Overcoming shortfalls and impediments in subterranean biology: a challenge for the future

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Abstract

Since the discovery and description of the first specialized cave species, subterranean fauna stimulated the scientific research of several generations of speleobiologists especially after the publication of Racovitza's classification of cave species, which is still used today, amended for non-karstic areas and groundwaters. More than 28,000 obligate subterranean species are known worldwide; however, these figures are likely to be underestimated since species richness is highly correlated with research effort (Stoch and Galassi 2010). Subterranean ecosystems are very rich in strict endemic species and taxonomic efforts are still quite low (i.e., the so-called "taxonomic impediment"), while several environments are very difficult to be explored (i.e., the "Racovitzan impediment: Ficetola et al. 2018).

Furthermore, several paradigms were debated for years. Albeit constrasting hypotheses were conceived to explain the colonization of subsurface habitats, their importance is still debated (i.e., climate relicts vs. adaptive shift in colonization and speciation, dispersal vs. vicariance in shaping distributional patterns, and selective vs. neutral hypotheses in explaining regressive evolution). Moreover, the paradigm of a "truncated functional diversity" of subterranean ecosystems (Gibert and Deharveng 2002) lasted for years but was recently challenged by the discovery of chemoautotrophic ecosystems in hypogenic and anchialine caves, and the recognition that caves are not isolated environments, but they are highly interconnected with surface ecosystems. The increased importance of their conservation (like in the case of GDEs, Groundwater Dependent Ecosystems) was recently recognized, together with their provision of important ecosystem services (Boulton 2020).

A deeper knowledge is required to assess biodiversity hotspots as well as to plan efficient monitoring surveys (Mammola et al. 2020). In the last decades, a growing amount of molecular data has been obtained for subterranean species, allowing some of the classical debates on colonization, evolution, and dispersal to be revisited (Bauzà-Ribot et al. 2012); moreover, novel promising techniques like metabarcoding and environmental DNA were applied in field surveys and monitoring efforts.

Unfortunately, after more than one century of research in subterranean biology, large gaps remain in our knowledge of phylogeny, richness, and distribution of subterranean fauna (formalized in the so-called Darwinian, Linnean and Wallacean shortfalls), preventing the definition of large-scale sound management and protection plans. It is proposed that data from recent biomolecular techniques coupled with remotely sensed data may enhance biodiversity mapping and conservation and are promising approaches to fill our knowledge gaps. Perhaps this is the greatest challenge that tomorrow's subterranean biologists will face.

Keywords

Speleobiological paradigms, biodiversity hotspots, metabarcoding, environmental DNA

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Author contributions

Both authors conceived and wrote the abstract.

Conflicts of interest

None.

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