **35**, 527–543.
- WILSON, K. A., UNDERWOOD, E. C., MORRISON, S. A., KLAUSMEYER, K. R., MURDOCH, W. W., REYERS, B., WARDELL-JOHNSON, G., MARQUET, P. A., RUNDEL, P. W., MCBRIDE, M. F., PRESSEY, R. L., BODE, M., HOEKSTRA, J. M., ANDELMAN, S., LOOKER, M., et al. (2007). Conserving biodiversity efficiently: what to do, where, and when. *PLoS Biology* **5**, e223.
- *WOOD, P. J., GUNN, J. & PERKINS, J. (2002). The impact of pollution on aquatic invertebrates within a subterranean ecosystem-out of sight out of mind. *Archiv für Hydrobiologie* **155**, 223–237.
- *WOOD, P. J., GUNN, J. & RUNDLE, S. D. (2008). Response of benthic cave invertebrates to organic pollution events. *Aquatic Conservation: Marine and Freshwater Ecosystems* **18**, 909–922.
- WYNNE, J. J., BERNARD, E. C., HOWARTH, F. G., SOMMER, S., SOTO-ADAMES, F. N., TAITI, S., MOCKFORD, E. L., HORROCKS, M., PAKARATI, L. & PAKARATI-HOTUS, V. (2014). Disturbance relicts in a rapidly changing world: the Rapa Nui (Easter Island) factor. *Bioscience* **64**, 711–718.
- *WYNNE, J. J., HOWARTH, F. G., MAMMOLA, S., FERREIRA, R. L., CARDOSO, P., LORENZO, T. D., GALASSI, D. M. P., MEDELLIN, R. A., MILLER, B. W., SÁNCHEZ-FERNÁNDEZ, D., BICHUETTE, M. E., BISWAS, J., BLACKEAGLE, C. W., BOONYANUSITH, C., AMORIM, I. R., et al. (2021). A conservation roadmap for the subterranean biome. *Conservation Letters* **14**, e12834.
- *WYNNE, J. J., HOWARTH, F. G., SOMMER, S. & DICKSON, B. G. (2019). Fifty years of cave arthropod sampling: techniques and best practices. *International Journal of Speleology* **48**, 33–48.
- *WYNNE, J. J. & PLEYTEZ, W. (2005). Sensitive ecological areas and species inventory of Actun Chapat cave, Vaca plateau, Belize. *Journal of Cave and Karst Studies* **67**, 148–157.
- *WYNNE, J. J. & SHEAR, W. A. (2016). A new millipede, *Austrotyla awishoshola* n. sp., (Diplopoda, Chordeumatida, Conotylidae) from New Mexico, USA, and the importance of cave moss gardens as refugial habitats. *Zootaxa* **4084**, 285–292.
- WYNNE, J. J., SOMMER, S., HOWARTH, F. G., DICKSON, B. G. & VOYLES, K. D. (2018). Capturing arthropod diversity in complex cave systems. *Diversity and Distributions* **24**, 1478–1491.
- *XU, K. W., ZHOU, X. M., ZHANG, L. B. & LIAO, W. B. (2018). *Hymenasplenium hastifolium* sp. nov. (Aspleniaceae) from a karst cave in western Guangxi, China. *Phytotaxa* **333**, 281–286.
- *ZAGMAJSTER, M., POLAK, S. & FIŠER, C. (2021). Postojna-Planina cave system in Slovenia, a hotspot of subterranean biodiversity and a cradle of speleobiology. *Diversity* **13**, 271.
- *ZAGREB SPELEOLOGICAL UNION. (2015). Clean Underground. Electronic file available at <https://theuiaa.org/uiaa/zagrebspaleologicalunion/> Accessed 15.2.2021.
- *ZAKŠEK, V., KONEC, M. & TRONTELJ, P. (2018). First microsatellite data on *Proteus anguinus* reveal weak genetic structure between the caves of Postojna and Planina. *Aquatic Conservation: Marine and Freshwater Ecosystems* **28**, 241–246.
