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

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In a recent paper published by Nitzu et al. (2018), the authors propose an algorithm to identify "hotspots of vulnerable karst areas" that uses frequency of endemic "cave-dwelling species". The authors viewpoint is that the occurrence of endemic troglobionts and stygobionts, or cave-dwelling species as given in the title, in 3-4 caves up to a maximum of 37 caves, can be used to rank caves in terms of their vulnerability. The proposed ranking is based on a published list of endemic species that can be found in Romanian caves (Nitzu et al., 2016). We discuss here the type of errors that encumber the correct and equitable protection of cave species and their habitat, which can derive from the use of quantitative criteria based on incomplete or incorrect datasets on cave fauna (troglobionts and stygobionts).

Type I error: assuming that the quantitative ranking of caves is based on a complete and correct inventory of cave species. The incomplete number of species is prone to inevitable errors (species present but not found or not published, incomplete databases etc.), which would place the caves with important species or communities at low ranks. In the list of Nitzu et al. (2016), notorious examples of missing data are apparent. For example, in Peştera (Cave) Vântului only six species are mentioned, while this cave is one of the richest in Romania with respect to cave fauna, containing twelve troglobionts and stygobionts, some of them strictly endemic to this cave. As a result, Peştera Vântului is not considered as one of the vulnerable caves. Peştera Lazului, one of the richest in cave fauna with eight troglobitic and two stygobitic species, is also under-ranked.

Out of more than 12,000 caves known in Romania, 830 are considered in Nitzu et al. (2016, 2018),

with many others that might be biospeleologically overlooked. In order to be certain that a species is present in one or more caves, repeated sampling is needed. Moldovan et al. (2012) have shown the large heterogeneity of stygobiontic fauna in caves, where some species were collected only once during several months in a single drip/pool inside a cave.

Type II error: assuming that the list of ranked caves is based on strictly regional endemic species. The list published by Nitzu et al. in 2016 has many examples of troglophilic species that are not even endemic at national level. For example, *Trachelipus trilobatus* is a troglophile isopod also mentioned from Poland and *Orthonychiurus ancae* is a troglophile also present in Slovenia (de Jong et al., 2014). There are also troglophilic species with wide distribution in Romania. For example, *Hyloniscus flammuloides* is distributed in two different mountain massifs of the Southern Carpathians with possible more extensive distribution (Tabacaru & Giurginca, 2013).

Niphargus "*ablaskiri variabilis*" (correct *N. variabilis*) is not endemic to only some particular caves, but present in the Bihor, Vâlcan and Şureanu Mountains (Apuseni Mountains and Southern Carpathians, respectively). *N. bihorensis* is also present in several other caves in the Apuseni Mountains, and not only in Meziad Cave (Dobreanu & Manolache, 1957). "*N. stygocharis stygocharis*" (correct *N. stygocharis*) is present in Peştera de la Vadu Crişului, but also in the hyporheic environment of the Crişul Repede River and in several drinking water wells along this river.

We argue that endemic species should be only considered when isolated populations are present in specific areas characterized by particular geological and geographical features. When a species is present

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in a larger territory such as that of a ~250.000-km^2 country, with such a heterogeneous landscape, then the species can no longer be considered a regional endemism.

Type III error: assuming that troglobionts and troglophiles are equal in setting protection priorities. Considering that caves can be ranked by using troglophilic species means prioritizing the protection of cave fauna by way of adding species that also use surface habitats. We picked randomly from the list (Nitzu et al., 2016) two examples of caves from Southern Carpathians: Peștera Piatra Scrisă, with two troglophile species and sharing the same ranking with Peștera Vacilor din Cheile Orzeștilor, which houses one troglobiont and one troglophile. Similarly, Peștera Piatra Scrisă has a higher ranking than Peștera de la Gălășeni, which has two troglobionts and one stygobiont, with one species being endemic to this cave, or higher than Peștera din Pietrele Negru, with one stygobiont and two troglobionts, one endemic to a few caves within a small area.

Troglophilic species might be mentioned in dozen of caves, but there is no study on their presence and abundance in surface and subsurface habitats. Troglophilic species can be found at the entrance of any small cave or even sheltered under the rocks at the surface and their distribution is higher than estimated.

Type IV error: assuming that frequency is a true estimator of endemicity. Sampling in a few caves in one area is also subject to erroneous frequency estimation of a species distribution. For example, the ranking of a species found in 30 caves in an area of 10 km^2 is the same as the ranking of a species found in the same number of caves (30) in an area of 100 km^2, where the other possible 300 caves with fauna were not inspected. Ideally, sampling should be carried out in all caves in a relatively small area. On the contrary, it becomes more difficult to estimate the presence/absence of species in larger areas, where the number of caves can be higher and nearly impossible to be entirely sampled.