- *ZHANG, Y. & LI, S. (2013). Ancient lineage, young trogloliths: recent colonization of caves by *Nesticella* spiders. *BMC Evolutionary Biology* **13**, 1–10.
- *ZHAO, H. (2020). COVID-19 drives new threat to bats in China. *Science* **367**, 1436
- *ZEPPELINI, D., BRITO, R. A. & LIMA, E. C. (2018). Three new species of Collembola (Arthropoda: Hexapoda) from central Brazilian shallow caves: side effects of long term application of environmental law on conservation. *Zootaxa* **4500**, 59–81.
- ZHANG, L., FU, B., LÜ, Y. & ZENG, Y. (2015). Balancing multiple ecosystem services in conservation priority setting. *Landscape Ecology* **30**, 535–546.
- *ZHANG, L. B. & HE, H. (2011). *Polystichum fengshanense*, sp. nov. (sect. Haplopolystichum, Dryopteridaceae) from karst caves in Guangxi, China based on morphological, palynological, and molecular evidence. *Systematic Botany* **36**, 854–861.
- ZHANG, L., JIANG, W., WANG, Q.-J., ZHAO, H., ZHANG, H.-X., MARCEC, R. M., WILLARD, S. T. & KOUBA, A. J. (2016). Reintroduction and post-release survival of a living fossil: the Chinese giant salamander. *PLoS One* **11**, e0156715.
- *ZHANG, Z., MAMMOLA, S., LIANG, Z., CAPINHA, C., WEI, Q., WU, Y., ZHOU, J. & WANG, C. (2020). Future climate change will severely reduce habitat suitability of the critically endangered Chinese giant salamander. *Freshwater Biology* **65**, 971–980.
- *ZHANG, L. B., SUN, Q. W. & HE, H. (2014). *Selaginella wangpeishanii* (Selaginellaceae), a new lycophyte from a limestone cave in Guizhou, China. *Phytotaxa* **164**, 195–199.
- *ZHANG, Y. J., ZHANG, J., LIU, Z. Y. & REN, M. X. (2019). *Parnassia zhengyuana* sp. nov. and *P. simianshanensis* sp. nov.: two new species of *Parnassia* (Celastraceae) from karst caves and Danxia landform in Southwest China. *Nordic Journal of Botany* **37**, e02414.
- *ZHANG, L., ZHU, G., JONES, G. & ZHANG, S. (2009). Conservation of bats in China: problems and recommendations. *Oryx* **43**, 179–182.
- *ZHELJAZKOVA, V. L., TOSHKOVA, N. L., DOOL, S. E., BONACCORSO, F. J., PINZARI, C. A., MONTOYA-AIONA, K. & PUECHMAILLE, S. J. (2019). Screening and biosecurity for white-nose fungus *Pseudogymnosascus destructans* (Ascomycota: Pseudeurotiaceae) in Hawai'i. *Pacific Science* **73**, 357–365.
- *ZHELJAZKOVA, V., HUBANCHEVA, A., RADOSLAVOV, G., TOSHKOVA, N. & PUECHMAILLE, S. J. (2020). Did you wash your caving suit? Cavers' role in the potential spread of *Pseudogymnosascus destructans*, the causative agent of White-nose disease. *International Journal of Speleology* **49**, 149–159.
- *ZINETTI, F., DAPPORTO, L., VANNI, S., MAGRINI, P., BARTOLOZZI, L., CHELAZZI, G. & CIOFI, C. (2013). Application of molecular genetics and geometric morphometrics to taxonomy and conservation of cave beetles in Central Italy. *Journal of Insect Conservation* **17**, 921–932.
- *ZORTEA, M., BASTOS, N. A. & ACIOLI, T. C. (2015). The bat fauna of the Kararaô and Kararaô novo caves in the area under the influence of the Belo Monte hydroelectric dam, in Pará, Brazil. *Brazilian Journal of Biology* **75**, 168–173.

XI. Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Appendix S1. Full list of papers extracted from the *Web of Science*, with an indication of whether it was included in the analysis and, if not, the reasons for exclusion.

(Received 1 September 2021; revised 22 February 2022; accepted 1 March 2022; published online 21 March 2022)