Type V error: ignoring species that should be on a red list of Romanian cave species. Some species are known to be very rare in caves, even when repeated sampling attempts are made, while other species form big populations in caves. Even if caves are not the unique habitat for the cave animals, they are part of their ecosystem and one cannot ignore the importance of caves as habitat. The cave species may be distributed in extremely limited areas in one cave. For example, Peștera Jgheabul lui Zalion is low ranked, although it contains a unique representative of the genus "*Romanosoma*" (correct *Hylebainosoma*) that is not present in other regions of Romania. In the same region, Peștera de la Izvorul Tăușoarelor, absent in the list of Nitzu et al. (2016), is the habitat of an endemic troglobiontic Diplura (*Litocampa humilis comani*), also representative of a rare fauna group in Romanian caves (Sendra et al., 2012).

Type VI error: ignoring the potential threats to cave fauna. By ranking caves that are highly vulnerable to anthropic impacts at low levels based on quantitative data is as dangerous as declaring the caves free to any usage. Although Nitzu et al. (2018) promised to add other criteria to cave ranking, we consider that one cannot start prioritizing caves for protection based solely on the number of species and their frequency and ignoring the actual threats. Many strategies of caves protection also include the possible or existent threats (e.g., Souza-Silva et al., 2015; Souza-Silva & Ferreira, 2016, and references in Nitzu et al., 2018). In Appendix 1 (Nitzu et al., 2018), 66 caves in Apuseni Mountains and 103 caves in Southern Carpathians have a small endemicity index, leaving less than 19 caves in Apuseni Mountains and 14 caves in Southern Carpathians for protection. According to the same reasoning, none of the caves in Banat Mountains (one of the most important hot-spots for cave endemics in Romania) are in the red zone and require protection. The same stands for caves in Eastern Carpathians, which contain less endemic species and therefore do not deserve much protection. Each of these mountain ranges has cave genera and species that are endemic to one or a few caves in a small area.

Today, one of the most important threats to caves in Romania is the so-called 'specialized speleological tourism' (literally translated from Romanian). This type of tourism involves the visiting of wild caves by groups of ordinary tourists that are provided with speleological equipment and a guide. The phenomenon is rapidly growing in Romania and affords access to hundreds of people in a single day, even in highly protected caves with little or no control and without knowing that they may destroy some of the most important and unique habitats for rare cave species. This threat was ignored by Nitzu et al. (2018). In Vântului Cave, which is often visited during weekends by hundreds of people, eleven species out of a total of twelve were described only in the lower level of the cave. This is exactly the place where the access for speleological tourism was granted, assuming incorrectly that the cave fauna can be found also in the upper levels, which is not the case.

Type VII error: ignoring the legislation in force that protects cave habitats or cave species. The idea of prioritizing caves based on species number can lead to unnecessary protection for caves that are not under threat, and to insufficient protection for caves that have not been studied enough and where rare species may live. First, it is hard to understand the need to prioritize cave conservation in Romania, since all caves (except for the show-caves) are protected by the European and Romanian legislations in force (Habitat Directive, (1992) Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora; Law 49/2011).

Conclusions such as "…caves where high EI (endemicity index) were recorded should be prioritized at national level in terms of conservation concern, while those with low EI should be included in regional conservation agendas" (Nitzu et al., 2018) should be considered with care. There are no such 'regional

conservation agendas' in Romania. A classification of caves based on such an index cannot be made, and caves cannot be prioritized for protection accordingly. A "low endemicity-index cave" can house at least one endemic species and so the habitat of this species should be unquestionably protected. A cave cannot be judged as being less important than others because of a lower "endemicity index", and so a prioritization of caves and karst areas in the context of their preservation, protection and sustainable management should not be made.

In the absence of a red list of cave species, which must be based on solid facts, cave fauna is protected through their habitats by Romanian and European legislation. The unit for protection and conservation of cave fauna must be the uniqueness, endangerment and irreplaceability of the species and their potential habitats. The number of species can be used in some cases of new threats to caves or cave habitats, like the opening of caves for uncontrolled tourism, but in no case for prioritizing caves for protection when legally all caves are protected. As a conclusion we consider that both poorly documented fauna lists and impact studies can represent major threats to the integrity of caves and their fauna.

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